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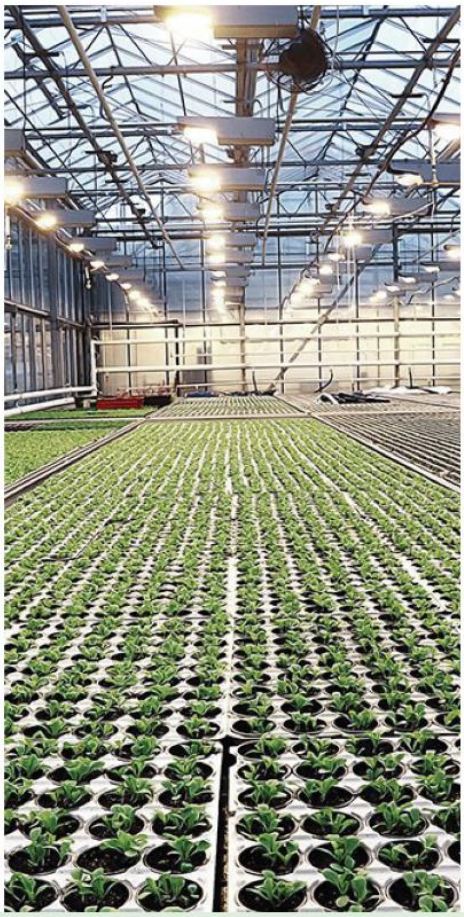
Extended Abstracts

4th International Conference of Agricultural Sciences


Faculty of Agricultural Sciences
Sabaragamuwa University of Sri Lanka
2022

4th International Conference of Agricultural Sciences

(AgInsight 2022)

Sabaragamuwa University of Sri Lanka

"Empowering Research for Innovative and Sustainable Agriculture"

26th and 27th January, 2022

Extended Abstracts

AgInsight 2022

Faculty of Agricultural Sciences,

Sabaragamuwa University of Sri Lanka,

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4th International Conference of Agricultural Sciences

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Extended Abstracts

Thematic Areas

Agribusiness and Agricultural Economics
Agriculture and Agri-Environment
Livestock and Aquaculture

Faculty of Agricultural Sciences,
Sabaragamuwa University of Sri Lanka,
P.O. Box 02,
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Keynote Address

Professor Andrea S. Cupp

Animal Reproductive Innovations During Pubertal Attainment to Increase Animal Protein

Andrea S Cupp[1], Sarah Nafziger[1], Mohamed A. Abedal-Majed[2], Jessica Keane[1], Jeff Bergman[1], Scott Kurz[1], Adam Summers[2]

[1]Department of Animal Science, University of Nebraska-Lincoln, Lincoln, Nebraska

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The world population is predicted to increase from approximately 7.9 billion in 2020 to 9.9 billion in 2050. In order to feed the world's population, innovation in how animal protein is produced need to be enhanced to ensure enough food for the world's growing population. Increased beef, dairy and production of small ruminants, and poultry will need to be produced in a sustainable manner to meet an ever-changing climate. Females that achieve earlier puberty respond to synchronization of estrous cycles, have offspring sooner, and are retained in the herd which enhances their reproductive longevity. These early puberty females are more cost effective since they can repay their development inputs and contribute to increased productivity for the producer. Heifers with earlier puberty have greater reproductive tract scores, respond to synchronization and artificial insemination with greater numbers that calve in the first 21 days of breeding compared to heifers that have delayed puberty. Heifers with delayed puberty have greater numbers of monocytes, and red blood cell parameters that also indicate inflammation and/or decreased liver function. Because attainment of puberty is affected by genetics and environment, we are evaluating differences in temperature, moisture, and drought to determine impact on pubertal attainment. Initial genome wide association studies identified loci contributing to phenotypic variation in genes involved in inflammation, ovulation, neuronal activity, and oxidative stress. Also, whole genome sequencing (WGS) of heifers identified SNPs in genes involved in follicular development, and puberty and are determining how these SNPs segregate among puberty classifications. The use of this genomic and environmental data would allow for better management of heifers for earlier puberty resulting in greater profitability and sustainability of cow/calf operations world-wide. This information could also be transferred to other livestock species to promote increase production of animal protein necessary to feed a growing world population.

Message from the Vice Chancellor
Sabaragamuwa University of Sri Lanka

Professor Udaya Rathnayaka

It gives me a great pleasure to extended my heartiest congratulations for the 4th International Conference of the Faculty of Agricultural Sciences Sabaragamuwa University of Sri Lanka (AgInsight 2022) under the theme of "Empowering Research for Innovative & Sustainable Agriculture". As one of the pioneering faculties of the university, Faculty of Agricultural Sciences has always boldly harbored its academic responsibility and this is indeed a historic milestone of the faculty.

When consider the complexity of the issues that we deal today, what we learn together and the way we share the new knowledge among academia and industry, is important to foster breakthrough ideas that will help in addressing such issues. This conference would provide ample opportunity for sharing knowledge generated through such latest research which is critical in enhancing the well-being of humans, while reviving the global economy in the midst of the present global pandemic.

Organizing an international conference is a big challenge and it has now become more difficult due the global Covid – 19 pandemics. However, I am confident that the Faculty of Agricultural Sciences will hold this conference to meet the global standard.

I extend my sincere thanks and congratulations to the organizing committee, keynote speakers, paper presenters and the participants of the conference and wish them all success.

Prof. Udaya Rathnayaka

Vice-Chancellor

Sabaragamuwa University of Sri Lanka

Message from the Dean
Faculty of Agricultural Sciences

Prof. P.M. Asha S. Karunaratne

I am delighted to issue this message to the proceedings of the 4th International Conference of the Faculty of Agricultural Sciences (AgInsight 2022) as the Dean of the Faculty of Agricultural Sciences of the Sabaragamuwa University of Sri Lanka.

The Conference is organized around the theme of "Empowering Research for Innovative and Sustainable Agriculture". Today, the world is changing rapidly and the problems observed in the agricultural sector are more complex than those in the past. We need multidisciplinary approaches on a global scale in order to solve these problems.

The aim of bringing together both the local and international researchers from different agricultural disciplines to a common platform is evident in this conference. Organizing such an event during this pandemic situation reinforces our objective of developing an environment of exchange of ideas towards the development of the agriculture sector.

The hard work and dedication of all the members of organizing committees during the preparation for this conference is highly appreciated. Without them the event would not have been possible.

I extend my best wishes for the success of the conference.

Prof. P.M. Asha S. Karunaratne

Dean/Faculty of Agricultural Sciences

Sabaragamuwa University of Sri Lanka

Message from the Conference Chair

Prof. Ruvini K. Mutucumarana

On behalf of the Organizing Committee, it is a great honour and privilege to me to extend the welcome message to the 4th International Conference of Agricultural Sciences (AgInsight 2022). To avoid the devastating impact of Covid 19 global pandemic on public health and societies around the world, this time AgInsight 2022 organized by the Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka will be held as a virtual conference on 26th and 27th January 2022, at the premises of the Faculty of Agricultural Sciences in Belihuloya, Sri Lanka.

Aligned with the theme 'Empowering Research for Innovative and Sustainable Agriculture' AgInsight 2022 proudly presents more than 100 extended abstracts representing diversified fields of Agribusiness & Agricultural Economics, Agriculture & Agri-environment and Livestock & Aquaculture. AgInsight shares and disseminates research outcomes from the national and international Universities to a wider global community and will get together both academics, industry professionals and research students to a common platform. AgInsight 2022 will show a brilliant path and unerring direction for future research. I wish two plenary sessions would be able to address and discuss the most argued themes of the agriculture and livestock sectors at both national and global levels.

On behalf of the AgInsight 2022 Organizing Committee, I would like to extend my heartfelt gratitude to the Vice Chancellor of Sabaragamuwa University of Sri Lanka, the Dean of the Faculty of Agricultural Sciences and the former Dean of the Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka for their immense guidance and support offered throughout the process. I would also like to convey my warmest thanks to all the members of the Organizing Committee and all those who worked hard to make AgInsight 2022 a reality and a delightful event especially at a period of an unprecedented global pandemic.

I wish that the AgInsight 2022 will be a tremendous success.

Prof. Ruvini K. Mutucumarana
Chair
4th International Conference of Agricultural Sciences

Plenary Session: Agribusiness and Agricultural Economics

Pandemic and the food security

By Prof. Champika Liyanage, University of Central Lancashire

Covid pandemic has severely hit many spheres of life. Its impact on the global economy, the rapid ways in which it spreads across the global population and the impact it is having on our daily lives is overwhelming. There're a lot of lessons to be learnt along the way, until the pandemic is over (if ever). One aspect is to consider how to build greater resilience in our food systems, so that we have the ability to better endure a crisis in the future (Eldidge, 2020). In the UK, the last major food crisis was during the second world war. During this era, there were government-led 'dig for victory campaigns which combined growing your own fruit and vegetables with a nationwide mobilization of farmers. A lot has changed since then obviously, as many systems have now been replaced with commodity-based supermarket sourcing system (Sustainable Food Trust, 2020). Many countries, including the UK, now depend on imported food, thus, food chains have become extremely long, which then creates vulnerability in itself to fall apart easily. This was evidence at the start of the pandemic with lack of food supplies in supermarkets leading to major disruptions. Since the we are yet to see an end to this pandemic as yet, it's high time we talked about some solutions to address food security issues.

Plenary Session: Livestock and Aquaculture

The Role of Nutrition in Sustainable Livestock Production

By Dr. Walter Samarasinghe, Managing Director of Superfeed (PVT) Ltd.

Nourishment of farm animal contributes approximately 85% of the total cost which is the second highest limiting factor in livestock production. Therefore, nourishment becomes huge challenge in sustainable livestock production. The role of nutrition in sustainable livestock production will be critically discussed and assessed by focusing on following areas relevant to farm animal's nourishment by assurance of sustainable livestock production for food security.

1. Present status of the formulated animal feed industry in Sri Lanka
2. Potentials of the animal feed industry in Sri Lanka
3. Constraints of the animal feed industry in Sri Lanka
4. Strategies/ Remedies of the animal feed industry in Sri Lanka
    - Cost effectiveness of feed production
    - Use of recent advances in feed technology
    - Application of simulation models in animal nutrition
    - Efficient use of nutrition on non-productive functions
    - Protection of the environment and animal farming systems
    - Minimize impacts of nutrition on health, welfare, and productivity
    - Future trends of the animal feed industry in Sri Lanka
    - Creation of appropriate / customize feeding systems based on local resources

LIST OF EXTENDED ABSTRACTS

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Agriculture and Agri-Environment

Anthelmintic effect of biorationals against the root knot nematode, *Meloidogyne incognita* colonizing chilli rhizosphere

P.D.N.S. Karunasena[1]*, K. Pakeerathan[1], T. Thileepan[2], G. Mikunthan[1]

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1. Introduction

Chilli is an important cash crop of Sri Lanka (*Capsicum annum*). A variety of biotic-abiotic stresses impair the chilli production particularly in high potential chilli producing areas in dry and intermediate zones of Sri Lanka. Multiple cropping and continuous cultivation of the same crop on the same plot of land increases the problem of soil-borne diseases, specially plant parasitic nematodes (Dhillon et al., 2019). Root-knot nematode causes damage on a variety of crops, including chillies, tomatoes, and potatoes. The Root-knot nematode (*Meloidogyne* spp.) belongs to the family Meloidogynidae is the primary nematode species infesting chili plants. They pierce the root and enter the vascular system, where they cause metabolic changes that contribute to gall formation (Thiyagarajan, 2014).

The root-knot nematodes manage by using various recommended tactics and management strategies. But, synthetic nematicides are preferred by farmers due to their quick knock-down effect. The use of synthetic nematicides is being limited due to the booming number of cancer and chronic kidney disease of unknown etiology (CKDU). Recently, Sri Lankan policy banned the importation of all forms of synthetic agrochemicals. As a result, scientists have been looking for long-term solutions to nematode problems. Many plants are known to produce secondary compounds to safeguard them from harmful pathogens through physiological pathways. Moreover, many higher plants contain nematicidal compounds that can kill, inhibit nematode hatching, or impair nematodes motility (Amora et al., 2017). This study was aimed to evaluate the anthelmintic effect of selected bio-rationals against *M. incognita* attacking chilli.

2. Materials and Methods

Isolation of female of *Meloidogyne incognita*

Root-knot infected root samples were collected from chilli fields in Jaffna District and brought to Nematology Laboratory at the Department of Agricultural Biology, Ariviyal Nagar, Kilinochchi and were washed and disinfected with 2% aqueous solution of NaOCl. Root galls were cut into small pieces and the upper layer of roots was peeled carefully. Pear-shaped females were picked out with the camel hair brush without damaging.

Raising of chilli seedlings

The nursery bed was prepared in sterilized soil to get *KA2* chilli seedlings for studies and all the agronomic practices were followed as the Department of Agriculture recommendation. Sieved sterilized (sterilized through Tyndallization process) soil was filled at the ratio of compost: top soil,1:2 in 6 kg capacity pots made using black polybags. Two weeks old *KA2* chilli seedlings were transplanted as two per pots.

Preparation and Application of treatments

Anthelmintic plants leave namely *Cassia alata* (Candle Bush), *Vernonia anthelmintica* (Ironweed), *Aristolochia bracteolata* (Worm killer), *Moringa oleifera* (Drumstick tree) were collected from herbal garden maintained at the same department and ground thoroughly using an electric grinder and water extract was prepared. Extracts were vacuumed in a rotary

evaporator at 50 °C- 55 °C. 40 ml of each extract and 200 ppm solution of fluopyram (400 g/l SC) were used as for root dipping of chilli seedlings (15-20 min) before transplanting. 20 Pear-shaped females of *M. incognita* were inoculated three days after transplanting. Soil application treatments (40 ml) were repeated at two weeks' intervals also.

Experimental design, data collection and Statistical analysis

This experiment was carried out under the experimental design of CRD in the green house with six treatments and four replicates. Plant height, number of galls according to scaled (Sasser et al., 1984) where 0=No galls; 1=1-2 galls; 2=3-10 galls; 3=11-30 galls; 4=31-100 galls and 5=>100 galls, length and diameter of galls were measured after uprooting of seedlings. The statistical analysis was performed by using ANOVA, and Tukey's HSD multiple comparison test was administrated to identify the best treatment at P <0.05 using SAS 9.1.

3. Results and Discussion

Influence of anthelmintic plant extract on plant growth

Initially all the chilli plants were selected in equal height (Fig. 1). Four weeks after planting, significantly different plant height of 12.2 cm was observed in *C. alata* treated trail but in control where plant height was 9.8 cm at P <0.05. Plant height was insignificant in other treatment combinations.

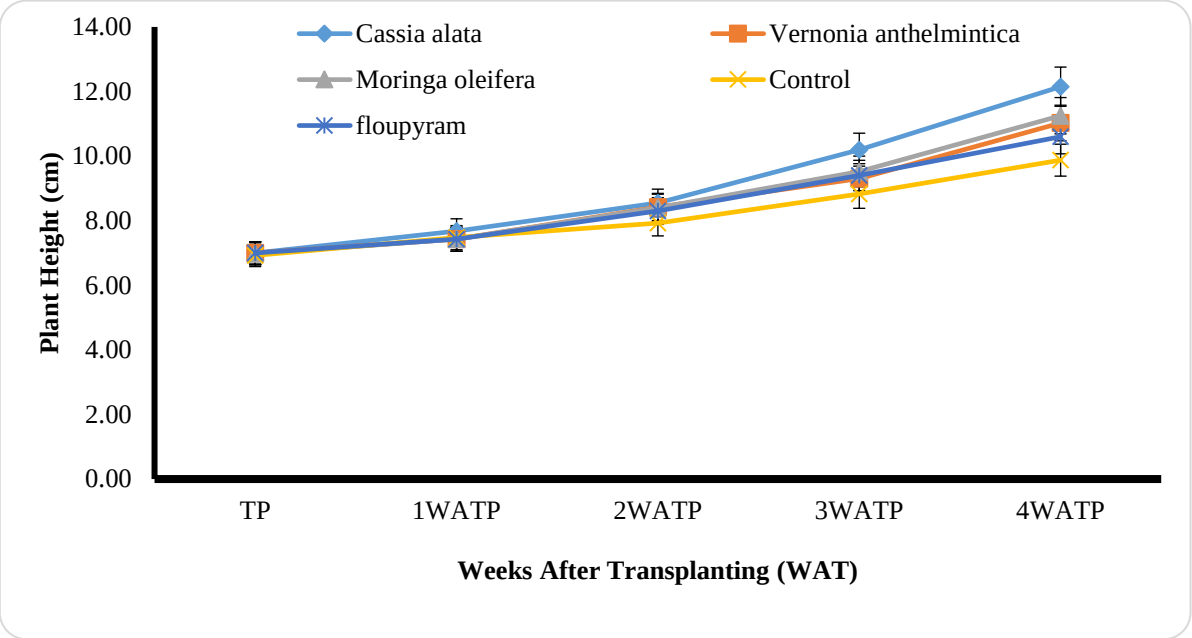

Figure 1. Plant height of *KA2* chilli in different treatments.

Efficacy of anthelmintic plant extract on root-knot nematode

The results show that the mean number of galls produced, length of the gall and the diameter of the galls were significantly different among the treatments (Table 1). The lowest gall number of 4.75, gall length of 1.19 mm and gall diameter of 0.57 mm were observed in *C. alata* treated trail. The number of galls counted in *C. alata* extract treated trail was significantly different from all other treatments except nematicide Floupyram applied trail. Number of galls comparatively less in *V. anthelmintica* and *M. oleifera* treated plants with the root-knot index value of 3 than control where the nematode index value was 4, but they were not significant than control treatment.

Mean length of gall is significantly lower in all the treatments than control. The lowest gall length of 1.19 mm was recorded in *C. alata* treated trail whereas second lowest mean gall length

of 1.33 mm was recorded in *V. anthelmintica* which was insignificant when compared with *C. alata* at $P < 0.05$.

Mean diameter of gall was less than 1mm in all the treatments except control. Diameters of galls were not significantly on par among them except in control where the highest diameter of gall (1.37 mm) was recorded. The gall diameter in *V. anthelmintica*, *M. oleifera* and floupyram treatments were 0.96 mm, 0.90 mm and 0.75 mm, respectively.

All the chilli plants treated with the *A. bracteolata* were dead few days after treatment. That extract may contain some toxic components; it may have negatively affected the plant's survival.

Table 01. Effect of different treatments on Root-knot nematode

Treatment	Number of galls	Length of gall (mm)	Diameter of gall (mm)
Cassia alata	4.75[b]	1.19[c]	0.57[b]
Vernonia anthelmintica	23.50[a]	1.33b[c]	0.96[b]
Moringa oleifera	24.00[a]	1.45[b]	0.90[b]
Floupyram	6.00[b]	1.45[b]	0.75[b]
Control	33.25[a]	1.63[a]	1.37[a]

Mean values with the same alphabets are not significant according to the Tukey's HSD at 95% confidence interval

From the obtained results, it was clear that the water soluble nemato-toxins or phytochemicals present in botanical are interfered with nematode growth and reproduction. Wondimeneh et al., (2013) reported that Mexican marigold leaf, bitter leaf, lantana leaf and baker tree seeds were inhibited the root-knot eggs hatching (95%) as well as reduced the formation of galls, number of eggs/egg-mass and final nematode population density in the soil and increased plant height of tomato. Khan et al., (2019) proved that *Phyllanthus amarus* leaf extract at 5000 ppm caused 86.5% inhibition in egg catching, 91% juvenile mortality, significant reduction of gall index and egg masses/root system of root-knot nematodes. Dahlin et al., (2019) reported that the nematicide Velum protected the plants from *M. incognita* by reducing the soil nematode population and protecting the plantlets against the initial penetration and significant root damage. Alkaloids, diterpenes, fatty acid, glucosinolates, isothiocya- nates, phenols are the potential nematicidal metabolites produced by the antihelmenthic plants (Asadi et al., 2015). These evidence tally with current experiment results.

4. Conclusions

The study revealed the potential of anthelmintic plant extracts in the management of root-knot nematode. Among the plant extracts, *C. alata* reduced the infestation, gall-forming ability, number of galls (4.75), length (1.19 cm) and diameter of gall (0.57 mm), even superior to the nematicide. Therefore *C. alata* extract could be used for the eco-friendly management of root-knot nematode in the chilli. The active ingredients present in the *C. alata* plant parts can be a potential source of new organic nematicidal compounds. However, further investigations are needed for recommendation.

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Impacts of selected pesticides on parthenium beetle, *Zygogramma bicolorata* pallister under laboratory conditions in Sri Lanka

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1. Introduction

Parthenium (*Parthenium hysterophorus* L.) is one of the Asteraceae family's most vicious herbaceous weeds. It emerged as the most significant invasive weed of the planet and has invaded 98 countries representing all the continents. Presence of toxic phytochemicals and allelochemicals like parthenon and coronopilin in Parthenium causes severe yield loss on economically important crops as well as poses threat to biodiversity, human and animal health. Among the management practices, chemical, physical, regulatory, fire, mycoherbicides, agronomic practices, competitive displacement, and traditional biological control are the options available for managing parthenium (Dhileepan *et al.*, 2009). Manual and chemical weed control are effective in agricultural fields to control parthenium, but not cost-effective in pastures, vast natural areas, or wastelands. By implementing an integrated pest management practices involving multiple tactics n combination can effectively control Parthenium weed (Dhileepan *et al.*, 2009). Parthenium beetle (*Zygogramma bicolorata*) is found to be a safe biocontrol agent, and its effectiveness has proven in many countries.

Adults and larvae of *Z. bicolorata* feed on parthenium causes meristem damage, resulting in a shorter primary stem and a different branching pattern, defoliation, decreased plant height and flower production. Even when there was no water stress, and plants will die when the plants were defoliated early in their growth cycle (Dhileepan *et al.*, 2000). The success of a biocontrol agent in a natural system is determined over time by biotic and abiotic factors. Recent researches claim that pesticides cause natural enemy mortality which leads to disrupting the equilibrium between pest species and their natural enemies. Therefore, this research study was conducted with the objective of examining the impacts of various pesticides on Parthenium beetle.

2. Materials and Methods

The research was conducted in the quarantine greenhouse at the Department of Agricultural Biology, Faculty of Agriculture, University of Jaffna, situated in dry zone of Sri Lanka (Longitude: 80.4, Latitude: 9.32, Altitude: 46m). Parthenium beetles were detected and collected first time in Northern Sri Lanka and brought to the Biocontrol Laboratory at the Department of Agricultural Biology, and fed with fresh parthenium grown in the insect rearing cages kept in the quarantine greenhouse. Parthenium beetles were adopted well and multiplied quickly under in-vitro condition.

Ten parthenium seeds were sown into 10L pots and the growth of the weed was monitored. At the two leaf-stage, excess weeds were thinned-out and only two parthenium per pot were allowed for further growth. The weed started flowering four weeks after sowing, and at that time, even aged parthenium beetles (10 beetles/plant) and grubs (10 grubs/pant) were released in all 40 cages (10 treatments and three replicates including untreated control) in the late evening (6.00pm) and allowed whole night (14 hours) for settlement.

The pesticides consisting of fungicides, herbicides and insecticides which are commonly used by the small and commercial farmers were selected (Table 1). Pesticides application was done carefully using a hand sprayer at the recommended dosage in an early morning.

Feeding behaviour, mobility and mortality of the beetle and grub population were observed and calculated, respectively. The data were subjected to ANOVA using SAS 9.1. Tukey's HSD multiple comparison test was used to determine the best treatment combination at $P < 0.05$

Table 01. Pesticides used and its rate used for experiment.

Treatments	Pesticide	Chemical name	Recommended dose (for 10 l)
T_1	Fungicide	Mancozeb 80% (w/w) WP	20 g
T_2	Fungicide	Chlorothalonil 500 g/l SC	30 ml
T_3	Fungicide	Propineb 70% (w/w) WP	20 g
T_4	Herbicide	MCPA 600 g	50 ml
T_5	Herbicide	Oxyfluorfen 200 g/l EC	16 ml
T_6	Herbicide	Glufosinate Ammonium 150 g/l SL	94 ml
T_7	Insecticide	Carbosulfan 200 g/l SC	30 ml
T_8	Insecticide	Abamectin 18 g	06 ml
T_9	Insecticide	Pymetrozine 50% (w/w) WG	05 g

3. Results and Discussion

The results of the impact of different types of pesticides on parthenium beetles and their life stages are explained below. Four hours from the application, adult beetles and grubs were found settled but failed to feed for six hours. In the fungicide applied treatments (Fig. 1) adult's and grub's mortality were significantly higher at $P < 0.05$. The grub's mortality was 60% in Chlorothalonil 500 g/l SC treated cages whereas in Mancozeb 80% WP and Propineb 70% WP treated trials, mortality was 40% and 25% respectively. The adult's mortality was 20% in Chlorothalonil 500 g/l SC and Propineb 70% WP treated trials, but no deaths were observed in Mancozeb 80% WP treated trials.

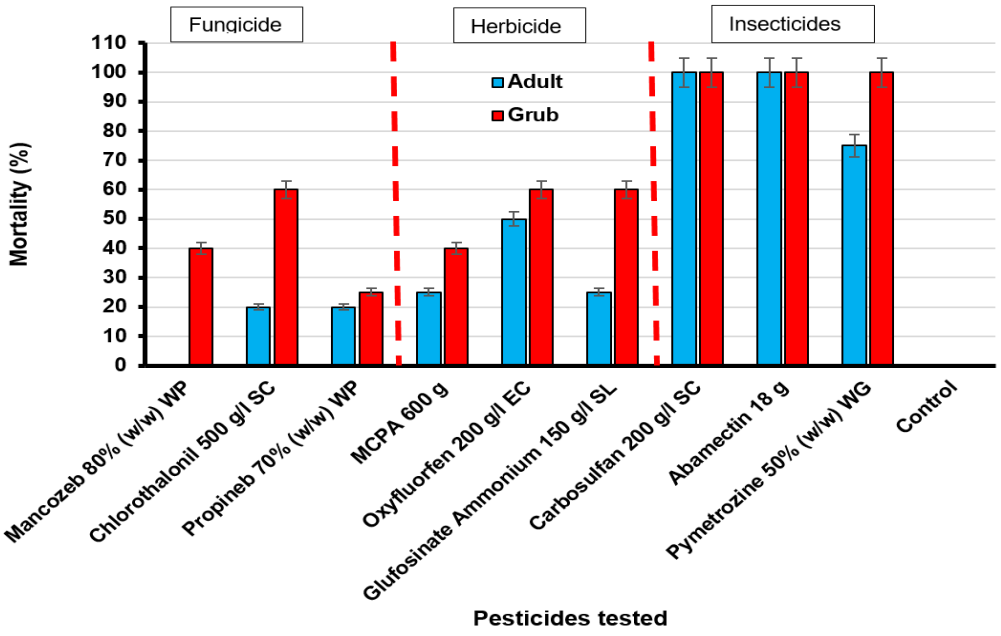

Figure 1. Mortality of life stages of Parthenium beetle due to the application of pesticides

In the herbicide applied trials (Fig. 1) adult's and grub's mortality were significantly higher compared to control at $P < 0.05$. The grub's mortality was 60% in Glufosinate Ammonium 150 g/l SL and Oxyfluorfen 200 g/l EC treated cages whereas in MCPA 600g treated trails, mortality was 40%. The adult's mortality was 50% in Oxyfluorfen 200 g/l EC treated trials, but the death rate was only 25% in MCPA 600g and Glufosinate Ammonium 150 g/l SL treated trials. In the insecticide applied trials (Fig. 1), grub's revealed 100% mortality to all the insecticides tested compared to control at $P < 0.05$. The adult's mortality was only 60% in Pymetrozine 50% (w/w) WG whereas in other two insecticides mortality was 100%.

Overall, insecticides showed an extremely high impact on the survival and existence of the Parthenium beetle population. According to the overall Tukey's HSD multiple comparison test results depicted that insecticides Carbosulfan 200 g/l SC, Abamectin 18 g and Pymetrozine 50% (w/w) WG are highly significant on grub mortality whereas Carbosulfan 200 g/l SC and Abamectin 18 g on adult mortality at $P < 0.01$.

To control weeds, a compatible combination of biological and pesticide approaches is recommended and not applicable if pesticides are toxic to the biocontrol agent (Hasan and Ansari, 2016). Control of parthenium plants using *Z. bicolorata* under various environmental conditions is being very successful. Due to the indiscriminate use of highly toxic synthetic herbicides and being the major polluting agents of the environment especially soil and water in Sri Lanka, the government has banned two potential herbicides paraquat in 2014 and glyphosate in 2017 (limited use allowed in 2019) (Marambe and Herath, 2020). Therefore, biological control of weed is highly being promoted in Sri Lanka. Parthenium beetle was first time recorded in Sri Lanka in 2019 (Pakeerathan, 2019), and observed that rarely available and eating parthenium in agricultural lands and was abundant in non-cultivated Parthenium grown fields. It was suspected that it may be the reason for the intensive use of pesticides. Therefore, the current study was planned, and it confirmed that the insecticides are highly dangerous to beneficial biocontrol agent *Z. bicolorata*

Hasan and Ansari (2017) reported that acute toxicity of insecticides monocrotophos and imidacloprid caused the highest mortality on third instars and extended the development time of treated larvae of parthenium beetle. Monocrotophos interfered severely on fecundity and egg

viability of the Parthenium beetle. Siddhapara *et al.* (2012) reported that insecticide chlorpyriphos 0.05%, atrazine 1 kg per ha, thiomethoxam 0.005%, glyphosate 1 kg per ha, metribuzin 1 kg per ha, and imidacloprid 0.005% per cent were most toxic to the grubs and adults in comparison to Endosulfan 0.075% and dimethoate 0.03% were moderately toxic to the grubs and adults and adults, respectively. Herbicide 2, 4-D sodium salt 1 kg per ha was found to be least toxic to the larvae and adults of *Z. bicolorata*. Moreover, Hasan and Ansari (2016) found that herbicides 2,4-D and alachlor are highly toxic to 3rd instar larva. These findings validate the current findings. Therefore, careful selection of pesticides is extremely important to safeguard the potential biocontrol agents

4. Conclusions

Among the pesticides tested insecticides Carbosulfan 200 g/l SC, Abamectin 18g showed highest mortality to the grubs and adult beetles, even at the recommended dose. In the field there are more chances of beetles to escape from one area to another, therefore to know the real impact of pesticides on various life stages of *Z. bicolorata* Further field trials are needed for recommendation.

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Nano-based formulation of *Acarous calamus* rhizome extract and its efficacy on *Aspergillus flavus*

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1. Introduction

Aflatoxin is a poisonous contaminant of food crops from *Aspergillus* fungi. It causes not only deleterious issues in humans and livestock, but also inflicts severe economic loss in agriculture production by the quality deterioration of more than 25% of food crops (Tinham, 2018). Aflatoxin is the secondary metabolites of Aspergillus species, especially *A. flavus* and *A. parasiticus* (Perrone et al., 2007). The use of fungicides to control this fungus may not be environmentally or socially acceptable due to their harmful nature. Plant extracts and secondary metabolites of microorganisms, on the other hand, have been demonstrated in multiple studies to effectively limit Aspergillus fungus growth, reproduction, and aflatoxin formation when treated (Reddy et al., 2009). The problem of plant extracts is less efficient. Nanotechnology opened an era to synthesize the Nano molecules of plant extracts using silver, copper, gold and clay. Nano molecules increase the efficacy of the active ingredients present in the plant extract through particle size reduction as well as increase surface area to volume ratio by altering the physical and chemical properties of the active ingredients (Kathiravan et al., 2015). Nano-based technologies are eco-friendly and safe but, have their own advantages and disadvantages too. The main objective of this study was to synthesise silver nanoparticles from medicinal plants with antifungal capabilities against Aspergillus and analyse their efficacy using an in vitro assay.

2. Materials and Methods

The investigations were conducted at Plant Protection & Bio Control Laboratory at the Department of Agricultural Biology, and Nanoparticles were characterized at the Chemistry Research Laboratory, Department of Chemistry, Faculty of Science, University of Jaffna.

Groundnut kernel contaminated with the *Aspergillus* fungus was surface sterilized and the infected portion was inoculated into PDA medium and pure culture was isolated by the standard tip culture method. Morphological and microscopic examination confirmed the isolate as *A. flavus*. The dry rhizome of *A. calamus* was sterilized using 3% NaOCl and dried at room temperature. *Acarous calamus* rhizome was ground to make a powder using an electric grinder. Hot water extract of *A. calamus* was prepared and was kept in the refrigerator at 4 ℃ for further studies. Silver nitrate was used for the synthesis of silver nanoparticles of *A. calamus*. Optimization of silver nitrate volume and shaking time in the mechanical shaker was conducted with 0.01 mol L^{-1} $AgNO_3$ solution. Nanoparticles were manufactured at a mass level via optimization, and nanoparticles were obtained. The poison food technique was used to investigate the efficacy of produced silver nanoparticles against *A. flavus*.

Synthesized Nano molecules were dissolved in double distilled water to prepare different concentrations [0.005 g, 0.01 g, and 0.02 g] to test their efficiency in controlling *A. flavus* growth, and reproduction. All the experiments were conducted in Complete Randomized Design (CRD), Data were subjected to ANOVA using SAS 9.1 and Duncan Multiple Range Test (DMRT) was used to identify the best treatment combination at $P < 0.05$.

3. Results and Discussion

Synthesis of Nanomolecules

Diluted *A. calamus* extract colour was yellow and immediately after the addition of a different volume of silver nitrate, it turned out to light yellow. After synthesis of nanoparticles, the colour was turned to brown and after shaking it further turned to blackish brown. Colour changes confirmed the formation of nanoparticles. Using a Jasco V-570 UV-VIS-NIR spectrophotometer, the maximum absorption peak for the green synthesised *A. calamus* nanoparticle was obtained in the wavelength range of 400 nm to 500 nm after 210 minutes of mixing with 20 mL of 0.1 mol L^{-1} $AgNO_3$. Efficacy of Nano molecules against the growth and reproduction of *A. flavus*.

The diameter of mycelial development was measured and spores were counted from the day of inoculation to fourteen days.

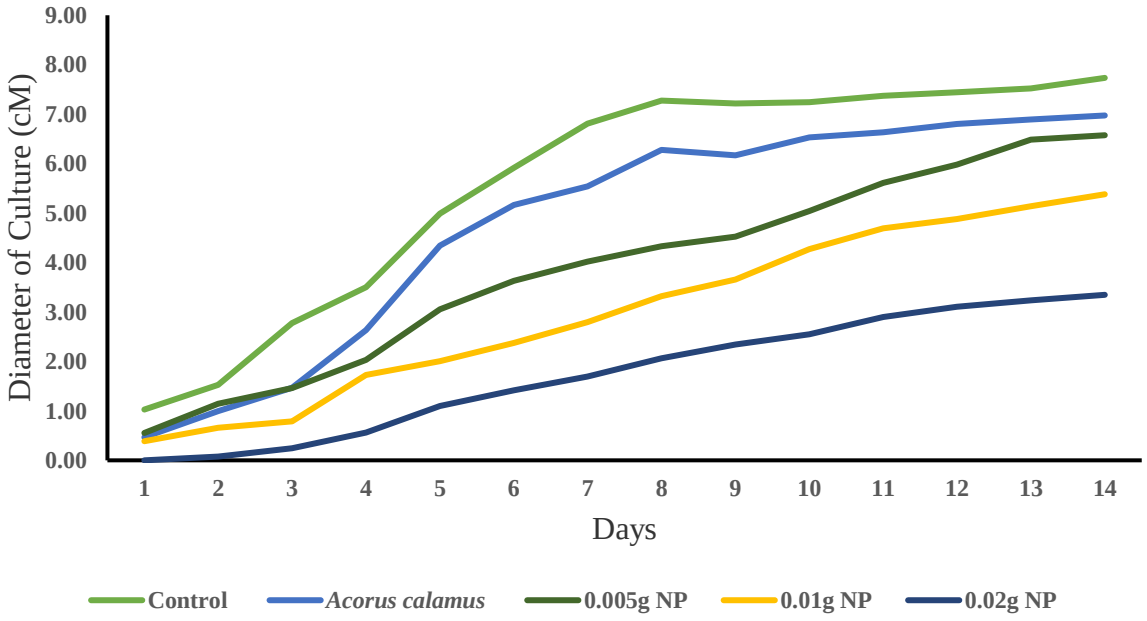

Figure 1. Comparison of Aspergillus growth in control, *A. calamus* extract and different amount of synthesized silver nanoparticles

Figure 1 illustrates the pathogen's growth rate in PDA (control), *A. calamus* water extract, and various amounts of synthesised silver nanoparticles from *A. calamus*, such as 0.05 g, 0.01 g, and 0.02 g. Nanoparticles synthesized from *A. calamus* water extract suppressed the growth of the *A. flavus* pathogen more efficiently than a direct application. In comparison to control (PDA), 0.02 g synthesized silver nanoparticles administrated trails *A. flavus* pathogen growth was significantly low (50 %) at $P < 0.05$.

The growth rate of *A. flavus* in 0.01g and 0.005g of Nanoparticle concentration were also comparably less and significant only at the concentration of 0.01g with control, *A. calamus* water extract and 0.02g concentration of Nano-synthesised *A. calamus* water extract at $P < 0.05$. Therefore, the results confirm that active ingredient(s) present in the Nano-synthesised *A. calamus* works better against test pathogen than Nano-free *A. calamus* water extract. Furthermore, when the concentration of Nanoparticles rises, the working efficacy of the active ingredient(s) rises as well.

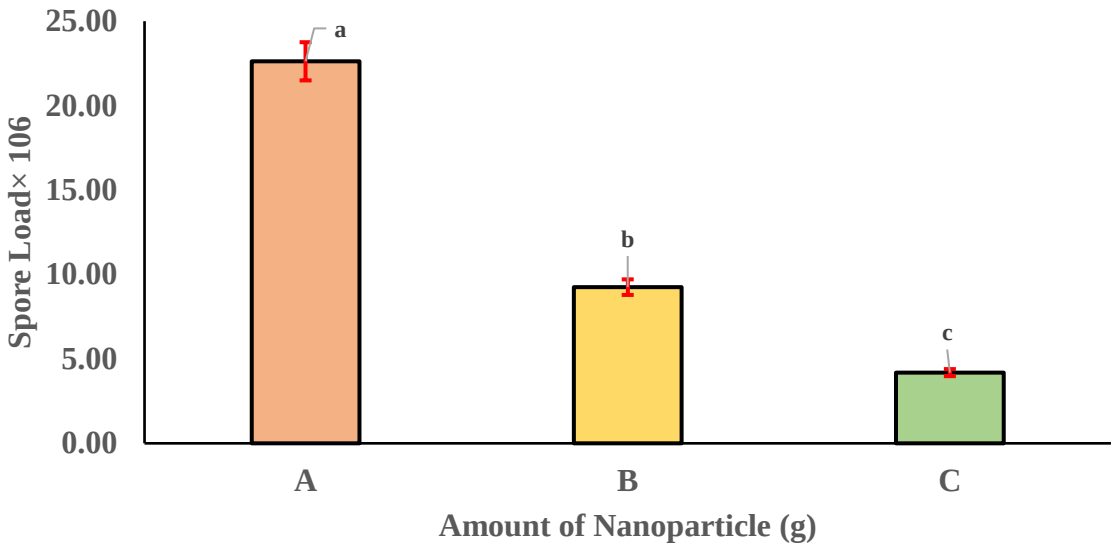

Figure 2. Number of spores produced in different amounts of nanoparticles mixed in culture media A) control B) 0.1 g, C) 0.3 g

Figure 2 shows that spore production of *A. flavus* in different amounts of synthesized silver nanoparticles present culture media. When the concentration of nanoparticles increased in the PDA media, the production of spores *A. flavus* was declined significantly at $P < 0.05$. In control (A), 0.10 g nanoparticles incorporated PDA(B), 0.30 g nanoparticles incorporated PDA(C) spore amount were 2.263×10^{7} ,9.25×10^{6},4.19×10^{6}, respectively.

Green synthesis of the metallic nanoparticle is a one-step process that reduces the metallic ion into metal by oxidizing phytochemicals that are present in the plant extract (Usha et al., 2017). Thus, this method is eco-friendly and less expensive compare to physical and chemical methods. Also, microorganisms have the ability to detoxify heavy metals. Intercellular and extracellular synthesis of metallic nanoparticles performs by using bacteria, yeast, and fungus (Singh et al., 2016).

Medda et al. (2015) green synthesized Silver nanoparticles using *Aloe vera* water extract and which was successfully controlled the plant pathogens *Rhizopus* sp. and *Aspergillus* sp. due to their antifungal activities. Jo, Kim and Jung, (2009) reported that Silver ion and Silver nanoparticles with a lower level of toxicity reduce colony formation of fungi *Bipolaris sorokiniana* and *Magnaporthe grisea*. Krishnaraj et al. (2012) reported that *Acalypha indica* leaf extract-based Silver nanoparticles inhibited the growth and reproduction of *Alternaria alternata*, *Sclerotinia sclerotiorum*, *Macrophomina phaseolina*, *Rhizoctonia solani*, *Botrytis cinerea* and *Curvularia lunata* effectively at 15 mg concentration of silver nanoparticles. These findings validate the current investigation. This study clearly shows that the green synthesized silver nanoparticles suppress the growth of *A. flavus* pathogens more effectively compared to the direct application of *A. calamus* water extract. Changes in the concentration of nanoparticles have a positive relationship with the suppression of pathogens and are inversely correlated with spore production

4. Conclusions

Silver Nanoparticles were green synthesized using *A. calamus* water extract and it took 210 minutes to synthesis Nano-particles. In the Jasco V-570 UV-VIS-NIR spectrophotometer, green synthesised silver nanoparticles exhibited a greater absorption peak in the 400- 500 nm region. Synthesized silver nanoparticles have suppressed the growth of the *A. flavus* than direct application of water extract of *A. calamus*. When the concentration of nanoparticles increased

inhibition percentage of pathogen growth increased and spore formation decreased. Green synthesized silver nanoparticles using *A. calamus* may be an effective alternative to synthetic fungicides but, further extensive studies are in progress to validate the findings.

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Starch hydrolysing ability of recombinant *Escherchia coli* containing candidate genes for alpha amylase enzyme

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1. Introduction

Starch hydrolysing enzymes are widely used in starch-based industries to produce numerous products which have a high demand in the current world. Today a large number of microbial amylases are available commercially and they have almost completely replaced the chemical hydrolysis in the starch processing industry (Sachdev et al., 2016). Bacterial and fungal sources are used to produce starch hydrolysing enzymes due to its high efficiency. In addition, overproduction of enzymes can be achieved by genetic engineering (Abdel-Fattah et al., 2013). Fungal strain *Thielaviopsis ethacetica* is a soil born fungus, which has been identified to exhibit high enzyme activity on starch substrates and would be an ideal candidate for production of starch hydrolyzing enzymes (Dissanayaka et al., 2019b). However, due to excessive biomass production by this organism and being an opportunistic pathogen makes this organism unsuitable for bulk production of the enzyme. Cloning the gene for starch hydrolases coding sequence of this organism and expressing it in *E. coli* is an alternative method to overcome this problem. Identification of alpha amylase gene from *T. ethacetica* was attempted and cDNA clones containing putative amylase gene in pH6HTN His6HaloTag® T7 expression vector system have been isolated. *E. coli* JM109 had been selected as the compatible host for protein expression. The present study aims at comparing the starch hydrolysing ability of selected *E. coli* JM109 colonies harbouring the recombinant pH6HTN His6HaloTag® plasmid vector containing the putative genes for alpha amylases.

2. Materials and Methods

Recombinant *E. coli* glycerol stocks from nine selected colonies were prepared according to Dissanayaka *et al.* (2019a). Approximately 10 µL from each glycerol stock were aseptically transferred into LB broth (15 mL) with ampicillin (60 µg/mL) separately. Culture flasks were allowed to incubate at 37 ºC at 160 rpm for 24 hrs. From each culture (1 µL) was transferred into LB culture plates separately and allowed to incubate at 37 ºC for 24 hrs.

Starch hydrolysing ability of selected clones were analyzed by observing the clear hydrolyzing zones formation. Single recombinant colonies from each of the clones were transferred onto LB plates containing 1 % starch by replicating three times. The culture plates were incubated at 37 ºC, one set for 24 hrs and a second set for 48 hrs. After 24 hrs and 48 hrs, four different concentrations (100 %, 50 %, 25 % and 10 %) of Lugols Iodine solution (10 mL) were slowly added to the four separate culture plates respectively and were shaken gently for 15 min. The excess volume of Lugols Iodine was removed and the plates, washed with distilled water (10 mL). Plates were then observed for clear hydrolysed zones formation.

Standard glucose curve was prepared by using 1 mg/mL, 2 mg/mL, 3 mg/mL, 4 mg/mL and 5 mg/mL glucose stock solutions and total starch hydrolysing activities were measured by the method described by Henry et al. (1974).

3. Results and Discussion

Out of nine recombinant *E. coli* clones from glycerol stocks (Clone 1 to Clone 9) only five {Clone 3 (C3), Clone 5 (C5), Clone 6 (C6), Clone 7 (C7) and Clone 8 (C8)} were successful in liquid cultures by showing that the cells were grown to an OD 600 nm of 0.3-0.6 and those were used for further analysis.

All five selected recombinant clones were grown on starch plates for 24 hrs and 48 hrs and observed the formation of clear zones by treating with four different Iodine Concentrations and the results of clear zone formations are shown in Table 01.

Table 01. Summarized results for clear zone formation at different levels of iodine concentration after 24 hrs and 48 hrs of incubation

Clone	After 24 hrs				After 48 hrs			
	100% IC	50% IC	25% IC	10% IC	100% IC	50% IC	25% IC	10% IC
C3	NF	F	F	F	F	F	F	F
C5	NF	F	F	F	NF	F	F	F
C6	NF	NF	F	NF	NF	NF	NF	NF
C7	NF	F	F	F	F	F	F	F
C8	NF	NF	F	NF	NF	NF	NF	NF

IC: Iodine concentration; NF: Clear zones were not formed; F: Clear zones were formed

According to the obtained results from clear zones formation, at 10%, 25% and 50% of iodine concentrations, only C3, C5 and C7 formed clear zones at both 24 hrs and 48 hrs of incubation periods. At 25% of iodine concentration was sufficiently enough to form clear zones after 24 hrs for all five selected recombinant clones. At 100% of iodine concentration, none of the recombinant clones was found to have any potential for formation of clear zones at 24 hrs but C3 and C7 formed clear zones after 48 hrs under the same iodine concentration.

These observations suggested that all five recombinant *E. coli* clones were able to produce starch hydrolysing enzymes at some stage of their life cycle. Among all the five recombinant *E. coli* clones, C3, C5 and C7 were able to produce clear zones by showing high enzyme activities under most of the iodine concentration levels compared to the other clones. The control clone (*E. coli* JM 109) showed negative results in all these conditions. Therefore, all five clones were subjected to total starch hydrolyzing assay to confirm their starch hydrolysing ability.

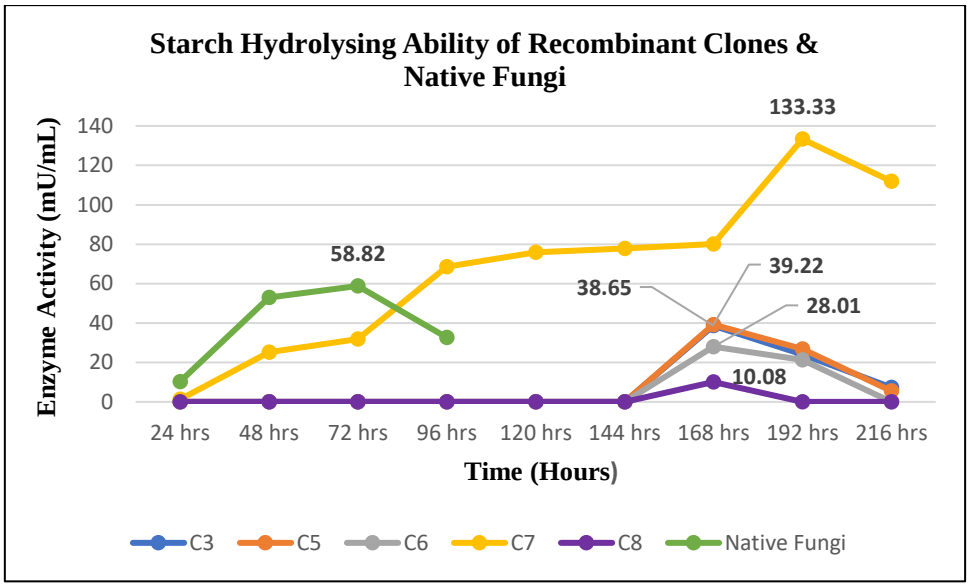

Figure 1. Comparison of total starch hydrolysing activities of recombinant *E. coli* clones and native fungi (*Thielaviopsis ethacetica*)

The graph shows that all the recombinant *E. coli* clones except C7 have late enzyme activities during their life cycles. Enzyme activities of all these clones have remained 0 until 144 hrs. In contrast to this behaviour, the recombinant clone C7 has shown starch hydrolysing ability at the very beginning of its life cycle. In accordance to the data shown in figure 1, the maximum enzyme activity of C7 has been obtained at 192 hrs (133.33 mU) and then a sudden decline has occurred after 216 hrs. Native fungi, *T. ethacetica* reached their maximum enzyme activity of 58.82 mU after 72 hrs then decreased gradually.

The maximum starch hydrolysing activities of recombinant clones C3, C5, C6 and C8 have been acquired at 168 hrs and the enzyme units were represented as 38.65, 39.22, 28.01 and 10.08 mU respectively. As illustrated by the figure 1, at 168 hrs of incubation time the enzyme activity of recombinant clone C7 has reached to 80.11 mU which was comparatively little low but significantly higher compared with other selected four clones. Thus, the overall results depict that the recombinant clone C7 has the highest potential of starch hydrolysing with compared to other studied clones.

4. Conclusions

The five selected *E. coli* clones (C3, C5, C6, C7 and C8) containing the recombinant pH6HTN His6HaloTag® plasmid vector showed starch degrading enzyme activity on LB starch plates by forming the clear zones. According to the results of the total starch hydrolysing assay, C7 has shown higher production of starch hydrolysing enzymes over other recombinant clones and native fungi, *T. ethacetica*. Therefore, feasibility studies will be carried out to optimize all the necessary conditions in the production of starch hydrolysing enzyme in C7 clone to meet the industrial demand effectively and efficiently.

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Do larval frass volatiles deter oviposition behaviour of fall armyworm (*Spodoptera frugiperda* J. E. Smith) (Lepidoptera: Noctuidae)?

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1. Introduction

The fall armyworm (FAW) *Spodoptera frugiperda* was reported in Sri Lanka in 2018 and led to considerable damage to maize mono-cropping. The selection of a suitable oviposition site is critical for the progeny survival of many insects (Schoonhoven et al., 2005). The larval frass, contain volatile substances (Molnár et al., 2017) and in many Lepidopterans, these compounds can serve as chemical cues for conspecific adults to avoid the selection of such places as an oviposition site, hence, larval frass has a repellent effect on ovipositing females (Molnár et al., 2017). During the lifecycle, it was observed that there is larval cannibalism and habitat demarcating behaviour among the larvae even in a single progeny. Further, it was observed that there are no overlapping generations on a single plant. This is possible when the female mother does not select the plants for oviposition when fresh larval frass is present. This behaviour ensures that the next progeny will survive on fresh plants. In various moth species, larval frass has been found to have a deterrent or repellent effect on conspecific females, resulting in delayed oviposition or further searching for other more suitable egg-laying sites (Anderson, 2002). Thus, the objective of this study was to identify the volatiles present in the larval frass and their effect on the oviposition preference of fall armyworm gravid female moths.

2. Materials and Methods

The experiment was conducted at the Department of Biosystems Technology, South Eastern University of Sri Lanka. The FAW culture was maintained on a natural diet as the method described by Du Plessis et al., (2020) to obtain the moths to the bioassays. Larval frass was collected daily from 4 – 6th instar larvae and volatile was collected using solvent extraction and dynamic headspace methods. The 100 ml of Dichloromethane (HPLC grade) was used for the solvent extraction of 25 g of frass. The dynamic headspace volatile collection was carried out as the method described by Kumara (2015).

The collected volatiles were identified using Gas chromatography coupled mass spectrometry (Agilent 8890 GC-5977B MSD). The electro-antennagramme (EAG) bioassay was conducted using the Syntech EAG system at the Coconut Research Institute. Pure synthetic chemicals of β-Myrcene, 2-Hexane-1-ol, α-Pinene, β-Pinene, n- Hexane, Thymol, Naphthalene, Menthone and Linalool were used as reference chemicals. Dual choice oviposition assays were carried out to determine the effect of the frass volatiles for oviposition site selection. The volatiles were kept on one side and other side was the control. Then 3 couples were placed inside the cylinder

and allowed to egg-laying. The number of eggs on both sides were counted daily until the death of the females. The EAG responses were compared by one-way ANOVA followed by Tukey's post hoc test and the oviposition preferences were compared by the paired-sample t-test at 0.05 significant level.

3. Results and Discussion

We identified 69 volatile compounds from solvent extracted samples and 83 volatiles from the dynamic headspace samples of larval frass. The EAG studies showed that 2-hexane-1-ol evoked the highest response against gravid female antennae and the second highest was α-Pinene which was not significant ($p<0.05$) with β-Pinene and β-Myrcene. Crude extract of FAW frass was showed a lower response moreover, which was not significantly different ($p<0.05$) from the lowest values possessed by DCM, Thymol and air (Figure 1).

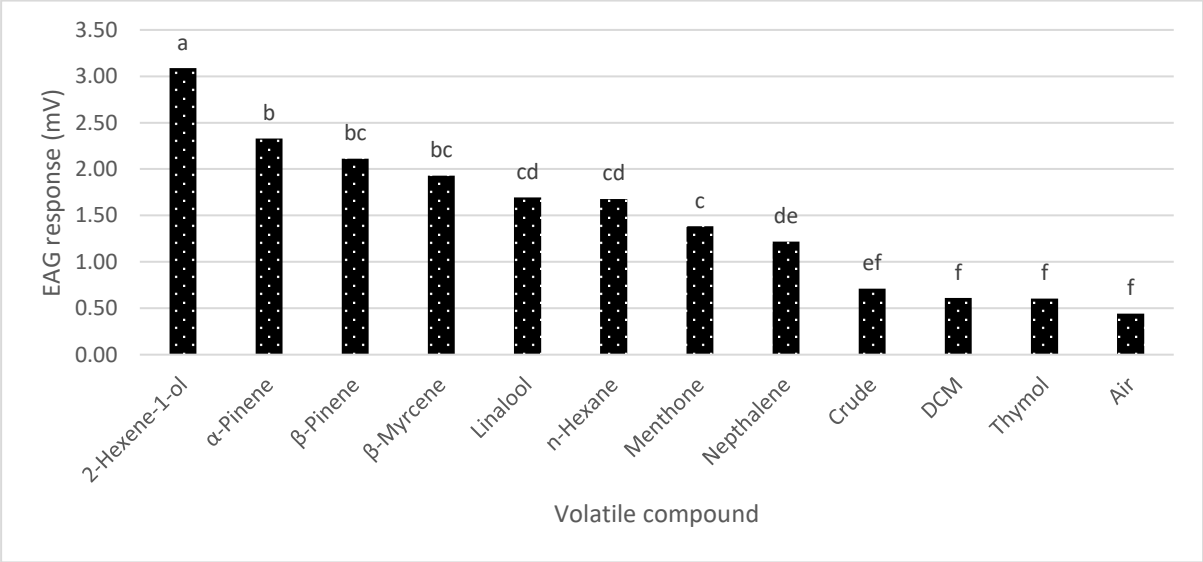

Figure 1. EAG response of FAW gravid females to selected frass volatiles

Note: Each column represents the mean EAG value and the different letters above the column indicate the significant difference at 0.05 significant level

Oviposition study results that β-Myrcene, α-Pinene and β-Pinene are related to neutral preferences of female egg-laying behaviour (Table 01). However, the females laid more eggs on the treatment side when 2-Hexene-1-ol, n-Hexane, Thymol and Naphthalene were used as the treatment. Moreover, a significantly ($p<0.01$) higher number of eggs were laid on the control arm of the oviposition chamber when Linalool was placed as the treatment (310.33 ± 67.41, $t= 4.23$, $p=0.003$) rather than treatment (15.33 ± 7.10). It seems that gravid females were sensitive to some volatiles emitted by the larval frass where they showed neutral, attraction and repellence behaviour against the volatiles.

Table 01. Number of eggs laid on the dual choice oviposition chamber between treatment and control arms

Volatile compound	Mean number of eggs (± SE)			
	Treatment	Control	t-value	P
β-Myrcene	207.67 ± 61.78	291.78 ± 106.31	0.978	0.357
2-Hexane-1-ol	296.56 ± 71.89	84.44 ± 29.01	3.862	0.005*
α-Pinene	188.00 ± 65.53	192.89 ± 33.46	0.100	0.923
β-Pinene	172.78 ± 64.76	242.00 ± 87.50	0.845	0.423
n-Hexane	180.56 ± 29.01	26.33 ± 8.71	4.626	0.002*
Thymol	407.00 ± 69.76	76.78 ± 25.61	6.132	0.000*
Naphthalene	531.89 ± 57.84	100.67 ± 21.67	6.495	0.000*
Linalool	15.33 ± 7.10	310.33 ± 67.41	4.233	0.003*

Note: The Non-significant (NS) and significant * indicate at 0.01 significant level and comparisons were performed by paired-samples t-test

The behavioural events leading to oviposition by a gravid moth or butterfly generally follow a sequence of searching, orientation, encounter, landing, surface evaluation and acceptance. All these stages of the host finding and acceptance sequence depend on a wide variety of sensory cues (Morris et al., 1991). Hence, present results are important when assessing host finding behaviour by an insect to chemical volatiles. Several studies found that chemicals in larval frass prevent conspecific females from ovipositing on previously occupied host plants to avoid competition for food among conspecific larvae (Guo & Li, 2009; Xu et al., 2006). We attempted to identify the effect of FAW larval frass cues for the repellence of conspecific females from egg-laying. The present study results indicate that Linalool showed a repellent effect for gravid females of FAW and similar findings were reported by Molnar et al. (2017). Where, a synthetic blend of Box Three Moth (BTM) larval frass compounds such as Linalool, Guaiacol and veratrol have a significant oviposition-repelling effect in BTM females. The fall armyworm oviposition affects the production of plant volatiles in maize (Peñaflor et al., 2011). Undamaged corn plants release linalool, which is likely the compound responsible for female moth attraction (Alessandro & Turlings, 2006) and this attraction behaviour is dependent on the dose level of the linalool (Signoretti et al., 2012). In our study, we used a 1% solution of linalool diluted in hexane for the behavioural experiment; hence, this could be a reason for the repellent behaviour of gravid females for the linalool. In the present study, we used selected 8 volatile compounds for the EAG and behavioural studies of gravid females. However, the present study identified more than a hundred volatile compounds elicit from FAW frass. Therefore, further studies are needed to remaining most abundant volatile compounds present in FAW frass.

4. Conclusions

The fall armyworm gravid females highly respond to 2-Hexane-1-ol, α-Pinene, β-Pinene and β-Myrcene from selected frass volatiles. Among them, 2-Hexane-1-ol attract gravid females while linalool showed repellent behaviour. Thus, the identified volatile chemicals could be used for the formulation of green pest management strategies after conducting more detailed studies.

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Isolation of metribuzin and profenofos resistant bacteria from agricultural soil collected in Uva province of Sri Lanka

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1. Introduction

Pesticides are complex chemicals used to combat pests. They are extensively used in agricultural activities to protect crops from pest attacks. Although pesticides are important in increasing productivity and quality of yield, they can cause harmful effects to the natural ecosystem through accumulating in the environment. Indiscriminate usage of pesticides has triggered this issue causing serious environmental consequences including human health problems. A triazine herbicide metribuzin and an organophosphate insecticide profenofos are two commonly used pesticides in agricultural lands all over the world including Sri Lanka. They have also been identified as two of major pesticides which cause harmful impacts on the environment. They are known to have some degree of persistence in the environment. Surface and groundwater contaminations followed by entering into live biomass have been observed. Some microorganisms have been identified to show a great tolerance to pesticides with pesticide degrading ability. There is a potential of using them in bioremediation of pesticide contaminants. Scientists have been working on exploring such beneficial microbes worldwide. In Sri Lankan context it's hard to find such studies conducted on exploring pesticide resistant ability of soil microorganisms. Uva province is an extensively cultivated area having a long history of intensive pesticides application in Sri Lanka. Hence there is a potential of the survival of pesticide resistant, soil inhabitant microorganisms in this area. Objective of this study was to isolate metribuzin and profenofos resistant bacteria from agricultural soil collected from Uva province, Sri Lanka to mitigate the knowledge gap in the relevant discipline.

2. Materials and Methods

Having identified suitable sample collection sites using a baseline survey, 20 soil samples were collected from agricultural lands with a long history of profenofos and metribuzin applications in Uva Province of Sri Lanka. Collected samples were immediately transported to the laboratory.

The isolation method used in Malghani et al. (2009) and Zhang et al. (2014) was used with some modifications. Minimal salt medium (MSM) broth was prepared by dissolving 8.5 g of $Na_2HPO_4.2H_2O$, 3 g of KH_2PO_4, 0.5g of NaCl and 1 g of NH_4Cl in 1000 ml of distilled water. Media sterilization was performed by autoclaving at 121^oC and 15 lb/inch^2 for 20 minutes.

An aliquot (20 g) from each soil sample was separately placed in conical flasks containing 100 ml sterilized MSM broth supplemented with 100 ppm concentration of metribuzine and profenofos. Separate sets were prepared under each pesticide and were then incubated at 37^o C with continuous shaking at 100 rpm for 7 days. Then aliquots of 100 µl from each enriched culture was separately spread on MSM agar plates supplemented with each selected pesticide

in different concentrations (100 ppm, 200ppm, 300ppm, 500ppm, 1000ppm). Inoculated plates were incubated at 37^{o} C for 24 hours.

Prominently grown single colonies in different pesticide concentrations were selected. Loop-full of each selected colony was separately streaked on nutrient agar plates until pure single colonies could be isolated. Each isolate was overnight enriched in nutrient broths at 37^{o} C and separately transferred to 30% glycerol stocks and stored at -80^{o} C.

3. Results and Discussion

Total of 44 of well -grown single colonies were able to sort out/ isolate. Among the colonies, 25 were resistant for Metribuzin and 19 for Profenofos, whereas from different pesticide concentrations. The number of pesticide resistant bacteria isolated from different concentrations of selected pesticides are given at Table 1.

Minimal salt medium consists of only the minimal essential nutrients required for microbial growth (Jabeen et al., 2015). Added pesticides were the sole carbon source in the medium. Satisfactory growth of the isolated bacteria in the presence of added pesticides shows their affinity to these pesticides. These bacteria may utilize metribuzin and profenofos as their carbon source. Some bacteria grew well under high pesticide concentrations as higher as 1000 ppm. It proves that they can tolerate such a high concentration of selected pesticides. Indicating that those bacteria are not adversely affected by those pesticides.

Previous literature on related studies have revealed that pesticide resistant bacterial species of these kinds are capable of degrading toxic pesticide compounds and convert them into less or nontoxic metabolites (Zhang et al., 2014; Jabeen et al., 2015; Wahla et al., 2019). Metribuzin and Profenofos resistant bacterial isolates found during this study may be having such beneficial potentials. Biochemical characterization or molecular characterization of those isolates by 16S rRNA sequencing like technique will be advantageous in future research activities on this area. The biodegradation ability of those isolates can be measured using Gas Chromatography-Mass spectrometry (GC-MS) (Johnson & Pepperman, 1995; Malghani et al., 2009; Zang et al., 2014; Wahla et al., 2019). Further studies are required to confirm whether these isolates are able to degrade the pesticide compounds by means of their metabolism. Besides some more such beneficial bacterial strains may be available in Sri Lanka. Implementing further researches in order to isolate and characterize some more soil bacteria will be important in contributing to the knowledge and practical applications such as bioremediation of pesticide residues in Soil, water environments using bacteria having the capability of degrading pesticides.

Table 01. The number of pesticide resistant bacteria isolated from different concentrations of each selected pesticide.

	Concentration of pesticide				
Pesticide	100 ppm	200 ppm	300 ppm	500 ppm	1000 ppm
Metribuzine	8	6	4	6	1
Profenofos	3	4	4	4	4

4. Conclusions

There are some soil bacteria that can tolerate Metribuzin and Profenofos up to 1000 ppm concentration in some agricultural lands in Uva province Sri Lanka. These bacteria may be having some capabilities of degrading these pesticides. Implementing further researches in order to test their pesticide degrading ability and the potential of using them in the bioremediation of pesticide contaminants can be suggested as a further improvement of the study.

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Quantification of changes in soil carbon after the establishment of tea plantations replacing native ecosystems: A case from the low and mid country

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1. Introduction

Soil carbon has been identified as the largest terrestrial pool of carbon storage. Globally, its storage capacity is much larger compared with the pools of carbon in the atmosphere and vegetation (Lal, 2004). Soil organic matter (SOM) refers to organic matter constituent of the soil, consisting of plant and animal waste, soil cells and tissues, and soil synthesized by soil organisms at various stages of decay. Soil carbon has two types namely soil organic carbon (SOC) and soil inorganic carbon (SIC). The work presented in this manuscript is focused on SOC. Changes in land use cause changes in the SOC content and affect mainly the topsoil layers (Hobley, 2015). Theoretically, changes in land use would also affect SOC stocks below this depth, as land-use change usually implies a vegetation change and vegetation type (Don, 2011). In the Sri Lankan context, there are few studies carried out to assess the SOC stocks. Vitharana *et al*. (2019) mapped the SOC stocks across the country at a spatial resolution of 30 cm considering top and subsoils. The objective of the current work was to assess and quantify the change of SOC stocks in established tea plantations compared to native vegetation originally present in the study area: (a) Designing paired sampling strategies for SOC stock quantification, (b) accessing the depth and transactions, locations and finally (c) checking whether there is a statistically significant difference between the two types of land use are the sub-objectives.

2. Materials and Methods

Two locations in the mid-country (Sripada, 6.5317˚ N, 80.3965˚ E) and low country (Kalawana, 6.436300 N, and 80.419300 E) tea growing regions were chosen. Three paired sites of tea plantations (same age) adjacent to the native ecosystem were selected and three Transects were used to collect the samples (Transect 01, Transect 02, and Transect 03). At those sites, 200 m transect (100 m up into the forest and 100 m downwards into the tea land from the forest border) was demarcated considering both tea and native land-use type. Soil samples were collected at a distance of 20 m along the transect. At each sampling location, two fixed depths (0 - 0.10 m and 0.10 - 0.30 m) were chosen. Soils were initially air-dried and sieved using a 2 mm sieve before the analysis. Soil samples were analysed for key soil physical, chemical and biological properties namely pH (water); pH ($CaCl_2$); electrical conductivity (EC). Particle size analysis (Day, 1965); bulk density (Blake & Hartage, 1986) soil organic carbon (Walkley & Black, 1934) were the methods used in this study. In the current study, only the results related to the SOC stock calculations were presented.
The SOC stocks were calculated as below using Equation 1 (Benbi et al., 2015).

SOC Stock (Mg/ha) = C content (%) x BD (Mg/m3) x D (m) x 100 ……. (1)

Where; SOC Stock is the soil organic carbon stock (Mg/ha), C content is the Soil Organic Carbon contents (%), BD is the bulk density (Mg/m^3) and D is the depth interval thickness (m).

The dataset was analysed using a linear mixed model considering land use, depth, location and transects as in fixed-effect terms and the sampling location as the random effect terms. The mean separation was carried out using the least-square means method.

3. Results and Discussion

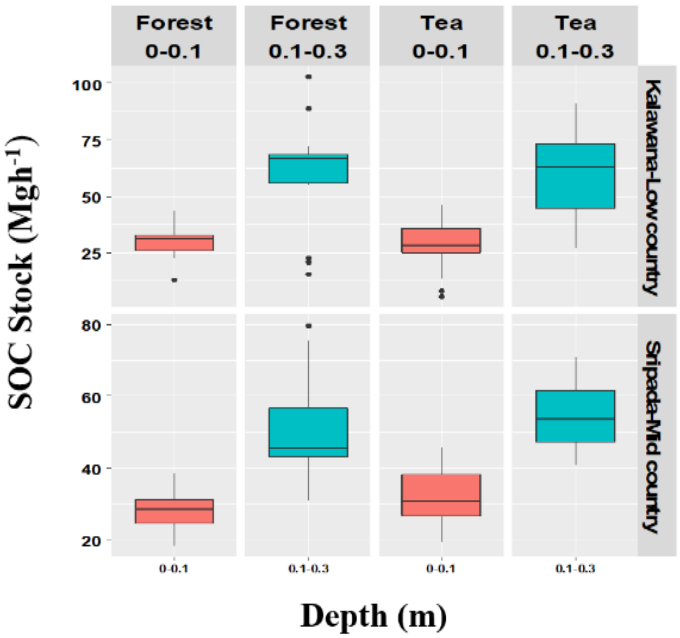

Figure 1. Distribution of soil organic carbon stock with depth for considered two locations

Figure 1, shows the distribution of SOC stocks across land-use types and depths considering two locations in Kalawana (low country) and Sripada (mid country). Despite the geographically distinct locations, the SOC distribution was almost similar based on its depth and land use type. However, the mean SOC at Kalawana (low country) tea plantations was almost similar irrespective of its depth level. When the two areas are considered, the forest topsoil has the higher mean SOC. According to figure 1, the mean SOC of Kalawana (low country) is higher based on each depth level and the land use type compared to Sripada (mid country) area. The highest SOC distribution at Sripada (mid country) and Kalawana (low country) were seen in the topsoil of forest and tea plantation respectively. As per the general distribution of SOC stocks in a soil profile, topsoil reports higher SOC content (Li et al., 2011). This is mainly due to the accumulation of carbon through the decomposition of surface litter and generally a high concentration of fine roots in topsoil. Out of several higher-order interactions and individual fixed effect terms such as land use, sampling depth (0.1 - 0.3 m), and the location was considered statistically significant ($p < 0.05$). It should also be noted that the intercept of the model was significant where other categorical variables were represented. Mean separation was carried out considering land use and depth interaction considering individual locations. For Kalawana (Low country) location, for the depth interval, 0 - 0.1 m both forest and tea confidence intervals were overlapping each other and similar results were reported for 0.1 - 0.3 m depth interval. Similarly, Sripada (mid-country) location reported a similar pattern (Table 1).

Table 01. Mean separation for the fitted linear mixed model

Location	Depth (m)	Land use	LS mean	Lower. CL	Upper. CL
Kalawana (Low country)	0-0.1	Tea	28.3^{bc}	21.5	35
		Forest	30^{c}	23.3	36.8
	0.1-0.3	Tea	58.7^{a}	51.9	65.4
		Forest	60^{ab}	53.2	66.7
Sripada(Mid country)	0-0.1	Tea	32.5^{bc}	25.8	35
		Forest	28.2^{c}	21.5	43.5
	0.1-0.3	Tea	54.5^{a}	47.7	61.3
		Forest	51^{ab}	44.3	57.8

LS - Least square; CL - Confidence interval; Means with same superscript letters are significantly not different at $P<0.05$.

In general, when land-use changes from native ecosystems to agricultural production systems, it records lower SOC stocks values unless high biomass pasture production systems. One possible reason for the accumulation of higher SOC stocks under tea plantations is possibly due to the addition of high biomass through agronomic practices such as periodic pruning of tea bushes (Li et al., 2011). As a result, the SOC stocks present under the two study sites that represented low and upcountry reported SOC stocks similar to their native vegetation types. Previous work by Twongyirwe et al. (2013) revealed that SOC contents stored in soils under tea were similar to the forest in terms of SOC content. Further Li et al. (2011) reported that tea plantations maintain high carbon density in their increased carbon inputs caused by the high amount of pruning material returned back to the soil.

4. Conclusions

Despite the land-use change from the native forest ecosystem to the tea plantations for the time intervals considered at locations and depth intervals, no significant difference was reported between the reported SOC stocks. Future studies require a large number of samples covering a large spatial extent to quantify the SOC stocks across the landscape.

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Screening of some antagonist soil fungi against white mold pathogen of mustard *in-vitro*

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1. Introduction

The stem rot fungus *Sclerotinia sclerotiorum* produces sclerotia which can survive a long time in the soil. These sclerotia give rise to fruiting body apothecia that produce a huge number of ascospores which create rot disease in different crops. This complicated pattern of life cycle and wide host range make it difficult to control the white mold disease of mustard. In general, plant diseases are controlled by using chemical fungicides and in certain cases by cultural practices. The widespread use of chemicals in agriculture has been a subject of public concern and scrutiny due to their potentially harmful effects on the environment and health. Some pest management researchers have focused their efforts on developing alternative inputs to synthetic chemicals for controlling pests and diseases. Many species of fungi such as *Penicillium, Aspergillus, Trichoderma, Gliocladium* and bacteria such as *Bacillus*, *Enterobacter*, *Pseudomonas, Streptomyces* are used as bio-control agents (Suárez-Estrella et al. 2007). There are some studies on the biological control of *S. sclerotiorum* by using fungal bio-control agents either in the laboratory or in the fields (Hjeljord & Tronsmo, 1998, Tiwari et al. 2011, Jawadayn et al. 2015). In Bangladesh commercially cultivated varieties viz. BARI Sharisa 14, BARI Sharisa 17, local Tori, are highly susceptible to white mold (please check it) disease. Search for resistance is one of the disease management options, but it is time-consuming. Thus, the study on biological disease management is essential. Therefore, the investigation was undertaken to search for effective antagonist soil fungi against white mold pathogen.

2. Materials and Methods

Test pathogen

Sclerotinia sclerotiorum was isolated from severely white mold disease infected mustard stems following "Tissue planting" method. The pathogenicity of the isolated fungi was tested following "detached leaf and stem technique" (Shamsi et al. 2013).

Antagonists

The fungal antagonist used in this study **(***Aspergillus flavus, A. fumigatus, A. niger* 1, *A. niger* 2, *A. niger* 3, *Penicillium* sp. *Trichoderma harzianum, T. viride* and *T. virens*) were obtained from Plant pathology lab, Department of Botany, University of Dhaka, Bangladesh.

Dual culture method

Fifteen ml of sterilized potato dextrose agar medium was poured into sterile Petri plates and allowed to solidify. Fungal antagonists were inoculated at one side of the Petri plate and the test pathogen was inoculated at the opposite side of the same plate by leaving a 3 cm gap and incubated at 25±1^{o}C for 7 days. The percentage of inhibition over control was measured according to the formula given by Jeyaseelan et al. (2012).

Effect of volatile and non-volatile compounds

In volatile methods, the fungal antagonists were grown in Petri plates on PDA medium at 25±1^{o} C for 3 days. After the inoculation, the lid of each Petri plate was replaced by the same sized bottom plate, containing 15 ml PDA medium, centrally inoculated with a test pathogen. Then Petri plates were covered by Parafilm so that no volatile substances can be moved from the

inside of the Petri plates. The percentage of inhibition of the test fungi was calculated after the 7^{th} day of incubation.

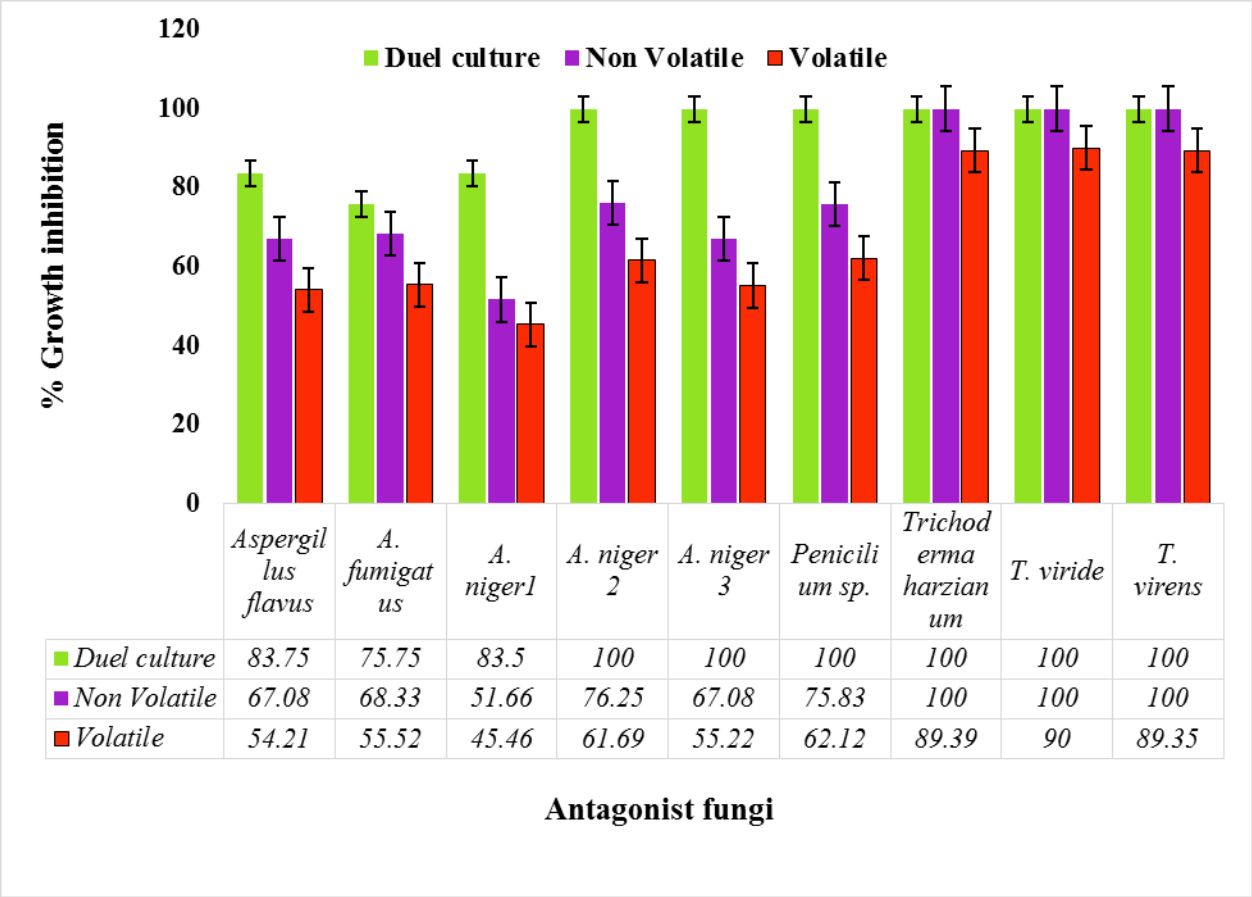
In non-volatile methods, nine fungal antagonists cultured in a conical flask on Potato Dextrose Broth and incubated at 25 ± 1° C for 15 days. Liquid culture filtrate was collected separately and filtered through filter paper; then, centrifuged at 3000 rpm for 20 minutes. Bio-efficacy of culture filtrates against test pathogen was tested by following "Poisoned Food Technique method". The percentage of growth inhibition was recorded by following the procedure mentioned earlier.

3. Results and Discussion

The result of colony interaction between the test fungi and the antagonist fungi has been summarized in Fig. 1. Out of nine soil fungi, six fungi *viz*. *Aspergillus niger* 2, *A. niger* 3, *Penicilium* sp, *Trichoderma harzianum, T. viride* and *T. virens* exhibited strong antagonistic effects against *Sclerotinia sclerotiorum* which were completely inhibited (100%) the radial growth of the test fungi in dual culture methods. The least inhibition of radial growth was noticed with *A. niger* 1 (45.46%).

The effect of volatile metabolites of antagonistic fungi against white mold pathogen is presented in Fig. 1. Volatile substances emanating from the cultures of the soil antagonist fungi inhibited the radial growth and sclerotia formation of pathogenic fungi. The maximum inhibition of radial growth of *Sclerotinia sclerotiorum* was observed in *Trichoderma viride* (90%) followed by *T. harzianum* (89.39%), and *T. virens* (89.35%) due to the volatile metabolites. *Penicillium* sp. showed an average mycelial inhibition (62.12%) followed by *Aspergillus niger* 2 (61.69%). The least radial growth inhibition was noted with *A. niger* 1 (45.46%).

The effect of non-volatile metabolites on the growth of *S. sclerotiorum* also has been showed in Fig. 1. The selected antagonists showed varying degrees of growth inhibition of the pathogen. The culture filtrates of three species of *Trichoderma viz*. *T. harzianum, T. viride* and *T. virens* equally inhibited the mycelial growth of *S. sclerotiorum* - 100% at 10% concentration after 5 days of incubation. Among the *Aspergillus* species tested, *Aspergillus niger* 2 inhibited the highest mycelial growth of the test fungi - 76.25%, followed by *A. fumigatus* (68.33%) and *A. flavus* (67.08%). The lowest inhibition of radial growth of *S. sclerotiorum* was observed in *A. niger* 1 (51.66%).



	Aspergillus flavus	*A. fumigatus*	*A. niger1*	*A. niger 2*	*A. niger 3*	*Penicilium sp.*	*Trichoderma harzianum*	*T. viride*	*T. virens*
Duel culture	83.75	75.75	83.5	100	100	100	100	100	100
Non Volatile	67.08	68.33	51.66	76.25	67.08	75.83	100	100	100
Volatile	54.21	55.52	45.46	61.69	55.22	62.12	89.39	90	89.35

Figure 1. Evaluation of *in vitro* inhibition of *Sclerotinia sclerotiorum* using antagonistic fungi in different methods. Vertical bars represent the standard error of the mean (*significantly different at 0.05% level)

Antagonistic level and grade of different antagonist fungi against stem rot pathogen

Maximum antagonist fungi showed common type of colony interaction (grade level 2). In dual culture method, eight fungi showed very high antagonistic level against test fungi. A low level of antagonistic reaction was found in *Aspergillus niger* 1 in volatile method. In the case of *Trichoderma harzianum*, *T. viride* and *T. virens*, very high level of antagonistic reaction was shown in dual culture, volatile and non- volatile methods.

The percentage of inhibition of the test pathogens against the soil fungi also varied due to differences in nature, quality and quantity of the inhibitory substances produced by the soil fungi. In the present investigation, five fungi (*Aspergillus niger* 2, *A. niger* 3, *T. harzianum*, *T. viride* and *T. virens*) were capable of stopping the sclerotia formation of *Sclerotinia sclerotiorum*. Hyphal interactions between *Trichoderma harzianum* and the pathogenic fungus *S. sclerotiorum* were examined in dual culture and found that *T. harzianum* hyphae grew towards and coiled around the *S. sclerotiorum* hyphae. *Trichoderma harzianum* and *T. virens* have also been capable to inhibit both sclerotia and mycelial growth of *Sclerotinia* spp (Jawadayn et al. 2015; Jacob et al. 1996).

4. Conclusions

The present observation suggests that there were qualitative and quantitative differences in the volatile substances and culture filtrate produced by various antagonist soil fungi, so they exhibited different degrees of growth inhibition against the test fungi. Among the nine antagonist soil fungi, *Aspergillus niger* 2, *Trichoderma harzianum*, *T. viride* and *T. virens* were

found to be effective which were capable to inhibit the mycelial growth and stop the sclerotia formation of *Sclerotinia sclerotiorum in vitro*.

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Relationship between essential minerals and toxic trace elements of major paddy growing soils in Sri Lanka

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1. Introduction

Mineral elements are important to develop physical structures, and maintain physiological and biochemical activities in plants. In agriculture, mineral elements can be classified as macronutrients, micronutrients and toxic trace elements (Moustakas, 2021). Macronutrients such as potassium (K) and calcium (Ca) are required in higher quantities for essential plant functions while micronutrients such as zinc (Zn) and molybdenum (Mo) are required in relatively lower quantities. However, all these elements are equally important for plant health (Nieder et al., 2018). In order to sustain soil fertility, these elements are supplemented by adding inorganic or/and organic fertilizers (Uchida, 2000). However, excessive or imbalanced use of fertilizers in agriculture not only stagnates crop yields, it can also create negative impacts on the environment. Moreover, the accumulation of toxic trace elements in soil causes adverse impacts to agriculture (Ong et al., 2007). Therefore, the knowledge on the current level of accumulation of essential and toxic trace elements (*i.e.*, Ca, K, Fe, Zn, Cu, Mn, Mo, As, Cd, Pb) in soils is crucial for sustainable soil nutrient management and crop production. As rice is the most important crop, covering the highest land extent used by a crop in Sri Lanka, the aim of this study was to determine the concentrations of selected essential mineral and toxic trace elements in paddy growing soils and the relationship between those elements.

2. Materials and Methods

2.1 Collection and processing of soil samples

Two hundred paddy soil samples were collected representing three climatic zones [Dry Zone (DZ)=145, Wet Zone (WZ)=18, Intermediate Zone (IZ)= 32] and major soil types (18 Soil types) used for rice cultivation using stratified random sampling approach as described in Kadupitiya et al. (2021). Each sample represented top 0-15 cm soil layer. Those samples were air dried, debris were removed, homogenized by breaking large particles manually and sieved using 2 mm sieve.

2.2 Metal concentration detection through ICP-MS (Inductively Coupled Plasma-Mass Spectrometry)

Four grams of soil was extracted with 40 mL of 0.01 M $CaCl_2$ solution at room temperature. Then it was shaken for two hours. After shaking, it was centrifuged for four minutes at 3600 rpm. Supernatant (35 mL) was collected and acidified using 0.5 mL conc. HNO_3. Then 6 mL of solution was filtered using 0.45 µm micro filter. Then 1 mL of solution was pipetted out and it was diluted with 6 mL of distilled water. Then solutions were subjected to ICP-MS analysis to determine the concentrations of essential mineral elements (*i.e.*, Ca, K, Fe, Zn, Cu, Mn, Mo) and toxic trace elements (*i.e.*, As, Cd, Pb). Blanks without soil samples, laboratory and manufacturer standards were used to check the consistency and ensure the quality across batches and samples.

2.3 Statistical Analysis

The mean, minimum and maximum element concentrations were determined using descriptive statistics. Strengths of the relationships between elements (paired comparisons) were determined using Pearson's linear correlation coefficient (*r*). Element concentrations among soil groups and climatic zones were compared using analysis of variance (ANOVA). All the interpretations are made at α=0.05.

3. Results and Discussion

3.1 Variation of element concentrations

The highest mean element concentration in soil samples was recoded in Ca followed by K, Mn and Fe (Table 1). Relatively lower concentrations of Zn, As, Mo and Pb were reported in soil samples than those of Ca, K and Fe. The ICP-MS technique didn't detect the Cu, Zn, As, Mo and Pb in some soil samples.

Table 01. Element concentrations in the soil samples tested (mean± stderr, n=200)

Mineral elements	mg kg^{-1}		
	Mean	Minimum	Maximum
Potassium (K)	57.57 ± 5.35	4.13	786.08
Calcium (Ca)	720.40 ± 37.70	4.95	1984.10
Manganese (Mn)	17.13 ± 1.63	0.11	143.59
Iron (Fe)	11.72± 0.79	0.26	55.78
Copper (Cu)	0.05 ± 0.00	0	0.26
Zinc (Zn)	0.32 ± 0.04	0	3.16
Arsenic (As)	0.02± 0.00	0	0.10
Molybdenum (Mo)	0.10± 0.02	0	2.51
Lead (Pb)	0.06± 0.01	0	0.79

3.2 Difference among climatic zones

There were significant differences in element concentrations in soil samples collected from three climatic zones ($P<0.05$). Wet Zone (WZ) soils contained higher concentrations of Ca (1226 mg kg^{-1}) and Fe (23 mg kg^{-1}) compared to that of the Dry Zone (DZ) and Intermediate Zone (IZ) soils ($P<0.05$). The concentrations of other detected elements in soil samples collected from three climatic zones were similar ($P>0.05$).

3.3 Difference among soil groups

When compared different soils groups, Red-Yellow Podzolic soils with soft or hard laterite (RYP), Bog and Half-Bog soils (BHB) and Rock Knob Plain (RKP) soils recorded higher Ca concentration than other soil groups (> 1000 mg kg^{-1}). RYP, BHB, Red-Yellow Podzolic soils; steeply dissected, hilly and rolling terrain (RYP-SD R) soils recorded higher Fe concentration than other soil groups (> 20 mg kg^{-1}). Solodized Solonetz and Solonchaks (SSS) soil had higher As and Mo concentration, while Calcic Red-Yellow Latosols (CRYL) soil had higher Cu

concentration. Concentrations of K, Mn, Zn and Pb among the soil groups were similar (P>0.05).

3.4 Relationships between elements

There were significant correlations between elements. Out of which the correlation between Cu and Mn was the strongest (r=0.477, P<0.001) (Fig. 1).

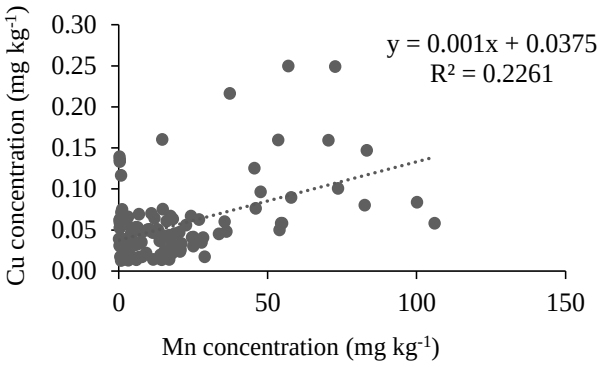

Figure 1. Correlation between Cu and Mn concentration in selected paddy soil

ICP-MS technique is widely used to detect multiple elements in soil samples. Moreover, 0.01 M $CaCl_2$ is widely used as a universal extractant of mineral elements in soil samples. Due to the weak molarity and strength, 0.01 M $CaCl_2$ solution reflects the soil solution concentrations of mineral elements *(Van Erp, 2002)*. As this reflects the rhizosphere element concentration, the values and correlations studied in this research represent the concentrations of different elements available for plant roots, and thus have a direct biological relevance. The concentrations of elements in Sri Lankan paddy soil samples varied due to numerous factors such as the differences in parental materials and geology, and the cropping systems and agronomic practices adopted by the farmers. Irrespective of the soil groups, presence of macronutrients were the highest, followed by micronutrients and toxic trace elements. Taking up of both toxic and essential trace elements depend on their accumulation and cycling in soil. Therefore, keeping a balance between these elements is important to ensure crop yield in terms of both quantity and quality (Rajmohan et al., 2007). In these soils, small quantities of heavy metals (*e.g.*, Pb; 0-0.8 mg kg^{-1}) and metalloids (*e.g.*, As; 0-0.1 mg kg^{-1}) were detected.

4. Conclusions

The concentrations of mineral elements determined in Sri Lankan paddy soils samples were in order of Ca>K>Mn>Fe>Zn>Mo>Pb>Cu>As. WZ soils recorded higher Ca and Fe concentrations than those reported in other zones. RYP and BHB soil recorded relatively higher Ca and Fe concentrations. This knowledge is important when designing sustainable nutrient management in Sri Lankan rice fields.

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Investigation of underlying causes for sudden tea bush death and feasibility of applying decanter cake of oil palm (*Elaeis guineensis*) as an organic fertilizer in tea

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1. Introduction

Synthetic fertilizer application has been practiced in many tea plantations of Sri Lanka over decades and consequently, some environmental issues are encountered. To overcome these environmental issues, replacement of synthetic fertilizer by natural manure application is promoted in tea plantations (Ji et al., 2018). Yet, finding required amount of manure is a challenge and thus, alternative sources are experimented.

During oil palm processing, oil palm mill effluent generates several waste products such as empty fruit bunches (EFB), palm kernel shell (PKS) and decanter cake (DC). These products contain water (~76%), residual oil (~12% on dry basis) and nutrients such as N, P_2O_5, K_2O, CaO, MgO, cellulose, lignin, and ash (Maniam et al., 2013). Therefore, such wastes are used as fertilizer for tea in some plantations like Watawala Plantations PLC. However, there is an issue related to the DC application as several tea bushes have shown dieback after application. Therefore, this experiment focused on looking into the scientific background of possible causes for dieback of tea bushes while applying DC of oil palm as an organic manure.

The general objective of this experiment was to investigate the underlying causes of sudden tea bush death with DC application which has a potential to be promoted as an organic fertilizer for tea fields. The specific objective was to investigate the physical and chemical changes of DC at different decomposition levels.

2. Materials and Methods

An experiment with three studies was conducted from January to April, 2021 in Nakiyadeniya at Thalangaha Division, Watawala Plantation PLCs, under Low Country Wet Zone (24-217 m.s.l.).

(I) Effects of decanter cake on soil physico-chemical properties

DC was heaped for four weeks and applied as 2 or 4 kg to a plot having 20 plants. A control was maintained without DC application. RCBD with three replicates was the experimental design.

After imposing treatments, soil samples were obtained at 0-15 and 15-30 cm depths. Following standard protocols, moisture content (MC), pH and electrical conductivity (EC) were measured. Total N and available P were determined following Kjeldahl method and Olsen method, respectively. Total organic carbon (OC) content was determined by ignition method.

(II) Investigation of fate of the DC heaped for decomposition

Fresh DC was decomposed for 4, 6 and 8 weeks, separately. Bulk density (BD) and other physico-chemical properties, as described above, were determined after 4, 6, and 8 weeks of decomposition and for the fresh DC.

(III) Physical observations of tea plant death

Five plots (Plot 1, 2, 3, 4 and 5), each having 100 plants, were demarcated and, totally and partially dead bushes were recorded. Then, five totally dead and five partially dead tea bushes were randomly uprooted; root systems, stems, leaves and branches were visually observed. Further information was collected from field officers through a questionnaire.

All data were subjected to one way ANOVA and means were separated following Tukey test. Minitab 17 was used.

3. Results and Discussion

(I) Soil physico-chemical properties after application of DC as a fertilizer

Significantly (P<0.05) highest total soil N was recorded at 0-15 cm depth with 4 kg DC decomposed for 4 weeks whereas the lowest was reported from control at 15-30 cm depth. Higher N content in treated plots could be attributed to the N amended with DC. There was no significant (P>0.05) difference in available P levels. Significantly (P<0.05) highest and the lowest OC was also recorded in the same treatments, as did for N above.

There was a significant (P<0.05) difference between soil MC based on depth: MC at 0-15 > MC at 15-30 cm. However, there was no significant (P>0.05) difference among MC based on amount of DC amended.

There was no significant (P>0.05) difference in soil pH values and EC values of the differently treated plots.

(II) Physical and chemical properties of decanter cake

pH, EC and BC of oil palm DC decreased over the time of decomposition (Table 1). MC ranged between 77.1 and 84.33% showing a decrease, over the time, except for 4 weeks. However, total OC, total N and available P gradually increased with the decomposition time. Decrease of BD, EC and pH together with increase of total OC, total N and available P of an organic compound is more favourable being a fertilizer. Therefore, allowing DC for 8 weeks period for decomposition is more favourable for DC to use as an organic fertilizer.

Table 01. Physico-chemical properties of oil palm decanter cake

DC decomposition (weeks)	pH	EC (µs/cm)	MC (%)	Total OC content (%)	Total N (%)	Available P (mg/kg)	BD ($g/cm^{3)}$
0*	6.57	668.0	84.33	41.36	3.2	1298.3	0.52
4	5.93	498.0	77.10	44.08	3.5	1381.4	0.39
6	5.52	328.7	83.93	47.56	3.8	1557.5	0.31
8	5.43	214.3	82.40	51.04	4.0	1640.6	0.24

*Fresh DC

(III) Physical observations on tea plant death

The highest totally dead (16%) and partially dead (27%) bushes were recorded in Plot 2. This might be due to the high amount of non-decayed DC dumped. The percentages of dead and partially dead bushes were significantly (P<0.05) lower in Plot 5: 7 and 9%, respectively, and may be due to the lowest amount of non-decayed DC amended.

Observations by field officers

8-year old tea bushes have been dead after adding fresh and non-decomposing DC very near to the tea bushes in 2018; some tea bushes were completely dead while the others showed a slight recovery.

Visual observation on dead and partially dead tea bushes

There were easily broken rotten black and brown root systems, stems, and branches with white-coloured fungal patches in dead and partially dead bushes. Death of bushes has started somewhere in 2018. Some feeder roots and termite-damaged patches were observed in both plants. These were seen because of the application of high-level, non-decomposed DC near the plant base.

4. Conclusions

Decomposed DC applied at the rate of 4 kg per tea plant is found to be more favourable for tea growth. Also, DC can be used as a fertilizer after allowing decomposing for at least 2-3 months' duration. Tea bush death in fields where decanter cake has been dumped is attributed to the dumping of very fresh DC just near the base of the plant. Fresh DC is very high in EC and therefor, plants cannot tolerate such a high level.

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A study on factors influencing land productivity of proprietary tea estates in Badulla district

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1. Introduction

Proprietary Tea Estates (PTEs) are considered middle-level tea estates that have a range of tea land extent between 10 to 50 acres (4 to 20 ha). The total extent of Proprietary holdings is 14710 ha of land which represents 6.6 percent of the total tea extent of Sri Lanka (Census of Tea Small Holdings, 2005). As compared to Tea Smallholdings (TSHs) and Regional Plantation Companies (RPCs) Proprietary Tea Estates are less influential to the Tea industry in terms of total land extent and national tea production in Sri Lanka. There are a number of factors affecting the productivity of these holdings such as soil and climatic limitations, negligence of adopting essential agricultural practices, limited availability of human resources, finance and inputs, low income, and other socio-economic factors; interaction with the tea-related public organization, management, etc. Even though several studies were undertaken on land productivity in the smallholding and regional plantation sectors, very limited investigation on addressing the issues related to the productivity of Proprietary Tea Estates is available. The findings of this study will help policymakers and relevant authorities to plan and implement the strategies development program for optimizing the land productivity of proprietary tea estates located in Badulla District and their long-term sustainability. The main objective of this research is to identify the factors that influence the land productivity of proprietary tea estates located in Badulla District and to propose strategies to optimize the above status for long-term sustainability. The specific objective is to determine the impact of key factors on the land productivity of proprietary tea estates in the Badulla district.

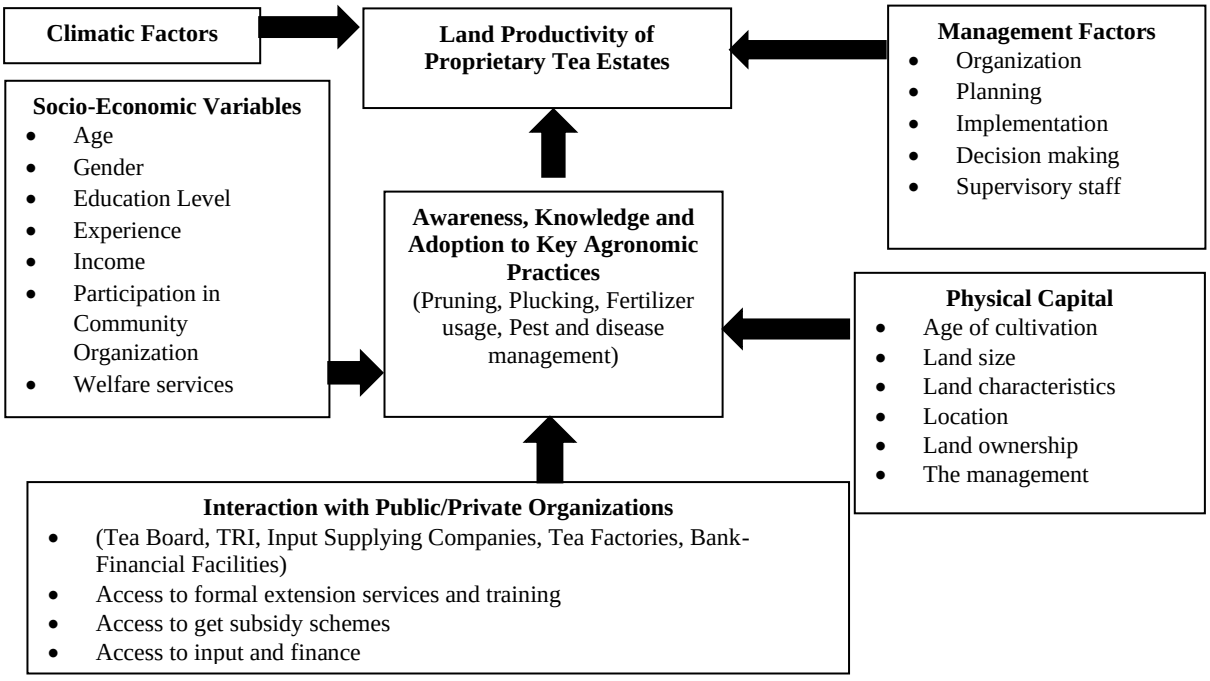

Figure 1. Conceptual framework of the study

2. Materials and Methods

The conceptual framework and methodology for this study were developed according to the information gathered in the literature survey and preliminary focus group discussions held with key experts attached to public institutions namely the Assistance Tea commissioner, and Tea Inspectors attached to tea commissioner's division, and Regional Manager and Tea inspectors attached to the Tea smallholding Development Authority, Bandarawela, and officer in charge of Tea Research Institute, Passara Sub Station. The stratified purposive sampling method was performed to select 33 proprietary tea estates in four tea inspector's ranges (Bandarawela, Welimada, Passara, and Hali-Ela) under the monitoring of Assistant Tea Commissioner, Bandarawela and Badulla District. A cross-sectional survey using pretested structured questionnaire together with focus group discussion was held for the collection of primary data. Secondary data were collected from the Census and Statistical report on the tea sector, Central Bank annual report, and official website of tea-related institutions. Climatic and soil factors were considered uniform throughout the study period (4 months) in the Badulla district. Data were analysed using Statistical Package for Social Sciences (SPSS). Collected data from questionnaires were coded. Descriptive statistics and multiple linear regression analysis were used to analyse the effect of independent variables on land productivity of proprietary estates in the Badulla district.

Empirical Model

An empirical model for the research was developed to identify the relationship between dependent and independent variables.

$$LP = \beta0 + \beta1(X1) + \beta2(X2) + \beta3(X3) + \beta4(X4) + \beta5(X5) + \beta6(X6) + \beta7(X7) + \beta8(X8) + \varepsilon$$

LP - Land Productivity (MT kg/ha/yr)
β0 - Intercept
β1 to β9 - Coefficients for independent variables
X1 - Age of cultivation
X2 - Soil Characteristics
X3 - Land Use Pattern
X4 - Experience of Estate Owners and Workers
X5 - Access formal extension services and training to Estate Owners and Workers
X6 - Access to inputs and finance
X7 - Knowledge of the recommended practices
X8 - Adoption level to the recommended practices
ε - Error term

Data were analysed using Statistical Package for Social Sciences (SPSS). Collected data from questionnaires were coded. Multiple regression analysis was used to analyze the effect of independent variables on land productivity of proprietary estates in the Badulla district.

3. Results and Discussion

Multiple Linear Regression Analysis

The regression model was significant at 0.05 significance level ($R2 = 0.870$, $P = 0.000$, $n = 33$). 87.0% of the variance of land productivity can be explained by the eight independent variables (Table 01)

Table 01. Results of multiple regression analysis

Independent Variable	Coefficients	P - value
Age of cultivation	-116.95 (β1)	0.047
Soil characteristics	-118.12 (β2)	0.346
Land use pattern	-106.11 (β3)	0.006
Experience	79.68 (β4)	0.046
Access to formal extension services and training	235.37 (β5)	0.035
Access to inputs and finance	-169.48 (β6)	0.041
Knowledge of estate owners on recommended practices	-275.64 (β7)	0.001
Adoption to recommended practices	335.38 (β8)	0.001

Age of Cultivation - The coefficient of age of cultivation is – 116.95. This means that an increase in age of cultivation by a year, the predicted probability (95%) of land productivity decreased by 116.95 MT kg per year. The finding reveals that the level of land productivity is declining due to the senility of tea bushes with the ageing.

Experience - While the other variables in the model are held constant, when tea growers' experience is increased by working in similar profession yearly, the predicted probability (95%) of land productivity increased by 79.68 MT kg per year. The findings indicate that experienced tea growers by working in similar profession for longer period are capable enough to improve their land productivity.

Access to Formal Extension Services and Training - When proprietary tea growers have an opportunity for accessing to formal extension services and training by exposing to training session, the predicted probability (95%) of land productivity increased by the 235.37 MT kg per year. The findings confirm that when tea growers are given more opportunities for accessing to formal extension services and training on time, it would enhance their land productivity as they are strengthened with an appropriate technology.

Adoption to Recommended Practices - When proprietary tea growers try to adopt each recommended practice, the predicted probability (95%) of land productivity increased by the 335.38 MT kg per year. The findings reconfirmed that when tea growers have more opportunities for accessing formal extension services and inputs on time, they would like to enhance their land productivity as they will tend to adopt recommended practices.

The model also shows that when the other variables in the model are held constant, the balance of variables such as knowledge of estate owners on recommended practices, access to inputs and finance, land use pattern have created a significant negative influence on predicted probability (95%) of land productivity. As compared to Tea Smallholdings (TSHs) and Regional Plantation Companies (RPCs) Proprietary Tea Estates are less influential to the Tea industry, the tea-related public and private organizations have focused less attention to enhancing the knowledge of estate owners as well as assisting them to have access to inputs and finance for tea land development. Hence, the finding of this study would be useful for relevant authorities to implement strategies to optimize the land productivity of proprietary tea estates in the Badulla District.

Empirical Model

According to the significance of coefficients (Table 1) we can rewrite the empirical model as follows;

LP = 1053.74 – 116.95 (Age of the cultivation) – 106.11 (Land use pattern) + 79.68 (Experience) + 235.37 (Access to formal extension services) -169.48 (Access to inputs and finance) – 275.64 (Knowledge level) + 335.38 (Adoption level) + ε

4. Conclusions

The findings of this study concluded that experienced proprietary tea owners, who have a sound knowledge of agricultural practices, would like to adopt recommended practices along with the supplement of extension services and inputs, which could significantly and positively contribute to the improvement of land productivity of the studied estates in the Badulla district. Although this investigation was limited to four Tea Inspector ranges; Bandarawela, Passara, Hali-Ela, Welimada in Badulla district, the findings of this study will help policymakers and relevant authorities to plan and implement the strategies development program for optimizing the land productivity of proprietary tea estates in Badulla district.

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Effects of soil moisture stress on the growth attributes and yield of three okra (*Abelmoschus esculentus* L.) cultivars in the sandy regosols

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1. Introduction

A water deficit stress is one of the major environmental constraints limiting agricultural productivity. Drought severely affects plant growth and development with substantial reduction in crop growth and biomass accumulation. Water stress on plants directly impacts the reduced fruit dry matter and yield of the plant (Bahadur et al., 2009). Drought decreases Leaf Area Index (LAI) in crop plants in general. Hussain et al. (2009) have reported decline in LAI of sunflower exposed to drought at budding and flowering stages. Drought also suppresses leaf expansion and reduces leaf area due to early senescence. Li et al. (2009) have stated that under moisture stress condition, total dry weight and their components will be reduced.

Okra is one of the most important vegetable crops belonging to the family Malvaceae. It is cultivated in the dry zone as a monocrop in irrigated uplands as well as in rice-based cropping systems during the '*Yala*' season and also in well drained highlands during the '*Maha*' season. Okra cultivation faces severe limitations and the main one is the lack of water which limits severely the potential production of Okra (Nana et al., 2014). Gunawardhana and Silva (2011) reported that water stress showed highly significant effect on growth, pod diameter and yield of okra. Therefore, the objectives of this study was to focus on the physiological parameters and agronomic performance of three okra varieties under moisture deficit conditions and identifying the most drought tolerant okra cultivar which can produce substantial yield under water limited situation.

2. Materials and Methods

This experiment was conducted at the Agronomy farm of the Eastern University, Sri Lanka. The type of soil of this area is Sandy Regosols and these soils are characterized by more than 85% sand and less than 5% clay in the top soil with the pH of 6.84. The annual mean temperature varies from 28 to 32°C. The mean annual rainfall is between 1800 to 2100 mm. A number of one hundred and ninety-two polyethylene bags (36 cm height and 45 cm diameter) were made for this experiment. These bags were filled with top soil, red soil and compost at the ratio of 1:1:1. The okra seeds cvs. 'Haritha', 'MI 5' and 'EUOK 2' were sown in these bags. The agronomic practices were followed based on the recommendation of the Department of Agriculture. Watering was done daily in the morning and evening until germination. Thereafter, it was applied at two days interval to field capacity, the soil moisture content remaining at field capacity was 21.0%.

Soil moisture stress was imposed for the okra cultivars for a period of 10 days during the flowering stage by withholding water completely at once. The control plants were watered to field capacity level at two days interval. The experiment was laid out in the 3×2 factor, factorial Randomized Complete Block Design with six treatments and four replications and the treatments T_1, T_3 and T_5 were 'Haritha', 'MI5' and 'EUOK 2' okra cultivars respectively watered at two days interval to Field Capacity. The T_2, T_4 and T_6 were 'Haritha', 'MI5' and 'EUOK 2' okra cultivars subjected to moisture stress during the flowering stage for 10 days.

Growth Measurements

Leaf Area Index

A number of two plants were randomly selected from each replicate of the treatments on the 10th day from the commencement of the stress during the flowering stage. These plants were uprooted and washed thoroughly with distilled water. The leaves of each plant were detached and the total leaf area per plant was measured by a leaf area meter (LICOR- 3100C). The Leaf Area Index (LAI) of each plant was calculated as follows:

$$\text{LAI} = \frac{Total\ leaf\ area\ of\ plant\ (Cm^2)}{Ground\ area\ occupied\ by\ the\ plant\ (Cm^2)} \times 100$$

Plant Dry Weight

The plants, uprooted to measure the LAI, were used for this purpose. The detached leaves of each plant along with its left out plant parts were used to measure the plant dry weight. These weights were obtained by drying in an oven at 105°C for 48 hours.

Yield

A number of two plants were randomly selected from each replicate of the treatments and the pods of these plants were collected on alternate days from the first to the eighth harvest. The fresh weights of these pods were recorded.

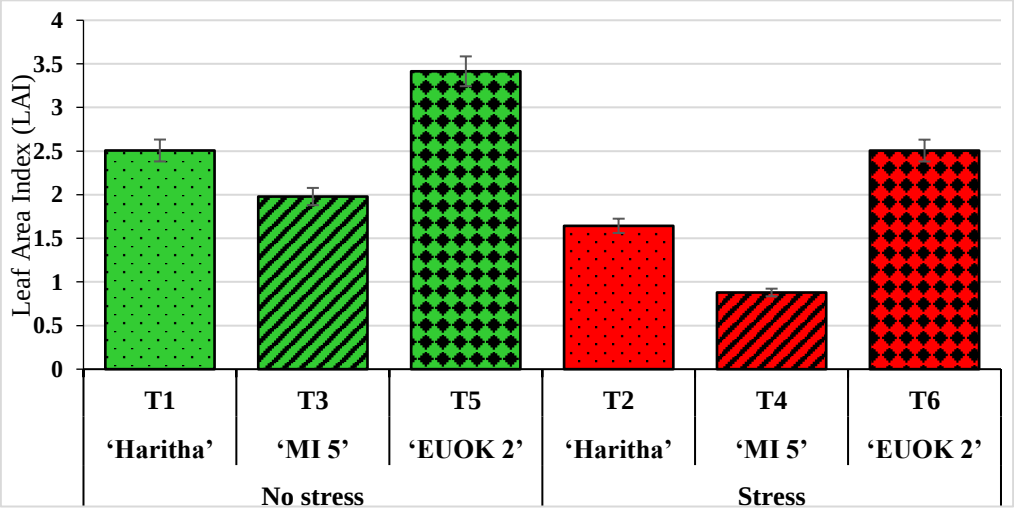
Statistical Analysis

All the analysis were carried out in triplicate and in randomized order with the mean values. The data were subjected to an analysis of variance (ANOVA), and the mean differences were compared using DMRT at probability level of P< 0.05.

3. Results and Discussion

Leaf Area Index (LAI)

There were significant ($p < 0.05$) differences between treatments in the LAI of tested okra cultivars when moisture stress was imposed during the flowering stage (Figure 1).



Values are the means of 8 plants in 4 replications.
Vertical bars indicate the standard error.

Figure 1. Effects of soil moisture stress on the LAI of three okra (*Abelmoschus esculentus* L.) cultivars during the flowering stage

The highest LAI (2.51) was obtained in the 'EUOK 2' okra cultivar and the lowest (0.89) was found in the 'MI 5' under moisture stress condition. Hence, moisture stress has reduced the LAI of all the tested okra cultivars. Leaf area expansion depends on leaf turgor and drought-induced reduction in leaf area is ascribed to suppression of leaf expansion through reduced photosynthesis. Diminished leaf area was attributed to the negative effect of stress on the rate

of cell elongation which resulted in leaves reduced in cell volume and cell number (Kawakami *et al*., 2006). The highest LAI found in the 'EUOK 2' compared to the others under moisture stress condition signifies its inherent drought tolerance feature and the lowest LAI recorded in the 'MI 5' showed its susceptibility to drought.

Plant Dry Weight

There were significant ($p<0.05$) differences between treatments in the plant dry weights of tested okra cultivars when moisture stress was imposed during the flowering stage (Table 1).

Table 01. Effects of soil moisture stress on the plant dry matter of three okra (*Abelmoschus esculentus* L.) cultivars during the flowering stage

	Cultivars	Treatments	Plant dry matter (g)
No stress	'Haritha'	T_1	251.1 a
	'MI 5'	T_3	233.4 a
	'EUOK 2'	T_5	218.6 a
Stress	'Haritha'	T_2	142.9 b
	'MI 5'	T_4	102.5 c
	'EUOK 2'	T_6	176.3 a

Values in the same column followed by the same letter do not differ significantly ($p<0.05$).
Values are the means of 8 plants in 4 replications.

The highest plant dry weight was obtained in the 'EUOK 2' okra cultivar and the lowest was found in the 'MI 5' under moisture stress condition. Moisture stress therefore has reduced the plant dry weights of all the tested okra cultivars. Reduction in plant dry weight was due to reduced production of photosynthates on account of stress. Many studies have indicated the increase in drought stress could decrease plant dry weight (Omidi, 2010). The decrease in dry weights of stressed shoots reveals the influence of water on stimulating and regulating photosynthetic enzymes which thus influence dry matter production and weights. The highest plant dry weight obtained in the 'EUOK 2' okra cultivar under drought condition would have been due to its inherent drought resistance feature. 'MI 5' cultivar showed the lowest plant dry weight among the tested ones which is a drought susceptible character of this cultivar.

Yield

There were significant ($p<0.05$) differences between treatments in the yield of okra cultivars when moisture stress was imposed during the flowering stage. The highest yield (3.8 tha^{-1}) was obtained in the 'EUOK 2' and the lowest (0.4 tha^{-1}) was found in the 'MI 5'under moisture stress condition 2.4 t ha^{-1} yield was recorded in the 'Haritha' okra cultivar. Moisture stress therefore has reduced the yield of all the tested okra cultivars. The yield of okra is influenced by the availability of soil moisture during the vegetative and reproductive stages and crop experiencing drought during the reproductive phase shows significant ($p<0.05$) yield reduction. Drought stress during reproductive stages like flowering and podding is crucial for yield in okra and this reduction of crop yield depends on okra varieties and tolerant genotypes will be able to give a better yield considerably due to physiological and biochemical changes that are triggered during drought stress. Vaidya *et al*. (2015) have indicated a reduction of yield due to drought stress and it was highly significant ($p<0.05$) between genotypes, drought stress and their interaction. The highest yield obtained in 'EUOK 2' cultivar compared to the others under moisture stress condition shows its drought tolerance.

4. Conclusions

Soil moisture stress imposed during the flowering stage has reduced the measured physiological parameters, agronomic performances and yield of the tested okra cultivars. The highest growth performance in terms of Leaf Area Index, plant dry weight and yield was obtained in the 'EUOK 2' okra cultivar and the lowest was found in the 'MI 5' under moisture stress condition. Hence, 'EUOK 2' was identified as the drought tolerant okra genotype among the tested ones which produced substantial yield under water limited situation and it could be recommended for drought prone areas of the sandy Regosols.

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Evaluation of physico-chemical and milling properties of selected paddy varieties in Sri Lanka

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1. Introduction

Rice (*Oryza sativa* L.) is the world's overwhelming cereal, providing 60-70% of the caloric value for human beings. To enhance the standard of rice varieties, it is essential to confirm the good post-harvest processing by providing information based on the physico-chemical and milling properties of paddy grains. For individuals involved in rice production, the physical parameters of grains are of critical concern. These dimensions are crucial for the commercialization, categorization, development of new rice varieties, and drying and processing processes. As well, the milling quality will determine the quality of rice. It involves the removal of husk and bran to get an endosperm for human consumption. A significant proportion of head rice, high milling recovery, low broken rice, lack of contaminants, and good appearance is the major quality determinants of rice. The milled rice has a longer shelf life and offers consumers the physical characteristics they want. Rice is a good source of energy and the protein quality of rice is relatively high especially in lysine amino acids. When rice is taken as whole grains rather than refined grains, it will provide a variety of minerals and vitamins, as well as bioactive components and dietary fibres. Rice quality determines the market value of the commodity, and it also influences the development and adoption of new varieties. Therefore, the research study was carried out to assess the physicochemical and milling properties of selected paddy varieties in Sri Lanka.

2. Materials and Methods

The research study was conducted at the Rice Research and Development Institute, Bathalagoda in the *Yala* season. The maximum temperature of 34 °C, minimum temperature of 19 °C and mean relative humidity ranged between 65-75% were noticed during the study period. The paddy grain varieties such as Bg 300, Bg 352, At 311, Suwendel, and Suduheenati were selected for the experiments. The initial moisture content of selected paddy samples were 12.5%, 13.1%, 12.9%, 13.2% and 12.6% respectively. The paddy rice was de-husked using rice husker (Satake, DH035B) and the obtained brown rice was polished with rice polisher (Satake THO 50) into milled rice. They were manually separated into head rice and broken rice grain. The weights obtained were recorded after each operation and they were used to determine the milling characteristics such as percentage of brown rice, polished rice, milling degree, head rice and broken rice according to the IRRI (2009).

The physical characteristics of milled rice such as length, width, and length/width ratio (L/W) were determined using Vernier calliper. RRDI (2018) was used to determine the size and shape of grains. The grain size was classified based on length; long (6-7mm), intermediate (5-5.99mm) and short (<5mm). The shape of grain was classified considering L/W; slender (>3.0), medium (2.4-3.0); bold (2-2.39) and round (< 2.0). A moisture metre (G-WON GMK303, South Korea) was used to assess the moisture content of rice samples. The protein and fat content were determined by AOAC (2005). Juliano's simplified technique for estimating amylose

content was used. The index of the alkali digestibility test was used to determine the gelatinization temperature. ANOVA was used to statistically evaluate the results of the experiment. Duncan Multiple Range Test (DMRT) was used to examine the differences in means using SAS package version 9.1. Further, the correlation was carried out to see the relationship between the amylose content and gelatinization temperature with the milling properties of rice.

3. Results and Discussion

Table 1 shows the milling and physical properties of different selected rice varieties. The highest brown rice percentage was recorded as 79.94% in Bg 352 and a minimum of 75.61% for Suwendal. In general, husk comprises 20-22 percent of rough rice, with a range of 18-26 percent reported (Cruz & Khush, 2000). The highest total milled rice percentage was observed 74.73% in Bg 352 and a minimum of 69.06% for Suduheenati and the highest percentage of head rice was recorded 83.34% in Suwendel and a minimum of 50.94% for At 311. The highest broken rice percentage was recorded at 12% in At 311 and a minimum of 1% in Suwendel. The highest degree of polishing was recorded in Suduheenati and the lowest degree was recorded in Bg 352. Suwendel had the shortest length of 4.47 mm, while At 311 had the longest length of 6.98 mm (Table 1). Three varieties were categorized under intermediate class except At 311 and Suwendel. The highest width was 2.92 mm for Bg 352 and a minimum of 1.92 mm for At 311 while the highest length and width ratio was 3.64 in At 311 was categorized slender in shape. Otegbayo et al. (2001) reported length-width ratio ranged from 2.12 mm to 2.62 mm.

Table 1. The milling and physical properties of different selected paddy grain varieties.

Variety	Brown Rice (%)	Total Milled Rice (%)	Head Grain (%)	Broken Grain (%)	Degree of Polishing (%)	Length (mm)	Width (mm)
Bg 300	79.62±0.07^{c}	72.56±0.2^{b}	65.04±0.15^{c}	3.4±0.09^{c}	8.87±0.12^{c}	5.7±0.04^{c}	2.84±0.1^{c}
Bg 352	79.94±0.06^{a}	74.73±0.09^{a}	77.06±0.25^{b}	2.1±0.07^{d}	6.52±0.09^{e}	5.93±0.07^{b}	2.92±0.14^{a}
At 311	79.69±0.04^{b}	72.20±0.15^{c}	50.94±0.19^{e}	12±0.12^{a}	9.40±0.21^{b}	6.98±0.06^{a}	1.92±0.09^{e}
Suwendel	75.61±0.08^{e}	70.54±0.21^{d}	83.34±0.17^{a}	1.0±0.07^{e}	6.71±0.09^{d}	4.47±0.04^{e}	2.86±0.14^{b}
Suduheenati	76.45±0.04^{d}	69.06±0.34^{e}	57.34±0.29^{d}	4.2±0.11^{b}	9.67±0.06^{a}	5.66±0.07^{d}	2.72±0.11^{d}

The values are the means ± standard error. Means with the same letter are not significantly different at the 5% level.

The nutritional characteristics of different selected rice varieties are shown in Figure 1. According to our study, the fat, protein, and amylose contents of the rice varieties differed significantly ($p<0.05$), while the moisture content of the rice varieties did not differ significantly ($p>0.05$). The highest moisture content was observed in Bg 352 (12.3%) and the minimum was observed in Suwendel (11.4%). Bg 352 had the highest fat content (4.6%) and the minimum was observed in At 311 (2.08%). Yodmanee et al. (2011) reported slightly lower values of the fat content of eight varieties of dehusked pigmented rice grain. While Cui et al. (2010) reported 3.27% fat content in brown rice. The protein content varied from 7.29% to 9.64%. The results were in accordance with Sompong et al. (2011) who reported 7.16-10.36% protein content in red rice varieties of different countries.

As shown in Figure 1, the highest amylose content was recorded 26.29% in Bg 300 and Bg 352, also the minimum was recorded 18.96% in At 311. According to the IRRI (2004) classification At 311 categorized as low amylose content, Suwendel and Suduheenati varieties were categorized into intermediate amylose content, also Bg 300 and Bg 352 were categorized into high amylose content. The results were in accordance with Gealy and Bryant (2009) who reported the amylose content in red rice ranged from 21.8 to 25.0% and in red rice crosses

ranged from 15.1 to 25.5%. There was a statistically significant relationship between the amylose content and milling properties such as head grain (r=0.733, p<0.01), broken grain (r= -0.817, p<0.01) and width of grain (r=0.863, p<0.01) and there was no statistically significant relationship between the amylose content and milling properties such as brown grain (r=0.154, p>0.01), total milled rice ((r=0.488, p>0.01) and length of grain (r= -0.512, p>0.01).

One of the most significant variables of cooking quality is the temperature at which the rice grain gelatinizes (Cuevas & Fitzgerald, 2012). Bg 300 and Suwendel varieties fall into the intermediate gelatinization temperature (GT) (70-74 °C) category as indicated by scale 4. At 311 and Suduheenati varieties were categorized into high gelatinization temperature (>75 °C) as indicated by scales 2 and 3. Low GT values were found in Bg 352 between 55 and 69 °C, as indicated by a scale of 6 (IRRI, 2004). There was a statistically significant relationship between the gelatinization temperature and milling properties such as total milled rice (r= -0.779, p<0.01) and head grain (r= -0.647, p<0.01) and there was no statistically significant relationship between the gelatinization temperature and milling properties such as brown rice (r= -0.388, p>0.01), broken grain (r=0.517, p>0.01), length of grain (r= 0.122, p>0.01) and width of grain (r= -0.546, p>0.01).

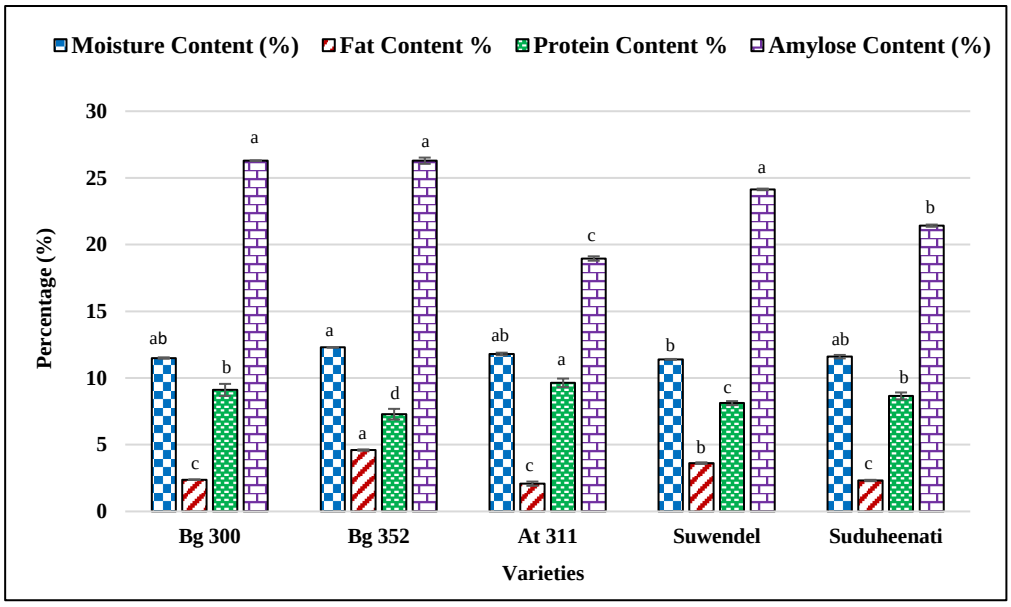

Figure 1. Nutritional composition of different selected rice varieties (% dry weight).
The values are the means of 4 replications. The vertical bars indicate the standard errors. The bars with the same letter(s) are not significantly different at the 5% level.

4. Conclusions

According to the study, the highest percentage of brown rice and total milled rice were observed for Bg 352 and the highest percentage of head rice was recorded in Suwendel. Three varieties were categorized under intermediate class except At 311 and Suwendel. There were significant variations (p<0.05) in the fat, protein, and amylose contents of five rice varieties other than the moisture content, and also there was a significant relationship (p<0.01) between the amylose content and milling properties such as head grain, broken grain and width of grain. Bg 300 and Suwendel varieties fall into the intermediate gelatinization temperature category and there is a distinct preference for those categories in rice-growing countries. There was a significant relationship (p<0.01) between the gelatinization temperature and milling properties such as total milled rice and head grain. Therefore, information from this study could be used to produce nutritious rice products and as well as in rice breeding programmes.

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Development of dehydrated avocado powder using different drying techniques and evaluation of their quality

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1. Introduction

In Sri Lanka, due to climatic and seasonal variations, postharvest losses in fruits and vegetables are estimated to be 30-40%. Avocado (*Persea americana*) is a climacteric fruit that belongs to the *Lauraceae* family. It is a well-known subtropical fruit with a high commercial worth. The fruit is particularly prone to postharvest losses in terms of both quality and quantity. Postharvest losses are mainly due to lack of correct maturity indices, uneven ripening, improper handling, lack of infrastructure, lack of transportation facilities and lack of attention to product development. It fulfils the requirement for monounsaturated fats, fibre, vitamins and minerals. The production of value-added food items utilizing the surplus of fruits will help to reduce the loss and improve customer demand. Due to its popularity as a food crop and the developing trend of commercial avocado farming in Sri Lanka, avocado production will be strong shortly. The drying technique used is determined by a number of criteria, including the kind of product, the availability of drying equipment, the cost of dehydration, energy efficiency and the ultimate product quality (Wijewardana et al., 2016). Freeze drying is one of the greatest drying processes since it preserves natural colour, maximal nutrients, original flavour, and fragrance (Marques et al., 2007). Fruits dried using conventional air dryer have poor product quality (Jain et al., 2011). Latest technological improvements are based on heat pump technology, which allows for high energy efficiency (Singh et al., 2020). The qualitatively impacts of drying methods were investigated in this study using eight treatments for conventional air dryer, heat pump dryer, and freeze dryer. This study was conducted to develop a dehydrated avocado powder and to optimize the pre-treatment for dehydration of avocado, to identify the proper drying method qualitatively and economically for avocado powder processing and to evaluate the physiochemical properties of dehydrated avocado powder.

2. Materials and Methods

The experiment was conducted in the laboratory of the National Institute of Post-Harvest Management, Anuradhapura. The "Pollock" avocado cultivar was harvested at the correct maturity stage. Fruits free from any visible defects were selected. Fresh fruits were cut into slices (5 – 8 mm thickness). Table 1 shows the different drying methods and treatments.

Table 01. Avocado powder processing

Dryer type	Temperature (°C)	Time (Hours)	Pre-treatment type	
			With blanching	Without blanching
Conventional air dryer	55	4	Citric acid 1.5 g/ L	Citric acid 1.5 g/ L
			Ascorbic acid 1.5 g/ L	Ascorbic acid 1.5 g/ L
			Citric acid + Ascorbic acid	Citric acid + Ascorbic acid

			(7.5 g/ L from each)	(7.5 g/ L from each)
			Control	Control
Heat pump dryer	40	2.30	Citric acid 1.5 g/ L	Citric acid 1.5 g/ L
			Ascorbic acid 1.5 g/ L	Ascorbic acid 1.5 g/ L
			Citric acid + Ascorbic acid (7.5 g/ L by each)	Citric acid + Ascorbic acid (7.5 g/ L by each)
			Control	Control
Freeze dryer	(-55)	15	Citric acid 1.5 g/ L	Citric acid 1.5 g/ L
			Ascorbic acid 1.5 g/ L	Ascorbic acid 1.5 g/ L
			Citric acid + Ascorbic acid (7.5 g /L by each)	Citric acid + Ascorbic acid (7.5 g/ L by each)
			Control	Control

Colour values were measured using Hunter lab colour difference meter (CR 400, Konica Minolta), the values of L*, a* and b* were recorded (McGuire, 1992). From above combinations, two treatments were selected from each drying method based on L* value. Then, Browning index was calculated based on the formula used by Maskan (2001); Saricoban and Yilmaz (2010); Kasim and Kasim (2015) to identify the better performing one treatment from selected two treatments from each dryer type. Used formula was,

$$BI = \frac{[100(X-0.31)]}{0.17} \quad Where,\ X = \frac{a+1.7L}{5.645L+a-3.012b}$$

L* - darkness or lightness of color and ranges from black (0) to white (100). Negative a* values indicate the greenness whereas positive values indicate redness. Negative b* values indicate the blueness and positive values indicate the yellowness (McGuire, 1992)

Quality evaluation for dehydrated avocado powder samples were analysed using Yield percentage, proximate analysis and physicochemical properties {titratable acidity (TA), ascorbic acid, total soluble solids (TSS), and calorimetric measurements} for two months of period.

3. Results and Discussion

According to the findings, in terms of Browning Index eight different treatments in Air dryer and Heat pump dryer were significantly different ($P = 0.000$) ≤ ($\alpha = 0.05$). Treatments without blanching ascorbic and blanching citric acid had the highest estimated median in both AD (56.45±5.17), (52.18±6.37) and HP (63.05±2.66), (63.61±3.92); the colour of browning in the freeze dryer was not substantially different across the eight different treatments ($P = 0.998$) ≤ ($\alpha = 0.05$). However, the treatment without blanching ascorbic and the treatment without blanching control had the highest estimated medians of (61.11±9.00) and (61.12±7.01) respectively. The treatment with the lowest browning index was selected as the best performing treatment according to the dryer type. Blanching followed citric acid (38.30±18.10), ascorbic

acid (56.03±3.28), and control (33.91±10.68) were the best performing treatments for AD, HP, and Freeze dryer respectively.

Yield percentages for AD, HP, and FD were 7.23%, 7.62%, 8.19% respectively. Proximate composition were analysed. The low moisture (6.57±0.00%) and highest ash (3.86±0.00%) was obtained by HP method, while the highest crude protein (14.84±0.00%) from FD method and the highest crude fat (20.31±0.00%) from AD method. A significant difference ($P \leq 0.05$) was observed in all physicochemical properties according to the completely randomized design. The lowest water activity (0.42±0.01%) and disperse of powder in the water (1.56±0.11%) was obtained with HP method.

During the two-months of storage period, physicochemical properties were observed according to the dryer types. TA in AD, HP and FD ranged as 0.75 ± 0.08 to 0.17 ± 0.08, 1.12 ± 0.28 to 0.65 ± 0.08, and 0.75 ± 0.08 to 0.54 ± 0.41) respectively. Acids may have lost during storage because they involved chemical interactions with sugars to inverse non-reducing sugars to reducing sugars (Rk et al., 2019). Ascorbic acid in AD, HP, and FD ranged as 161.20 ± 0.61 to 94.55 ± 0.57, 155.79 ± 0.50 to 88.28 ± 1.00 and 159.70 ± 0.49 to 96.93 ± 0.52 respectively. The ascorbic acid contents in fruits may degrade due to heat, preserving duration, pH value, moisture content, direct exposure to sunlight and amount of oxygen (Ali et al., 2016). TSS in AD, HP, and FD ranged as 1.43 ± 0.05 to 1.83 ± 0.05, 1.53 ± 0.05 to 2.13 ± 0.05 and 1.43 ± 0.05 to 1.93 ± 0.05 respectively. The inversion of non-reducing sugars and other polysaccharides into reducing sugars is responsible for the modest rise in reducing sugars in dried fruit after storage (Rk et al., 2019). As the colorimetric measures got using Chroma meter, L* value ranged as 56.79 ± 0.59 to 51.55 ± 0.92, 61.57 ± 0.10 to 55.58 ± 0.54 and 67.74 ± 0.13 to 58.91 ± 0.62 respectively. The L* coordinate denotes colour darkness or brightness and runs from black (0) to white (100) (McGuire, 1992).

4. Conclusions

From the present study, it can be concluded that the dehydrated avocado powder successfully developed according to the physicochemical properties. Pre-treatments for dehydration of avocado was optimized; AD – Citric acid followed by blanching; HP – Ascorbic acid; FD – control (without using any pre-treatment). Optimum drying time and temperature to achieve less than 8% of moisture in avocado powder; AD - 55℃ for 4 hours; HP – 40℃ for 2.30 hours; FD – (-55℃) for 15 hours. Heat pump drying method was identified as the proper drying method according to the physicochemical analysis, colorimetric values, and proximate analysis for avocado powder processing. During the two-month storage period, physicochemical properties were conserved in dehydrated avocado powder.

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Pre-drying of fermented black tea leaves using far-infrared

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1. Introduction

Orthodox broken types of tea are produced in about 130 tea factories in Sri Lanka. Fluid bed tea driers (FBD) are the preferred option to dry the types of tea. The FBDs are available in different sizes and their output varies between 220 and 360 kg dried-tea hr^{-1}. During tea drying, chemical reactions are arrested and its moisture content is reduced to 3%. The main drawback of the FBD method is using firewood as the main source for producing hot air for drying tea. This releases harmful gases (carbon mono and dioxides) and it is difficult to find dried firewood during the wet season. To overcome these limitations, far-infrared (FIR) could be used as an alternative source of tea drying.

Far-infrared (FIR) has been used to dry many food commodities (Abhiram & Amaratunga, 2014). It does not release harmful toxic substances. This drying method increases energy efficiency, decreases the processing time, provides uniform heating and has a high heat transfer coefficient (Sakare et al., 2020). Only limited knowledge is available for the application of FIR for tea drying. For example, Subankan et al. (2016) developed a batch-type FIR tea dryer and found that the optimum drying conditions were 185 °C and 2.5 minutes of exposure time. In this study, FIR was used for pre-drying of tea leaves since pre-drying could decrease the firewood consumption for FBD drying and arrested the fermentation quickly. The pre-dried tea samples were analysed for (theaflavin (TF): thearubigin (TR) ratio and organoleptic properties, and compared with the factory-made tea samples.

2. Materials and Methods

A prototype tea dryer was developed with four FIR emitters and a thin layer of fermented tea was pre-dried by changing the combinations of temperatures (350, 300, 250, 200 and 150 °C) and exposure times (2.2 and 3.2 mins) (Table 1). The pre-dried tea was dried using a laboratory-scale fluid bed drier. Sensory evaluation was conducted on dried tea by three professional tea tasters and chemical analysis (theaflavin (TF) and thearubigin (TR)) was conducted for quality parameters. Samples of tea dried using conventional fluid bed drier, collected from a typical tea factory (factory samples), were included along with the test teas for the analysis.

Table 01. The sample numbers of the tea dried under different combinations of temperature and exposure time

Time	Temperature				
	350 °C	*300 °C*	*250 °C*	*200 °C*	*150 °C*
2.2 minutes	S1	S3	S5	S7	S9
3.2 minutes	S2	S4	S6	S8	S10

3. Results and Discussion

Results of the 5-point hedonic scale sensory evaluation on dried tea with the estimated median value for liquor characteristics (liquor colour, flavour and aroma), dried tea leave characteristics (appearance and colour) and overall acceptability is presented in a radar graph (Figure 1). The overall acceptability of dried tea samples with exposed temperature of 250 °C & exposed time of 2.2 minutes (S5) and exposed temperature of 250 °C & exposed time of 3.2 minutes (S6) in the FIR pre-drier were superior to most of the other dried tea as well as to factory dried tea sample (Figure 1). Dry leaf colour and appearance are mainly attributed to the results.

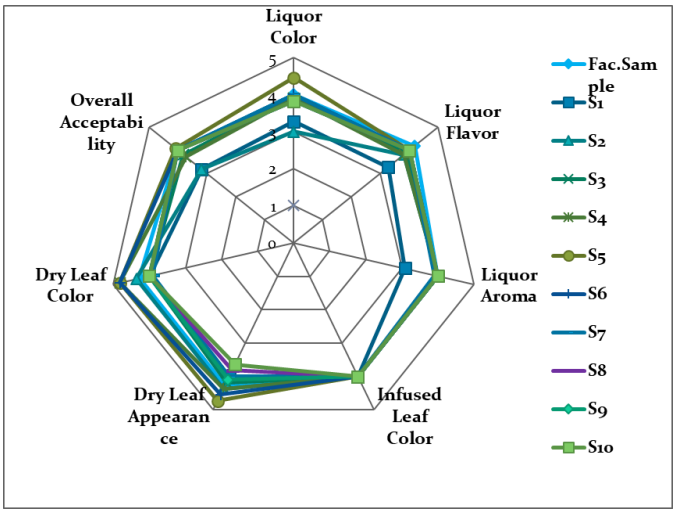

Figure 1. Radar graph for 5-point hedonic scale sensory evaluation of dried tea leaves and tea liquor

The results of the chemical analysis showed a high percentage of theaflavin (TF) and a moderate percentage of thearubigin (TR) in the dried tea samples, S5 & S6. Lowest TR: TF ratio, further attributed to the overall acceptability. Higher percentages of TR in dried teas exposed to 2.2 minutes compared to that with 3.2 minutes at exposure temperatures of 350, 300 & 250 °C indicate post-fermentation reaction. Longer exposure time under the FIR emitter led to arresting of fermentation reactions. Longer exposure time at exposure temperature of 200 & 150 °C facilitated post-fermentation during pre-drying with elevated temperature.

Table 02. The theaflavin (TF), thearubigin (TR) and TF:TR ratio of the samples dried under FIR

Sample	TF%	TR%	TR: TF ratio
S1	0.557	8.838	15.858
S2	0.476	7.519	15.810
S3	0.507	9.124	18.012
S4	0.456	8.456	18.534
S5	0.553	8.724	15.780
S6	0.564	7.750	13.736
S7	0.410	8.838	21.582
S8	0.422	9.057	21.458
S9	0.404	8.541	21.147
S10	0.424	9.236	21.800

4. Conclusions

Fermented tea types were pre-dried under FIR emitter at different exposure time and temperature and finally dried using a laboratory-scale fluid bed drier. Sensory evaluation and chemical analysis were conducted for dried tea samples and factory tea sample. When the exposure time increased from 2.2 to 3.2 minutes, enzymatic reactions appears to be arrested at high temperatures in the range of 250 to 350 °C. The sample dried under 250°C temperature and 2.2 minutes exposure time showed overall better characteristics. These results showed the potential use of FIR emitter for pre-drying of tea before fluidized bed drying.

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Recent applications of UAVs in sustainable horticulture: A review

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1. Introduction

With the increasing demands in food production and consumption, the modern farming industry has gained more prominence than ever before from several decades (Davis et al., 2016). For streamlining the farming operations in a sustainable agricultural management system, to accurately plan and monitor the existing and ongoing improvements for researchers, agronomists, agricultural engineers, and farmers, the use of unmanned aerial vehicles (UAVs) is a steadily blooming effective approach. Smart agriculture is an active field of science with the usage of robust data analytics to gain effective insights into the crops and fields has a high possibility for future avenues (Sekaran et al., 2020). Particularly for planet well-being and minimizing the adverse health impacts, while acquiring economic benefits, optimizing the sustainability credentials remains a priority (Legun & Sautier, 2018).

Precision agriculture plays a major role to achieve enhanced sustainability measures while enabling agriculture professionals to focus on the existing resources and techniques more effectively to make farming practices more sustainable (Monteiro et al., 2021). Using unmanned aerial vehicles, with the combination of communication and information technologies, artificial intelligence, and advanced data models is one of the most recent applications in precision agriculture, and with high technical advancements like positioning systems, remote sensing abilities with soil and crop sensing software and variable rate technologies (Daponte et al., 2019). Hence, UAVs can be used for a wide range of agricultural applications in horticultural practices including field mapping for crop growth assessments, detection of pests and disease, and apply remedial measures at the early stages, crop and nursery monitoring (Radoglou-Grammatikis et al., 2020). We review the most recent applications regarding UAVs for precision agriculture based sustainable horticulture in this systematic review.

2. Results and Discussion

Most Recent Applications of UAVs on sustainable horticultural practices:

Precision agricultural practices can help farmers in making better-informed decisions for increasing production level, security of constant supply, and profitability (Yost et al., 2019). Though UAVs are not only less expensive than most other agricultural machines, they are also easily operated within a range of technical knowledge (Perz & Wronowski, 2019). However, even though UAVs are not made widely into the agriculture mainstream, they can reduce working hours which is resulting in increased stability of the production upon the demand, measurement accuracy, and productivity (Boursianis et al., 2020). In various environmental conditions UAVs can perform numerous agricultural tasks basically in horticulture with the steadily increasing demand as follows:

A. Mapping

By using high-resolution UAV images within a farmland area, soil conditions of the respective land area and mainly the crop growth status can be measured (Candiago et al., 2015). Since UAVs have the ability to provide 2D and 3D maps, agricultural experts can take advantage of model enhancements and when deciding crop efficiencies (Mahmood et al., 2012). The

generated maps by UAVs allow for increasing the profit margin by giving information on homogeneous zones of the vast cultivated fields.

B. Crop Monitoring

Crop monitoring is the task conducted to predict the yield or quality of a crop via analysis of crop data. Crop monitoring is essential for optimal crop production. However, monitoring a large farm requires significant time and labor (Harshani, 2017). Very large farms are often monitored via satellite. However, this is not suitable for precision crop monitoring. Crop monitoring via UAVs has been proposed for this. Thus, high-resolution data has been obtained, and weather effects have been reduced. UAVs are providing important indicators of improvement and productivity by the vegetation index data (Dutta & Goswami, 2020). Nowadays there are more sophisticated UAVs available in the market which are having the self-calculating ability of the vegetative indices such as NDVI and GNDVI (Candiago et al., 2015).

C. Phenotyping

UAVs can quickly gather efficient phenotypic information non-destructively (Yang et al., 2017) to make management and breeding decisions for optimizing agricultural production with the demand of the booming human population all over the world (Tilman et al., 2011). For example, leaf color can be estimated by using UAV-based color sensors that can capture diverse data (Abdulridha et al., 2019), size of plants (Han et al., 2018), canopy cover (Lee & Lee, 2011) average number of flowers (Adamsen et al., 2000), and quantity of fruits in plants (Dorj et al., 2017). To estimate the nitrogen content of plant leaves (Serrano et al., 2002), leaf area index (Boegh et al., 2002), leaf chlorophyll content, plant biomass and to quantify the yield from a field (Solari et al., 2008) spectral sensors of UAVs can also be used. Thermal sensors of UAVs have the ability to roughly measure canopy temperature which is important in calculating water use efficiency and water potentials and can measure stomatal conductance (Santesteban et al., 2017).

D. Yield assessment

Crop yield quantification and quality assessments are vital to commercial level farmers, researchers, insurance agents, agricultural policymakers, local and international agencies (Rembold et al., 2013). By using UAV-based imagery, particularly in combination with artificial intelligence, not only enhancing assessment accuracies but also offers possibilities for reducing or eliminating the need for ground-based surveys (Mekonnen et al., 2020). The collective data is useful for financial planning, estimating prior crop requirements to go for a reasonable yield, insurance purposes, timely harvest for optimization of the yield quality, and to predict storage requirements.

E. Planting

Planting can be made more efficient in vast fields using UAVs. They make it possible to plant in an uneven field as well. Nowadays there is a modified system for perfect plant growth: properly distributed seeds in proper environmental conditions can be accomplished by UAVs. Although to produce efficient planting tasks, the use of UAVs is still in the development stage, and UAVs that are equipped with high image recognition capacity can optimize planting tasks efficiently (Lu et al., 2021).

F. Spraying

Compared to a conventional chemical sprayer or a wide range-area sprayer, UAVs can maximize the efficiency of chemical applications such as pesticides, herbicides, and nutrient solutions by spraying only to the identified areas which are in extreme need of those chemicals (Zhu et al., 2019). A selective application can be done by drones to reduce the unnecessary applications of chemicals to the field while reducing the impact on the environment and

increasing the profit margin by eliminating the higher costs for chemicals. Also, this strategy can achieve chemical applications up to 50 ha per day in large-scale farms and it requires only about 10 min of work per 0.5 ha of area. Thus, UAVs can help commercial-level farmers to reduce labor requirements as well (Islam et al., 2021). Recent studies have shown that UAVs are used to spray chemicals onto the plant canopies at various heights by using height sensors. Recently researches have also been conducted by developing precision algorithms to improve the accuracy of control over crops (Burgués & Marco, 2020).

G. Irrigation

UAVs with multi-spectral cameras and heat sensors can use to detect areas with water scarcity and recent researches show that UAVs with electromagnetic spectrum sensors and RGB and NIR cameras can be used to obtain data for water management and irrigation control to achieve maximum irrigation effects (Hassan-Esfahani et al., 2015). Most recent studies have focused on image processing and data acquisition of drones. However, some UAVs also perform plant irrigation tasks in areas where water is scarce by loading water instead of pesticides (Talaviya et al., 2020). With future smart farming, an irrigation automation system will be applied effectively by using a collaborative system of integrating UAVs, Unmanned Ground Vehicles (UGVs), or swarms (Choi & Kim, 2013).

H. Diagnosis of Insect Pests

Pests and diseases caused enormous damage to the field and it resulted in the high reduction of the profit in huge lots compared to other problems (Tsouros et al., 2019). Early diagnosis is essential because pest damages spread quickly in a blink of an eye. To achieve this target high-resolution RGB cameras and multi-spectrum sensors mounted on UAVs were combined to examine fields for infections. They provide maps with high accuracy and fast pathogen detection using high-quality spectral measurements.

I. Artificial Pollination

As the population of natural pollinators such as honeybees continues to decrease worldwide with the environmental pollution, people tend to do artificial pollination. Since it was a labor-intensive practice, people nowadays trying to do artificial pollination through small UAVs which can carry pollen from its extraction site to the field with the integration of artificial intelligence, ground positioning systems (GPS) as well as cameras with UAV robots (Fan et al., 2021). Pollination has also been carried out using the wind power generated from UAVs, rather than by direct contact. Some recent research shows that the wind field created by UAV exerted an asymmetrical influence on pollen distribution (Jiyu et al., 2017).

3. Conclusions

Agricultural UAVs show diverse potential in agriculture mainly in horticultural practices regarding sustainable development. This study investigated the importance and the application of UAVs for agricultural practices on horticulture and presented a systematic review of the agricultural UAVs which have outstanding utilization and potential in mapping, phenotyping, crop assessments, pest and diseases early detection, irrigation, chemical spraying, and planting mainly. Therefore, this paper contributes to future research, markets, and modifications of existing capabilities of agricultural UAVs on horticulture.

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Comparison study to investigate the rice yield, using inorganic NPK fertilizer and Environmentally Friendly Liquid (EFL) fertilizer

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1. Introduction

Oryza sativa is the most commonly grown rice variety in Sri Lanka. Presently cultivated about 100 species in both improved (Weerakoon et al., 2011) and traditional varieties (Ginigaddara & Disanayake, 2018). Paddy has played a major role in supplying food to growing population. Therefore, paddy cultivation is distributed throughout the country, predominantly low country dry and wet agro ecological zones with favourable climatic condition. Modern agricultural methods in paddy sector are supported by improved high yielding rice varieties (Dharmasena, 2010), machineries and pest control. According to the sources, 1,117,000 ha cultivated in 2019 Yala and Maha seasons in Sri Lanka (Central bank report, 2020) and depends largely on subsidies; free water supply, fertilizer subsidiary scheme, free extension services are some of them. Fertilizer subsidy is the major and the most controversial input subsidy program for paddy sector. Yield of paddy cultivation is mainly depending on soil fertility, therefore, applying high efficient inorganic fertilizer is inevitable. However, adding excessive inorganic agro-inputs to soil over a long period leads to various repercussions such as soil deterioration, environmental toxicity and poor public health. Moreover, most of paddy lands are abandoned in low country wet zone due to iron toxicity. Therefore, government is trying to promote environmental friendly farming to minimize using toxic agro-inputs. As a result, paddy farmers in southern province were introduced Environmental Friendly Liquid (EFL) Fertilizer as a subsidy. The objective of this study was to compare the productivity of paddy cultivation with EFL fertilizer and conventional inorganic fertilizer.

2. Materials and Methods

The experiment was carried out in Galle district, in southern province in WL1b geographical location under field condition, during *Yala* season in 2020 of low country wet zone. Annual rainfall ranges between 2500mm and 3000mm, daily mean temperature ranges fluctuate from 24 ^{o}C to 30 ^{o}C. Improved paddy variety BW-372 was used for the experiment. T tests were carried out to compare two treatments. Each plot size was 1,011.71 m^2 (¼ acre) and both tests were repeated 15 times. Significance level 0.05. Treatments are as follows;

T1 - Application of inorganic conventional fertilizer (NPK)
T2 - Application of conventional fertilizer with EFL fertilizer

Inorganic fertilizers (T1) were applied according to the recommendation of Department of Agriculture (DOA) as shown in Table 1. In treatment two (T2), EFL fertilizer was applied together with inorganic NPK fertilizer mix. EFL fertilizer was applied twice in 14 and 28 days. NPK inorganic fertilizer mixes were added three times in 3, 5 and 7 weeks after sowing seed. In T2 trial, NPK inorganic fertilizer quantity was reduced comparing the DOA recommendation as given in the Table 2.

Table 01. Application of inorganic fertilizer with time Kg/Acre

Time	Urea	TSP	MOP
Basal fertilizer	-	10	-
Top dressing 1 (3 week after sowing)	12	-	12
Top dressing 2 (5 week after sowing)	14	-	18
Top dressing 3 (7 week after sowing)	10	-	10

Table 02. Application of EFL fertilizer and inorganic fertilizer mixes Kg/Acre

Time	Urea	TSP	MOP	O.L. F
Basal fertilizer	-	14	-	-
EFL Fertilizer (14 days after sowing)				500ml
Top dressing 1 (21 days after)	10	-	10	
EFL Fertilizer (28 days after)				500ml
Top dressing 2 (35 days after)	10	-	15	
Top dressing 3 (49 days after)	7	-	5	

3. Results and Discussion

Data on plant height, number of leaves, number of tillers, number of panicles, number of seed in a panicle, total yield and the cost of fertilizer were collected and analysed as given in Table 3.

Table 03. Mean values of quantitative characters

Measurements	Conventional fertilizer application (T1)	EFL fertilizer + conventional fertilizer application (T2)
PH (cm)	84.3	97.8
NOL	16.5	29.2
NOT	7.9	9.4
NOP/B	7.8	9.3
LOFL (cm)	30.2	40.0
WOFL (cm)	1.47	1.4
NOS/P	171.4	175.1
YIELD (bushels/Acre)	41.2	55.2
TCOFA (Rs.)	1302.9	1853.8

EFL with inorganic fertilizer (T2) application has depicted greater values of Plant Height (PH), Number of leaves (NOL), Number of Tillers (NOT), Number of Panicles/ Bush (NOP/B), Length of Flag Leaf (LOFL) than T1. Width of Flag Leaf (WOFL) and Number of Seeds/Panicle (NOS/P) were almost similar in both treatments. 13.8 bushels were harvested from T2 whereas 10.4 bushels were given from T1 per 1011.7M^2. Total Cost of Fertilizer Application (COFA) was indicated as higher value in T2 (Rs. 1853.85) comparing to T1 (Rs. 1302.90).

4. Conclusions

EFL fertilizer with NPK application (T2) has shown better performances than T1 in most of the parameters even though the result was not statically significant. Most importantly, rice yield was increased with EFL fertilizer. In addition, there were no pests and diseases incidents in T2. Average cost for application of EFL fertilizer was greater than Inorganic fertilizer as EFL should be sprayed twice as foliar application. Bacterial blight (*Xanthomonas oryzae)* was found in T1 and controlled by using Carbendazim pesticide. Further improvement of EFL fertilizer may leads to commercialized and it will give promising results in paddy cultivation, which helps to cut down inorganic fertilizer application while increasing rice productivity.

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Wild plants and vegetables: source of diet and nutrition in Bangladesh

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1. Introduction

Wild vegetables and plants which grow naturally in abundance around dwelling houses, roadside areas and unused lands can meet up the requirements of food and nutrition in Bangladesh. Rural women can play an important role in collecting the vegetables. Arable lands do not increase in proportion with the population flourishing in our country. In such a situation, it is essential to look for alternative sources of food and nutrition (UNICEF, 2001). Wild vegetables are one of the important sources of healthy and nutritious food. It's played a significant role in supplying food and nutritional necessities and enhances the health status of poor communities in many rural populations in the world. Some edible wild vegetables also have medicinal properties (Duguma, 2020). Green leafy vegetables have various dietary and health benefits, being very rich sources of carbohydrates, proteins, vitamins, calcium, iron and minerals which can be used as alternatives diets (Ebert, 2014; Jimoh & Oladiji, 2005).

In Bangladesh wild vegetables are usually used as fodder for cattle. After cooking the vegetables become tasty and nutritious food items for poor villagers. The researchers emphasize that the difference between supply and demand would be much wider if wild food was absent from our daily dietary system. Therefore the present study is undertaken to i) Present research is focused on sorting out the wild vegetables which are beneficial to health, ii) To find out different kind of unknown wild vegetables, those are useful for human and iii) To find out medicinal value of the wild vegetables available in Bangladesh.

2. Materials and Methods

This study has been undertaken to identify the wild vegetable and its impact on human health. This article is depended on secondary sources, books, journals, articles and, published documents. Relevant all sources according to different criteria based on topic will be collected. A total 85 articles were reviewed thoroughly in relevant field. To identify the commonly consumed plant parts, mode of consumption, nutritionals and medicinal value of wild vegetables will also study.

3. Result and Discussion

Contribution of wild vegetables to Food security in Bangladesh:

Wild vegetables contain vitamins and minerals. Integrated Action Research and development, a Dhaka based organization, has found that a vast resource of vegetables and plants still remains undiscovered. Wild edible fruits have become a very important part of human nutrition and cannot be overlooked as far as food security (UNICEF, 2001).

Complementary Role of wild edible vegetables:

Everybody knows, milk is the main source of calcium. But some wild and unpopular leafy vegetables have contained more calcium than milk or milk product food item. This comparison has shown below the table number -01.

Table 01. Quantity of Calcium per 100 gm. some wild vegetables and other food products in Bangladesh

Milk/other food item	Calcium (milligram)	Wild/ Leafy vegetables	Calcium (milligram)
Dairy milk	130	Leaf of turnip	710
Paneer	790	Mathe shak	395
Yogurt	149	Kalmi shak	107
Egg yolks	50	Leaf of cauliflower	626
Fried peanut	77	Pui shak	164
Cat fish	670	Moringa leaf	440
Red lentil	69	Black taro	460
Powder milk	1370	Coriander leaves	1450

Source: Ahamed (2005): Food and Nutrition, Ideal Publication, Dhaka, Bangladesh.

It is apparent from this comparison that the nutritional value (Calcium) of wild and unpopular leafy vegetables have contains more calcium than milk or milk product which helping prevent problems like osteoporosis.

Wild edible plants and vegetables used as traditional medicine

Research of wild vegetables has been conducted by the project of Cooperative for American Remittances to Everywhere (CARE) Bangladesh. They have found that, different wild edible plants parts are used as traditional herbal medicine in rural people in Bangladesh (UNICEF, 2001). Medicinal plants are also extensively used in many countries as dietary supplements, as daily foods and as functional foods to improve immune system and promoting health. Globally, about 64% of the total world population are reliant on traditional medicine for their healthcare needs (Garcia-Herrera et al., 2014). It has contain a huge amount of plant secondary metabolic that contain potentially health-promoting ingredients (Garcia-Herrera et al., 2014).

Market values of wild edible plants and vegetables

Income derived from the sale of wild plant species is helpful to improve the livelihood of rural villager's (Assefa & Abebe, 2011). So, income and employment can be obtained by the sale of these types of wild edible fruits and vegetables.

Opinion of users to consume wild edible plants

Another research of wild vegetables has been conducted by the project of CARE Bangladesh and found that most aging rural women are more aware about the benefits of wild vegetables than others. They know well about the benefits of different types of wild edible vegetables such kalmi shak (spinach), Leaf of turnip, mathe shak, pui shak, leaf of cauliflower, telakucha (ivy gourd), helencha shak (water cress, mash herb), kata note shak (prickly amaranth), dheki shak (fiddlehead fern), bothua shak, lafa shak, pat shak (jute leaves), moringa leaf etc. and also aware about the medicinal value and use of these vegetables (UNICEF, 2001).

The indigenous people in Bangladesh who mostly habituated to consume those types of wild foods have a greater capacity to maintain good health conditions. Consumption of wild edible plants carries the connotation of belonging to a lower stratum in society and is considered an insult, because of lack of knowledge. The literature indicates that the awareness of wild edible plants as food varies from location to location, and it also depend on gender and the age of the consumer.

4. Conclusions

The present study has an attempt to review the available information about the nutritional value, supplementary role and medicinal value of wild edible vegetables available in Bangladesh.

Wild vegetables are not only good for human health, but also eco-friendly and cost effective. The unwanted plant effectively checks erosion of land and increase land fertility resulting in higher production of other crops. Nutrition policies have to promote the utilization of wild vegetables as part of a strategy to improve food security, nutrition as well as improve livelihoods of rural people of Bangladesh. Now a time should be taken for widespread advertising of these plants and vegetables.

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Analysis of extreme climate events in Sri Lanka from 1981-2019: Case study in wet, intermediate and dry zone

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1. Introduction

The occurrence of weather variables beyond the thresholds is known as 'extreme climate events' (Field et al., 2012). The indicated changes in the climate in turn has commuted dynamics in terms of frequency and intensity of these extreme events. Thus, several studies have revealed that the Asian region has undergone significant changes in the trends of climate extremes during the last few decades and those have been characterized by strong variability (Choi et al., 2009; IPCC, 2014). As a result of such cognate changes in the climate, Asian countries are highly vulnerable to extreme climate events. In recent years, Sri Lanka has witnessed numerous extreme climatic events, originated by catastrophic floods, and droughts. Naveendrakumar et al. (2018) has proclaimed that the consequent fluctuation with regard to minimum and maximum temperature are immensely noticeable in Sri Lanka. Despite the temperature rising, the Sri Lanka national report on disaster risk, poverty and human development relationship reveals that drought and floods affect up to 4 million people every year. Similarly, a recent study demonstrated a declining trend in the annual counts of days with heavy rainfall in Southern India and Sri Lanka based on the definitions of extreme climate events. According to the literature, it is clear that the climate of Sri Lanka has changed crucially. Although there are adequate studies on climate variability, there is a lack of information on extreme climate events in Sri Lanka. Therefore, the present study was conducted to analyze the occurrence of extreme climate events and short-term climate variability from 1981-2019 in major Agro-ecological regions of Sri Lanka.

2. Materials and Methods

This study was conducted in seven selected locations covering all three Agro-ecological zones of Sri Lanka including Mahailuppallama, Hambantota, Batalagoda, Monaragala, Nuwara Eliya, Galle and Katugastota (Figure 1).

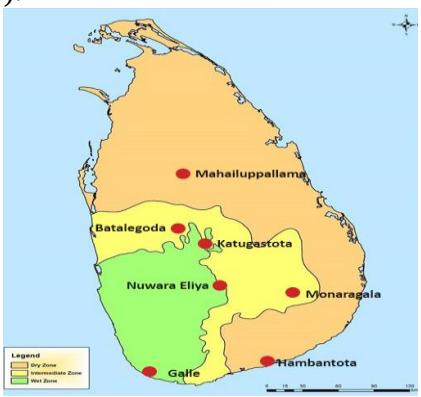

Figure 1. Selected locations

Data on Daily rainfall, minimum and maximum temperature from 1981-2019 were collected from the Department of Meteorology, Sri Lanka. Data quality control was done by using the RClimDex (version 4.0.2.) software. Ten indices were selected for the study as defined by the Expert Team on Climate Change Detection and Indices (ETCCDI) (Table 1). Extreme climatic events were identified for the aforementioned indices from the RClimDEX software package. Annual trends of extreme climatic events were identified by using Non–Parametric Mann Kendal test and regression analysis.

Table 01. Selected Temperature and Precipitation Indices

Index	Definition	Unit
Temperature Indices		
TXn	Annual minimum value of daily maximum temperature	^{o}C
TXx	Annual maximum value of daily maximum temperature	^{o}C
DTR	Annual mean difference between maximum and minimum temperature	^{o}C
TN90p	Annual percentage of days when minimum temperature greater than 90th percentile	%
Precipitation Indices		
CDD	Maximum number of consecutive days with RR < 1mm	days
CWD	Maximum number of consecutive days with RR >= 1mm	days
R95p	Annual total PRCP when precipitation is greater than 95th percentile	mm
R99p	Annual total PRCP when precipitation is greater than 95th percentile	mm
RX5day	Annual maximum of consecutive 5-day precipitation	mm

3. Results and Discussion

The Coldest days (TXn), which are the annual minimum and maximum temperatures, did not show any significant ($p>0.05$) trend in all the selected locations.

Similar to the coldest day, the warmest days (TXx) also did not show any significant ($p>0.05$) trend within the 1981 to 2019 period.

The change in Diurnal Temperature Range (DTR) is rather regional than global (Jayawardena et al. (2018). In this study, no significant ($p>0.05$) trends were observed in Dry zone and Wet zone for the DTR. The intermediate zone showed a significant ($p<0.05$) negative trend in Monaragala and a significant ($p<0.05$) positive trend in Batalagoda.

Accordingly, over 70% of the selected stations in this study showed significant increasing trends in the percentage of warm nights (TN90p). Regarding the warm nights (TN90p) Wet zone showed a significant ($p<0.05$) positive trend for all the selected locations. Similar to the Wet zone, Dry zone also showed a positive trend in Hambantota which was significant ($p<0.05$). thereupon, conspicuous variations could be observed from the locations in the intermediate zone, Batalagoda during the study period. While all the other locations showed a positive trend for warm nights Batalagoda showed a significant ($p<0.05$) negative trend. This result is coinciding with the previous studies done by Jayawardena et al. (2018), as deliberated there, over 60% of the stations showed significant increasing trends in the percentage of warm nights.

In Warm days (TX90p), Dry zone showed a significant positive ($p<0.05$) trend in Hambantota while the Intermediate zone showed a significant ($p<0.05$) negative trend in Monaragala. The wet zone showed no significant ($p>0.05$) trend for warm days within the study period.

When considering the Precipitation Indices, no significant trends were observed for Consecutive Dry Days (CDD) in selected locations in Wet, Dry and Intermediate zones within the study period.

Both positive and negative trends were displayed by all three zones during the study period for Consecutive wet Days (CWD). Nuwaraeliya (in the wet zone) showed a significant ($p<0.05$) negative trend while Hambantota in Dry zone showed a significant ($p<0.05$) positive trend. The intermediate zone showed no significant trends for CWD within the study period.

Very Wet Day precipitation (R95P) in Mahailuppallama, Dry zone showed a significant ($p<0.05$) positive trend, while all the other locations in Wet and Intermediate zones showed no any significant ($p>0.05$) trends.

For extremely wet days (R99P) within the study period, all the zones showed no any significant changes except Mahailuppallama in the dry zone which showed a significant ($p<0.05$) positive trend.

Trends for 5-day precipitation (RX5day) among the selected stations, a significant ($p<0.05$) positive trend was observed in Mahailluppallama in the Dry zone while all the other selected locations showed no any significant ($p>0.05$) trends.

4. Conclusions

In general, a warming trend was observed in temperature indices through this period. DTR in the Intermediate zone showed a significant increasing and decreasing trend. An increasing trend was shown in TN90p for all locations except Batalagoda which showed a significant decreasing trend. An increasing trend showed in Hambantota and a decreasing trend showed in Monaragala for TX90p were found significant. Considering Rainfall indices, a significant positive trend was observed for R95p, R99p and RX5day in Mahailuppallama showing that rainfall intensity in

Mahailuppallama has increased. In general, trend analysis revealed dynamic rainfall trends with both increasing and decreasing patterns in Sri Lanka.

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An inquiry into propensity of dwellers in the Udagaldebokka isolated forest-dependent community to resettle off the forest: A cultural consensus analysis

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1. Introduction

This ethnographic study investigates the culturally determined tendency of the dwellers in an isolated forest-dependent community in Sri Lanka to resettle away from the forest and closer to other human settlements. This community, residing in a small hamlet (Udagaldebokka) surrounded by the thick Knuckles forest, consists of 33 families belonging to four generations. Our observations revealed that most of the dominant cultural components, such as food habits, medicinal practices, livelihoods, and spiritual beliefs of the Udagaldebokka dwellers, are closely linked to the forest. Given the heavy dependence of the Udagaldebokka dwellers on forest resources and their dire living conditions, a culturally sensitive program to relocate the entire community can have implications on both forest conservation goals and welfare standards of the community. Such a relocation program needs an in-depth insight into shared cultural models shaping dwellers' willingness or reluctance to migrate. To quantitatively determine whether the tendency of the Udagaldebokka dwellers to leave their current hamlet and resettle elsewhere off the forest remains a coherent culture within their community, a cultural consensus analysis was conducted.

2. Materials and Methods

An ethnographic research design was adopted to conduct this study. A close mode of communication was maintained with the members of the community to learn their perspectives on resettlement.

A Cultural Consensus Analysis (CCA)(Paris et al., 2015; Romney et al., 1987) was performed to investigate the factors (i.e., Contentment with the current place of residence, uncertainty in capacity to adapt to a new environment, perceived opportunities for development if resettle off the forest and subjective norms on migration and resettlement) underlying the Udagaldebokka dwellers' propensity to leave their village and resettle off the forest. CCA is founded on the assumption that people who share a common culture also possess a shared cultural knowledge. A questionnaire containing 36 items, which attempted to gauge the aforementioned four construct factors, was developed based on field observations, semi-structured/ unstructured interviews and a free listing survey (Quinlan, 2017). The data, using the questionnaire, was collected from a sample of 28 community respondents.

First, an Informal Cultural Consensus Model (ICCM)(Weller, 2007) was employed over the entire sample and the same analysis was repeated with different subgroups of the sample (i.e., clustered based on gender and generation). The ICCM applied a non-rotated un-weighted least squares factor analysis that was performed on respondents after transposing the data matrix.

Next, Cultural Answer Keys (CAKs) were constructed to identify the culturally appropriate answers. By using the constructed CAKs, a Spearman Correlation Analysis was conducted to investigate whether the dwellers' cultural knowledge varied by subgroups. Finally, a Correspondence Analysis was conducted to identify whether there was a pattern in the way how dwellers were willing to resettle off the forest.

3. Results and Discussion

Table 01. Cultural Consensus Analysis Results

	Eigenvalue ration	Percentage of variance explained	Number of negative loadings	Mean 1st factor loadings	Number of Cases
Full Sample	5.06	42.17	0	.63	28
Gender					
Male	4.39	44.13	0	.63	16
Female	3.84	45.09	0	.59	12
Generation					
1st Generation	2.77	44.53	0	.64	10
2nd Generation	4.37	48.47	0	.68	12
3rd Generation	2.65	48.36	0	.69	06

An ICCM is deemed valid if three criteria are met :1) The ratio of the first and the second eigenvalues must be larger than three to one; 2) Loadings on the first factor for individuals must be positive; and 3) The mean factor loading must be greater than .50. (Weller, 2007)

According to the results obtained, for the whole sample, the ratio between the first (11.808) and the second eigenvalues (2.33) equalled 5.06, which was over the cut-off ratio of 3 to 1. The average variance accounted for by the first factors was 42.17%, and the mean first factor loading (0.63) was over the threshold value of 0.5. Individual loadings on the first factor for all the items were positive. As the model met with all the three criteria, it can be concluded that a cultural consensus on resettlement exists among the community.

As stated earlier, an ICCM was employed on each sub-group extracted based on gender and generation. Each sub-group scored a mean first factor loading that was above 0.5 and none of the sub-groups reported negative loadings on the first factor. The ratio of the first and the second eigenvalues for all the sub-groups either surpassed or approximated the accepted threshold value.

As each sub-group revealed a coherent cultural model on 'resettlement propensity' among the members within each sub-group, a Spearman Correlation Analysis was conducted to see whether the dwellers' cultural knowledge varied by gender or generation. According to Spearman's Correlation Analysis results, there was no statistically different cultural knowledge on resettlement between men and women in Udagaldebokka community ($r_{s\,=\,0.85}$, $p<0.001$). As the results further revealed, regardless of generational differences, all the members within the community shared a common cultural knowledge on resettlement (1st-2nd generations: $r_{s\,=\,0.83}$**, $p<0.001$ / 1st-3rd generations: $r_{s\,=\,0.71}$**, $p<0.001$ / 2nd-3rd generations: $r_{s\,=\,0.77}$**, $p<0.001$).

The final cultural answer key confirmed that the cultural model consisted of four belief dimensions; 1) Contentment with the current place of residence, 2) Uncertainty in adaptive

capacity, 3) Perceived opportunities for development if resettled off the forest and 4) Subjective norms on migration and resettlement. No major differences were observed between the cultural answer key obtained for the total sample and each answer key obtained for each sub-group. In overall, the results indicate the homogeneity in perceptions and preferences regarding resettlement that exist within the population of this traditional community regardless of demographic differences.

According to Correspondence Analysis results, the study could identify how different rewards can shape the willingness of Udagaldebokka dwellers to resettle off the forest. Most of the dwellers were willing to resettle off the forest if a three-acre land is provided to each household in a context where the whole community is willing to migrate together. If a house is provided, most of the dwellers were willing to leave the current location with their respective families and close allies, even if the other people in the village are reluctant to go with them. A job was found to be the most influential reward that could motivate most of the dwellers to resettle off the village as individuals.

4. Conclusions

As the findings revealed, a coherent cultural model on 'Resettlement Propensity' exists among the Udagaldebokka dwellers regardless of their age and gender differences. The revealed cultural model consists of four belief dimensions; (1) contentment with the current place of residence, (2) uncertainty in adaptive capacity, (3) perceived opportunities for development if resettled off the forest, and (4) subjective norms on migration and resettlement. Therefore, the above dimensions can be considered in designing a program to effectively resettle the people in Udagaldebokka away from the forest. As the study further revealed, rewards can be used to motivate the Udagaldebokka dwellers to leave the village and resettle elsewhere.

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Effects of different ambient temperatures for growth and development of fall armyworm, *Spodoptera frugiperda* (Smith)

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1. Introduction

The environmental, economic, and social impacts of invasive alien species are jeopardizing the livelihoods and food security of small-scale farmers in developing countries. (Pratt et al. 2017). Among them, the fall armyworm (FAW) *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae), is a polyphagous lepidopteran pest native to tropical and subtropical America which is mainly associated with maize was serious concern (Sarmento et al., 2002). The pest was confined to the American continents where in late 2016, it was reported in Africa and spread rapidly across 44 African countries (Sisay et al., 2019). In 2018, FAW was reported in India (Karnataka) (Sharanabasappa et al., 2018) and Sri Lanka caused an outbreak with significant yield losses of all maize growing areas (Perera et al., 2019; Wijerathna et al., 2020). According to Begon et al., (2006) thermal optimum is the temperature at which a species thrives in terms of growth, reproduction, and survival. Hence, the length of instars, the number of instars that larvae undergo before reaching adulthood, is influenced by temperature (Aguilon et al., 2015). Moreover, the relationship between temperature and development rate has a big impact on pest biology, distribution, and abundance (Tobin et al., 2003). In pest management, life table information is useful for evaluating and comprehending insect population, survival, reproduction, and intrinsic rate of increase (Ashok et al., 2020). Hence the present study was planned with the aims of evaluating the effect of different temperatures on the growth, development and survival of *S. frugiperda* under three ambient temperatures.

2. Materials and Methods

The Experiment was conducted at the Department of Biosystems Technology, South Eastern University of Sri Lanka. FAW larvae were collected from infected maize fields and reared in laboratory conditions on a natural diet. The pupae were sexed and monitored daily until moths emergence. Same aged male-female pairs were confined to oviposition cages and kept temperature conditions viz. 25±1°C (T25), 30±1°C (T30) and 35±1°C (T35) to determine the age-specific fecundity. Meantime, 100 eggs (F1) were kept in the same different temperatures and inspected daily. First instar larvae were transferred to the individual bottles and their duration was recorded by observing head capsules exuviae using a dissecting microscope.

Age-specific fecundity tables were constructed described by Atwal and Bains (1974) and Howe (1953) viz., x = Pivotal age in days; lx = Survival of female at age 'X'; mx = Age schedule for female births at age 'X'. Further, Net productive rate (Ro), Mean duration of generation (Tc), Innate capacity for increase (rm), the finite rate of natural increase (λ). The life table for computing life expectancy, Cohort age-specific life tables, dx = number of dying during the age interval x to x+1, qx = rate of mortality during the age interval x to x+1 were determined using the methods given by Krebs (2001) and Kyi et al. (1991). The different temperatures were compared using one-way ANOVA followed by DMRT at a 5% significant level.

3. Results and Discussion

The present study found that the mean duration of each stage at three different temperatures was significantly different except for the egg hatching period. Where 1st to 3rd instar larvae took the longest duration at T25 and 4th to 6th instar larval durations were significantly higher at T35. However, the total larval days were higher at T25 (20.17) and T35 (17.89) compared to the T30 (14.92) (Table 01). Our results agreed with mean instar (1st- 6th) durations reported by Pitre and Hogg (1983) at 25°C.

Table 01. Duration (days) of each stage of the FAW life cycle in different temperatures

	Duration (days)		
Particulars	35°C Mean±SD	30°C Mean±SD	25°C Mean±SD
Egg	2.78 ± 0.46[a]	2.17 ± 0.38[a]	2.14±0.35a
1st instar	2.78 ± 0.42[b]	2.33 ± 0.50[c]	3.14±0.79[a]
2nd instar	2.38 ± 0.76[b]	1.92 ± 0.60[c]	3.02±0.85[a]
3rd instar	2.71 ± 0.75[a]	2.13 ± 0.60[b]	2.72±0.88[a]
4th instar	3.20 ± 1.48[a]	2.01 ± 0.72[b]	2.54±0.95[a]
5th instar	4.00 ± 0.70[a]	2.81 ± 0.82[b]	2.81±0.72[b]
6th instar	5.20 ± 0.83[a]	3.72 ± 1.07[b]	3.66±0.63[b]
Pre pupae	1.20 ± 0.44[b]	1.64 ± 0.75[a]	1.84±1.02a
Pupae	5.75 ± 0.50[b]	8.61 ± 0.75[a]	9.21±1.02a
Male	-	9.29 ± 0.46[a]	10.00±0.75[a]
Female	5.66 ± 0.57[b]	8.12 ± 0.48[a]	8.52±0.65[a]
Pre oviposition	5.00 ± 1.732[a]	2.85 ± 1.11[b]	2.82±0.52[b]
Oviposition	-	4.73 ± 0.77	5.25±1.73
Post oviposition	-	1.23 ± 0.59	1.62±1.06

Values indicate the mean ± standard deviation (SD) (days) and different letters within the rows show significant differences at a 5 % significant level.

The age-specific cohort life tables resulted in 95% accumulated mortality (dx) where 100 eggs were kept at T35 and high mortality was observed in the egg (42) and 1st instar larval (36) stages with qx values 0.42 and 0.62 respectively. Whereas survival rate was higher at T30 (61%). In addition, egg mortality was less compared to the T35 and the highest dx was in the 1st instar larval stage (32). Similarly, the qx values are very low in egg (0.08), 5th (0.01), 6th (0.03) and pupal (0.06) stages. Comparatively, a middle level of survivorship (36%) was observed with less mortality at T25 than T35.

There were only 4 adults emerged and most of the larvae was died at T35 compared to the other two temperature conditions. In T30 pre-oviposition period lasted from the 28-30 days of pivotal age while the 31- 33 days on T25. At T30 first batch of eggs was laid by females on the 31st day with mx of 160.27 and lasted until the 38th day (mx=11), with lx values of 0.28 and 0.03 respectively. After the 32 days of pivotal age, the first female mortality was observed on the 4 days after emergence of adult and mortality increased, as evidenced by the steady decrease in the lx values. It had lx value of 0.24 on the 32 days of pivotal age. The maximum mean progeny production/day (mx = 168.57) was reported on the 38th day (mx=11). As in T25 pre oviposition and oviposition, periods took comparatively longer while the first batch of eggs was laid by females on the 34th day. They had mx of 258.86 and lasted until the 42nd day (mx = 09), with

lx values of 0.17 and 0.03 respectively. Moreover, the average period of generation time (Tc) was less in T30 compared to T25. However, the daily finite rate of increase in number (λ) and a population doubling time at T30 is higher than days in T25. Similarly, the intrinsic rate of natural increase in number (rm) was higher in T30 than in T25. Finally, the hypothetical female population in the F2 generation was found to be higher in T30 than T25. Similar observations were reported earlier by Ashok et al., (2020) by evaluating adult longevity, oviposition period, fecundity and fertility using 30 pairs of FAW.

4. Conclusions

The duration of each stage at different temperatures was significantly different except for egg-hatching. Accumulated mortality of adults was 95%, 61% and 64% at T35, T30 and T25 respectively. These rates were comparatively high due to maintaining the constant temperature conditions. The optimal thermal range of FAW lays between 25 to 30°C and it is indicating that towards the lower temperature as well as above the 30°C their reproduction, survival rate and life cycle duration vary and difficult to survive. However, the pest status and survival may vary from this finding due to temperature fluctuations and affecting other climatic factors.

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Effect of organic amendment on the yield of Radish (*Raphanus sativus*) to ensure food safety

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1. Introduction

Radish (*Raphanus sativas)* is a popular edible root vegetable of family *Brassicaceae*. Unlike other vegetables, entire radish plant is edible. The most demanded part is tuber, leaves can be consumed after cooking or in fresh salad mix (Shirani & Seran, 2009). Farmers tend to practice intensive agriculture in vegetable cultivation which leads to lose nutrients from soil in large quantities. Therefore, inorganic fertilizers are used as a quick alternative to increase soil nutrient levels. However, many researchers have proved that inorganic fertilizer may have negative impacts on soil properties, ground water and ecosystem when presenting in excess quantities (Afriyie & Amoabeng, 2017; Camargo & Alonso, 2006) and accumulation of heavy metal (Singh & Agrawal, 2018).

Therefore, introducing alternative methods for enhancing soil fertility is very important to ensure crop productivity and food security, while securing ecological sustainability. Compost, bio char, fish emulsion, fish meal powder, seaweed extract and livestock manure are some of commonly used organic manure to improve soil fertility (Tarabily et al., 2003). Radish is a short term vegetable, when soil enrich mainly with nitrogen (N), phosphorus (P), and potassium (K), fertilizers influence the growth and yield of crops regardless the type of fertilizer; organic or inorganic (Imthiya & Seran, 2014). However, due to cost and ecological damage made by inorganic fertilizer, farmers are encouraged to reduce use of inorganic fertilizer. With the broad involvement of scientist, a range of improved organic fertilizers were discovered. Present study focused on identifying an alternative improved organic fertilizer mix to replace inorganic NPK fertilizer recommendation and optimize radish yield.

2. Materials and Methods

Radish seeds were purchased and all fertilizer formulas were prepared according to the Department of Agriculture (DOA) guidelines.

a) Statistical Analysis: Experiment was setup as Completely Randomized Design with 5 treatments and 4 replicates. Top soil obtained from virgin land.

Table 01. Treatment plan.

Treatment number	Type of fertilizer mix
T1	Inorganic fertilizer
T2	Ordinary compost fertilizer
T3	Fish tonic liquid fertilizer
T4	Compost tea liquid fertilizer
Control	Top soil

Soil characteristics; pH -5.87, EC -1.052 dS/m, Texture - sandy clay loam.

Fertilizer mixes were prepared as follows;

a) Chemical fertilizer (T1) was applied according to DOA recommendation. Two application basal dressing and top dressing.
b) Certified ordinary compost (T2) was purchased from a local supplier and applied 1.5kg per each pot in T2. Compost was applied twice.
c) Fish tonic liquid fertilizer (T3); 1kg of jaggery (caramelized sugar cane juice) was mixed with 1L of water and added to 3kg of fish waste, and stored under anaerobic condition. 7 days after, 1kg of Jaggery and 6L of water mixed and added to the previous mixture and continue fermentation till 14 days. 1:200 proportion of non-chlorinated water was added. 10ml of solution was sprayed on each plant twice in 2 week intervals.
d) Compost tea fertilizer (T4); 1kg of jaggery was dissolved in 60L of non-chlorinated water and added 12kg of compost, the mixture was stirred well and stored while aerating for 7 days to enhance aerobic microbes. Then diluted proportionately (1:3) with water before applying. 10ml of final solution was sprayed on each plant in T4. Compost tea was applied twice.
e) Top soil was obtained virgin land with no contamination of agro-chemical for control

3. Results and Discussion

Plant height: Was measured from ground level to highest point of the tallest leaf. According to Figure 1. T1 (NPK), T2 (Compost), T3 (Fish tonic), T4 (Compost tea) treated plants were observed. Treatment T3 and T4 were demonstrated better performance. The lowest leaf height was recorded in control.

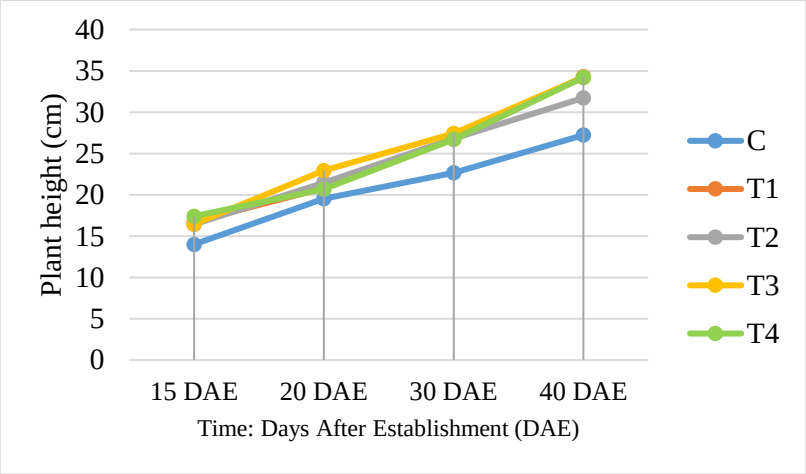

Figure 1. Average plant height of radish in all treatment up to 40 days.

Total number of leaves: Plants in T2, T3 and T4 were recorded same average number of leaves per plant until 20 days. However, T3 was recorded the highest number of plant at harvest. Control was recorded lowest leaves number throughout the vegetative period as shown in Figure 2.

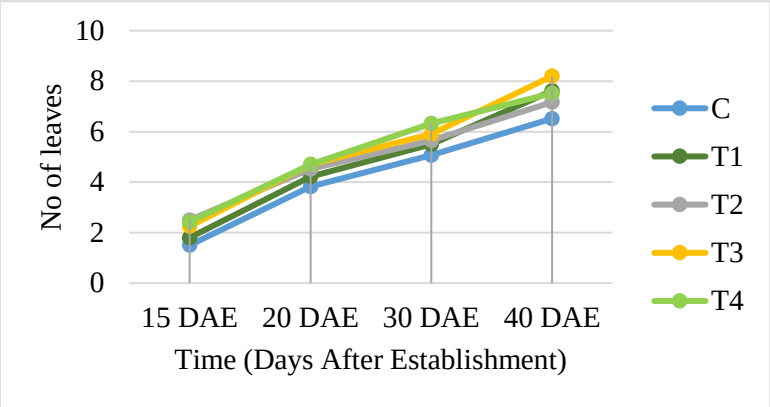

Figure 2. Average number of leaves up to 40 days.

Mean total yield of radish: At harvest (45 days after planting), Total yield weight of radish was measured and the data were analyzed. According to the result in Figure 3, the highest mean yield was shown by T4, T3 and T1 have demonstrated second and third best performance respectively in total mean yield. The least performance was given by the control experiment.

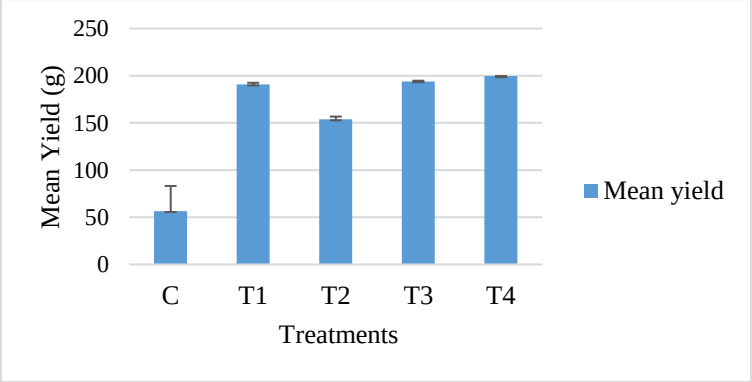

Figure 3. Mean total yield difference among treatments.

Wet & dry weight of tuber: After the harvest, randomly 3 plants were selected form each treatment to measure wet and dry weight of tuber. T3 and T4 treatments were not significantly different in wet and dry mean tuber weight. T1 treatment, in wet and dry mean weight of tubers was significantly different against the T3 and T4. T2 treatment was significantly different from all other treatments in wet and dry mean weight of tubers. Control has depicted significantly poor result as shown in Table 2.

Table 02. Wet and dry mean weight (g) of radish tuber at 45 days.

Treatment	Wet weight (g)	Dry weight (g)
C	51.89 ± 6.62 ^{c}	7.95 ± 1.63 ^{c}
T_2	87.55 ± 8.09 ^{a,b}	17.76 ± 1.68^{a,b}
T_1	107.74±6.70 ^{b}	23.10 ± 2.90 ^{b}
T_3	121.77 ± 6.89 ^{a}	24.59 ± 1.82 ^{a}
T_4	124.90 ± 13.07 ^{a}	26.57 ± 1.39 ^{a}

(Note: Mean with the same letter are not significantly different (P = 0.05)

Wet & dry weight of radish leaves: According to the analysis given in Table 3, wet weight of T1 and T2, leaves were not significantly different. However, a significant difference was shown by the T4 than the T1 and T2 treatments, T4 has demonstrated the highest mean value in wet

and dry mean weight of leaves. T3 was significantly different from the T1, T2, T4 treatments. The lowest value was shown in control experiment.

Table 03. Wet and dry mean weight (g) of radish leaves at 45 days.

Treatment	Wet weight (g)	Dry weight (g)
C	51.04 ± 3.55 ^{c}	3.09 ± 0.04 ^{c}
T_1	62.67 ± 1.85^{b}	8.44 ± 0.29^{a,b}
T_2	63.65 ± 5.49 ^{b}	7.50 ± 1.31 ^{b}
T_3	68.21 ± 1.39 ^{a,b}	10.43 ± 0.38 ^{a}
T_4	76.85 ± 3.99 ^{a}	9.26 ± 0.52 ^{a,b}

(Note: Mean with the same letter are not significantly different (P = 0.05)

4. Conclusions

The overall highest average of vegetative growth such as total number of leaves, plant height, were recorded in radish experiment with fish tonic treatment (T3). Radish plant treated with NPK inorganic, fish tonic and compost tea fertilizer showed significantly higher plant fresh weight. Fish tonic liquid fertilizer and compost tea treated plants have depicted significantly higher fresh and dry weight of tuber. Compost tea treated plants gave significantly higher fresh weight of leaves. Evident from the result confirmed that radish can be cultivated with locally prepared organic fertilizer mixes without economic losses. NPK demands of plants were satisfactorily met by Fish tonic and Compost tea.

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Effect of BAP and hypocotyl explants of tomato (*Lycopersicon esculentum* Mill.) var. KC1 for *in vitro* plant regeneration

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1. Introduction

Tomato is considered an important vegetable crop that belongs to the family Solanaceae. The tomato contains vitamins, minerals, fibre, protein, carotenoids, polyphenols, amino acids, fatty acids etc. (Chaudhary et al., 2018). It is highly popularized due to its anticancer and antioxidant characteristic (Khuong et al., 2013). Also, it is consumed as fresh fruit and processed in multiple forms such as salads, cooked vegetables, sauce, and pickle (Lenucci et al., 2006). Several kinds of explants have been used specifically in tomatoes to regenerate plants (Raziuddin et al., 2004). The types and positions of explants and also plant growth regulators used in the culture medium mainly affect the success of *in vitro* response of tomato (Yildiz, 2012). The different concentrations of plant growth regulators and various sources of explants have been used for the plant regeneration of tomatoes. Several studies show that the hypocotyl explant is an effective explant source for the induction of callus for plant regeneration (Setiaji, 2020). Park et al. (2003) reported that MS medium with 1.0 mg/l BAP and 0.1 mg/l NAA enhanced callus formation and shoot regeneration in tomatoes. Further, MS medium with BAP and NAA gave the best responses in terms of callus induction for hypocotyl explants of tomato cultivars (Chandel & Katiyar, 2000). Accordingly, there is a need to find optimum concentrations of plant growth regulators and position of explants for the shoot and root induction from hypocotyl explants of tomato. Therefore, this study was done to select the suitable concentration of BAP for *in vitro* response of hypocotyl explants and to evaluate the effect of different positions of hypocotyl explants of tomato variety KC1 for the plant regeneration process.

2. Materials and Methods

This experiment was conducted to study the effects of BAP on *in vitro* regeneration of tomato plants from hypocotyls explants at the Tissue Culture Laboratory, the Eastern University of Sri Lanka in 2017. The experiment was laid out in complete randomized design (CRD). Mature seeds of tomato cv. KC-1 was obtained from the Horticultural Crops Research and Development Institute, Department of Agriculture, Gannoruwa, Sri Lanka and used as a source of explants in this experiment. Surface sterilization of tomato seeds was done by spraying with 70% ethanol for 3 min followed by 5.23% sodium hypochlorite (Clorox^{TM}) at 20% (v/v) treatment with two drops of Tween-20 for 20 min. The seeds were then washed with sterilized distilled water four times until washed out the detergent. Seeds were then kept in a sterilized Whatman No. 1 paper for germination. *In vitro* 12 days old seedlings were used to excise the hypocotyl explants for the regeneration process. In the present study, Murashige and Skoog (MS) basal medium (1962) along with various concentrations of different growth hormones were used. A quantity of 30 g/l of sucrose and 0.8% w/v agar was added to the medium. The pH of the medium was adjusted to 5.8. Media containing culture vessels were then autoclaved at 15 psi at 121º C temperature for 20 min.

Hypocotyl explants (1.0 cm long) were collected from 12 days old *in vitro* grown seedlings and surface sterilized. Then they were inoculated onto MS medium containing 0, 0.5, 1.0 and 1.5 mg/l BAP with 0.2 mg/l NAA. Subsequently, hypocotyl explants were excised in three different positions, such as top portion (near to cotyledonary node), middle portion and bottom portion (near to root base) from *in vitro* germinated seeds under aseptic conditions and inoculated onto

MS medium containing 1.5 mg/l BAP with 0.2 mg/l NAA. The culture vessels containing explants were incubated at 25±0.5ºC under white fluorescent light. A photoperiod of 16 hours light with the intensity of 2000 lux and 70% humidity was maintained. The observation was made at regular intervals and this experiment was laid out in complete randomized design and repeated. The collected data were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of Statistical Analysis Software (SAS). The mean comparisons between treatments were done by using Tukey's (HSD) test at 5% significant level.

3. Results and Discussion

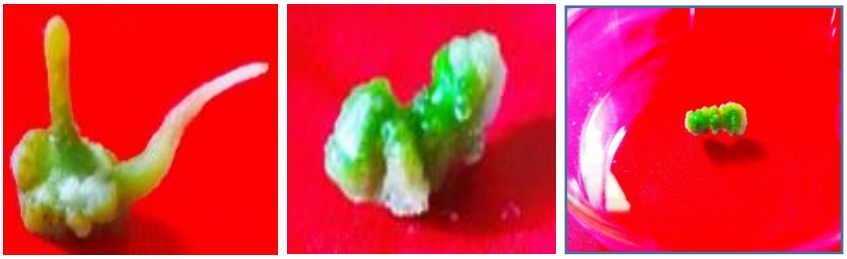
Results showed significant influence (P<0.01) on callus induction at the 4th week of culture (Table 01) and higher callus induction % was obtained in 1.5 mg/l BAP with 0.2 mg/l NAA medium. The least callus induction % was remarkably (P<0.05) obtained from the control treatment among the treatments. There was no any significant variation in callus induction % (P<0.05) between 1.0 mg/l BAP and 1.5 mg/l BAP in combination with 0.2 mg/l NAA. The different concentrations of BAP with 0.2 mg/l NAA in the culture media significantly influenced (P<0.05) the shoot bud formation percentage at the 8th week of culture (Table 01). Higher shoot bud formation was recorded in 1.5 mg/l BAP + 0.2 mg/l NAA medium than the other media. These findings are confirmed by Sarker (2013) reporting that the highest number of shoots in Tomato was noted from MS medium containing 2.0 mg/l BAP. Osman et al. (2010) reported the highest callus formation on hypocotyl explants from MS medium supplemented with 0.5 mg/l BAP and 0.1 mg/l NAA.

Table 01. Callus induction % and shoot bud formation % of hypocotyl explants cultured on MS medium with BAP and 0.2 mg/l NAA

BAP with 0.2 NAA (mg/l)	Callus induction % at 4th week	Shoot bud formation % at 8th week
0	33.3±2.0c	0.0±0.0 c
0.5	60.0±4.6b	0.0±0.0 c
1.0	80.0±2.0ab	61.3±0.6 b
1.5	93.3±1.2a	75.0±2.9 a
F test	P<0.01	P<0.05

Data are based on the availability of surviving explants cultured in the medium. Values represent the means ± standard error of the replicates. Means followed by the same letter in each column are not significantly different according to Tukey's HSD Test at a 5% significant level.

Higher root formation of 60% was noted in 0.5 mg/l BAP + 0.2 mg/l NAA medium. Further, there was no shoot bud formation on the control medium and also medium supplemented with 0.5 mg/l BAP + 0.2 mg/l NAA. Rooting is the final step of the regeneration protocol in plant tissue cultures. However, in most cases, root formation would be achieved with auxins alone with concentrations ranging from 0.1 to 1.0 mg/l (Sherkar & Chavan, 2014).



a b c

Figure 1. Callus formation in MS media containing a) 0.5 mg/l BAP and b) 1.0 mg/l BAP and c) 1.5 mg/l BAP with NAA at 3rd week

Further, different positions of hypocotyls as explants cultured in MS medium containing 1.5 mg/l BAP and 0.2 mg/l NAA also showed diverse morphogenic responses. After four weeks of culture, micro shoots were formed directly in some cultured top positions of hypocotyls on the edge of the hypocotyls while the bottom positions of hypocotyls exhibited green calli on the surface of the cultured explants. Compacted callus formed from the top portion of the hypocotyl explants near to cotyledonary node and callus colour was ranged greenish-yellow colour to green colour (Figure 2a). Further, shooty friable callus was observed from the middle portion of the cultured hypocotyl explants (Figure 2b). The bottom portion of hypocotyl explants showed thick and yellowish-white compact callus formation. Yildiz (2012) reported that shoot-regeneration efficiency is rapid in the upper part of hypocotyl explants.

a b

Figure 2. Induction of shoot regeneration from the top (a) and middle (b) hypocotyl explants after 2-3 weeks of culture

4. Conclusions

The results showed that higher callus induction % was obtained from the hypocotyl explants cultured in MS medium with 1.5 mg/l BAP and 0.2 mg/l NAA at the 4th week of culture. Similarly, higher shoot bud formation was recorded in 1.5 mg/l BAP + 0.2 mg/l NAA incorporated medium at the 8th week of culture. And also, it was concluded the top position explants of hypocotyls tend to produce direct shoots from the cultured explants whereas the bottom portion of hypocotyl explants formed compact callus.

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Assessment of seed characteristics of progenies in tea (*Camellia sinensis* L.) seed gardens: towards facilitating effective utilization of tea seeds and the productivity enhancement of the gardens

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1. Introduction

Tea seeds were used as the only source of planting material at the beginning of the tea industry and later replaced by the improved vegetatively propagated (VP) cultivars. However, as an alternative planting material to combat effects of global climate change, there is reviewed interest among growers for seeds. With the expansion of the tea industry, the natural vegetation of tea has been undergoing significant alteration in the recent years and as a result, key seed characteristics such as storage, germination etc. have gained increasing attention (Song et al., 2018).

In Sri Lanka improved seed progenies developed in isolated tea seed gardens are in the eve of recommendation as an adaptation measure to climate change. Reproductive phenology and breeding system studies in seed gardens have been conducted simultaneously (Piyasundara et al., 2018) to plan and implement productivity enhancement programmes of seed gardens in order to ensure availability of adequate materials before making the recommendations.

Some basic studies on effect of storage on germination have been conducted and information are available. However, information on seed germination of progenies developed from different parental cultivars in seed gardens are not available. This information is immensely useful in utilizing these progenies in commercial planting. Therefore, the present study conducted to assess the variations in key seed characteristics: seed weight, time taken to 50% germination and germination percentage of seed progenies derived from parental cultivars of selected tea seed gardens. Aiming to utilize the information for effective utilization of seeds and productivity enhancement programmes to fulfil the increasing demand of the growers.

2. Materials and Methods

Study was conducted in a representative sample of three isolated tea seed gardens: One Bi-clonal Garden at Reucastle Estate, Dehiowita and two Poly-clonal Gardens at Salawa Estate, Hanwella and Rambukkanda Estate, Ratnapura. The Gardens were selected based on adequate representation of parental cultivars and the performances of seed progenies found in adaptive trials conducted previously (Piyasundara et al., 2012). Study was carried out during April to August 2018, the peak fruiting season of the year.

Two hundred mature fruits were collected from each parental cultivar at each location: 40 fruits each from five randomly selected healthy trees.

Pericarps were removed and seed weight of cleaned seeds were recorded at the laboratory. Seeds were soaked overnight for floater-sinker assessment. Then seeds were propagated in standard clean sand bed in RCBD (Randomized Complete Block Design) in four replicates comprising 50 seeds each.

Observations were made in regular intervals till germination commenced, germination was defined as when radical pierced the seed coat. Observations continued up to 8 weeks.

Germination percentage was calculated as described by Yang et al., 1999.

$$\text{Germination percentage} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \text{ X } 100$$

Number of days taken to reach 50% germination of each progeny also recorded.
The data subjected to two factor factorial analysis and mean comparison based on Duncan's test using SAS.

3. Results and Discussion

Factorial analysis of the data reveled there was no significant interaction with the location (garden) in both seed weight and germination percentage of the progenies. In the cultivars which are present in more than one location (TRI 2027, TRI 3055, KEN 16/3 and S 106). Therefore, mean comparison of both seed weights and germination percentage was carried out of 13 seed progenies of 9 parental cultivars of the 3 locations. TRI 3047 present in Both Salawa and Rambukkanda did not produce seeds at all.

The results revealed that significant variations in seed weights (Table 1) among the progenies of different parental cultivars.

Table 01. Mean seed weight and number of seeds per kilograms of 13 seed progenies

Seed Progeny	Mean seed weight (g) N=200	No. of seeds per kilogram*
Rambukkanda - TRI 2025	$2.99^{a} \pm 0.04$	334
Rucastle -TRI 3063	$2.81^{b} \pm 0.05$	356
Rambukkanda - TRI 2022	$2.80^{b} \pm 0.05$	357
Salawa - TRI 2016	$2.55^{c} \pm 0.05$	392
Rambukkanda -KP 204	$2.52^{cd} \pm 0.05$	397
Rambukkanda - TRI 3055	$2.40^{de} \pm 0.05$	417
Salawa -TRI 3055	$2.38^{e} \pm 0.05$	420
Reucastle -S 106	$2.32^{ef} \pm 0.05$	431
Salawa -S 106	$2.29^{ef} \pm 0.05$	437
Rambukkanda - TRI 2027	$2.25^{gf} \pm 0.04$	445
Salawa - TRI 2027	$2.21^{gf} \pm 0.04$	453
Rambukkanda - KEN 16/3	$2.21^{gf} \pm 0.04$	453
Salawa - KEN 16/3	$2.14^{g} \pm 0.04$	467
CV	26.71	

* calculated based on mean seed weight / ± standard error

Progenies derived from three cultivars: TRI 2025, TRI 2022 and TRI 3063, exhibited comparatively higher mean seed weights and progenies of four cultivars TRI 2016, KP 204, TRI 3055 and S 106 with medium seed weights. Progenies of TRI 2027 and KEN 16/3 recorded the lower seed weights. Table 1 further compares number of seeds per kilograms of seeds in each progeny.

Seed germination commenced 21 days after sowing and notable deviations observed in the time taken to reach 50% germination among the progenies (Figure 1). Progenies of cultivars KEN 16/3, S 106 and TRI 2016 reached 50% germination in comparatively shorter time period.

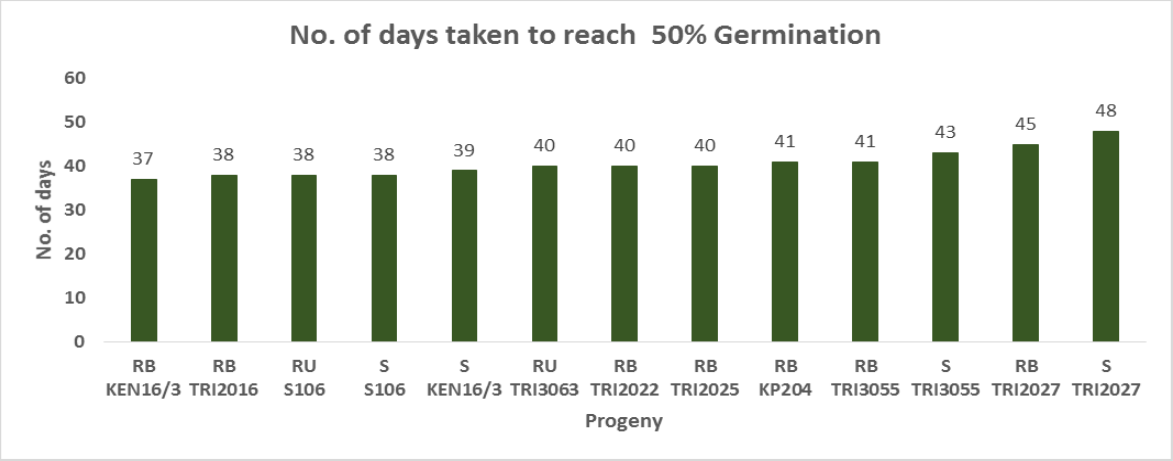

Figure 1. No. of days taken to reach 50% germination

Significant variations were recorded in mean seed germination percentage (Figure 2) among the 13 progenies.

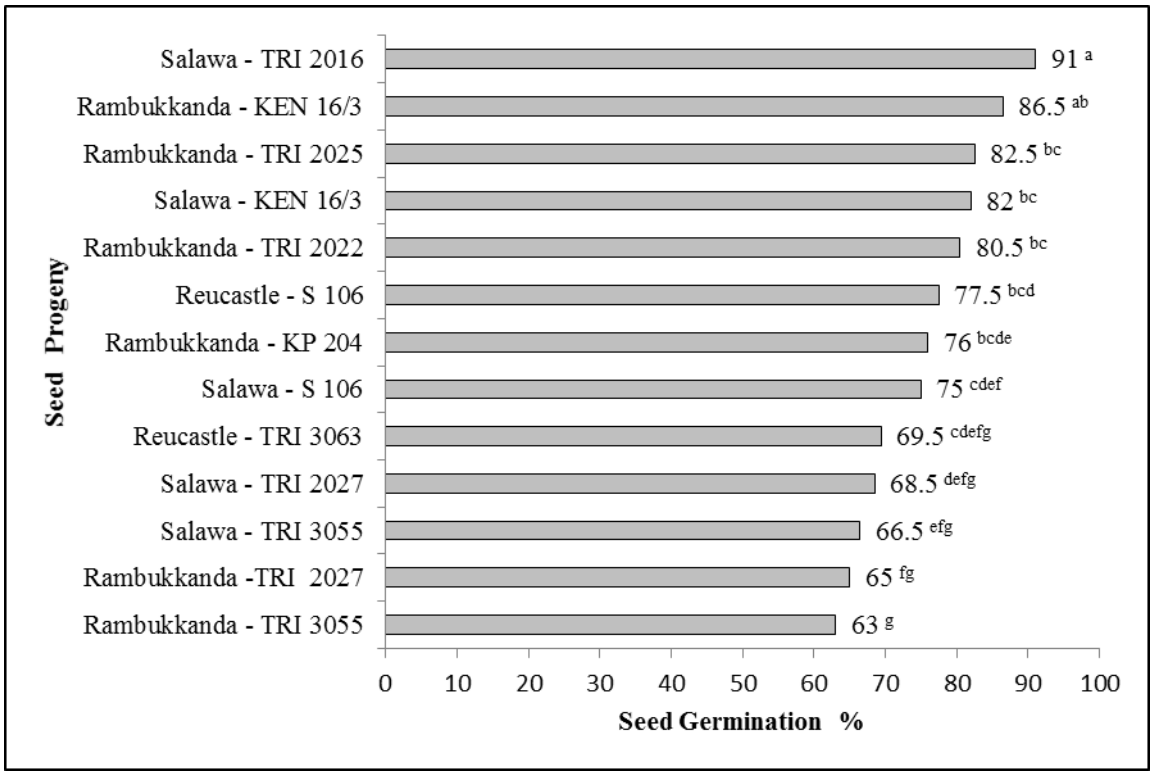

Figure 2. Mean seed germination percentages of the thirteen seeds progenies (Means with the same letter/s are not significantly different)

The highest mean germination percentage was exhibited in the progeny of Salawa TRI 2016. Out of the 13 progenies 8 (of 6 parental cultivars) recorded comparatively higher (over 75%) germination. In the meantime, 5 progenies (of 3 parental cultivars), recorded comparatively moderate (63 – 69.5%) germinations.

Both seed weight and germination collectively indicates productivity of each seed progeny. The parental cultivars with comparatively higher seed weights as well as ones with comparatively lower seed weights have exhibited higher germination parentages suggesting that there is no direct relationship between seed weight and germination percentage. However, should be studied further before coming to a final conclusion.

Findings of the present study is summarized (Table 2) along with findings of previous study on Reproductive phenology (Piyasundara et al, 2018) to utilize the information to facilitate seed collection & handling and as well as to select suitable parental cultivars for future gardens.

Table 02. Summary of the seed characteristics and fruit setting potential of the nine parental cultivars of the 3 gardens

Parental cultivar	Germination %	Number of seeds per 1 kg	Fruit setting potential*
TRI 2016	High	Medium	High
TRI 2022	High	Low	High
TRI 2025	High	Low	High
TRI 2027	Moderate	High	Moderate
TRI 3055	Moderate	Medium	Moderate
TRI 3063	Moderate	Low	Moderate
KEN 16/3	High	High	High
KP 204	High	Medium	Moderate
S 106	High	Medium	High

* Piyasundara et al., 2018

4. Conclusions

Seed weight and germination percentage is cultivar specific other than the location. Seeds collected from cultivars KEN 16/3, TRI 2016, S 106 and KP 204 characterized with comparatively low to medium seed weight and high germination percentage are more effective and economical for commercial planting. Seeds collected from cultivars TRI 2022 and TRI 2025 characterized with comparatively high, seed weight and germination percentage is the next option. Information generated useful in rational selection of parental combinations for future gardens aiming to fulfil the increasing demand for tea seeds among the growers.

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Chemical composition, antioxidant activity and sensory evaluation of six accessions of wood apple (*Feronia limonia*) growing in Sri Lanka

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1. Introduction

Wood apple (*Feronia limonia* L.) (Syn. *Feronia elephantum, Limonia acidissima*,) belongs to family Rutaceae. It is known as Diwul or Jool in Sri Lanka. Elephant apple, Monkey fruit and Curd fruit are the names used by some countries of Southeast Asia. (Singhania & Ray, 2019).

Wood apple tree is a moderate size plant which is grown in all dry zone and some parts of intermediate zone in Sri Lanka. The tree which reach to height of about 10m and girth is about 0.6 to 1.6m (Troup, 1921). Physiologically fully matured fruit contains 55.67% of outer shell, 31.55% of pulp and the rest 12.22% is fiber and seed.

Wood apple has higher medicinal value. Fruit is used as a liver tonic and to treat certain cardiac problem. Wood apple has higher antioxidant ability and it is used for diabetic patients due to its effect on pancreas to secretion of insulin (Yadav et al., 2018)

This fruit contains protein, fat, fiber, carbohydrate, ash, calcium, phosphorus, iron, Vitamin C, Thiamin, Niacin and other mineral compounds. Gopalan *et al*., (1984) and Morton (1987).

Chemical compositions, anti-oxidant activity and sensory evaluation are significant parameters to introduce new varieties. These characters will be considered when selection of fruit according to status of industry. Therefore objectives of this study was

- to identify the best variety with maximum nutritional value.
- to find out the level of deferent nutrient in selected wood apple varieties.
- to find out the best varieties which provide maximum favor of the consumer.

2. Materials and Methods

The experiment on chemical composition, antioxidant activity and sensory evaluation of wood apple fruit was conducted in the laboratory of Faculty of Agricultural sciences, Sabaragamuwa University of Sri Lanka.

Wood apple accessions were collected from ex-situ field gene bank of wood apple placed in the Grain Legumes and Oil crop Research and Development Centre (GLORDC), Angunukolapellessa. Six accessions of wood apple were selected such as Acc63, Acc53, Acc52, Acc35, Acc17 and Acc16.

Fallen matured fruits were kept about 5 days to become fully matured stage. After that crack open the wood apple fruit, scooped out the pulp manually. The pulp without debris sealed in the labeled polythene bags and stored in refrigerator at minus eighty Celsius (-80 $^{\circ}$C) until used.

Wood apple fruit extract was prepared with Methanol (Analytical regent (99.9)). Dried extracts were measured by analytical balance with transferring extract into the epandoff tubes (1.5 mL). After labeling, Epandoff transferred in to refrigerator at minus eighty (-80 $^{\circ}$C).

Evaluation of chemical parameters

Determination of moisture content, titratable acidity, ash, protein content, fat content and crude fiber of wood apple were done by following the method specified in Association of Official Analytical Chemist (AOAC, 2000). Ascorbic acid was determined by using titration method (Ranganna, 1986). Phosphorus content of wood apple was determined by dry ashing method (Wekumbura *et al*., 2010). Determination of total phenolic content of crude extract was done using Folin-Ciocalteu method (Singleton *et al*., 1999). Total flavonoid content was determined by aluminium chloride method (Siddhuraju and Becker, 2003).

Free radical scavenging activity was determined using 2, 2-azinobis-3-ethylbenzothiozoline-6-sulfonic acid ($ABTS^{+)}$ radicals. Sensory evaluation was conducted in the laboratory of faculty of Agricultural Sciences Sabaragamuwa University of Sri Lanka.

Data analysis was carried out by Statistical Analysis System software (SAS). The mean comparison was done by using Duncan's Multiple Range Test (DnMRT). Friedman test was conducted to analysis sensory evaluation and data was analyzed by using Statistical Package for the Social Sciences (SPSS) software.

3. Results and Discussion

Table 01. Values of chemical parameters of six accessions

Sample No.	Average moisture	% of Acidity	Average Ash	Average fat	Average Fiber	Average Protien	Average Vit C	Average P %
Acc63	80.590	3.91	5.000	0.283	4.800	0.1868	0.3638	1.537
Acc53	76.840	4.57	8.700	0.200	5.400	0.2057	0.2078	1.018
Acc52	77.490	4.06	7.200	0.500	6.500	0.2247	0.1964	1.768
Acc35	76.020	3.56	8.300	0.167	6.600	0.1211	0.3701	1.482
Acc17	80.770	3.25	4.700	0.383	6.500	0.1620	0.2484	1.763
Acc16	78.180	3.85	5.300	0.467	7.300	0.1868	0.3638	1.898

Accession number (Acc) 17 (80.766 ±0.30) was reported the highest value of moisture content. Ko and Naing, (2014) reported that moisture content as 78.62%. It was a higher value when considering the previous studies. Acc53 was the accession which recorded highest value of titratable acidity (4.570±0.11) and it was significantly different from other accessions. The highest value of ash content by Acc53 (8.675±0.03) and it was significantly different from others. Maximum fat value was showed by Acc52 (0.50 ± 0.04). According to the Figure 4.7, Acc16 (7.3 ±0.14) was the prominent accession which showed highest fiber content among accession. Highest protein content was recorded by Acc52 (0.2247±0) which significantly different from the other accessions. The data were not significant among accessions. Highest vitamin C value was recorded by Acc35 (0.370 ±0.11). Highest phosphorus content was recorded by Acc16 (1.898 ±0).

Values of Antioxidant activities

Total phenolic content of six accessions were significantly different ($P<0.005$). According to the results highest value of total phenolic content was recorded by Acc52 (0.0024 ±0.0002). According to results, highest TFC value was recorded by Acc53 (0.1606 ±0.008) and it was significantly different from other accessions. IC_{50} value was significantly different ($P<0.05$) among accessions of wood apple. Highest IC_{50} value was recorded by Acc52 (6.4593 ±0.08) and which significantly different from other accessions.

Sensory evaluation

Highest value of Appearance was recorded by Acc53 (4.67) and it was significantly different from other accessions except Acc52 (4.17). Highest Juiciness value was recorded by Acc63 (4.5) and it was significantly different from Acc16 (1.6) and Acc17 (2.83). The highest value of Flavor was recorded by Acc53 (5) and significantly different from other accessions. Highest overall acceptability was recorded by Acc53 (4.90) and which significantly different from other accessions except Acc35 (3.63).

4. Conclusions

According to the results, higher Titratable acidity and Ash content were showed by Accession 53, higher Fat and protein by Accession 52, higher fiber and Phosphorus content showed by Accession 16. Higher value of moisture content was showed by Accession 17, higher Vitamin C content by Accession 35. When consider about Antioxidant activity, Total Phenolic content was maximum in Accession 52 and maximum Flavonoid content showed by Accession 53. Lowest $ABTS^{+}$ radical scavenging activity was recorded by Acc63.

When considering these results, Acc53 was expressed higher performance. Acc52 and Acc63 also can be introduced as better accessions.

According to the results of sensory evaluation, Acc53 was the accession which provide better consumer satisfaction.

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Predatory potential of Coccinelid beetle spp. on *Deltocephalus menoni*; vector of sugarcane white leaf disease

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1. Introduction

Sugar is one of the major food commodities in Sri Lanka, and it has become an important sub-sector in the economy of the country. Currently, Sugar production is reduced due to several kinds of problems (Keerthipala, 2016). Among them, Sugarcane White Leaf Disease (WLD) is a highly contributing factor for the drastic reduction of production and hence, WLD is one of the major threats to the cane sugar industry in the country. *Deltocephalus menoni* (Hemiptera: Cicadellidae, Deltocephalinae) is the only locally identified vector of this phytoplasma disease.

Therefore, the management of WLD vector has been identified as a strategic and integrated approach to prevent the rapid spread of this disease in sugarcane plantations. Natural enemies are reported as one of the most effective management strategies to manage the WLD vector. Typically, Hemipterans are attacked by a range of predators and parasitoids. Hence, those predatory and parasitic insects play a vital role in agriculture ecosystems as a sustainable hemipteran pest control strategy.

Coccinellid beetle spp available in the sugarcane ecosystem are common predators of the sugarcane pest and they are recorded to be predating on *D. menoni* too. The objective of the study is the identification of the predatory potential of the naturally available Coccinellid beetle *spp* in the sugarcane ecosystem on *D. menoni* to incorporate them into vector management program.

Specific objectives of the study will be the identification of the,

I. Naturally available Coccinellid beetle *spp* in sugarcane ecosystem
II. The predatory potential of the collected Coccinellid beetle *spp* on *D .menoni*
III. Identifying the potential Coccinellid beetle *spp* to incorporate into the vector management program

2. Materials and Methods

I. Identification of the naturally available Coccinelid beetle *spp* in sugarcane ecosystem

The coccinellids beetles were collected from UdaWalawa, Sevanagala, Pelwatta, Siyambalanduwa, Passara, Higurana, Kanthalai areas using sweep nets, glass vials, and aspirators.

The collected Coccinelid beetles were knocked down and dried in an oven for 5-6 hours under 45°C temperature and stored. Different *spp* were separated based on morphological features. Identification was done using available literature.

II. Identification of the Predatory potential of the collected Coccinelid beetle *spp* on *D. menoni*

Insect cultures of all collected Coccinelid beetle species and were maintained separately. *D. menoni* adults and nymphs were provided separately to larvae and adults of each Coccinelid beetle species. The number of *D. menoni* nymphs or adults predated by Coccinelid beetle species within 24 hour period were recorded separately.

III. Identification of the potential Coccinelid beetle *spp* to incorporate into the vector management program

The predatory potential of each Coccinelid beetle *spp* were compared. Preference of selected *spp* for *D. menoni* over the other available insect *spp* in sugarcane ecosystem was studied.

Thiomethoxam (Actara) chemical treatments were used. Sugarcane leaves from four-month old plants were collected just after application to the plants as per the vector management recommendation. Survival of the Coccinelid beetle *spp* on them was studied to confirm the abundance and survival during the periods where *D. menoni* populations are lower.

3. Results and Discussion

1. Naturally available Coccinelid beetle *spp* in sugarcane ecosystem

Ten Coccinelid beetle spp belongs to 4 sub families and 5 tribes were recorded. Some species were recorded with several morphotypes. Variation within same species were observed due to fading of pattern in elytra with the age.

Coccinelid beetls species of *Coccinellinae* subfamily and *Coccinellini* tribe

1. ***Micraspis discolor***
2. ***Micraspis allardi***
3. ***Propylea dissecta***
4. ***Cheilomenes sexmaculata***
5. ***Coccinella transversalis***

Coccinelid beetls species of *Chilocorainae* subfamily and *Chilocoraini* tribe

1. ***Brumoides piae***
2. ***Brumoides suturalis***

Scymninae sub family

1. ***Scymnus nubilus***
2. ***Pseudaspidimerus trinotatus***

Sticholotidinae sub family and *Sticholotidini* tribe

1. ***Jauravia dorsalis***

a. Population density of naturally available Coccinellids beetles

Highest number of coccinellid beetle species were recorded from the Siyambalanduwa (S=7) and Sevanagala (S=6) Species dominance was high in Pelwatta (D=0.823) by recording 3 spp and *M. discolour* represent 90.5% of total population. Species dominance was lower in Siyambalanduwa (D=0.427) where 8 *spp* present. Shannon-Wiener's species diversity index (H') was highest (H'=1.182) in Siyambalanduwa.

b. Population dynamics of naturally available Coccinellid beetles

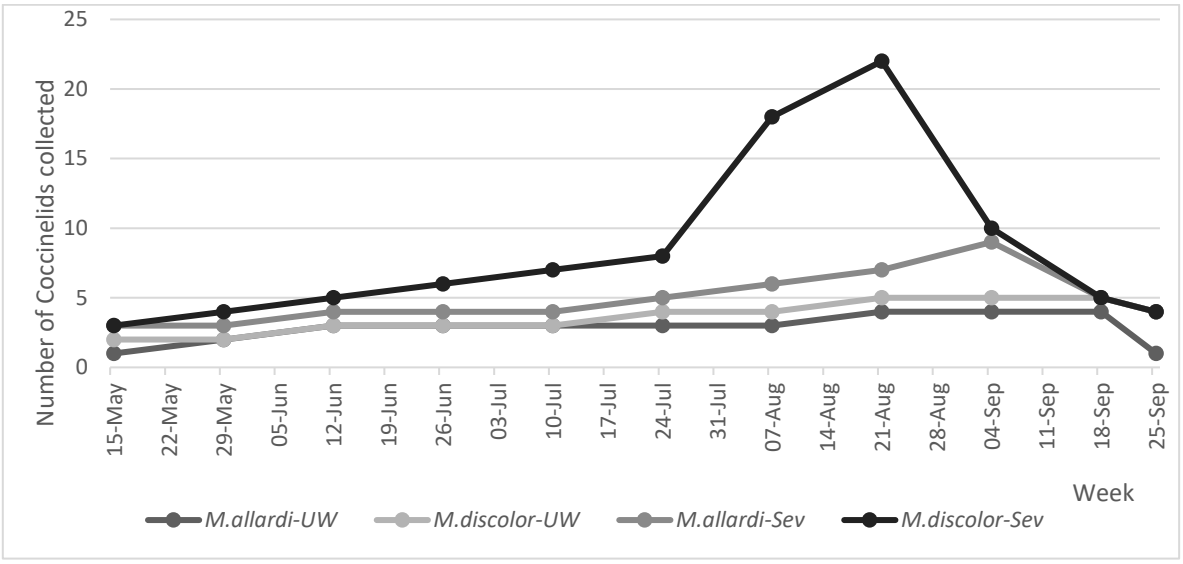

Figure 1. Population dynamics of naturally available Coccinellid beetles Uda Walawe and Sewanagala

II. Predatory potential of the collected Coccinellid beetle *spp* on *D. menoni*

From ten coccinellid beetle spp collected only six species fed on the *D. menoni.*

Feeding rate of the considered coccinellid beetle spp was significantly different ($F_{15, 29}$=12.9. P<0.05). Highest feeding rates were recorded in two morpho types of *Micarspis discolor* (MT1:0.36± 0.023, MT2: 0.32± 0.007) and *Micraspis allardi* (0.32± 0.025). Lowest feeding rates were recorded in *Propylea dissector* (0.28± 0.015) and *Pseudaspidimerus trinotatus* (0.16± 0.005).

III. Identifying the potential Coccinellid beetle *spp* to incorporate to vector management program

a. Feeding potential of M. discolour adult on deferent stages of WLD vector

Feeding rate of *M. discolour* on five (5) nymphal stages, eggs and adults was significantly different (ChiSq 102.77, Pr<.0001). Highest feeding rate of *M. discolour* was recorded in *D. menoni* eggs (6.00±0.258) and 1st instar nymphal of (1.56±0.151)

b. Feeding potential of M. discolour adult on deferent pest species in sugarcane eco-system

M. discolour was fed on Pyrilla eggs, Pink mealy bug and Sugarcane Wholly Aphid efficiently during the study period. Wanasinghe *et al.* (2014) recorded *M. discolour* as an efficient predator of SWA in the natural environment.

c. Potential of *M. discolour* adult to survive during pesticide spray (Thiomethoxam 5g/16l water)

Insecticide recommendation for *D. menoni*; Thiomethoxam 5g/16l water was having significant effect on *M. discolour* adults (ChiSq 21.54, Pr<.0001). But 20% of *M. discolour* adults were survived after 48hrs from the treatment and was capable to withstand the insecticide recommendation, which should be a good predatory insect to incorporate to an integrated vector management program with insecticide application.

4. Conclusions

Ten Coccinelid beetle *spp* belongs to four (4) sub families and 5 tribes were recorded. Highest abundance was recorded in Siyabalanduwa area and species dominance was high in passara. *Micarpis discolor* has the highest distribution and abundance over other spp. Six species were recorded as predatory spp over *D. menoni. M. discolor* was capable to feed efficiently over all life stages of *D. menoni*, specialy on eggs and first instrar nymps. *M. discolor* predate over other sugarcane pest *spp*. Twenty percent of *M. discolor* population was survived after heavy application of pesticide. Accordingly, *M. discolor* have potential to incorporate in an efficient vector management program

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Potential of *Chlorella* sp. grown in wastewater on the growth and yield of *Amaranthus* sp.

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1. Introduction

Global usage of chemical fertilizer has been increasing over the last three decades to meet the food demand due to the growing population. Consequently, this can lead to soil degradation (Shaaban et al., 2010). Organic fertilizer is a good alternative to inorganic fertilizers as it is an environmentally sound as well as economically viable option. Due to the present covid-19 situation, readily available organic fertilizers are limited. To counteract the current issues, biofertilizer has become the best alternative solution. Biofertilizer, a new tear that's being used widely nowadays to enrich the soil with microalgae, bacteria, and fungi that promote the growth and yield of crops (De Jesus Raposo & De Morais, 2011). Microalgae biomass is one of the sources of biofertilizer. *Chlorella* sp. can be cultivated for biofertilizer production, which provides a high amount of macro and micronutrients, metabolites like protein, carbohydrates, and constituents, and growth-promoting substances such as cytokinin (Dineshkumar et al., 2020).

In Sri Lanka, there is an increasing trend for consuming leafy vegetables to obtain nutrients, especially micronutrients. Dark leafy vegetables are preferred due to the rich sources of vitamins such as A and C; minerals calcium, iron, and phosphorous; antioxidants and phytochemicals. Amaranthus is one of them and is highly cultivated in Sri Lanka (Nadeeshani et al., 2018). As *Chlorella* sp. is an aquatic organism it demands water for its growth. However, wastewater could be used to supplement nutrients as well as to replace freshwater to grow *Chlorella* sp. The objective of this study was to assess the potential of *Chlorella* sp. grown in parboiled effluent on the growth and yield of *Amaranthus* sp.

2. Materials and Methods

Selected physical and chemical properties of soil and the nutrient analysis for both soil and the algae biomass were done to determine the treatment combinations. The microalgae were obtained from a previous study from the Department of Civil Engineering, Faculty of engineering which was grown in parboiled effluent.

Nutrient Analysis

Nutrient contents such as C, N, P, and K were analyzed to ensure enough nutrient availability. Kjeldahl was used to estimate the total nitrogen, Vanadomolybdate method was used to determine the phosphorus content of algae and ammonium molybdate- $SnCl_2$ method was used at the wavelength of 660 nm to determine the phosphorous content in the soil, the flame photometer was used to measure the potassium content and total organic carbon content was estimated by loss on ignition method.

Pot Experiment

The plant was grown in the poly house for two months from December to January. During the growth period, the plant growth parameters such as plant height, number of leaves, and leaf

area measurements were recorded. There were eleven treatments with three replicates under CRD (Complete Randomized Design) was practiced as follows: T1 - Control, T2 - *Chlorella* sp. 2g/kg, T3 - *Chlorella* sp. 4g/kg, T4 - *Chlorella* sp. foliar application 100% Live biomass, T5 - *Chlorella* sp. foliar application 0.2g Dry biomass/ Plant, T6 - cattle manure 20 ton/ha, T7 - 50% cattle manure + *Chlorella* sp. 1g/kg, T8 - 50% cattle manure + *Chlorella* sp. 2g/kg, T9 - 50% cattle manure + *Chlorella* sp. foliar application 50% Live biomass, T10 - 50% cattle manure + *Chlorella* sp. foliar application 0.1g Dry biomass/ Plant, T11 - 50% cattle manure.

Each pot was prepared by adding 1kg of soil with the nutrient content of nitrogen, phosphorous, and potassium respectively 20.3 ppm, 27.6 ppm, and 57.9 ppm and for treatments having cattle manure with the nutrient content of nitrogen, phosphorous, and potassium respectively 1.42 ppm, 0.31 ppm, and 1.21ppm, it was added two weeks before seed sowing for better incorporation of nutrients. Fifty seeds were added to each pot and thinning out was done after 10 days of germination. While sowing the seeds, they were mixed with algae dry biomass according to the treatment requirements. The fresh biomass was obtained to produce foliar spray by centrifugation at 5000 rpm for 15 minutes. The foliar spray was prepared and it was given in 4 days intervals for two weeks after thinning out. After a month the plants were harvested the yield weight and dry biomass weight was taken. Data analysis was done by using a statistical analytical system (SAS University version) with Duncan's mean separation at P=0.05.

3. Results and Discussion

The soil texture was Sandy clay loam and the physical and chemical properties were pH 6.9, electrical Conductivity 72 µS/cm, bulk density 1.55 g/cm^{3,} and organic carbon content 0.88 %. The nutrient availability of soil was 20.3 ppm nitrogen, 27.6 ppm phosphorus, and 57.9 ppm of potassium. Comparatively all nutrients were poor and there was a need to be fed by an external source for nutrients.

The nutrient content of *Chlorella* sp. was observed to be 27%, 3.23%, 0.73%, and 38.05% of nitrogen, phosphorous, potassium, and organic carbon respectively. Table 01 shows the plant height, leaf number, leaf area, fresh yield, and dry biomass yield of *Amaranthus* sp at the time of harvest. Plant height was comparatively higher in T7 treatment (50% Cattle manure + *Chlorella* sp. 1g/kg soil) which was 23.8 cm. However, there were no any significant differences (p=0.05) in height among treatments T2 (*Chlorella* sp. 2g/kg), T3 (*Chlorella* sp. 4g/kg), T6 (Cattle manure 100% 20 ton/ha), T7 (50% cattle manure+ *Chlorella* sp. 1g/kg), T8 (50% cattle manure+ *Chlorella* sp. 2g/kg), T9 (50% cattle manure+ *Chlorella* sp. foliar application 50% Live biomass) and T10 (50% cattle manure+ *Chlorella* sp. foliar application 0.1g Dry biomass/ Plant). Treatment T2 (*Chlorella* sp. 2g/kg) recorded the highest number of leaves. Meanwhile there were no any significant differences among the treatments T2 (*Chlorella* sp. 2g/kg), T3 (*Chlorella* sp. 4g/kg), T8 (50% cattle manure+ *Chlorella* sp. 2g/kg), T9 (50% cattle manure+ *Chlorella* sp. foliar application 50% Live biomass) and T10 (50% cattle manure+ *Chlorella* sp. foliar application 0.1g Dry biomass/ Plant). As it is a leafy vegetable, the number of leaves matters a lot on a commercial scale. A large leaf area was observed in the treatment T2 (*Chlorella* sp. 2g/kg) soil application that is significantly highest among the treatments. In the yield comparison, treatment T8 (50% cattle manure + *Chlorella* sp. 2g/kg) had the highest yield among others. However the yield of T2 (*Chlorella* sp. 2g/kg), T3 (*Chlorella* sp. 4g/kg), T6 (100% Cattle manure (20 ton/ha), T7 (50% cattle manure+ *Chlorella* sp. 1g/kg), T9 (50% cattle manure+ *Chlorella* sp. foliar application 50% Live biomass) and T10 (50% cattle manure+ *Chlorella* sp. foliar application 0.1g Dry biomass/ Plant) treatments were not significantly different compared to T8 (50% cattle manure+ *Chlorella* sp. 1g/kg). According to the nutrient uptake the nitrogen, phosphorous and potassium were higher in treatments T8 (50% cattle manure + *Chlorella* sp. *2*g/kg), T10 (50% cattle

manure+ *Chlorella* sp. foliar application 0.1g Dry biomass/ Plant) and T11 - 50% Cattle manure (20 ton/ha) respectively. As *Chlorella* is rich in nitrogen content, which is essential to improve the vegetative growth of plants, it improves the yield.

Table 01. *Amaranthus* sp. plant height, leaf number, leaf area, fresh yield, and dry biomass yield at the time of harvest

Treatments	Plant height (cm)	Leaf Number	Leaf Area (mm^2)	Fresh yield (g)	Dry biomass Yield (g)
T1	18.7^{b}	12^{bc}	441.75^{e}	4.66^{cd}	0.11^{cd}
T2	23.3^{a}	18^{a}	2898.99^{a}	13.11^{ab}	0.24^{ab}
T3	18.8^{b}	16^{a}	2407.89^{ab}	12.64^{ab}	0.18^{bcd}
T4	19.7^{ab}	12^{bc}	1549.91^{cd}	3.77^{d}	0.02^{d}
T5	17.7^{b}	12^{bc}	1612.16^{bcd}	7.74^{bcd}	0.11^{cd}
T6	18.7^{b}	10^{c}	2048.29^{abcd}	11.09^{ab}	0.17^{bcd}
T7	23.8^{a}	12^{bc}	2212.69^{abcd}	10.20^{abc}	0.18^{bcd}
T8	22.8^{a}	16^{a}	2583.04^{ab}	15.50^{a}	0.34^{a}
T9	20.8^{ab}	15^{a}	2048.09^{abcd}	10.05^{abc}	0.21^{abc}
T10	19.2^{ab}	16^{a}	2001.38^{abcd}	10.11^{abc}	0.12^{cd}
T11	18.2^{b}	10^{c}	1356.03^{d}	8.12^{bcd}	0.11^{cd}

T1 Control (No fertilizer application), T2 *Chlorella* soil application (SA) - 2g/kg soil, T3 *Chlorella* SA - 4g/kg soil, T4 *Chlorella* foliar application (FA) - 100% live biomass, T5 *Chlorella* FA- 0.2g dry biomass/L, T6 100% cattle manure - 20 tons/ha, T7 *Chlorella* SA- 1g/kg soil + 50% cattle manure, T8 *Chlorella* SA 2g/kg soil + 50% cattle manure, T9 *Chlorella* FA 50% live biomass + 50% cattle manure, T10 *Chlorella* FA 0.1g dry biomass/L + 50% cattle manure, T11 50% cattle manure (10 tons/ha).

4. Conclusions

Nutrient analysis of *Chlorella* sp. grown in parboiled effluent indicated that it has a considerable amount of potassium (0.73%), phosphorous (3.23%), nitrogen (27%), and carbon (38.05%). According to the overall observation, *Amaranthus* sp. shows best results in T8 which is 50% cattle manure + *Chlorella* sp. 2g/kg, and T2 which is only the algae biomass 2g/kg. Comparing the yield of *Amaranthus* sp. T8 (50% cattle manure + *Chlorella* sp. *2*g/kg) shows a higher response. However, there were no significant differences among T8, T2, T3, T6, T7, T9, and T10 in yield. Considering the cost-effectiveness, treatment T2 *(Chlorella* sp. 2g/kg) is the best as it uses the lowest amount of *Chlorella* sp. biomass among all the treatments. With the least input, the wastewater-grown biofertilizer also can be obtained which is a win-win situation for a farmer. The present study concluded that the *Chlorella* biofertilizer positively influenced on growth and yield of *Amaranthus* sp.

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Agribusiness and Agricultural Economics

Evaluation of impact of non-tariff measures on tea exports from Sri Lanka by gravity model

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1. Introduction

Tea is one of the most widespread beverages of the world, traded worldwide for centuries. Sri Lanka is the largest value-added tea exporter and largest orthodox tea producer and exporter. Turkey, Russia, Iraq, Iran, and China were the major destinations of Sri Lankan tea in 2020 (Export Development board). International trade have been exposed to diversified range of policy measures. Among those, there are policy measures which aim to ensure production quality standards and consumer safety, and they are referred to as non-tariff measures (NTMs). According to the United Nations Conference on Trade and Development (UNCTAD, 2015), any trade policy instrument used to regulate international trade other than ordinary tariffs is defined as NTMs. Generally, NTMs are raising the export cost of suppliers, especially in developing countries such as Sri Lanka. Nevertheless, the highest number of NTMs are imposed by developed countries. Under the General Agreement on Tariffs and Trade (GATT), tariff barriers were reduced through multilateral negotiations and therefore, countries use more NTMs (Melo & Nicita, 2018). Analysis of the effect of NTMs for several export commodities have been done in the literature. Thus, the study focuses on determining the impact of NTMs on the tea exports from Sri Lanka. Since tea is one of the major agricultural export commodities in Sri Lanka, it is very important to study about the effect of NTMs to tea exports.

2. Materials and Methods

The methodology of the study focused on determine whether there is an impact from NTMs to tea exports from Sri Lanka. The most famous model used in the literature to analyze the effect of NTMs is the gravity model. Recognition of the gravity model to measure trade restrictions by NTMs has improved over the last decade (Xiong & Beghin, 2011). The empirical gravity model used in the study is given below.

$$lnX\ kijt = \beta_0 + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnDIS_{ij} + \beta_4 ln\ \mathrm{POP}_{it} + \beta_5 ln\ \mathrm{POP}_{jt} + \beta_6\ \mathrm{SAARC}_{ijt} + \beta_7\ \mathrm{DNTM}k_{ijt} + \varepsilon\ kijt$$

Where, $X\ kijt$ is the export value of tea to the ith importing country from Sri Lanka at time t, GDP_{it} is the gross domestic product of ith importing country at time t, GDP_{jt} is the gross domestic product of Sri Lanka at time t, DIS_{ij} is the distance between the capital of the ith importing country and capital of Sri Lanka, POP_{jt} is the population of Sri Lanka at time t, POP_{it} is the population of ith importing country at time t, SAARC_{ijt} is the dummy for membership of SAARC, $\mathrm{DNTM}k_{ijt}$ is the dummy for the total NTMs country i has imposed on the exported product k from Sri Lanka and $\varepsilon\ k\ ijt$ is the error. Dummy variables are equal to one when the tested variable is present in the particular country and zero otherwise.

Hypothesis tested in the study were,

H0- There is no any significant impact from non-tariff measures on export value of tea

H1- There is a significant impact from non-tariff measures on export value of tea

The data set included data from 2007 to 2017 on yearly basis, from top 15 tea import countries from Sri Lanka regarding Tea, black; (fermented) and partly fermented tea, in immediate

packing of a content exceeding 3kg in the harmonized system (HS) 6-digit level. Tea export data were obtained by United Nations Commodity Trade Statistics Database (COMTRADE). GDP and population data were extracted from World Bank database. Bilateral distance between capital cities of Sri Lanka and the importing countries were taken from the Institute for Research on the International Economy (CEPII). The data on NTMs were obtained by Trade Analysis Information System (TRAINS) of the UNCTAD and WTO integrated database provided by World Integrated Trade Solutions (WITS).

Ordinary Least Squares (OLS) and Poisson Pseudo Maximum Likelihood (PPML) techniques were used to estimate the gravity model. PPML can counter the heteroscedasticity in the log linear form of gravity variables due to the existence of many zero values (Sandaruwan et al., 2020).

3. Results and Discussion

Results obtained from the estimation of gravity model are shown in the following table (Table 01).

Table 01. Results of the gravity model estimations

Variables	Unit	OLS	PPML
Ln_Exporter GDP	US $ billion	0.648 (0.93)	-0.054 (0.28)
Ln_Importer GDP	US $ billion	0.055** (0.14)	-0.066 (0.07)
Ln_Distance	Km	-5.041*** (0.33)	-1.580 (0.26)
Ln_Exporter population	Number	-.0.178 (1.25)	3.160 (0.35)
Ln_Importer population	Number	0.343 (0.15)	0.215** (0.08)
Dummy SAARC country	Dummy	0.748 (0.53)	-1.283 (0.277)
Dummy NTM	Dummy	-0.733** (0.53)	-0.018** (0.46)

Robust standard errors are in parentheses.
*, ** and *** asterisks denote significance at 10%, 5% and 1% levels respectively
Source: Prepared by the authors based on the regression estimates

Overall model is significant with a high F statistic which means coefficients are jointly zero at the 0.05 confidence level. Both GDPs influences exports positively. Nevertheless only importing country's GDP is statistically significant. According to the parameter estimates, when distance increases, exports decreases. The population of the export country was not significant while that of the import country was significant. Parameter estimation for dummy variable for total NTMs was negative and statistically significant. Compared to no NTMs, when there are NTMs imposed, tea exports decreases.

4. Conclusions

The study focused on providing some empirical evidences on the effect of NTMs on Sri Lankan tea exports. According to the literature, because of the decreasing of tariffs and increasing of NTMs, importers used to set more NTMs for import products, especially from developing

countries. In the recent past, there were some sanitary issues raised with exported tea bulks from Sri Lanka and such problems should be avoided by adapting sanitary and phytosanitary requirements. The production cost of tea may be increased by fulfilling these requirements. Nevertheless the relevant institutes of Sri Lanka such as, tea board, Export Development Board and Tea Research Institute should support the producers and exporters to adopt the changing NTM requirements in importing countries with additional subsidies. One of the issues faced during the study was the unavailability of NTM data for some countries in UNCTAD database. This will be discounted by a country level literature surveys in further researches.

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Paddy farmers' perception on banning of inorganic fertilizer: A case in Mapalana village in Sri Lanka

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1. Introduction

In Sri Lanka, rice can be identified as the major food and is approximately grown over 983,550 ha (Department of Agriculture, 2018). Outstanding growth in paddy production has arisen due to the introduction of high-yielding varieties and they are in high demand for fertilizer. Moreover, government subsidies have influenced farmers to apply higher degrees of fertilizer (Ekanayake, 2009). However, the overuse and mismanagement of fertilizer may cause undesirable impacts including ground and surface water contamination, soil acidification etc. (Lan & Xia, 2008). Fertilizers applied in rice cultivation may accumulate high concentrations of heavy metals in soil and eventually cause Chronic Kidney Disease (CKD) (Chandrajith et al., 2010). In 2020, 325,000 metric tons of fertilizers were imported for paddy cultivation and the cost of the subsidy program for paddy and other crops was $253 million (Mariano et al., 2021). Ultimately, this can be a threat to the national economy. In this context, attention should be paid towards alternatives such as organic farming that improves soil productivity and helps to solve soil pollution problems (Siavoshi et al., 2011). Accordingly, farmer perception should be taken into account, as they are the grass root level players in paddy cultivation. However, adequate attention is not given to farmers' thoughts within Sri Lankan decision-making processes. Hence, this study focused to identify paddy farmers' perception on inorganic fertilizer banning while assessing its impact and examining alternatives for inorganic fertilizer usage. The findings will give new insights for policymakers to become more concerned about banning inorganic fertilizer in the Sri Lankan context.

2. Materials and Methods

This study was quantitative in nature and a convenient sampling technique was adopted. The farmers of Mapalana village belonging to the Kamburupitiya DS division in Matara district were selected as the respondents of the study. Structured questionnaires were administered among the farmers and 32 dully filled questionnaires were collected. This study was conducted during June-August in 2021. The questionnaire consisted of three sections; respondents' demographic information, respondents' perception on the banning of inorganic fertilizer and alternative suggestions for this decision. Five point Likert scale (1= strongly disagree, 2=disagree, 3=no idea, 4=agree, 5=strongly agree) was adapted to access respondents' perception on banning of inorganic fertilizer. Secondary data were collected from research articles and reports of the Central Bank of Sri Lanka. SPSS version 25 software was mainly utilized for analytical purposes and the collected primary data were analysed by using descriptive methods and inferential statistical methods such as the Wilcoxon Signed Rank test.

3. Results and Discussion

According to the results, a majority of the sample consisted of male farmers (87.5%) and there were 12.5% of female farmers. When the farmers' level of education is taken into account, 53.1% were educated up to A/L, while 25% had diploma level qualification, 18.8% respondents were educated up to O/L and only 3.1% had degree level qualification. The majority of the respondents (43.8%) have been engaged in paddy cultivation for more than 10 years while 43.8% and 12.5% have been involved for 5-10 years and for less than 5 years respectively.

Table 01 shows the results of the Wilcoxon Sign Rank Test obtained from responses with respect to each statement on the perception of banning inorganic fertilizer and promoting organic farming given by the respondents.

Table 01. Farmers' Perception on banning inorganic fertilizer and promoting organic farming

No	Statement	Mean	Test value	P value
1	Banning inorganic fertilizer and promoting organic farming is a timely decision	1	-4.759	.000
2	Banning inorganic fertilizer and promoting organic farming is a necessity for the paddy cultivation	1	-4.590	.000
3	This will ultimately strengthen Sri Lanka economy	1	-5.027	.000
4	Banning inorganic fertilizer in paddy farming will protect the biodiversity	1	3.838	.000
5	The application of organic substances will eventually decrease the yield of the paddy cultivation	1	-6.80	.496
6	The use of organic fertilizer will increase the cost of production	1	2.887	.004
7	The application of organic fertilizer will improve the efficiency of nutrient use to produce more robust crops	1	1.86	.853
8	Organic farming will improve the fertility of the soil	1	0.655	.513
9	Promoting organic farming will contribute towards the effective waste management	1	.000	1.000
10	Promoting organic substances will create more employment opportunities and reduce the rate of unemployment in Sri Lanka	1	2.524	.012
11	Banning inorganic fertilizer will help in reducing non-communicable diseases	1	-1.500	1.34

Significance level = 0.05

According to Table 01, the respondents' perception of timeliness and requirement of the decision on banning inorganic fertilizer and promoting organic proved valid and significant. As per the respondents' points of view, organic farming results in a beneficial impact on the environment by protecting biodiversity and it also strengthening the country's economy and creating employment opportunities while they stated that organic fertilizers increase the cost of paddy production in Sri Lanka. Further, respondents revealed that promoting organic farming will not result in reducing non-communicable diseases, contributing to effective waste

management, improving soil fertility and nutrient utilization. According to the responses, the yield of the paddy cultivation would not be decreased by the application of organic substances.

As per the results, the majority of the respondents (62.5%) stated that banning inorganic fertilizer and promoting organic farming may have a direct impact on their economy, while 6.3% stated that there may be an indirect impact and 31.3% stated that there may be both direct and indirect economic impact of banning inorganic fertilizer.

As an alternative to inorganic fertilizer, the farmers suggested a mixture of neem (10%) as an insecticide, gliricidia (35%), cow dung (25%) and chicken manure (15%) as organic fertilizers. According to the findings, the majority of farmers (62.5%) suggested utilizing a low quantity of inorganic fertilizer and applying a high quantity of organic substances such as gliricidia, cow dung and chicken manure is the best option while 21.9% suggested applying equal quantities from both organic and inorganic is the best. However, 15.6% of them suggested the best option is applying only organic substances to the cultivation

4. Conclusions

According to the view of paddy farmers, banning inorganic fertilizer and promoting organic farming may have a positive impact on the Sri Lankan environment and economic condition. As the farmers have a negative mindset regarding organic farming, the attention of respective parties will be required to give further awareness to farmers on the advantages of organic agriculture. Having considered the findings reported, the best method is not going for 100% organic farming but applying high rates of organic matters with low rates of inorganic fertilizer. The findings of this study provide an overview for the policymakers to become more concerned about banning inorganic fertilizer in the Sri Lankan context.

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Sustainability of the women-led SMEs in the economic competition in Sri Lanka: Does financial literacy matter?

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1. Introduction

Small and Medium Enterprises (SMEs) are not just a supporting source for total value creation of economies, it is an important source of GDP. Similarly, they are recognized as a coping mechanism for many of the challenges that are faced by the economies of the developing nations such as poverty, inequality of income, unemployment, particularly among women and youth (Asare et al. 2015). Thus, the SME's sustainability is critical for economies to achieve sustainable growth. Main problem facing the SMEs is the low survival rate in the economic competition and situation is worst in the women-led SMEs (Prasanna et al. 2019). One of the critical determinants that affect the performance outcomes of the women-led SMEs is the level of financial literacy (Pandey & Gupta, 2018).

According to OECD (2013), effective financial decisions of SMEs depend upon several factors such as awareness, knowledge, skill, and attitude. The studies provide evidence that woman entrepreneurs are likely to adopt measures to make balance between the financial returns, specifically minimizing the risk, and firm sustainability (Gottschalk & Niefert, 2012). However, there are limited number of studies which attempted to study the relationship between gender and firm sustainability, specifically study the effects of financial literacy of women entrepreneurs. Thus, the subject – sustainability aspirations of women-led SMEs – are still remain in debate. Therefore, the objective of this study is to determine whether there a significant association of gender and gender-based financial literacy level on SEM performance by taking agro-based SMEs in Sri Lanka as a case.

2. Materials and Methods

The study first narrowed down its survey focus to agro-based SMEs concerning the significance of agricultural sector economy. A field survey was conducted to collect the data of agro-based SMEs located in formal and informal settings by administering a pre-tested questionnaire during March to December 2020. The survey covered 462 SMEs located in the 30 DS divisions in the country. The study used growth in business/production scale as a proxy variable to business performance. The level of financial literacy of the SMEs was assessed using two variables – credit market accessibility and financial record keeping behavior. The reliability of the variables was tested by using the Cronbach's alpha test. In the analysis of data, cross tabulation and chi-squire test was performed to test the study hypothesis and existing understandings in the field were used in extending the interpretations.

3. Results & Discussion

First, the study separated the male and female entrepreneurs in the sample into high and low business performance categories in order to test the hypothesis (H1) – no effect of gender of entrepreneur on SME performance in the economic competition. As results presented in Table 1 (a), within the gender category, 85.7% of male and 99% of women reported the low business performance. It indicates that less business performance of the women-led SMEs compared to male-led SMEs. The chi-square test, which was performed to check whether there a statistically

significant relationship between gender and SME performance, confirmed association between gender and business performance ($\chi^2 = 17.390, p = 0.000$) in low and high business performance categories. Thus, the study rejected hypothesis H1 indicating the existence of gender-based difference in business performance in the SME sector.

Table 01. (a). Cross tabulation of business growth and gender of SME owner

	Gender of SME Owner		Total
Business Growth	Male	Female	
Low Performance	289	124	413
High Performance	48	01	49
Total	337	125	462

Table 01. (b). Pearson chi-square and likelihood ratio estimates

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	17.380	1	0.000		
Likelihood Ratio	24.941	1	0.000		
Fisher's exact test				0.000	0.000
Linear by linear Association	17.343	1	0.000		
No of valid case	462				

Second, the study performed the cross tabulation and Chi-Square test to test the hypothesis H2 – no effect of gender on business record keeping behavior - and H3 – no effect of gender on credit market accessibility. According to Table 2 (a), 76.8% of male and 84.8% of women entrepreneurs had been maintained the business records. It indicates women-led entrepreneurs are more likely to maintain business related records or with high book keeping attitude. The chi-square test confirmed an association between gender and business records keeping ($\chi^2(1) = 3.470, p = 0.000$). In terms of financial risk-taking behavior which was assessed through variable credit market accessibility, Chi-square test confirmed no statistically significant association between gender and financial risk-taking behavior of the entrepreneurs in the SME sector, and thereby rejected the H3 hypothesis. The results of cross tabulation revealed that both groups are in the modest level of credit market accessibility indicating existing gap in credit market accessibility.

Table 02. (a). Cross tabulation of records maintained and gender of SME owner

Attribute	Category	Gender of SME Owner		Total
Business record keeping		Male	Female	
	Business records were not maintained	78	19	97
	Business records were maintained	259	106	365
	Total	337	125	462
Financial risk-taking behavior	Credit market were not accessed	139	52	191
	Credit market were accessed	198	73	271
	Total	337	125	462

Table 02. (b). Pearson chi-square and likelihood ratio estimates

Attribute	Statistics	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig (1-sided)
Business record keeping	Pearson Chi-Square	3.470	1	0.062		
	Likelihood Ratio	3.658	1	0.056		
	Fisher's exact test				0.072	0.039
	Linear by linear association	3.463	1	0.000		
Financial risk-taking behavior	Pearson Chi-Square	0.05	1	0.945		
	Likelihood Ratio	0.05	1	0.945		
	Fisher's exact test					
	Linear by linear association	0.05	1	0.945		

4. Conclusions

The study, first, revealed the low business performance of women entrepreneurs-led SMEs compared to male entrepreneurs-led business model and effect of gender on SME performance. The study, second, revealed a relatively high rate of business record keeping by women entrepreneurs in the SME sector. Also, the statistically significant association between gender and business record keeping were reported. As record keeping is a key component of financial management of SMEs, it indicates that women entrepreneurs in the sector are with better financial management due to the risk-averse position of them. Third, the study revealed a no association between gender and financial risk-taking behavior of the entrepreneurs, but cross tabulation indicated the existing gap in accessing the financial markets for business growth in both categories.

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Economic orientation of Egypt's cotton exports and imports

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1. Introduction

Cotton is the most crucial Egyptian fiber crop because of its economic value in production, consumption, industrialization, and foreign trade. Moreover, it has a social significance since a large percentage of labor works in its production at all stages. In addition to the crucial of Cotton in the production of clothing and non-clothing household uses, its by-products are used in several activities that contribute to satisfying the needs of living beings, humans and animals, and represent a critical source of national income.

A necessity of developing a trade among the producing and consuming countries has arisen, because of the centralization of producing cotton, especially certain types, in few countries versus the need of all the countries of the world to consume cotton.

Unfortunately, the pricing and marketing Egyptian policies regarding cotton crop led to the reluctance of many farmers to cultivate cotton. So, the cotton cultivated area, which was about 1.7 million acres during the 1960s, shrunk to be 575.000 acres then 214.000 acres in 2007 and 2015 respectively. Accordingly, the exports of cotton decreased dramatically from about 111.000 tons in 1999 to be about 36.000 tons in 2015. Additionally, the imports of cotton increased from about 500 tons in 1998 to be about 74.5 thousand tons in 2015.

The research aims to identify the current situation of the cotton's imports and exports trade in Egypt, its global distribution and investigate the alternatives to determine the best export destination which maximizes export revenue or minimize export cost.

2. Materials and Methods

The linear programming approach was used for identifying the best distribution for Egypt's cotton exports that will maximize the exports' revenue as well as the best distribution for Egypt's cotton imports that will minimize the imports' payments.

Linear programming is a mathematical method aimed at maximizing or minimizing a linear function called the goal function and defined by known or assumed limits called restrictions, and this method is based on a set of conditions, the most important of which is that the relationships between all factors or variables are linear and based on this condition, so linear programming derives its name from this condition.

Objective function: The goal behind the optimal exploitation of the available resources through a function that includes a group of variables called resolution variables we seek to determine their values, which in turn determines the value of the desired goal.

The constraint functions the set of determinants or obstacles to which they must be subjected in order to achieve the goal and reach the best decision and basically reflect the resources available in a limited way.

The linear programming model consists of the objective function that should be increased or decreased, the possible activities and alternatives, besides the restrictions and limitations of these activities. The research utilized several international and local bulletins and periodicals, international trade publications for the Central Office for General Mobilization and Statistics,

as well as bulletins of the National Bank, the Central Bank, FAO, and the Cotton Exporters Union magazine, besides websites.

3. Results and Discussion

1- Maximizing the revenue of Egypt's cotton exports

In (2013- 20016) Egypt exported cotton, 32898 tons annually, to 32-country, with a revenue of 93.5 Million$. Regarding the exportation prices, the maximum price was paid by Switzerland, as it was 6,78 thousand dollars\ton. Then the price decreased till it reached the minimum price, 2.99 thousand$\ tons, for Morocco.

The study hypothesizes several alternatives for distributing the Egyptian exports of Cotton, and defines the best preference using linear programming,

1st alternative: open, not limited to a certain country, distribution for the highest price.

2nd alternative: exporting cotton for the importing countries who imported the Egyptian cotton for the last four years, but the exporting amount for each country should not exceed

a) 40% of the total exports.
b) 20% of the total exports.
c) 10% of the total exports.

3rd alternative: exporting cotton to the key importing countries that its annual average of exporting the Egyptian cotton is not less than 3% of the total average of the cotton's exports.

According to 1st alternative, the exports of Egyptian cotton will be for Malaysia, followed by Switzerland and Saudi Arabia, and the current revenue of the cotton's exports will be increased by 48%.

According to the 2nd alternative,

assumption (a): the exports will be for 3 countries; Japan, Italy and South Korea, and the current revenue of the cotton's exports will be increased by 27.6%.

assumption (b): the exports will be for 6 countries; Japan, Italy, Korea, Germany, America and Thailand, and the current revenue of the cotton's exports will be increased by 17.7%.

assumption (c): the exports will be for 10 countries; Japan, Italy, Korea, Germany, America, Thailand, Belgium, Turkey, China, and Mexico respectively and the current revenue of the cotton's exports will be increased by 10.37%.

According to the 3rd alternative, the exports will be limited to Italy, and the current revenue of the cotton's exports will be increased by 27.7%.

2- Reducing the cost of Egypt's cotton imports

During (2013-2016) Egypt exported cotton from 12- country, Greece, America, Benin, Burkina Faso were the key exporters, with an average cost of 144.5 million dollar\year. Regarding the importing price, the minimum price was from Greece, 1926$\ton, then Benin followed by Burkina Faso, then the prices increased gradually till it reached the maximum price, 4767$\ton from Malaysia.

The study hypothesizes several alternatives for the Egyptian's Cotton imports, and defines the best preference using linear programming,

1st alternative: the open, not limited to a particular country, distribution for the lowest price.

2nd alternative: distributing the Egyptian's imports of cotton according to the lowest price from the Key exporting countries, from which Egypt imports at least 10% and not more than 60% of its imports of cotton.

According to the 1st alternative, the imports will be from one country, Greece, and the importing costs will be reduced by 7.4%.

According to the 2nd alternative, the imports will be from two countries, Greece, and Benin, as a result, the importing costs will be reduced by 7.3%.

4. Conclusions

The study defines 3 alternatives for Egypt's exports of cotton, which will increase the revenue of the cotton's exports by 10.37% to 48% compering to the current revenue. Furthermore, the study defines two alternatives for Egypt's imports of cotton, which will reduce the costs of the cotton's imports by 7.4% or 7.3% compering to the current costs of imports.

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Impact of fertilizer subsidy on paddy cultivation in Sri Lanka

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1. Introduction

Concerning many successive governments in the world, they pushed towards providing subsidies especially for agricultural sector (Mint & Benson, 2009). Successive governments have provided high yielding rice varieties and chemical fertilizers as high yielding rice varieties are more responsive to the fertilizer they used. The Fertilizer subsidy scheme was initiated in 1962 with the invention of High Yielding Varieties parallel to the Green Revolution. There were three main components given under the subsidy program such as urea, triple super phosphate (TSP) and potassium chloride (MOP). The overuse or misuse of fertilizer have impacted disadvantageously to the paddy yield and also to make soil less productive as revealed many researches. The main objective of the study is to explore the impact of Fertilizer Subsidy on paddy cultivation in Sri Lanka in order to make appropriate policy recommendations. The study found that there is a significant positive relationship between use of fertilizer and paddy yield. Hence, it suggests more modifications to the fertilizer subsidy scheme as well as implementing new infrastructure and institutional facilities that are required to increase the productivity and efficiency in paddy cultivation in Sri Lanka.

2. Materials and Methods

Descriptive data has been used for the analysis of the government expenditure for fertilizer subsidy hence it could be evaluated how far the government has emphasized on paddy cultivation as a share of total government expenditure. For the descriptive analysis, secondary data were collected from the Department of Census and Statistics (DCS), Department of Agriculture, The Ministry of Finance, The Mahaweli Development Authority, Department of Agrarian Services and the Central Bank of Sri Lanka related to the paddy cultivation. For the regression analysis data were collected from 1990 to 2018 from Department of Agrarian Services.

The impact of fertilizer subsidy on paddy production has been evaluated through the Multiple Regression Analysis using fertilizer subsidy as dummy variables. Time series data were collected from 1990 to 2018 for the analysis (Bhavan & Maheshwarathan, 2012). The following conceptual framework shows the variables that has included within the model and the organizing of variables.

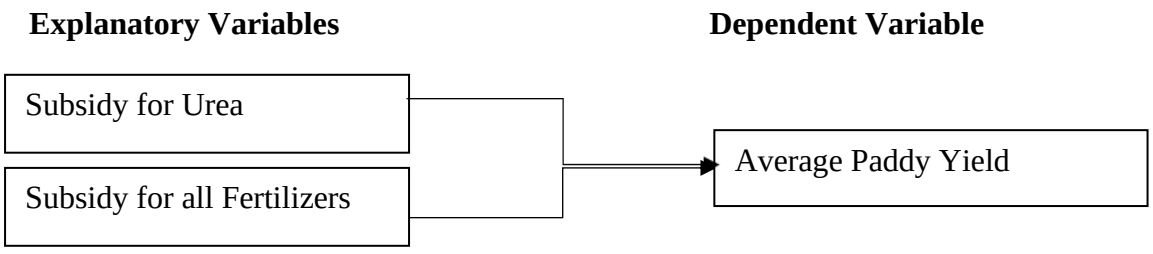

Table 01. Organization of Variables

Descriptive Variables	Regression Variables
Annual Total Usage of Fertilizer	Dependent variable- Average Paddy Yield
Fertilizer Subsidy as a Government Expenditure	Independent variable I-Providing Subsidy only for Urea (1) Otherwise (0)
Impact of fertilizer as a share of Import	Independent variable II- Providing Subsidy for Three Fertilizers (1) Otherwise (0)

Several econometric tools are applied to estimate the regression function in order to analyse the impact of fertilizer subsidy scheme such as Unit Root Test, Normality Test, Multicollinearity Test, Homoscedasticity Test etc.

3. Results and Discussion

Descriptive Statistics

Usage of Fertilizer on Paddy Cultivation and Fertilizer Subsidy as a Total Government Expenditure

In 1961, the usage of fertilizer in paddy sector, was about 10 % while it was increased up to 53 % by 1996. The average use of Urea in 1960s was recorded as 4.3 kg per hectare and it was accounted as 284 kg per hectare in 2005 (Wickramasinghe et al., 2009). The usage of fertilizer was recorded as 457 kg per hectare from 2006 to 2017. The following graph shows that how the expenditure on fertilizer scheme is in cooperated with the years.

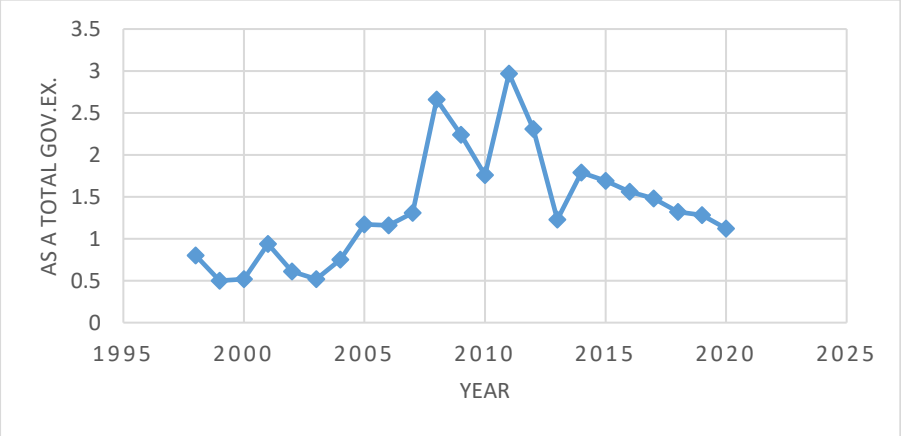

Figure 1. Fertilizer Subsidy as a Total Gov. Expenditure (Source: Central Bank of Sri Lanka (1995-2015))

Average Paddy Yield- There could be seen a gradual increase of the average paddy yield over past few decades in Sri Lanka. It was increased from 1230kg in 1950s to 2735kg in 1980s. In 2018 it was accounted for 4443 kg per hectare compared to 4297 kg per hectare in 2017.

Regression Analysis

AVE_YIELD = 3430.4+394.82*SUB_UREA + 815.66*SUB_ALL

β0= 3430.4 means, when no subsidy is given either for Urea or all fertilizers, the average yield is 3430.4kg. In simply, in the period of subsidy removal (1990-1994) the average paddy yield is 3430.4kg per hectare. β1=394.82 means, considering subsidy is given only for urea rather than removal of subsidy, it increases the average yield by 394.82 units, holding subsidy

providing for all fertilizers constant. β2=815.66 means, considering subsidy given for all fertilizers rather than removal of subsidy, it increases the average paddy yield by 815.66 units keeping subsidy provided only for Urea constant. F value (15.6) for the test indicated that the overall model is significant under 5 percent level of significance.

Considering descriptive analysis for expenditure on fertilizer subsidy as a share of total government expenditure, the data provides the implication that, fertilizer subsidy scheme is significantly affected to the average use of fertilizer over the years. Accordingly, it can be stated that, there is a significant relationship between fertilizer usage and average paddy yield over the past five decades. With the increase of fertilizer usage, government burden on fertilizer expenditure has also increased gradually. Average paddy yield has also increased over the time by having a look on past few data. This improvement can be caused by several factors such usage of fertilizer, the impact of fertilizer subsidy program and availability of water resources etc. Hence, it can be stated that both the fertilizer expenditure and paddy yield has increased over the time by indicating a significant involvement from fertilizer subsidy scheme to the paddy yield.

As shown in the statistical analysis (Regression Analysis), it can be stated that there is a positive relationship between two variables. So, the results indicate that the expenditure on providing Urea by 1kg will cause to increase the paddy yield by 394.82 kg per hectare. A similar result can be found in a research by Wanninayake and Semasinghe (2012). According to their model, they also found that a positive relationship between average paddy yield and fertilizer subsidy. According to the study, providing subsidy for three fertilizers would affect to increase the paddy yield largely than providing fertilizer subsidy only for urea. What these results show that fertilizer subsidy contributes to produce relatively a higher average yield in the paddy cultivation. In terms of economic viewpoint, this finding justifies the fertilizer subsidy of paddy cultivation in Sri Lanka. Then, the hypothesis formulated in the study as,

H1: Fertilizer subsidy has a positive relationship with average paddy yield

Can be accepted by reviewing the results of the study.

4. Conclusions

With the analysis of results, it can be concluded that, the involvement for the paddy cultivation is highly affected by the fertilizer subsidy in Sri Lanka. Even though the impact of fertilizer subsidy scheme is positively related to the paddy cultivation, it may cause to decrease the soil productivity and efficiency as many other researchers revealed. Hence, the policy makers should emphasize pros and cons of using chemical fertilizer to paddy cultivation before making a decision. Meanwhile, the government should focus on providing infrastructure and institutional facilities that are required to improve the productivity and efficiency in the paddy cultivation.

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Empowerment of women farmers' and its' contribution on household poverty reduction: A case of Imbulpe DS division in Sri Lanka

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1. Introduction

Women empowerment and poverty reduction are inter-connected social phenomena for achieving the sustainable development in most of the developing countries (Weinstein., 2019; Jaka and Shava., 2018). Gender differences affect the agricultural knowledge barrier for the women farmers (Rathnachandra & Malaknthi, 2020; Mojaki & Keregero, 2019; Malkanthi, 2016).

Women empowerment and poverty reduction are naturally depend on the socio-economic aspects of the women farmers (Wei et al., 2021). In most of the developing countries, male counterparts have become highly upgraded in their capabilities in the level of education, accessibility to modern farming technologies as well as agricultural information (FAO, 2018). Since women farmers have more social responsibility to perform in household activities and caring of family members, they have lack of access to social networks and also in poorer status in their monetary facilities than the male farmers (Medagbe et al., 2020; Bahadurghartimagar, 2011). Therefore, women farmers need to be empowered in their capabilities to reduce the gender discrimination in developing countries (Rathnachandra & Malkanthi, 2020; Ibharhokanrhowa, 2016).

When consider the situation in Sri Lanka, about 14% of women represent those with economically active status practicing agricultural activities within the rural sector. (Madurawala, 2018; Annual Labor Force Reports, 2017). In Imbulpe area, a considerable proportion of male counterparts are engaging in industrial sector and service sector as their livelihood. Therefore, women farmers have to perform both domestic activities and also the farming activities simultaneously. Most of the women farmers in this area have lack of access to adequate assets and resources, credit facilities and freedom of decision making within the households. Therefore, women empowerment is a timely important requirement to reduce household poverty of rural women farmers under these circumstances. Thus, this research aimed at identifying the determinants of empowerment of women farmers and assessing the association of determinant of empowerment of women farmers with their contribution in poverty reduction within the study area.

2. Materials and Methods

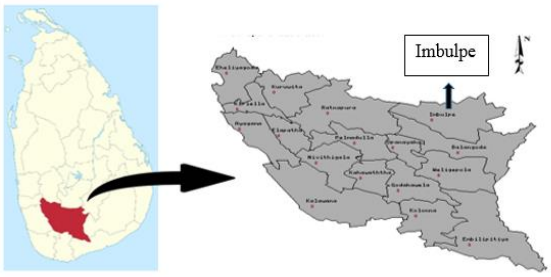

Figure 1. Map of the Imbulpe DS division

The study area is situated in Rathnapura district and a considerable share of male counterparts has moved to urban areas for their employments. The majority of women engage in agricultural activities while performing domestic activities.

In this study, from Imbulpe DS division, seven Grama Niladhari (GN) divisions were randomly selected for the study. They were Halpe, Seelogama, Kinchigune, Puwakgahawela, Muttettuwegama, Imbulpe and Karagastalawa. Then, a sample of 238 women farmers were randomly selected. Primary data were gathered from a field survey using a pre-tested, self-administered questionnaire from May to July 2019. Descriptive statistics was used to identify the nature of socio-economic factors and the determinants of empowerment of women farmers were identified using descriptive statistics: age, education, marital status, farm land size, farming experience and monthly income, ability to control their economic resources, freedom of mobility and participation in decision making within the households were considered the determinants of women empowerment. The ability to control their economic resources and participation in decision making within the households were measured by taking various categories based on the identified distribution patterns as husband, wife, both and other, according to the findings of the pilot study. Chi-square analysis was used to assess the association of the determining factors of empowerment of women farmers with their contribution in poverty reduction within the study area.

Women farmers' contribution towards poverty reduction was measured using eight dimensions based on the studies of Moussa et al. (2011) and Khan et al. (2017), with necessary modifications in categories which were denoted by high (3), moderate (2) and low (1) considering as ability to earn considerable monthly income from the marketing of agricultural products, ability to use home garden products in meal preparation, ability to preserve excess home garden products for off season, ability to get home garden medicine for simple health disorders, ability to share excess home garden products among neighbors, ability to do day-to-day household expenses, ability to obtain a own bank saving with a considerable deposited amount and ability to bear the household shocks by getting support from neighbor farm women.

Women empowerment was measured using selected factors: economic resource accessibility, freedom of mobility and participation in decision making within the households and categorized as high (3), moderate (2) and low (1) based on the study of Khan et al. (2017). Economic resources accessibility was studied using eight dimensions: ability to control day to day household expenses, ability to maintain bank savings, ability to purchase necessary fancy items, ability to control valuable instruments and machinery, ability to maintain their home lands and farm lands, ability to perform farm management and budgeting activities, ability to purchase necessary farming inputs and ability to sell, exchange and repurchase land/ livestock/ house. Freedom of mobility was assessed through seven dimensions as; going to market place, friends and relatives houses outside the home village, agrarian service center, the neighboring houses, capital city, other districts and religious places. Participation in decision making within the households was measured using ten dimensions: day-to-day household expenses, agricultural production activities, buying and selection of agricultural inputs, marketing of agricultural products, family health issues, education of children, selecting and using family planning methods, constructing and repairing of houses, celebration of social and religious events and giving loans to others.

3. Results and Discussion

Socio-economic factors of the respondents

According to the findings, most of the respondents (62.6%) were in between 40 -59 years of age. The majority of the respondents (90.3%) married and 64.3% of them had studied up to secondary education (GCE Ordinary level). The average size of farm land was showed as 0.84

acre and average duration of experience of farming was 15 years. Also, 65.5% of respondents have earned LKR 20,001 – 40,000 as their monthly income.

Situation of empowerment of women farmers

According to the findings, husbands have more accessibility or power regarding the maintenance of their home lands and farm lands (56.7%) than the other dimensions. However, women farmers (wives) showed low level of overall accessibility regarding the purchasing ability of necessary farm inputs, ability to performing farm management and budgeting activities, ability to maintain bank savings and ability to control day to day household expenses were showed higher level of accessibility by husbands of the households. Women farmers showed the lowest level of accessibility for ability to manage their home lands and farm lands.

The situation of participation in decision making within the family are as, husbands have more power to take decisions regarding the marketing of agricultural products (56.7%) than the other dimensions. However, women farmers mentioned that they had a low level of overall participation regarding the marketing of agricultural products, constructing and repairing of houses, selecting and using family planning methods, giving loans to others and celebration of social and religious events. Women farmers showed the lowest level of power of taking decisions about the construction and repairing of houses. Furthermore, freedom of mobility of the women farmers was studied using seven dimensions. According to them, most of the women farmers needed permission to move capital city (31.1%), other districts (31.9%) and friends and relative's houses outside the home village (32.8%). However, women farmers needed the least level of permission when moving into the religious places (5%).

Women farmers' contribution in poverty reduction

Women farmers' contribution to poverty reduction was investigated with the support of eight dimensions. As per the results, women farmers have a higher potential to enhance their contribution to poverty reduction using the ability to share excess home garden products among neighbors and a lower level of monthly income from marketing of agricultural products facilitate lower opportunity to enhance the women farmers' contribution to poverty reduction. Based on the calculated weighted average, while 35 women farmers have showed higher level of contribution to poverty reduction, only 71 respondents showed a low level of ability in their contribution in poverty reduction. Moreover, 132 women farmers have gained moderate status in their contribution to poverty reduction.

Impact of socio-economic factors and women's contribution in poverty reduction

Selected socio-economic factors were taken as the independent variables and contribution in poverty reduction was used as the dependent variable of the study. Results of the chi-square analysis are presented in table 01.

Table 01. Impact of socio-economic factors and women's contribution to poverty reduction

Factor	Category	Their contribution in poverty reduction					
		High		Moderate		Low	
		F	%	F	%	F	%
Age	20-39 Years	26	10.9	11	04.6	03	01.3
	40-59 Years	87	36.6	53	22.2	09	03.8
	> 60 Years	08	03.3	22	09.2	19	07.9
	Chi-square = 48.07 Gamma value = 0.451			df = 4		p value = 0.00	
Educational level	No Primary education	1	0.42	2	00.8	5	02.1
	Primary education	5	02.1	26	10.9	37	15.5
	Junior secondary education (O/L)	62	26.1	69	28.9	22	09.2

	Senior secondary education (A/L)	4	01.7	3	01.3	2	00.8
	Chi-square = 50.72 Gamma value = 0.64		df = 6			p value = 0.00	
Monthly income (LKR)	Less than 20,000	13	05.5	22	09.2	26	10.9
	20,001 – 40,000	88	36.9	62	26.1	6	02.5
	40,001 – 60,000	12	05.0	7	02.9	2	00.8
	Chi-square = 58.65 Gamma value = 0.56		df = 4			p value = 0.00	

f = frequency % = percentage

Age of women farmers and their contribution to poverty reduction showed a moderately significant positive relationship and its findings showed as gamma value is 0.451 and p value is less than 0.05 confidence level. Also, a moderately significant positive relationship was obtained between the level of education of the respondents and their contribution in poverty reduction as Chi square analysis showed gamma value as 0.64 and p value as less than 0.05 confidence level. Findings of the monthly income and their contribution to poverty reduction had a moderately significant positive relationship, as per Gamma value is 0.56 and p value is less than 0.05 in Chi square analysis.

Factors affecting for poverty reduction of women farmers

The relationship between economic resource accessibility and participation in decision making within the household with their contribution to poverty reduction was assessed by using Chi-square analysis. Economic resource accessibility and participation in decision making within the household were taken as the independent variables and women's contribution to poverty reduction was used as the dependent variable of the study (Table 02).

Table 02. Chi-square analysis of the empowerment of women farmers on their contribution in poverty reduction.

Factor	Chi-Square value	p value	df	Gamma value
Economic resource accessibility	31.48	0.000	2	0.683
Participation in decision making within the household	93.59	0.000	2	0.589

As per Table 02, economic resource accessibility of women farmers and their contribution in poverty reduction noted as gamma value was 0.68 and p value was less than 0.05 confidence level. Therefore, a moderately significant positive relationship was obtained between the economic resources accessibility of the respondents and their contribution to poverty reduction. Also participation in decision making within the household and women farmers' contribution in poverty reduction showed that gamma value was 0.59 and p value was 0.00. The results indicate a moderately significant positive relationship between the women farmers' participation of decision making within the household and their contribution in poverty reduction.

Based on the study of Khan et al. (2017), age of the respondents and participation in decision making of the respondents have shown a positive and weak relationship with the women's contribution to poverty reduction. Educational level of the respondents obtains a moderately positive relationship with their contribution to poverty reduction. Based on the findings of the

Nadim and Nurlukman (2017), education, monthly income, institutional participation and training program participation of women farmers have caused an increase in the women's contribution to household poverty reduction.

4. Conclusions

As per the findings of the research, women farmers show the lower level of accessibility to maintain their home lands and highest level of accessibility regarding the purchasing of necessary farming inputs. However, women farmers obtain a higher level of participation in the decisions associated with the education of children and the lowest level of power was obtained when taking decisions about constructing and repairing of houses. Most of the respondents need permission to move to the capital city, other districts and friends and relatives' houses outside the home village. Age, education, monthly income, participation in decision making, economic resources accessibility and freedom of mobility act as the determinants of women empowerment. The relationship between the age and its' contribution to poverty reduction shows a moderately significant positive relationship. Also, moderately significant positive relationships were obtained for education, monthly income, economic resources accessibility and participation of decision making within the household with their contribution to poverty reduction. Hence the findings conclude that women empowerment and their contribution to poverty reduction are interconnected and household poverty may be reduced by empowering the women farmers in the rural areas of the country. The findings may be useful for the policy makers, administrators and other workers in development activities to formulate and implement suitable strategies for women's empowerment to minimize the household poverty in the rural areas of Sri Lanka.

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An economic analysis of the crop losses induced by wild animals in Netolpitiya, Hambantota district

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1. Introduction

The conflict between human and wildlife is one of the greatest challenges these days owing to the crop-damage by wild animals. It leads farmers' economic loss causing into expanding of food insecurity and poverty across the country (Emongor, Maina, Nyongesa, Ngoru & Emongor, 2021). There is an extensive variation throughout the world in the type and the nature of damage to crops by wild animals (Fang, Hong, Zhou & Chen, 2021). Sri Lankan agriculture had forest-based shifting cultivation in the uplands and small scale rice farming in the lowlands. Therefore, the land use has changed considerably during the last few decades (Zomer et al., 2007). In the wet zone, shifting cultivations have been replaced by large crop plantations. In the dry zone, extensive irrigation projects have been promoted for rice farming. In this process poor farmers have been driven into more marginal lands close to wildlife reserves. Therefore, wild animals are seen as a prodigious threat to agriculture toward 40% annual local production and economic losses (De la Torre et al., 2020). The livelihood of people in Netolpitiya area of Hambantota district mainly depends on agriculture. Farmers in this area mostly cultivated rice and vegetable under the huge wild animal constrains (Ehelepola, Ariyaratne & Dissanayake, 2021). The study offers some important insights into overcoming the wildlife problems which have a huge impact on their livelihoods toward fulfilling unreported information on different crop types, major wild animals that damage each crop type and related economic losses referring to past researches as (Awasthi & Singh, 2015). Henceforth, this study aims at identifying the major types of wildlife and their damage in Netolpitiya area, to calculate the economic loss of crops due to wildlife and to propose appropriate suggestions to minimize crop losses due to wildlife.

2. Materials and Methods

The target population of this study was farmers in Netolpitiya, Hambantota district. 60 farmers who are cultivating rice and vegetables were selected using simple random sampling technique. The farmers list prepared by the Agriculture Instructor of the area was used as the sample frame. The empirical data for the study were gathered through a well- structured questionnaire, direct field observations, interview and discussions. Secondary data were collected using reports from the Department of Agriculture, journal articles and other published materials. The calculation of crop loss caused by wild animals was done under the following assumptions and equation:

AS: Crop losses are exclusively caused by wild animals, and other losses such as weed, insect, and disease assault are preventable in the region at the time of data collection.

$$TL = \frac{L1 - W1}{L1} \dots\dots\dots\dots\dots (i)$$

TL = Crop loss amounts / ac/ person (kg)
W1 = Actual yield received /ac/ person (kg)
L1 = Possible expected yield/ ac/person in the area (kg)

Using the above equation, the crop loss amounts (kg) were calculated and the values were multiplied from the "selling price" for each crop. The total economic loss per acre per farmer was calculated using the following equation (ii). Finally, an average value was calculated per acre per farmer.

$$EL = TL * Ps \ldots\ldots\ldots\ldots\ldots\ldots\text{(ii)}$$

EL = Average actual total economic loss per acre per farmer
Ps = Selling price
Descriptive methods of analysis were followed using SPSS version 16 software. In statistical analysis, the value of $p < 0.05$ was selected as to be statistical significance.

3. Results and Discussion

Results revealed that 85% farmers cultivated more than one crop types while 15% cultivated only one crop type. The crop damages were caused by wild animals in descending order from peacock (75%), monkey (50%), rat (39%), parrot (20%), giant squirrel (15%) and jungle fowl (5%). Figure 1 illustrates the percentage of farmers who faced losses of crops by each animal type. It was clear that Peacocks, monkeys and rats were the major animals damaging the cultivation in the study area. Wild pigs were not reported as a harmful animal to agriculture in the area.

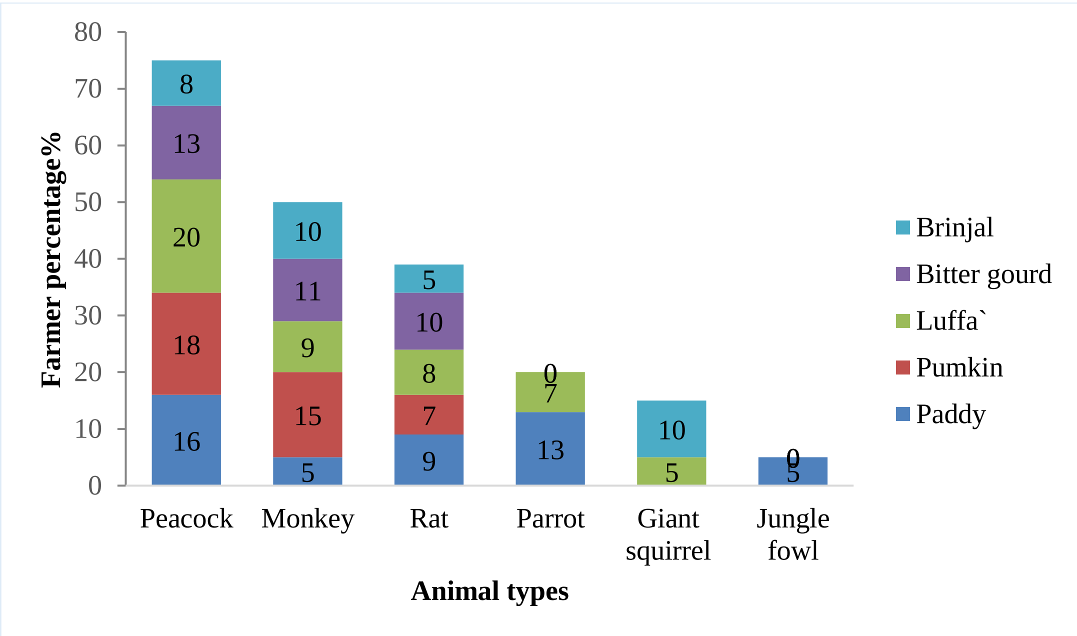

Figure 1. Percentage of farmers and crop losses by each animal

Luffa was highly damaged by peacocks while pumpkin by monkey, bitter gourd by rats, rice by parrot, brinjal by giant squirrel and rice by Jungle fowl. Further, jungle fowl only damaged rice.

According to the perception of the farmers, the average economic loss per season per acre per person was LKR 8849.45 for Rice (*Oryza sativa*), LKR. 16400.00 for Pumpkin (*Cucurbita moschata*), LKR 7537.56 for Luffa (*Luffa aegyptiaca*), LKR 6011.59 for Bitter gourd (*Momordica charantia*), LKR. 7277.94 for Brinjal (*Solanum melongena*). Table 01 illustrates the calculated loss and the differences as compared to the farmer's perception of crop losses for each crop. The highest calculated crop loss was reported in Luffa while the lowest actual

loss was recorded in brinjal. According to the difference, it was realized that the farmers have underestimated their economic crop loss of each crop.

It was observed that farmers have used both modern and traditional technologies. An attempt was made to recognize the cost of controlling the damage. Furthermore, the average cost for using modern technologies (Rs. 3900/acre) was high when compared to average cost of using traditional methods (Rs. 1850/acre). The majority of farmers (95.7%) applied traditional methods and only 4.3% farmers used modern technology to minimize crop losses caused by wild animals. The mostly used traditional methods were guarding, using crackers and using nets. The usage of air riffle was the modern technological method used by farmers.

Table 01. Calculation of expected loss per acre per farmer

Crop type	Actual economic loss (Rs./acre/person)	Differences (Rs./acre/person)
Rice	10487.23	1637.55
Pumpkin	31272.58	14871.74
Luffa	38259.58	30722.05
Bitter gourd	17439.85	11428.26
Brinjal	9550.17	2272.23

The ideas of the farmers regarding the following suggestions were tested by using the Wilcoxon signed rank test interpretation of SPSS Statistics software. From the tested criteria, farmers were marked of their willingness level for different suggestions that help prevent crop damages by the wild animals. They gave the highest priority to Trans-locate wild animals (mean= 1.709, p= 0.00). Other than that, they are willing to accept the support of government institutions to minimize crop losses (mean= 1.636, p= 0.00) and willing to spend money on new technologies to minimize crop losses (mean= 1.254, p= 0.00). However, the farmers give positive response to kill animals (mean= -1.182, p= 0.00).

4. Conclusions

The highest crop loss was caused by peacock (50%) and the lowest crop loss was done by jungle fowl (5%). The highest calculated crop loss was reported in Luffa while the lowest loss was recorded for Brinjal. Farmers that cultivated Luffa have highly underestimated while those cultivating rice were found to be the lowest underestimated group. Further, most of the farmers were mainly using traditional methods to minimize crop losses by wild animals. Furthermore, there is a high preference among the farmers to Trans-locate wild animals to other protected places. Therefore, proper awareness on crop losses, estimated methods, prevention methods with new technologies and suitable methods to translocate animals should be established towards food security and economic uplift by minimizing crop losses.

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Effect of non-tariff measures on the spice exports of Sri Lanka: a gravity approach

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1. Introduction

The spice sector is one of the important sources of generating foreign exchange for Sri Lanka. Sri Lanka has a comparative advantage with higher quality spices, and hence there is an opportunity in the international market that is yet to be exploited. To penetrate such markets, adhering to the certain regulations and policies in the importing countries becomes pivotal. These regulatory measures are commonly referred to as Non-tariff Measures (NTMs). According to the United Nations Conference on Trade and Development (UNCTAD, 2015), NTMs are defined as any trade policy instruments used to regulate international trade other than ordinary tariffs. This study focuses on quantitatively analyzing the impact of NTMs on Sri Lankan spice exports. There is a dearth of studies conducted in Sri Lanka investigating the link between NTMs and spice exports. To fill this gap, this study uses a detailed dataset and a gravity model to identify the key drivers that determine spice exports from Sri Lanka.

2. Materials and Methods

A panel dataset was constructed after extracting data from several databases[1]. Data were extracted from 2001 to 2017 from the top 12 spice exporting countries (Canada, Egypt, France, Germany, India, Mexico, Pakistan, Saudi Arabia, Spain, U.A.E., UK, USA) across 18 product categories[2] at the HS-6-digit level for pepper, cinnamon, clove, nutmeg, mace, and cardamom. For NTMs, the standard classification of the UNCTAD (2015) was used and data were collected for Sanitary and Phyto-sanitary Measures (SPSs), Technical Barriers to Trade Measures (TBTs), and other types of NTMs which were applied for the selected spices.

Trade literature elicits several analytical techniques used in gravity modelling (Weerasooriya, 2021). Out of these, the Poisson Pseudo Maximum Likelihood (PPML) regression model was used to counter the highly heteroskedastic error term and the presence of zero trade flows (Santos Silva & Tenreyro, 2006). The following two regression equations were estimated using PPML.

$$X_{ijt}^{k} = \beta_0 + \beta_1 \ln(GDP)_{it} + \beta_2 \ln(GDP)_{jt} + \beta_3 ln(POP)_{it} + \beta_4 ln(POP)_{jt} + \beta_5 \ln(DIS)_{ij} + \beta_6 colony_{ij} + \beta_7 ln(1 + tariff)_{ijt}^{k} + \beta_8 bsps_{ijt}^{k} + \beta_9 btbt_{ijt}^{k} + \varepsilon_{ijt}^{k}$$

$$X_{ijt}^{k} = \alpha_0 + \alpha_1 \ln(GDP)_{it} + \alpha_2 \ln(GDP)_{jt} + \alpha_3 ln(POP)_{it} + \alpha_4 ln(POP)_{jt} + \alpha_5 \ln(DIS)_{ij} + \alpha_6 colony_{ij} + \alpha_7 ln(1 + tariff)_{ijt}^{k} + \alpha_8 btotntm_{ijt}^{k} + v_{ijt}^{k}$$

[1]Export value data: Trade Map and UNCOMTRADE, GDP and population data: World Bank Database, the distance between bilateral trade partners and common colonies: Institute for Research on the International Economy (CEPII), tariff rates: World Integrated Trade Solutions (WITS), NTMs: Trade Analysis Information System (TRAINS) of the UNCTAD.
[2]Pepper: HS090411, HS090412 Cinnamon: HS090610, HS090611, HS090619, HS090620 Clove: HS090700, HS090710, HS090720 Nutmeg: HS090810, HS090811, HS090812 Mace: HS090820, HS090821, HS090822 Cardamom: HS090830, HS090831, HS090832

where X_{ijt}^{k} is the export value of product k to the i[th] importing country from Sri Lanka at time t, GDP_{it} and POP_{it} are the gross domestic product and population of i[th] import country at time t, $GDP_{jt}$and POP_{jt} are the gross domestic product and population of Sri Lanka at time t, DIS_{ij} is the distance between the capital of the i[th] import country and the capital of Sri Lanka, $Tariff_{ijt}^{k}$ is the tariff rate imposed by country i for exported product k from Sri Lanka, $bsps_{ijt}^{k}$, and $btbt_{ijt}^{k}$ are dummy variables where 1 if SPS or TBT measures in country i are present for the exported product k from Sri Lanka at time t, and 0 otherwise respectively, $btotntm_{ijt}^{k}$ is a dummy variable where 1 if NTM measure in country i is present for the exported product k from Sri Lanka at time t and 0 otherwise, $colony_{ij}$ is a dummy variable where 1 if country i and Sri Lanka were in a colonial relationship and 0 otherwise, and ε_{ijt}^{k} and v_{ijt}^{k} are the error term. The Ad-valorem equivalent was computed to compare the effects of NTMs and tariffs using the method which was suggested by Kalaba and Kirsten (2012) and Weerasooriya (2021).

3. Results and Discussion

All the variables showed an increasing trend with the time except for distance and colony. The Cinnamon "Cinnamomum zeylanicum Blume" (excluding crushed and ground) (HS090611) is the highest exported spice whereas Cinnamon and cinnamon-tree flowers (excluding cinnamon "Cinnamomum zeylanicum Blume" and crushed and ground cinnamon) (HS 090619) is the least exported. It was found that cinnamon is highly regulated through NTMs and nutmeg, mace, and cardamom also had similar regulations. SPS measures contributed 63% of the total NTMs followed by TBT measures (15%) and other types of NTMs (22%) for Sri Lankan spices. From 2001 to 2017, tariff rates on spice exports have declined whereas NTMs have increased as shown in Figure 1. This highlights the importance of NTMs in the export of spices.

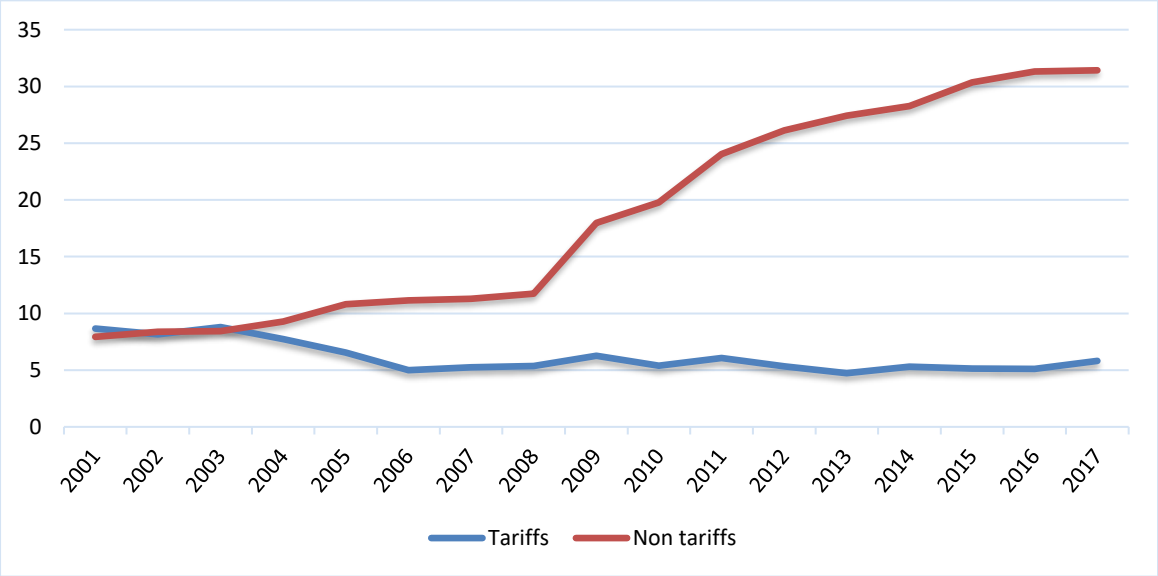

Figure 1. NTM frequency and average tariff rates from 2001 to 2017
(Source: Author's calculation based on WTO and TRAINS database)

The disaggregated type of NTMs applied for all types of spices are requirements for the restricted use of certain substances in foods and feeds and their contact materials (A22), labelling requirements (A31), labelling and directions for use (B31), packaging requirements/restrictions on materials to be used when packaging (A33), licensing, permit, registration requirements for exports (P33), and inspection requirements (A84).

Table 01. Results of the PPML estimation

Variables	Coefficients of the 1st model	Coefficients of the 2nd model
$\ln(GDP)_{jt}$	0.716 (0.712)	0.858 (0.700)
$\ln(GDP)_{it}$	-1.494* (0.271)	-1.132* (0.212)
$ln(POP)_{jt}$	1.841 (11.768)	-0.654 (11.688)
$ln(POP)_{it}$	2.627* (0.317)	2.429* (0.297)
$colony_{ij}$	0.103 (0.322)	0.036 (0.330)
$\ln(DIS)_{ij}$	2.501* (0.408)	2.094* (0.344)
$ln(1+tariff)_{ijt}^{k}$	-0.499* (0.137)	-0.442* (0.136)
$bsps_{ijt}^{k}$	-0.828* (0.360)	-
$btbt_{ijt}^{k}$	1.099* (0.390)	-
$btotntm_{ijt}^{k}$	-	-0.483* (0.254)
$Constant$	-25.234 (32.491)	-17.740 (32.375)

Robust standard errors are in parentheses
*Significance at 5% level

Two models were estimated using PPML. The first model included the dummy variables of specific types of NTMs (i.e., SPS and TBT). Based on the results shown in Table 1, the GDP of the importing country, the population of the importing country, distance, tariff, SPSs, TBTs are statistically significant ($p<0.05$). The GDP of Sri Lanka, the population of Sri Lanka, and the dummy for the colony were not statistically significant ($p>0.05$). Also, the GDP of the importing country, tariffs, and SPS measures have a negative effect whereas the population of the importing country, distance, and TBT measures have a positive effect on Sri Lanka's spice exports.

A 1 percent increase in the GDP of the importing country decreases the spice exports by 1.494 percent, and a 1 percent increase in the tariff decreases the spice exports by 0.499 percent. When SPS were imposed, the spice exports decreased by 56.3 percent ($e^{-0.828}-1=-0.563$), and surprisingly when TBT measures were imposed, the spice exports increased by 200.1 percent ($e^{1.099}-1=2.001$).

The second model included the dummy variable for total NTMs. The results of the second model are in line with the first model. According to the results of the second model, a 1 percent increase in the GDP of importing countries decreases the spice exports by 1.134 percent. A 1 percent increase in the tariffs decreases the spice exports by 0.442 percent. When any kind of NTM was imposed, the spice export decreased by 38.3 percent ($e^{-0.483}-1=-0.383$). Ad-valorem equivalent of total NTMs had an equivalent tax of 1.98 percent increase on spice exports. Further, SPS contributed to increasing spice exports by an equivalent tax of 4.30 percent whereas TBT decreases the exports prices by an equivalent tax of 0.90 percent.

4. Conclusions

SPS measures and total NTMs have a negative effect on spice exports of Sri Lanka whereas TBT measures have a positive effect on Sri Lankan spice exports. Therefore, the combined result could have a mixed effect on spice exports. This highlights the importance of NTMs in shaping spice trade and hence would help promote spice growers and policy makers to be aware and understand how NTMs work and how they can influence exports.

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Revealed comparative advantage and trade patterns in international trade: A study based on leading agricultural exports in Sri Lanka

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1. Introduction

Agricultural trade plays a vital role in the Sri Lankan economy as a promising source of foreign earnings. Moreover, Sri Lanka had a strong competitive position in the agriculture sector (Hettiarachchi, 2018). However, it is questionable whether Sri Lanka's existing major agricultural exports are based on comparative advantage and how this advantage is used over a past period. Therefore, this study mainly focused on examining the Revealed Comparative advantage (RCA) during 2007- 2019 and Revealed Symmetric Advantage (RSCA) in the years 2007 and 2019 of the agricultural commodities.

Further, COVID -19 creates a tremendous impact on human lives by creating unprecedented changes including in the agriculture sector and trade. The measures taken by the government as outbreaks continue to spread have a severe impact on international trade and the Sri Lankan government adopted different trade policies during the COVID-19 pandemic. Hence the study is timely and attempted to identify the potential commodities in trading during this COVID- 19 pandemic and the way of taking this situation as an advantage. No recent study was attempted to examine the comparative advantage throughout the years and impact of COVID-19 on agricultural trade in Sri Lanka. By having a deeper insight into the comparative advantage and the patterns of trade, the policymakers could make sound policy strategies to focus on goods in which Sri Lanka's comparative advantage in agricultural exports exists. Finally, a comparison is carried out to see the differences in the comparative structure of agricultural commodities between Sri Lanka and Bangladesh as Bangladesh is considered a country with positive economic growth in South Asia which is very similar to that of Sri Lanka. With this background, it would be of timely importance to analyze the patterns of trade and the comparative advantage of the agricultural commodities in Sri Lanka**.**

2. Materials and Methods

Data were obtained from the Central Bank monthly Bulletins and UNCTAD stat web portal. In analyzing the patterns of trade during the COVID-19, the study used the monthly export values from Central Bank monthly bulletins for having a broad insight.

The Revealed Comparative Advantage concept is developed by Balassa (1965 and 1977) to identify the relative trade performance of individual countries for a particular country. Balassa Index (Balassa, 1965) is the widely used in the literature to calculate the RCA for the countries with the sectorial specialization. RCA values were obtained from the UNCTAD stat web portal and RSCA values are calculated to have a complete view of the comparative advantage that Sri Lankan agricultural commodities enjoy in international trade. Results will be analyzed through Descriptive analysis methods (by Graphs, charts, and tables) and RCA values and RSCA values as the theoretical frameworks.

Revealed Competitive Advantage Index

RCA Values were obtained for the agricultural commodities from 2007-2019 by using the following equation (Balassa 1965; 1997).

$RCA_i = \left(X_{ij} \in X_j\right) / \ X_{I,World} / \in X_{World}$

$RCA_i =$ Revealed Comparative Advantage

$X_{ij} =$ Exports of good i by country j

$\in X_i =$ Total Export of country j

$X_{I,World}$ = World Exports of good i

$\in X_{World} =$ Total world exports

Classification of RCA (Hinloopen & Marrewijk, 2001)

Class A
RCA Value = 0-1
Interpretation = No comparative advantage

Class B
RCA Value = 1-2
Interpretation = Weak comparative advantage

Class C
RCA Value = 2 – 4
Interpretation = Moderate comparative advantage

Class D
RCA Value = 4<
Interpretation = Strong comparative advantage

Revealed Symmetric Advantage Value (RSAV)

The concept of RSAV is developed by Dalum et al. (1998) and Widodo (2009) to measure trade competitiveness. The purpose of this analysis is to have a complete view of the comparative advantage that Sri Lankan agricultural commodities enjoy in international trade and to calculate the RSCA values in the years 2007 and 2019 by referring to the method introduced by Dalum et al. (1998) and Widodo (2009) as following.

$$RSCA = (RCA - 1) / \ (RCA + 1)$$

3. Results and Discussion

3.1 Revealed Comparative Advantage of main Agricultural Commodities (2007 – 2019)

Table 01. Revealed Comparative Advantage of main Agricultural Commodities (2007 – 2019)

Class	SITC code	Type of Product	2007	2009	2011	2013	2015	2017	2019
D	074	Tea and Mate	348.4	324.2	330.7	315.4	240.1	239.8	237.9
D	075	Spices	53.1	42.3	49.1	77.9	53.4	48.5	34.2

D	046	Meal and flour of Meslin	20.5	15.7	41.3	11.1	8.5	5.9	8.0
D	058	Fruit preserved and fruit preparation	2.6	3.3	4.1	4.3	5.1	6.5	6.1
D	034	Fish (Fresh live or dead)	5.8	5.9	4.4	5.3	3.5	3.8	4.0
C	057	Fruits and nuts (Excluding oil nuts)	2.4	2.1	3.4	2.3	3.3	2.2	3.2
C	036	Crustaceans, Molluscas and aquatible invertibrates	3.0	2.3	2.8	3.5	2.0	1.8	2.4
C	072	Cocoa	<0	<0	1.7	<0	<0	<0	<0
C	098	Edible products and preparations	1.8	1.0			1.5	1.5	1.8
B	081	Feeding stuff for animals (No unmilled cereals)	1.8	2.2	1.8	1.4	1.6	1.6	1.6
B	035	Fish, Dried salted or in brined , smoked fish	1.3	1.2	1.4	1.3	1.1	1.6	1.5
B	047	Other cereal meals and flour	<0	1.0	<0	1.2	1.2	1.7	1.5
A	054	Vegetable	<0	1.1	<0	<0	<0	<0	1.1
A	025	Birds eggs and Egg yolks egg albumin	<0	<0	<0	<0	<0	<0	1.0

Source: UNCTAD stat web portal

According to the results, roughly 14 agricultural products in Sri Lanka enjoy a comparative advantage. The country holds a strong comparative advantage in tea and mate, spices, meal and flour of meslin, fruit preserved and fruit preparation, fish (fresh live or dead). Unfortunately, all these five product groups exhibited downward trends in their comparative advantage throughout these years. However, there is an increasing trend in Fruits and nuts (excluding oil nuts), edible products and preparations, and fish dried salted or in brined smoked fish. Vegetables and cocoa loss their advantages in many of the years. Considering the comparative advantages between Sri Lanka and Bangladesh, Sri Lanka is more advantageously placed than

Bangladesh in 8 agricultural commodities, and Bangladesh is more advantageously placed than Sri Lanka in 2 agricultural commodities.

3.2 Revealed Symmetric Advantage (RSCA) (2007 and 2019)

Concerning the RSCA values, tea and mate, spices, meal and flour of meslin, fruit preserved and fruit preparation, and fish (Fresh life or dead) accounted for high values of RSCA. Comparing the RSCA values (in 2007 and 2019) of the top 5 commodities with the highest RCA values 4 commodities show a declining trend whilst only fruit preserved and fruit preparation indicate an increasing trend for RSCA values.

3.3 Patterns of trade of agricultural commodities during COVID -19

Concerning the tea sector, after COVID-19 hits, it can see a huge drop in value between March – April 2020. The worldwide logistics networks are messed up, and cargo and port clearance processes in Sri Lanka have been delayed. RCA value for tea in 2020 is at 143.87 and is a huge drop compared to previous years. Besides the tea industry, other agricultural commodities like spices, coconut-based products, fruits, and vegetables also show a declining trend. However, the rubber base products indicated an increasing trade during COVID -19 period.

4. Conclusions

As indices by RCA values, the five main agricultural commodities of Sri Lanka enjoy a strong comparative advantage. It is sad to note that all these five commodities experiencing a downward trend in RCA. Moreover, the COVID- 19 creates a favorable environment to increase the trade-in Tea and Spices as many researchers profound that the more tea and spices as immunity boosters. Unfortunately, these commodities do not show any positive sign in trade. As a result, the country must pay close attention to current policies and diversify high-tech, and value-added products to increase the country's share of agricultural export in international trade.

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Consumer perception and willingness to pay for organic vegetables vs. non-organic vegetables: Insights from Gampaha district in Sri Lanka

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1. Introduction and Objectives

Vegetable cultivation has a long history in Sri Lanka. As an agricultural country, farmers cultivated vegetables in *Chena* in early time. They used traditional methods and all the vegetable productions were organic. But in recent decades all the agricultural lands were commercialized to cater the demand for food with increasing population in Sri Lanka (Weerakkody & Mawalagedara, 2020). Various types of agrochemicals are introduced to the market and farmers use them without any limitation. Researchers have identified the negative effects of such agrochemicals on human health like chronic kidney disease, neuron disease, cancers and the environmental issues like contamination of soil and water with toxic heavy metals in agrochemicals (Wimalawansa & Wimalawansa, 2014). Due to these various negative consequences of non-organic productions, today's food consumption patterns are changing towards organic foods (Wijesinghe and Nazreen, 2020; Reganold & Wachter, 2016).

There are some difficulties faced by organic farmers i.e. high initial cost for the protected houses and the extra costs for getting certifications like pesticide residue testing and some other services for organic farming (Muhammad *et al*., 2015). Further, researches have mentioned that organic farmers gain lower yield instead of higher cost per acre when compared to non-organic farming. Researchers have pointed out that organic farmers need higher break-even prices and price premiums for organic vegetables compared to non- organic vegetables (Muhammad *et al*., 2015). Hence, the objectives of this study were to determine: the consumers' perception on organic vegetables, consumers' willingness to pay for organic vegetables over non-organic vegetables, and the effects of socio-demographic characteristics on willingness to pay for organic vegetables in case of Gampaha District in Sri Lanka.

2. Research Methods

Conceptual Framework

Selected variables for the research were depicted as in the following conceptual framework (Figure 1).

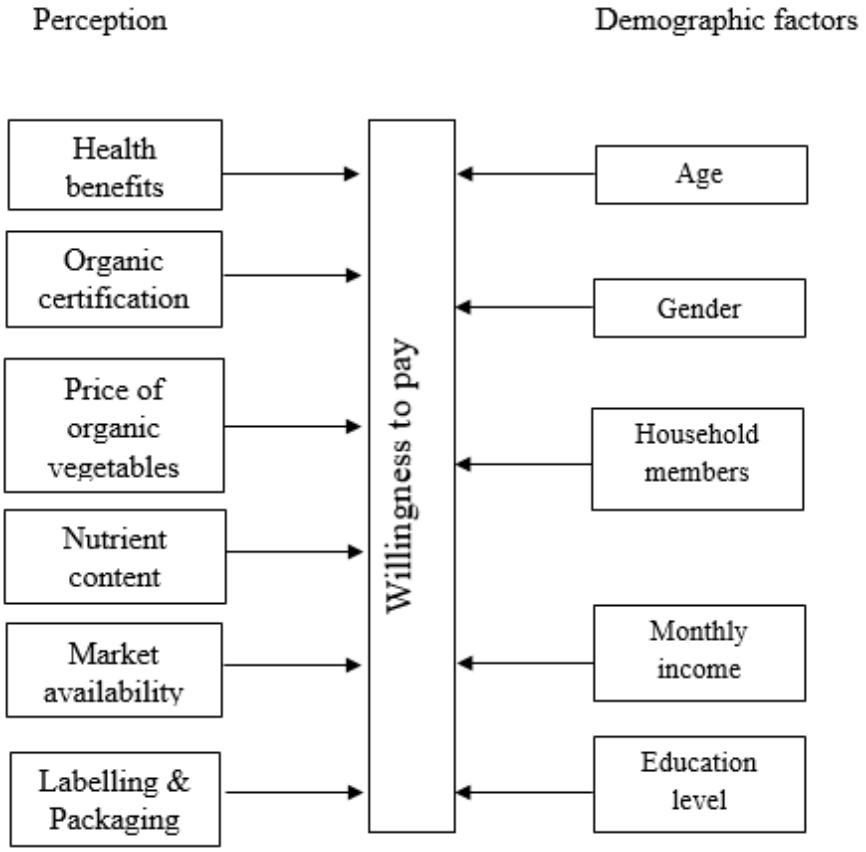

Figure 1. Conceptual framework for the study

The survey questionnaire was consisted of information on consumers' socio-demographic factors i.e. age, gender, number of household members, monthly household income, education level and consumers' perception on organic vegetables and willingness to pay. Consumer perception was measured by six criteria i.e. health benefits (benefit of not containing chemicals), organic certification, price, nutrient content (freshness and content of nutrition), availability & labelling and packing of the organic vegetables. Perception factors were measured using five-point Likert scale ranging from 1(strongly agree) to 5 (strongly disagree).

Data Collection

Primary data were collected from 260 consumers selected by multi-stage sampling technique in Gampaha district. Four Divisional Secretariats (DS) were selected in the first stage and five Grama Niladari (GN) divisions were selected from each DS division as the second stage. Selected DS divisions were Attanagalla, Divulapitiya, Dompe and Mahara. Thirteen households were selected randomly from each GN division, and one family member (mainly house wife or head of the household) from each household was interviewed by face to face.

Data Analysis

Willingness to pay has been defined as the maximum amount a person would be willing to pay, or sacrifice to purchase a product or not to purchase that is undesired or uninterested (Wijesinghe and Nazreen, 2020). Data were analysed by using the R 3.6.2 statistical software. Logistic Regression was used to determine the impacts of independent variables on willingness to pay. The contingent valuation method was used to determine the consumer preference for vegetables with the 'organic' attribute.

3. Results and Discussion

The percentage values considered for the premium bids that the respondents were willing to pay additional for the organic vegetables over non-organic vegetable prices were 5%, 10%, 15%, 20%, 25% and 30% and the lower bids for the organic vegetables over non-organic vegetable prices were 5%, 10%, 15%, 20%, 25% and 30% .

The study found that 100 percent of consumers have chosen organic vegetables instead of non-organic vegetables at the equal price. The results revealed that seventy percent of vegetable consumers agreed to pay an additional amount for organic vegetables. The majority of them (32%) selected 5% price premium for organic vegetables than non-organic vegetables. Another 22% of consumers willing to pay 10% of price premium for organic vegetables, 20% of consumers willing to pay 15% of price premium, 17% of consumers willing to pay up to 20% additional, 6% of consumers willing to pay 25% of price premium and 3% of consumers willing to pay 30% of price premium for organic vegetables than non-organic vegetables. When bid prices are increased the consumers' willingness to pay decreases. Further the results revealed that 30% of consumers disagreed to pay any additional amount for organic vegetables even though there are benefits as defined in the research.

The indicators used to measure the perception of healthiness of organic vegetables were, organic vegetables are safe to consume, having negative effects of synthetic chemicals on the environment, having negative effects of chemicals on human health and belief of no any chemical residue in organic vegetables. The indicators used to measure the perception of organic certification were, it is important for a product to be certified as organic, organic vegetables are more expensive and cost of production for organic vegetables are higher. The indicators used to measure the perception of organic vegetables are more nutritious were, organic vegetables have more freshness and organic vegetables have more nutritive values than non-organic.

Results reveal that monthly income and education level significantly influence on willingness to pay for organic vegetables (Table 01).

Table 01. Estimation results of the full model of contingent valuation method for organic vegetables

Variable	Co-efficient	SE	P-value
Age	0.36099	0.18842	0.05538
Gender	0.39559	0.49740	0.42644
Number of household members	0.10580	0.23128	0.64735
Monthly income	0.22090	0.08747	0.01155*
Education level	0.34512	0.15968	0.03067*
Perception on health benefits	-2.70472	0.51023	0.000***
Perception on certification	0.84295	0.40900	0.03930*
Perception on price	0.43337	0.34648	0.21102
Perception on nutrient content	-0.84777	0.30506	0.00545**
Perception on market availability	0.83023	0.50477	0.10002
Perception on labelling & packaging	-0.63019	0.40429	0.11905

*Note: SE-Standard error, *P < 0.05, **P < 0.01, ***P < 0.00*

Perception factors i.e. organic vegetables are healthier, certified organic vegetables are real organic, and organic vegetables are more nutritious significantly influence on willingness to pay for organic vegetables. The reason of getting negative co-efficient values for the above perception factors is due to the reversed corded questions used as 1 denoted strongly agree and 5 denoted strongly disagree in the Likert Scale. Hence, negative values showed positive effects. Age, gender and number of household members do not show any significant impacts on willingness to pay for organic vegetables.

Consumers prefer to consume organic vegetables due to the belief of not containing residues of pesticides. Further, consumers prefer to purchase certified organic vegetables due to the belief of certified products are real organic. Through this study organic farmers and policy makers can get an idea about consumers' willingness to pay attributes for organic vegetables. Policy-makers can identify cross price effects refers to the organic and non-organic vegetables. Accordingly they can set the pricing policies for organic products.

4. Conclusions

Seventy percent of consumers agreed to pay an additional amount for organic vegetables and thirty percent of consumers do not agree to pay any additional amount for organic vegetables.

Monthly income and education level significantly influence on willingness to pay for organic vegetables. When consumers' income is increased price premium for organic vegetables are increased. Perception factors i.e. organic vegetables are healthier, certified organic vegetables are real organic, and organic vegetables are more nutritious are the factors contribute to extra pay decision for organic vegetables.

As the majority of consumers (70%) were willing to pay extra for organic vegetables, there is a huge potential to expand the organic vegetable market in Sri Lanka. Organic foods are the new market concept in the world. This is the best time to introduce new market strategies to extend the market segment in organic vegetables in the country. Through these findings, organic farmers can get an idea about what consumers expect from organic attribute and cross price effects of organic and non-organic vegetables. As consumers believe organic vegetables are as real organic, farmers should practice exact organic practices in the field.

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Revisiting the trends of Covid-19 pandemic to shape the export-oriented beverage sector in Sri Lanka

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1. Introduction

World has experienced a devastating health pandemic which has influenced almost all the sectors around the world. Export industry is one of the prominent industries panicked due to the shock and tensions evolved by the COVID-19 pandemic (Roshana et al., 2020). Beverage industry in Sri Lanka was renown to the world due the production and exporting of world best quality tea since the colonial era. By taking the ongoing disruptions into consideration, the pandemic allows to rethink about creating an efficient market for food and beverages (Chowdhury et al., 2020). Beverage industry performance in Sri Lanka has decreased by 4.5 percent in first quarter of 2020. Impose restrictions has crippled the economic activities further including the exports (Goolsbee & Syverson, 2021). Food and beverage sector has contributed 4.7 percent to the 2020 exports earning (Central bank of Sri Lanka, 2020). In early stages of the pandemic, a trend of increased hot beverages consumption was exhibited in the international market (Pieroni et al., 2020). Identification and capitalization of opportunities immediately were resulted high gains such as Canadian agriculture industry recorded an economic boom by 11%. Only a hand full of studies have eyed to evaluate the impact of the pandemic to other industries and none of the studies were conducted to capitalize the potential opportunities. The study aims to identify the beverage industry trends during the pandemic in Sri Lanka and identify the possible new opportunities in the world to capture the new markets.

2. Materials and Methods

Research methodology of this study was best described as mixed methods, comprising of quantitative data of export quantities of beverages used for trend analysis from 2018 to 2021 March for export-oriented beverage market using moving average forecasting. Qualitative data collection by key informant interviews were deployed to gather data to identify the potential opportunities and markets. Behaviour of the industry performance was analysed based on the export volumes and export earnings. Trend analysis was conducted with secondary data sources of all resisted beverage exporters under Sri Lanka Export Development Board (EDB), Sri Lanka Customs and data base of Forbes & Walker Tea Brokers (Pvt) Ltd. Key informant interviews (15) and structured telephone interviews (11) were used to extract the new market information.

3. Results and Discussion

The study identified the export-oriented beverage industry in Sri Lanka has affected by the COVID-19 pandemic and the activities were restricted due to various impediment including travel restrictions, curfews and closing down the ports. Fifteen major categories (Bulk tea, tea Bag, Green tea, Herbal tea, White tea, Flavoured tea, Herbal Infusion, Ice tea, Coconut water, Coffee beverages, Fruit beverages, Carbonated drink, Dairy products, Chocolate drinks, Alcoholic beverages) were identified by the research via analysing the product categories of each registered exporters related to export-oriented beverage industry. Online directory of the beverage exporters (203) at Export Development Board online platform were analysed with the product sub categories. Majority of the exporters (93.75%) in the beverage industry of Sri

Lanka were identified as Ceylon tea related product exporters. The results provide significant insights of increasing trend in exporting the value-added forms of Ceylon tea products. Export figures of instant tea have indicated the level of increasement in export quantities during the pandemic. Figure 01 explain the exports of tea bags forms also deployed an increasing trend during the pandemic and most importantly, analysis has not recognized a significant increment of exports in the form of bulk tea or non-value-added tea.

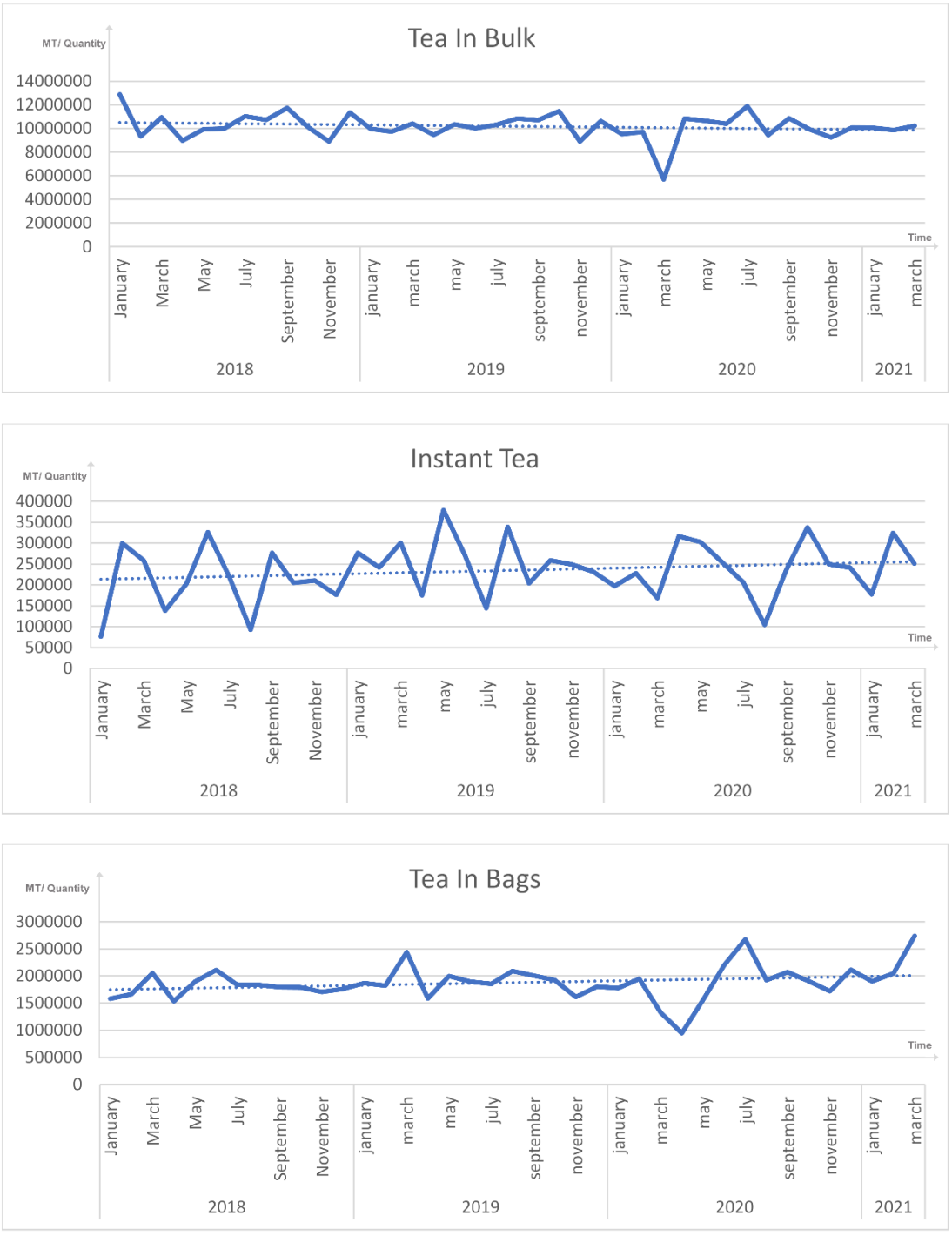

Figure 1. Export trend in bulk tea, instant tea and tea in bags

Industry experts and key informants have confirmed the demand for the value-added forms of beverages have increased during the pandemic. By the analysis the data indicated the tea sector

has severely affected during the inception of the pandemic in March 2020. Colombo Tea Auction was responsible for exporting around 90% of the Ceylon tea to global destinations while weekly an average of 6,000 - 7,000 MT was purchased through the platform. Government decision on taking the tea auction on in to online platform created a huge impact in revenue generation. If the tea auction was not be able to operate in online platform, it could have been resulted devastating consequences to the industry since the ground level production was continued with the usual capacity. Prompt implementation of strategies to mitigate the adverse effects helped to regain the performance. Further, the export data of beverage sector has indicated a behaviour in increasing trend towards the Chinese market. Study has recognized the importance of digitalization of the market which allows value-chain members to participate in the business activities even during the pandemic conditions accordance with the information extracted from key informants. Beverage industry consists of a crying need to convert the less and non-value-added forms to high value-added forms which has a high demand during the pandemic.

4. Conclusions

Study recognized 93.75% of concentration of tea related products in the export-oriented beverages industry in Sri Lanka. Industry has recognized digitalization activities will result to efficient the market activities and positive trends in digitalization of market. Tea related products were gaining profits back to country due to adaptation to digitalized market platforms. Lack of flexibility in manufactures and exporters to adopt to the new normal situation and product diversification have resulted losing the potential markets. Improvement of the demand towards the value-added products and increasement the Chinese market demand were identified as a positive trend in exports and market diversification.

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Analysis of market participation among vegetable farmers in north- central province, Sri Lanka

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1. Introduction

Market participation can be identified as a means of effectively integrating smallholder farmers into commercial-level agriculture. Improved market access provides the opportunity for agricultural households to shift from subsistence farming to commercial level farming (Makhura, 2001; Jagwe et al., 2010). Nevertheless, the participation of farmers in domestic and regional markets in Sri Lanka remains low due to a range of constraints. Poor market access of the farmers can be specified as one of the constraints. Market participation of farmers has been widely studied in other developing countries (Kassa et al., 2017; Amao & Egbetokun, 2018; Kyaw et al., 2018). However, very few studies have empirically investigated the market participation of smallholder farmers in Sri Lanka (Abeykoon et al., 2014). The objectives of the current study were to analyze the market participation among vegetable farmers and to determine the factors that influence market participation in North- Central Province, Sri Lanka.

2. Materials and Methods

Using stratified sampling technique, 93 smallholder vegetable producers in Anuradhapura and Polonnaruwa districts were selected for the primary survey. Data were collected using pre-structured, interviewer-administered questionnaires through face-to-face interviews and telephone interviews. Before the original survey, for the initial research, pilot tests were conducted with a sample of 10 smallholder farmers to confirm that there were no limitations, weaknesses, or shortcomings in its design and data collection equipment. The data were analyzed using the descriptive statistics, and Heckman two-stage selection model. To process the data STATA computer program was used.

3. Results and Discussion

Descriptive analysis results showed that 89% of market participants are male farmers. This showed that a large percentage of market participants are male-headed households. Smallholders, mean age was 48 years old; the mean household size was 4. Among them, 46% of the respondents had access to agricultural extension services. The remaining 54% of the respondents did not have access to extension services. Regarding access to credit, 74% of the respondents had access to credit. The educational attainment of the respondents revealed that 48% have secondary education up to GCE O/L. Regarding access to market information, 71% of the respondents had access to market information from formal and informal sources (like neighbours' and brokers), and the remaining 29% of the respondents did not have access to information. Out of the total vegetable growers, most of the market participants have inherited lands (68%). When considering farmers' perception of vegetable market price 51%, of the farmers, were satisfied with vegetable market price while none of the farmers were dissatisfied with the vegetable market price. 30% of the farmers, were facing the problem of the intermediary effect both from medium and large-scale producers and from brokers.

The Heckman two-step model was used to determine the factors influencing market participation decisions and the extent of the market participation decision of the farmers. According to the probit model results (Stage 1) reported in Table 1, gender, off-farm income status, vehicle ownership, access to market information, and farming experience significantly

influenced the farmer's decision to participate in the vegetable market. Ordinary lease squared regression was estimated in the second stage of the Heckman outcome equation to determine the factors that influence the extent of market participation. The results revealed that access to market information and farmers' perception about vegetable prices significantly determine the extent of market participation.

The Inverse Mills Ratio (IML/Lambda) or selectivity bias correction factor was positive at (4.2666) but had a statistically insignificant impact on the value of the vegetable sale. This result suggests that no unobserved factors that might affect both probabilities of market participation and the level of market participation. The difference in the probability of market participation among smallholders was defined using marginal influences.

Table 01. The Heckman two-step: **selection equation and outcome equation results**

Heckman selection model -- two-step estimates Number of obs = 93 Selected = 65, Non-Selected = 28, Prob > chi2 = 0				
Variable	Parameter Estimates			Marginal Effect
Market Participation	Coef.	Std. Err.	P>|z|	Coef.
Gender	2.198**	1.003	0.028	0.157
Education	0.798	0.546	0.144	0.057
Off-farm Income	-1.812**	0.902	0.044	-0.129
Vehicle ownership	2.743**	1.075	0.011	0.196
Access to market information	2.776**	1.384	0.045	0.198
Access to extension services	-0.527	1.124	0.639	-0.038
Farming Experience	0.112**	0.058	0.055	0.008
Land size	0.199	0.211	0.343	0.014
Access to credit facilities	0.544	0.977	0.578	0.039
Constant	-6.391	2.808	0.023	
Level of Market Participation				
Farming Experience	0.111	0.137	0.415	
Gender	0.607	4.581	0.895	
Household size	1.475	1.058	0.163	
Off- farm income	2.349	2.029	0.247	
Access to market information	15.336**	6.295	0.015	
Market value	17.475***	2.682	0	
Constant	16.811	10.995	0.126	
Mills lambda	4.267	5.767	0.459	
Rho	0.543			
Sigma	7.859			

*** = significant at 1%, ** = significant at 5%

4. Conclusions

This study analysed the market participation of vegetable farmers in North Central Province, Sri Lanka. These findings provide useful insight into what factors need to be the target to stimulate market participation and the intensity among farmers. The study found that the market participation of vegetable farmers is constrained by several factors such as intermediary effect and poor infrastructure. As revealed by the econometric analysis, market participation is

significantly determined by such factors as gender, off-farm income, vehicle ownership, access to market information, farming experience, while the intensity of market participation is determined by access to market information and market value. In order to promote the market participation the government and the non-government institutions should concentrate on improving the accessibility for market information (price trends, market requirements and standards, future demand and dynamics in consumer preferences) and lowering the transaction costs.

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Consumer choice of branded and unbranded edible oils: A case in Badulla region

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1. Introduction

Currently, Sri Lankan domestic market has high substitutability of a wide variety of edible oils. There are branded and unbranded oils as imported and local types in the current cooking oil industry. Coconut oil and other vegetable oils such as palm oil, soybean oil, sunflower oil, and corn oil are the most popular edible oils among the Sri Lankan community. Due to this increased variety, the customers are led to difficulties in deciding which type or a particular brand of edible oil to purchase. Although, some consumers are certain of the form and brand of edible oils they choose, others are torn between the two. In addition, besides the fact that consumers are loyal to specific edible oils or not, it is debatable whether they are fully aware of why and how these oils could satisfy their consumption goals. According to Taylan (2013), the key issue currently faced by the consumers is a lack of awareness/perception and information about edible oils. In addition, there could be certain other determinants that affect the purchasing behaviour of edible oils by the consumers. In the light of this context, the authors attempted to identify consumer behaviour in terms of edible oil purchases by consumers in Badulla, the capital region in Uva province. Consequently, the study was conducted to investigate the factors affecting consumer choice of branded and unbranded edible oils in the Badulla region.

2. Materials and Methods

The study employed primary data gathered from consumers in the Badulla region. Prior to the formal survey, a pilot study was carried out with 10 respondents who consume the edible oils in the Badulla region. Subsequently, the field survey was conducted to collect the required information on consumer socio-economic factors, food context, awareness of edible oils and concern on marketing mix in relation to edible oil purchase (Figure 01), by administering a structured questionnaire. Consumers, who purchase edible oils in the Badulla region, were selected as the population of the study. Among them, 200 respondents were selected as the study sample, using cluster sampling at the first stage, followed by systematic random sampling in the second stage. Out of 15 Grama Niladhari divisions in the Badulla region, 10 were selected using cluster sampling technique. Collected data were analysed using the Statistical Package for Social Science (SPSS) 23 version by conducting both descriptive and econometric analyses. In addition, Cronbach's Alpha Reliability test was performed to check the internal consistency of selected composite variables. In this study, the dependent variable, consumer choice for edible oils was measured based on the category of oil purchased (i.e.; branded edible oils, unbranded edible oils, and both branded and unbranded edible oils). Since the dependent variable is a nominal variable, multinomial logistic regression analysis was performed to identify the significant factors that affects the consumer choice of branded and unbranded edible oils in the Badulla region.

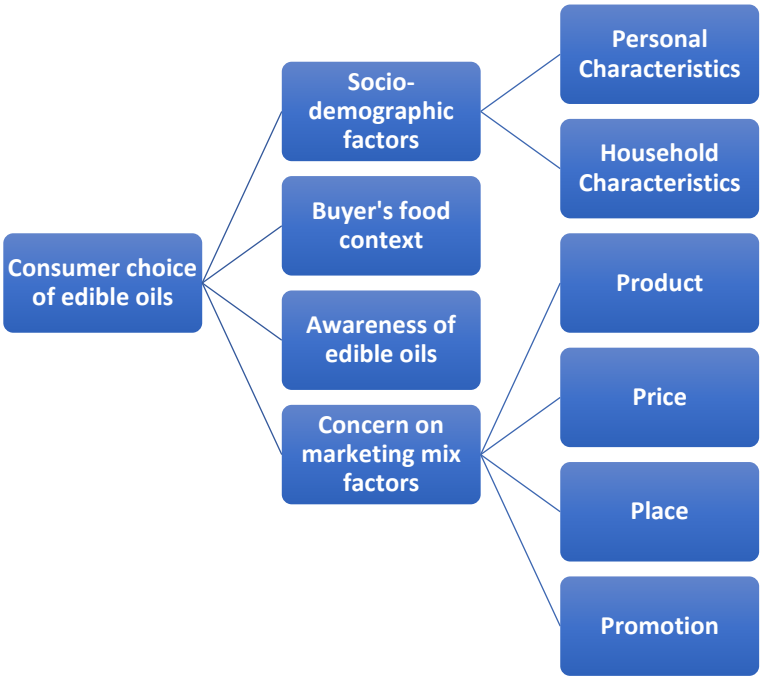

Figure 1. Conceptual framework of the study

3. Results and Discussion

The age of the consumers varies from 24-78 years with an average age of 49 years. Of the sample, majority of the respondents (56.5%) were female. The respondents were engaged in different employments such as private sector employees, self-employees, government sector employees as well as unemployed and retired respondents, while their average monthly income is 40,800.00 LKR. Most respondents have been educated up to G.C.E. Ordinary level (29%) and G.C.E. Advanced level (24.5%) while a considerable number of consumers have obtained tertiary education (16%). The families contain two to eight members, where approximately one member has some special concern on health.

In our study, the consumer awareness on edible oils was measured by obtaining a score to a predetermined set of questions. Accordingly, it was recognized that the majority of the edible oil purchasers (49%) had a low awareness on edible oils. 44.5% show a moderate level of awareness while a small proportion of the sample (6.5%) had a high level of awareness on edible oils. As far as the types of edible oils purchased by the consumers is concerned, it is evident that most of the consumers (71%) buy unbranded Coconut oil while the second highest majority buy branded Coconut oil. The purchase of other types of edible oils is very low among the consumers in the Badulla region.

When the consumer choice of unbranded edible oils was compared relative to the choice of branded edible oils, the multinomial logistic regression results (Table 01) revealed that the multinomial logit for females relative to males is higher for preferring unbranded edible oils to branded edible oils. This indicates that females are more likely than males to prefer unbranded to branded edible oils. When the consumer's age, education level, monthly income, number of persons with non-communicable diseases in the family, concern about product attributes and promotion, awareness about edible oils and monthly expenditure for edible oils are increased by one unit, the multinomial log-odds of preferring unbranded edible oils over branded edible oils would be expected to decrease while the other factors held constant.

When the consumer choice of both branded and unbranded edible oils was concerned relative to the choice of branded edible oils, the multinomial logistic regression results revealed that the multinomial logit for females for preferring both branded and unbranded edible oils (both types of oil) to only branded edible oils relative to males is higher given all other predictor variables in the model are held constant.

Table 01. Results of the multinomial logistic regression

Consumer choice for edible oils		B	Significance	Exp (B)
Unbranded edible oils	Intercept	-1.481	.597	
	Male	-.639	.172	.528
	Age (years)	-.004	.352	.996
	Education level	-.138	.000	.871
	Monthly income (LKR)	-.573	.000	.564
	Family size	.257	.206	1.293
	Diseased persons in the family	-.157	.000	.855
	Concern on product characteristics	-.581	.006	1.788
	Concern on marketing promotion	-.716	.000	.488
	Concern on product price	.129	.000	1.137
	Concern on place	.167	.645	1.181
	Awareness on edible oils	-.353	.000	1.423
	Monthly expenditure for edible oils	-.001	.012	1.001
Both branded and unbranded edible oils	Intercept	-1.507	.557	
	Male	-.548	.206	.578
	Age (years)	.005	.299	1.005
	Education level	-.018	.000	.982
	Monthly income (LKR)	-.602	.000	.548
	Family size	.241	.199	1.272
	Diseased persons in the family	-.051	.002	.950
	Concern on product characteristics	.384	.000	1.468
	Concern on marketing promotion	-.381	.000	.683
	Concern on product price	.076	.025	.927
	Concern on place	.330	.334	1.391

	Awareness on edible oils	.417	.000	1.517
	Monthly expenditure for edible oils	.001	.002	1.001

a. The reference category is: Branded edible oils

The findings indicated that there are three categories of edible oil consumers. They are consumers who purchase only unbranded edible oils, only branded edible oils and both branded and unbranded edible oils. Consequently, most people tend to purchase unbranded edible oil category without considering their health. The most popular edible oil category was unbranded edible oils. Very few people tended to consume branded type edible oils.

4. Conclusions

The findings established that the educational level, monthly income, monthly expenditure for edible oils, concerning product attributes, concerning product promotions, product price, awareness of edible oils and household's persons with non-communicable diseases was a significant factor in its choice of edible oils with a relatively small variation of data. Most consumers in the Badulla region show less awareness of edible oils while the majority purchase unbranded coconut oil for consumption. Very few people tend to consume branded type edible oils.

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Effect of socio-demographic factors on advertising appeals underpinning food choice behavior of young adults in Sri Lanka

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1. Introduction

Advertising appeals; a specific way of framing and delivering a message intended to persuade a consumer to make a purchase, can be used to manipulate people's purchasing decisions. Food choices are often nudged through advertisements (Kahneman, 2011) via different advertising appeals. Thus, advertising appeals have implications for anyone interested in promoting a food product across a target population. Among the two cognitive systems which people use to make decisions, the automatic system underpins intuitive thinking is more pervasive and dominant than rational thinking. Advertisers often make use of a package of techniques, referred to as "nudging" (Thaler & Sunstein, 2008), to target the automatic thinking of people and persuade them to effortlessly buy their target products.

Do advertising appeals have different nudging effects on different people in Sri Lanka?

Although advertising appeals are proven to nudge food choices made by consumers to a great extent, their differential effect on people based on socio-demographic variability is less known. This study attempts to fill the above knowledge gap related to a Sri Lankan population. The study attempted to reveal the effect of socio-demographic factors on advertising appeals underpinning food choice behavior among young adults in Sri Lanka.

The objectives of this research are to identify the advertising appeals that are most receptive to the young adults in Sri Lanka, to investigate whether there is an effect of socio-demographic factors on advertising appeals, and to investigate the effect of socio-demographic factors on the association between food consumption preferences and advertising appeals.

2. Materials and Methods

An online quasi-experiment was conducted over a sample of 445 young Sri Lankans within the age category of 18-39 years. The quasi-experiment sought to find the association between 16 selected socio-demographic characteristics and food choices structured by six different sets of advertising appeals. The respondents were asked to make a choice between two similar food products advertised by two different advertising appeals representing the two opposite ends of the same concept (e.g., modern Vs. traditional).

Socio-demographic information was inquired under four categories as given below.

Table 01. Socio-demographic information

Socio-demographic Category	Variable
1. Biographical and structural demographics (Bio-Structural-Demo)	• Gender (G) • Marital status (MS) • Having children (HC)

2. Household related demographics (House-Demo)	• Type of residence (TR) • Current living status (CLS) • Household type (HT)
3. Employment and career-related demographics (Employment-Career-Demo)	• Employment status (ES) • Current study Status (CSS) • Place of employment (PE) • Transport method to the workplace (TW) • Monthly income (MI)
4. Social learning-related demographics (Social-Learning-Demo)	• Type of area lived at childhood (CA) • Childhood-company (CC) • Type of freedom had at childhood (CF) • Thinking style (TS) • Personality type (PT)

The six pairs of advertisements, each arranged on a bi-polar continuum, were carefully developed. The efforts were made to neutralize the effect of possible other contaminant factors affecting the respondents' choices. For example, to neutralize the logo effect of the brands advertised by each appeal, the logos in each pair of advertisements were designed following a similar format. Similarly, to eliminate the price effect, it was mentioned that the prices of the two products were similar. The questions for the advertising appeals and the food preferences and their answers were shuffled to neutralize the order effect bias.

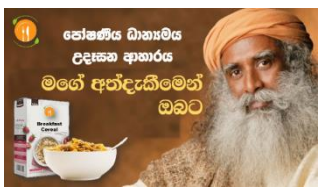
The Cognitive Reflection Test (CRT) was applied to gauge the thinking style (Frederick, 2005) of the respondents. The limitation of having already performed CRT in the past was overcome by asking a question whether the respondents had done these tasks before. The records which had answered "YES" were excluded in the data cleaning process.

A modified ten-item version of the Multidimensional Introversion-Extraversion Scale (MIES) was used to determine the personality of the respondents (So, 2020). The k–means clustering was employed to categorize the sample into two personality groups as introverts and extraverts.

3. Results and Discussion

Table 1 illustrates the most preferred 6 advertising appeals among the 12 advertisements.

Table 01. The twelve advertisements designed under six appeal categories

Category 1			
	Modern Appeal (MA)* Percentage–61.3%		Traditional Appeal (TA) Percentage-38.7%

Category 2

Rural Appeal (RuA)*

Percentage–72.8%

Urban Appeal (UrA)

Percentage–27.2%

Category 3

Oneness with nature Appeal (ONA)*

Percentage–62.7 %

Manipulated Nature Appeal (MNA)

Percentage–37.3%

Category 4

Collectivistic Appeal (ColA)*

Percentage–76.6%

Individualistic Appeal (InA)

Percentage–23.4%

Category 5

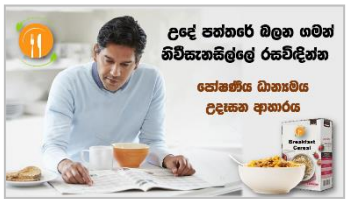
Gain-framed Appeal (GFA)*

Percentage–69.7%

Loss-framed Appeal (LFA)

Percentage–30.3%

Category 6:



Relaxation Appeal (ReA)*

Percentage–69.7%

Convenience Appeal (ConA)

Percentage–30.3%

* The most preferred advertising appeal within each category

With a 2-way chi-square test of independence, the association between each demographic variable and choice corresponding to each advertising appeal was tested. Although there were statistically significant ($p<0.05$), associations between many socio-demographics and choices structured by advertising appeals, the strengths of all the associations were deemed weak by the obtained Cramer's V values (<0.3).

Then, a 3-way chi-square test was run to test the same associations while controlling for each socio-demographic factor concerned. Among the resulted significant relationships, there were strong (Cramer's V>0.5) and moderately strong (Cramer's V>0.3) associations between the socio-demographic factors and the choices structured by the advertising appeals. Furthermore, the odds ratio (OR) was calculated for the associations which were strong and moderately strong.

Among the respondents who had spent their childhood alone, married respondents were 16 times likely to choose collectivistic appeal than the unmarried ones who had a similar childhood experience (OR=16).

Next, with a 2-way chi-square test of independence, the association between relevant food consumption preference and choice corresponding to each advertising appeal was tested. Since the significant association strengths were deemed weak, with a 3-way chi-square test of independence test, the same associations were tested while controlling for each socio-demographic factor concerned. There the strength of the associations seemed to be increased up to moderately strong and strong associations between the food consumption preferences and the choices structured by the advertising appeals. The odds ratios were also calculated for further interpretation.

After scrutinizing the results thoroughly, a pattern could be identified. When considering all the significant associations, among all the socio-demographics, "social learning-related demographics" were found to be more pervasive and influential on the choice for food nudged by advertising appeals. This observation can be explained well following the Social Learning Theory (SLT) (Bandura, 1969). The "social learning" structured by environmental and cognitive factors, aid the choices people make in various circumstances such as in this case; the choice for the food nudged by advertising appeals.

Figure 1 was developed with the results obtained from the 3-way chi-square test of independence for the association between socio-demographic factors and advertising appeals. It interprets the results of the odds ratio for each strong and moderately strong association.

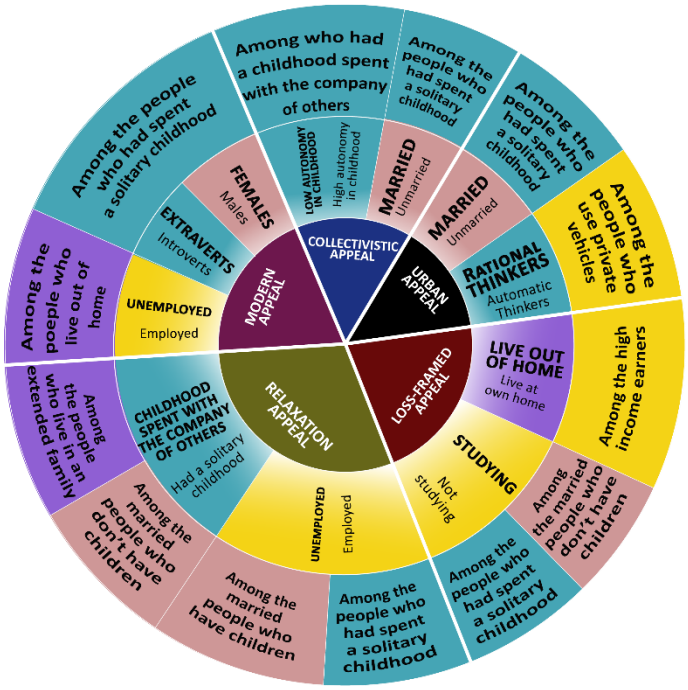


Figure 1. Graphical representation of results of the 3-way chi-square test with odds ratios for the association between socio-demographic factors and advertising appeals

4. Conclusions

The nudge principle that targets the automatic thinking system and its heuristics can be taken into account as a way to approach the above target via advertising appeals that nudge the food choices of people. The results supported the three objectives to be met. It was found that there is an effect of socio-demographic factors and food consumption preferences on advertising

appeals. Within the Sri Lankan context, social-learning-related demographic factors are the most influential on the food choices structured by advertising appeals.

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My special thank is deserved by my beloved family who was with me through thick and thin. Finally, big applause goes to my friends who gave their feedback and encouraging words till the end of this work.

Qualitative study on consumer willingness on value flavored spice coffee

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1. Introduction

The target coffee is defined as a coffee beverage comprised with coffee element. Coffee element of the target coffee is derived from a plant of the family *Rubiacea,* Genus *Coffea*. The coffee element can take the form of soluble coffee, roast and ground (Morrison et al., 1997). The coffee element may be caffeinated, decaffeinated, or a blend of both. The coffee source component modifiers may be obtained with any of these additional ingredients, in a suitable form, such that they are capable of adjusting the perceived concentration of the coffee source component, in the final consumable form of the coffee beverage (Yuwono et al., 2019). The desired mean particle size distribution of the coffee component particles and the flavoring component particles of the present finding is determined in part by the exact type of coffee component and flavoring component in the range, from about 250µm to about 2360µm, and the moisture level in the range, from about 1% to 4.5%. The ratio of coffee component particle size is in the range, from about 100:1 to about 5:1 (Sargent et al., 2005). Sensory test has mainly focused on untrained general consumers and their feedbacks on different spice flavored coffee under 9 point hedonic scale-ranking test. The main approach of this study is to determine sensory acceptance for admixing dry coffee compound with dried flavoring ingredient of spices and willingness of university students and to determine whether there is a significant difference between plain coffee and flavored coffee under Kruskal Wallis test, SPSS 2017 (Prakash et al., 2000).

2. Materials and Methods

A total of 6 different types of coffee were selected and assessed in this study; natural spice powders were added to Arabica coffee. Cinnamon flavored, ginger flavored, clove flavored, vanilla flavoured, cardamom flavored, and masala flavored coffee coded as F1, F2, F3, F4, F5 F6 respectively (Table 1). All coffee samples were bought from Indian Export Company and spices were collected from supermarket. Coffee samples were stored at room temperature, in a cool, dry storage area. Commercially packaged coffees were opened fresh on each trial day.

Coffee preparation

A kettle was filled with cold water and boiled to 100°C. Once the temperature of the water in the kettle cooled to 95°C, a cafetiere was warmed by filling it with 130 ml of the boiled water and swirling it around 30 seconds (s). Fresh filter coffee powder (20g) and spice powder (0.2g) was added into the cafetiere. The cafetiere was filled with 1070 ml of boiling water, and the contents were stirred after adding sugar (80g) with a metal table spoon. A 237-ml paper-based cup (methyl cellulose internally and externally coated with polythene) was filled with approximately 30 ml of flavored coffee was served for panelist at 70°C.

3. Results and Discussion

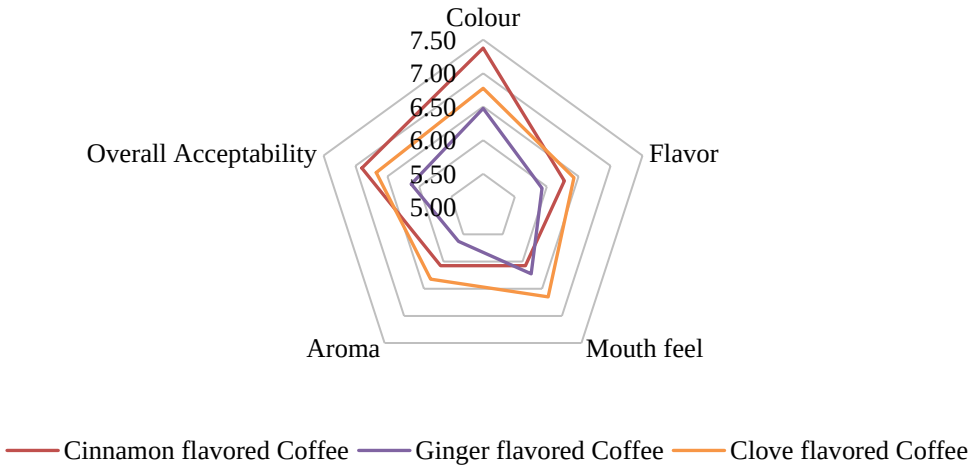

Figure 1. Consumer willingness on cinnamon, ginger and clove flavoured coffee with 9-point hedonic scale

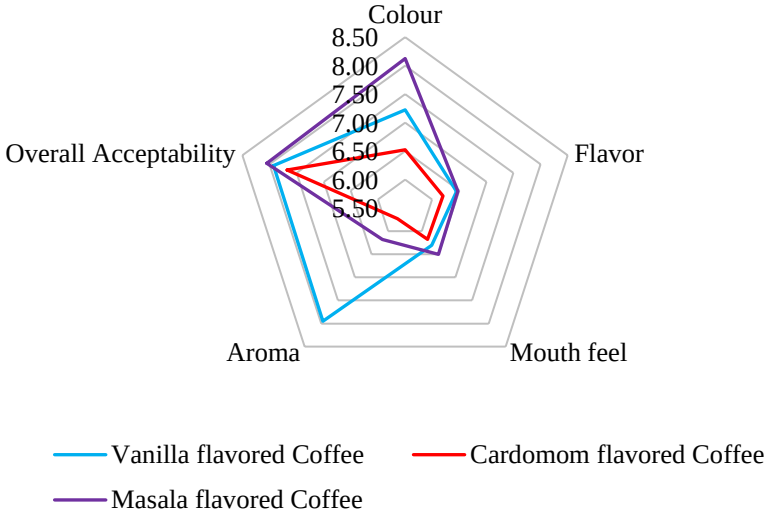

Figure 2. Consumer willingness on vanilla, cardamom and masala flavoured coffee with reference to 9-point hedonic scale

Mean of colour

F2< F5< F6< F3< F4< F1

Based on Robust test for equality means P (0.042) <0.05 and mean values of colour is significant.

Mean of flavour

F2< F5< F1< F3< F4< F6

Based on Robust test for equality means P (0.745)>0.05 and mean values of flavor is not significant.

Mean of Mouthfeel

F1< F5< F2< F4< F6< F3

Based on Robust test for equality means P (0.708)>0.05 and mean values of flavor is not significant.

Mean of Aroma

F2< F5< F4< F6< F1< F3

Based on Robust test for equality means P (0.496)>0.05 and mean values of flavor is not significant.

Mean of Overall acceptability

F2< F5< F4< F3< F6< F1

Based on Robust test for equality means P (0.301)>0.05 and mean values of flavor is not significant.

According to the Kruskal Wallis test, there is a significant difference between the flavored coffee and the plain coffee at 0.05 level of significance (P 0.01<0.05). Thus, consumer preference has increased with flavor, aroma and taste.

4. Conclusions

There is also market potential for a good quality spice flavored coffee in local and export market. Commercial prototype formulations can be developed from the information obtained in this study. This study can be extended further with trained panelists with different proportions of coffee and spice powders.

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Consumer feedback in Ratnapura district related with the marketing mix theory to improve the present vegetables markets

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1. Introduction

Sri Lankan economy was based on agriculture until the later part of 20th century. Still in most rural areas the key income generates through agriculture field. Vegetable cultivation is a major part of that. A range of people are engaged in vegetable supply from farm gate to the ultimate consumer. The country was 91% self sufficient in vegetables with a production of 2962000 metric tons at 2017 (Department of Census and Statistics of Sri Lanka, 2017). Though this production was increased extensively enhancing its supply, the demand from consumers has been remained less. The per capita vegetable consumption was 112g/day which was far below the recommended level of 200g/day (Marambe et al., 2020). One of the root causes identified for this situation was decreased purchase of vegetables from the markets. This less purchase leads to severe breakdown of the economic and social condition of most of the parties involved in vegetable supply chains. Therefore, a study has been conducted to collect consumer feedbacks in accordance with four P's of marketing mix theory about present vegetable markets. This study was planned to collect suggestions regarding the improvements to be done in present situation. The objectives of the study were to discover the expectations of consumers to be improved in vegetable markets related to marketing mix components and inform them to respective parties, to upgrade the current system to that attract consumers back to the market and secure the sustainability of whole sector.

2. Materials and Methods

This study was conducted as a part of a survey that had done in Ratnapura District. According to geographical and socio economical positioning of the district, a good variation of household establishment from urban to rural areas is existed with a significant diversification of socio economic backgrounds. That was important to collect data from consumer segments with a broad diversification. The estimated population of the district by 2017 was 1151451 (Sabaragamuwa Provincial Council, 2018). Sample size was calculated using the standard Yamane Formula.

n = N/ 1+ N (e) 2

Under a confidence level of 95 % and level of precision as 5%, the sample size was 399.86 which has rounded up to 400. Respondents, each from a single household were selected by convenience sampling technique Data collection was done at the first quarter of 2018. A structured type self-administered questionnaire was used to collect data. From one part of the questionnaire collected the respondents' expectations and suggestions to be upgraded or reformed further in the vegetable markets. The resulted suggestions then categorized according to the marketing mix theory. Marketing mix is not a scientific theory, but merely a conceptual framework that identifies the principal decisions taken by managers while organizing their offerings to suit consumers' needs (Londhe, 2014). A business should plan targeted approach

on four different components as product, price, and place & promotion to fulfil the targeted consumer segment requirements (Law, 2012).

3. Results and Discussion

Suggestions were expressed by 318 respondents or 79.5% of the sample. They were allowed to express 1-3 suggestions each. Total number of feedbacks were 722. They were categorized under four groups as their relevance to four marketing mix categories. As these results were taken from a sample at a selected district, to check whether they are based on pure chance a hypothesis test was conducted at first.

H0 – Results are based on pure chance

H1 - Results are not based on pure chance

A chi square test has conducted for suggestions in product category as a sample. Degree of freedom 5, significance level 0.05 and chi square table value was 11.071. All the suggestions included in the product category (105.21124, 20.9612403, 1.98449612, 21.7751938, 26.9844961, 40.746124) exceeded that table value.

The suggestions in each category and their frequency of occurrence was mentioned in below table both as in numeric value and percentage.

Table 01. Consumer suggestions to improve the vegetable markets

	Suggestion	Frequency	Percentage
Product			
1	Maintain freshness and cleanliness of the vegetables	135	39.24
2	Use proper containers for packing and transportation	92	26.74
3	Vegetables should be chemicals free	68	19.74
4	Discard damaged vegetables	22	6.39
5	Introduce value added products	18	5.24
6	Provide several standards and package sizes	9	2.62
	Total	344	100
Place			
1	Properly arrange the vegetables to secure the hygiene	72	35.29
2	Take actions to reduce unnecessary middlemen involvement	37	18.13
3	Increase the availability of vegetables in the market	27	13.23
4	Improve direct marketing to buy at the farm gate	23	11.27
5	Apply strict rules on weight measurement	21	10.29
6	Widen the area for fresh vegetables	20	9.8
7	Display the price list, nutrients values of the vegetables	4	1.96
	Total	204	100

Price			
1	Arrange a process to keep a constant price range throughout the year	80	73.39
2	Make a fair price according to the quality	29	26.61
	Total	109	100
Promotion			
1	Easy and time saving strategies at purchasing	25	38.48
2	Friendly staff	13	20.00
3	Promote the sales of native vegetables	9	13.84
4	Facilities for one stop purchase everything	7	10.76
5	Market place is open on every day	6	9.23
6	Mobile or home delivery service	5	7.69
	Total	65	100

At first according to the chi square value H0 has rejected and it indicated the results were not based on pure chance. Then in both product and place categories consumers' major expectation was the hygienic level of the vegetables. They have proposed various methods to keep it as usage of proper containers at transport and packing, discard the damaged ones and maintain a clean market place. In price category consumers dominantly expected to have a constant price range. Therefore, it engaged with proper management of vegetables supply also. If it could not be solved then this threat lies all through the supply chain which directs to a drastic uncertainty. Moreover encouraging the sales of native vegetables in promotion category and reduction of unnecessary middlemen consumers have expected the government to implement restricted rules and regulations on marketing places regarding the hygiene and weight measurements.

4. Conclusions

Two basic expectations of consumers were arisen as changes to be practiced in the vegetable markets. They are secure the hygiene of the vegetables and keep a constant price range. According to them the whole supply process of vegetables must preserve a firm sanitation level in every possible step to produce a safe outcome for consumers. Above discussed consumer suggestions will be effective on controlling the price range. Those steps should initiate from the ultimate farmer level as the applicability. Home delivery system of vegetables would be a potential business opportunity furthermore.

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Dynamics of Mango Value Chain

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1. Introduction

The value chain concept has been described as a mindset shift from a traditional producer-focused supply-push approach to a consumer-focused demand-pull approach (Collins, 2009). These chains are critical to human society as providers of food and income to the majority of the world's population (Collins, 2009). An agricultural value chain referred to as the people and activities that transport a fundamental agricultural commodity like maize, vegetables, or fruits from inputs and production in the field to the customer, through stages such as processing, packaging, and distribution (Gagnon, 2012). Value chains encompass the flow of products, knowledge, finance, social capital, payments and information that are needed to organize producers and communities. However, these value chains are significantly differing in their dynamics in terms of product, technology, financial and information flows (Badar et al., 2019).

Fruits in both fresh and processed, have been identified as a global sector with high potential due to rising consumer demand. Performing value chain analysis on fruits are considered significant, as it carries promising economic returns. In this context, mango, both in fresh or processed form is a favourable sector that requires much consideration for its high market potential with rising demand from the local and export markets. In 2019, around11,130 ha of mango extent was cultivated in Sri Lanka with a production of 80,000mt of fruits. Out of the total production of mango in average, only 0.85% were exported as fresh and dried forms (TAMAP Report, 2019). Existing literature on mango value chain are limited to identifying actors and mapping the chain. A little information on typology and dynamics of financial and information flows of mango value chains are available in the previous studies (Gagnon, 2012). Further, in the Sri Lankan context, studies on mango value chain are very limited. Considering that, the aim of this study is to define a typology of Sri Lankan mango value chain models, to explore the input-output relationships of mango value chains in Sri Lanka and to study the economic return and marketing margin through the mango value chain in Sri Lanka.

2. Materials and Methods

This study is a qualitative in nature and case study methodology was adopted when addressing its objectives. In achieving the first objective, this study has defined its' typology based on end market (Gereffi et al., 2003) and ownership structure. In the second objective, input-output relationships were mapped according to the value chain model proposed by Taylor (2005). When determining the consumer price indexes this study followed the formulars of Acharya and Agarwal (1987).

The sample of this study was drawn from Anuradhapura, Pollonnaruwa, Kurunegala, Hambanthota and Ratnapura districts of Sri Lanka, due to the higher extent and production. Participants (315) represented mango value chain actors from farmers to wholesalers to retailers. Participants were identified through snowball sampling technique because of unavailability of statistics about the actors of the value chain. Primary data were collected from the focus group discussions and in-depth qualitative interviews. An interview guide with open ended questions was prepared for the focus group discussions and interviews with key stakeholders in the chain. This allowed for an informal but guided conversation with

respondents. Secondary data and information were collected from the Department of Agriculture (DOA), Department of Census and Statistics, Department of Customs published reports and websites.

3. Results and Discussion

Typology of mango value chain in Sri Lanka based on end market and ownership structure

Targeted end market and ownership structure have selected as main characteristics to define the value chain typology. Accordingly, we identified three major mongo value chain models established in Sri Lanka. They are traditional, modern and export-oriented value chain models. Traditional value chain model caters to the local market and main product is fresh mangoes, modern value chain model targeted towards to the supermarkets/hotels and end products were both in fresh or in processed form and export-oriented value chain model provides fresh or processed mangoes for the export market.

Traditional value chain consists with lower level of actors; producers, collectors, whole sellers and retailers. Modern value chain consists with farmers, collectors, processors, whole sellers and retailers. Export value chain consists with several factors in different path ways including; farmers, collectors, processors, exporters, whole sellers and retailers. In our observations, we identified different types of end markets based on the typology. Accordingly, traditional value chains are catered to the local retailers, modern value chains are targeting the super markets, hotels and restaurants, and for the processing factories. Finally, the export value chains are supplying to the export market.

Table 1 provides the characteristics of each value chain model based on the following features. As per the table, key features of the export-oriented value chain were high in quality, most GAP certified, grading and packing, value creation, smooth information flow as well as premium in price. Traditional value chain model operates in volume basis, seasonal and handle higher quantities with a limited attention on grading, packing, value creation, fragile information flow, varied price and targeted across all income groups of the domestic market. Modern value chain model characteristics in a considerable level of quality, grading, value creation, price and targeted for the upper income class domestic consumers.

Table 01. Features of Sri Lankan Mango Industry Value Chain

Features	Traditional	Modern	Export
Quality	Mixed	Medium to Good	High
Grading	Basic	Good	Excellent
Product Flow	Major	Minor	Minor
Information Flow	Weak	Strong	Strong
Value Creation	Low	Medium	High
Price	Low	Medium	High
Consumer	Domestic (All income classes)	Domestic (Upper income class)	Foreign
Retailer	Traditional	Urban/Modern	Foreign

Input-Output relationships of mango value chain in Sri Lanka

In the second objective, we explored the input-output relationships of mango value chain. Accordingly following relationships (Figure 1) have built up. We identified input suppliers as the people who provide inputs (agro-chemicals, fertilizer, planting materials, plant protection

equipment, etc.) to the mango farmers. Producers were small holder farmers who grow mango and supply to wide range of middlemen including collectors, wholesalers, processors, retailers or consumers. Collectors are collecting harvest from mango producers at a farm gate price and supply to wholesalers or processors. Wholesalers perform post-harvest functions like; grading, sorting, washing, packing and supply to retailers or to consumers. Retailers purchased fruits from either producers or from wholesalers in small quantities. Finally, consumers are the end users who bought mangoes for consumption. Restaurants and fruit juice bars are also identified as the separate group of consumers in the study. The sample highlighted that the actors in the value chain are differed in business volume/ production and management practices.

Further, it is observed how input information, products, technical knowledge and finance move through the mango value chain and directions of the flows (figure 1). Government organizations like DoA, Institute of Post-harvest Technology, Foreign funded projects like Agriculture Modernization Project and Asian Development Bank as identified as the supporting organizations. Both government and private sector initiatives assist mainly through advisory services, technology transfer, infrastructure, financial services and trainings for the value chain actors. Moreover, postharvest losses vary among different actor combinations, such as; % post-harvest losses from producers to collectors (10%), collectors to wholesalers (7%), wholesalers to retailers (6%) and retailers to consumers (3%) in the chain.

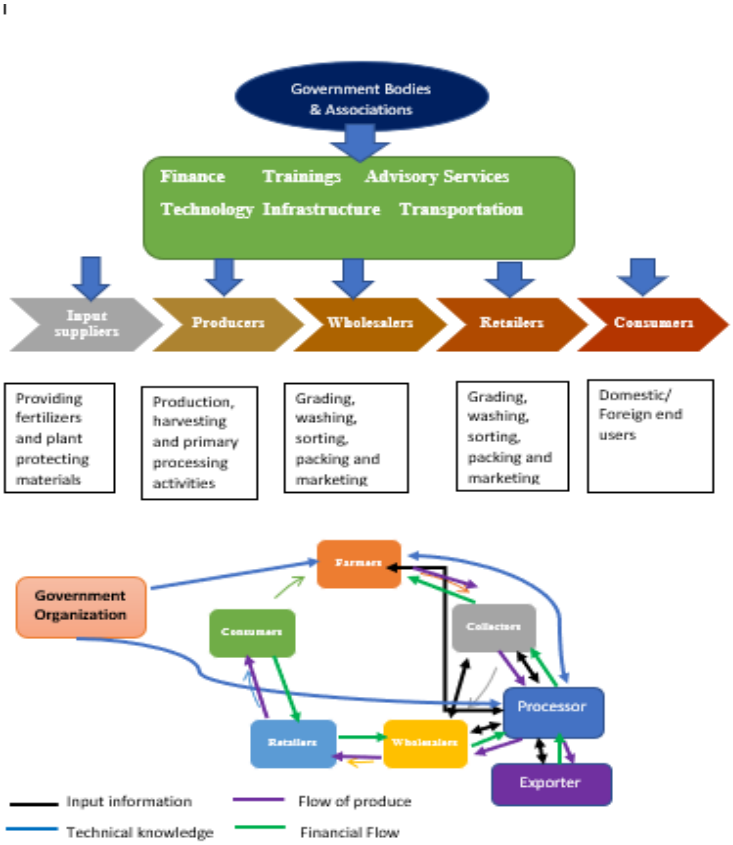

Figure 1. Comprehensive map of mango value chain in Sri Lanka (Source: Developed by the author)

Economic return and Marketing Margin through the mango value chain in Sri Lanka

In finding the economic return and marketing margin over the Sri Lankan mango value chain, we studied three major mango varieties that are frequently trading in the Sri Lankan market namely; TJC, Karthakolomban and vilad. This price information was collected during the major mango season in 2021, which is May-July. TJC is the commercially cultivating mango variety in Sri Lanka. Karthakolomban and Vilard are cultivated in small holder farms and home gardens in Sri Lanka.

Table 02. Return and market margins earned by different market functionaries in Mango value chains

Return/Margin	TJC (Rs/Kg)	Karthakolomban (Rs/Kg)	Vilard (Rs/Kg)
Wholesaler purchase price	350	100	50
Retailer purchase price	500	150	100
Consumer purchase price	760	250	200
Retailer share in consumer price	34.2%	60%	50%
Wholesaler share in consumer price	19.7%	20%	25%

4. Conclusions

It can be concluded that, typology of Sri Lankan mango value chain can be categorized as traditional, modern and export categories much similar to other developing countries in the region. These chains significantly differ in their dynamics in terms of product, volume flow, postharvest chain management practices (cleaning, grading, packing, etc), level of quality, value creation, financial and information flows. Further, these chains are differed in terms of value chain profile consist in structure, actors and end markets. Input suppliers, producers, wholesalers, retailers and consumers are identified as the major actors in the value chain but they differ in business volume, production and management practices. Findings of the return and market margins revealed that, wholesalers and retailers yield a considerable share in consumer price throughout the mango value chain.

In overall, the findings of this study suggest that, there's a need to build and coordinate relationships and foster information exchange among the value chain actors. Further to change the dynamics of mango industry through gradual transformation of traditional to modern. Moreover, the huge market margin taken by the retailers and wholesalers can be subtracted, if the farmers are empowered for the value creation and direct marketing strategies.

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Responses of rural agricultural households to COVID-19 pandemic: A case study on food security of rural farmers in Belihuloya, Sri Lanka

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1. Introduction

When COVID-19 hit Sri Lanka in 2020, the government imposed travel restrictions, curfews and lockdowns to control the spread of the pandemic. These restrictions impacted rural households more than urban households (Phillipson et al., 2020). According to Mastercard Foundation (2020), the response of every rural household to this new normal is different from one another. As identified by Phillipson et al. (2020) rural households were impacted economically, socially, psychologically due to the pandemic. Researchers identified a lack of literature to identify COVID-19 pandemic's impact on Sri-Lankan rural agricultural community. Thus the study addresses this knowledge gap by identifying the issues in food security, market access, and children's education and the coping strategies developed by the rural farmers to mitigate the identified issues. The majority of the rural farmers were unable to sell their fresh/processed produce at the markets, leading to lower household income (Phillipson et al., 2020). The rural context in Sri Lanka is unique with features that support resilience in food systems, mainly due to the availability of nearby food forests and home gardens. These features support household food and nutrition security to a greater extent. Home gardens in rural Sri Lanka have a high diversity of crops, fruits, vegetables, medicinal herbs etc. (Thamilini et al., 2019). Given this rural setting, the objective of this study was to investigate the challenges of the pandemic on rural households in terms of food security and to understand the coping strategies adopted leveraging natural endowments such as home gardens and forests. The research will be useful in recognizing the unique challenges that a rural agricultural community faces during a crisis. With 81% of Sri Lanka's population living in rural areas (World Bank, 2018), the Challenges and coping strategies outlined will be important in identifying, planning, and executing government/regulatory body interventions in rural areas.

2. Materials and Methods

Belihuloya located in Imbulpe DS division, Rathnapura district of Sri Lanka was purposely selected as the research location. A sample of 25 rural farm households in the area was purposively selected for data collection in two stages. Initially, a focus group discussion was held at Sri Suvisudhdharamaya Temple, Galagama, Belihuloya in March 2021. Digital storytelling method was used to conduct these focus groups (Gubrium, 2009). Fifteen farmers were first grouped into five clusters depending on the crops cultivated: fruits and vegetables, turmeric and ginger, traditional paddy and improved paddy varieties. Farmers in each group were accompanied by a researcher and farmers were allowed to talk freely while their storytelling session was recorded by the researchers. Unlike other methods of data collection, storytelling enabled gathering in-depth and detailed understanding of the topic through story teller's verbal and non-verbal responses (Njeru, 2015). The focus group discussion aimed at gathering common constraints faced by the farmers and the common coping strategies they had developed to mitigate the challenges during COVID-19.

In the second step of the study, 10 farmers were studied over a period of one month to record the insights of rural farm households, again, using the storytelling method. This stage of

research targeted gathering individual experiences on household food security, market access opportunity for agricultural produce, and the market access for daily necessities, household-level income generation, food production, processing and value addition, and the children's education during the pandemic. Rural home gardens were given special attention in the study since it contributes more to the household economy and household food security in Sri Lanka (Pushpakumara et al., 2010). Photographs and audio recordings of the stories were collected from the individual farmers. Home gardens of selected farmers were visited and observed during July 2021.

3. Results and Discussion

According to the demographic profile of the studied 25 farmers, 60% had engaged in farming as their primary source of income, while 40% engaged in farming and agricultural activities as a secondary source of income making agriculture a crucial livelihood opportunity. Of the 10 farmers whose home gardens were studied, 70% had multifunctional home gardens (all food, medicinal and horticultural focused), while 30% had horticultural crop-based home gardens. Multi functionality enabled rural households to yield a diversified daily harvest and sell/share excess of the harvest with the neighbours (Pushpakumara et al., 2010; Yapa, 2018).

Challenges faced by the farmers could be categorized into three categories viz food supply, market access, and children's education. Rural households' food security has not been affected a lot by the travel restrictions unlike the urban dwellers because their food supplies came from the local food production systems; home garden/backyard, paddy field, food forests and the rivers or the reservoirs. Due to the diversity of the crops in the home gardens, farmers' household food security status was not affected. Table 01 depicts the species richness of the 10 home gardens under each crop category. Rural farmers had three main sources of food; i.e. paddy fields, home gardens and the nearby forests. Also, protein requirements were fulfilled from the freshwater fish, poultry, and from dairy and swine farmers in the village.

The commercially oriented farmers have faced huge barriers due to the closure of farmer markets/village fairs in the locality. The majority of the smallholder farmers could not sell as much harvest as before.

Large scale farmers have also faced challenges in selling their harvest to the collector due to the travel restrictions between provinces that limited transportation of the harvest to the Dedicated Economic Centres in Colombo and to the Manning market. Farmers who were supplying harvest to the retail chains, hotels or restaurants on a contract basis also faced difficulties due to poor demand for their produce, as a cascading effect of COVID-19 to the hotel industry.

Since all the schools in the country were shut down during the lockdowns, conducting online sessions was a must for households. On one hand, this was an additional burden on household expenditure, as the farmers were compelled to buy laptops or mobile phones for their children to continue their educational activities. On the other hand, smartphones and mobile applications used by the farmers were important strategic interventions in agricultural marketing. Communication apps linked farmers with intermediaries, end markets and created access to new markets that did not exist before the pandemic. Moreover, farmers who were traditionally cultivating paddy for the commercial market shifted to cultivating traditional paddy varieties such as *madathawalu, suwadel, kalu heenati* etc. to enter new high-value markets that can be accessed through the use of mobile platforms. Also, some farmers have developed the habit of entering into a contract with a buyer before the cultivation, in order to avoid instability of the food market due to prevailing pandemic-related conditions situation. This establishes a promising secure market for the farmer even before cultivating the crops. Rural women of the households had developed the habit of food preserving, processing and value addition to increase the shelf-life of the harvest. Preserving helps farmers to use the food during the

offseason for their own consumption and farmers don't need to spend money on buying those food items from the market.

Table 01. Species richness of rural home gardens

Crop Category		Species richness			
		Total number of species identified	Mean	Min	Max
1. Fruits	[1]Underutilized fruits	22	7.7	2	18
	[2]Abundant fruits	22	9.2	2	22
2. Vegetables	Underutilized vegetables	6	2.7	0	5
	Abundant vegetables	20	8.7	3	12
3. Green Leaves	Underutilized Green Leaves	20	8.5	3	17
	Abundant Green Leaves	11	7.5	4	11
4. Grains		3	1.9	0	4
5. Cereals / legume		3	1	0	2
6. Spices and condiments		11	6.2	2	11
7. Yams	underutilized yams	7	3.1	0	8
	Abundant yams	4	3.1	2	4
8. Medicinal herbs		32	12.6	5	28
9. Other food crops		10	4.6	2	10
10. Forest trees		19	8.6	3	17

[1]Crops that are valuable, yet are not widely grown, rarely seen in the market, and not commercially cultivated
[2]Commercially cultivated crops that are available in larger quantities in market places

4. Conclusions

Study findings concluded that the food security of the rural farming households have not been affected by the pandemic due to the availability of the home garden/food forests. Farmers have developed opportunities to enter new market places through online existence and contracts with the buyers. The coping strategies identified are important in scoping policy interventions to uplift rural livelihoods. But a nationwide study is crucial to generalize the strategic interventions in to rural context. This study clearly shows how rural farm households have leveraged the rural setting to build household resilience in this evolving pandemic.

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An empirical study on the impact of declining coconut production in Sri Lanka on kernel-based export products and coconut oil production for the domestic market

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1. Introduction

More than nine varieties of coconut (*Cocos nucifera*) are grown in the island. Domestic coconut consumption, however, is a priority and accounts for 65 to 70 percent of the overall annual production of nuts. The remaining 30 to 35 percent of production is used to produce a variety of coconut-based value-added products as desiccated coconut, copra, coconut oil, cream, and milk powder, etc. both for the domestic and export market (Samarajeewa, 2002). Currently, a shortage of coconut nuts exists in the country. As a solution, coconuts based on value addition while allowing to import raw materials for other industries can be recognized. Nevertheless, the Sri Lankan government has allowed short-term importation as a temporary solution only during a shortage. As other countries make good decisions to unravel the impact of the decline in nut production, it needs to develop a timely important proper plan in Sri Lanka too by coming up with important and acceptable decisions that can be implemented during a shortage in the production of nuts. This plan will help to overcome the shortage and increase exports whilst minimizing the price fluctuation of coconut and continuing the proper supply and demand process in the coconut industry. Accordingly, the study was conducted to identify the impact of declining production of coconut in Sri Lanka on kernel-based export products and coconut oil (excluding export). In addition, the researchers aimed to forecast of coconut production in Sri Lanka, while identifying the impact of palm oil and dehydrated chips imports to the coconut industry, and the export behavior of selected kernel-based products.

2. Materials and Methods

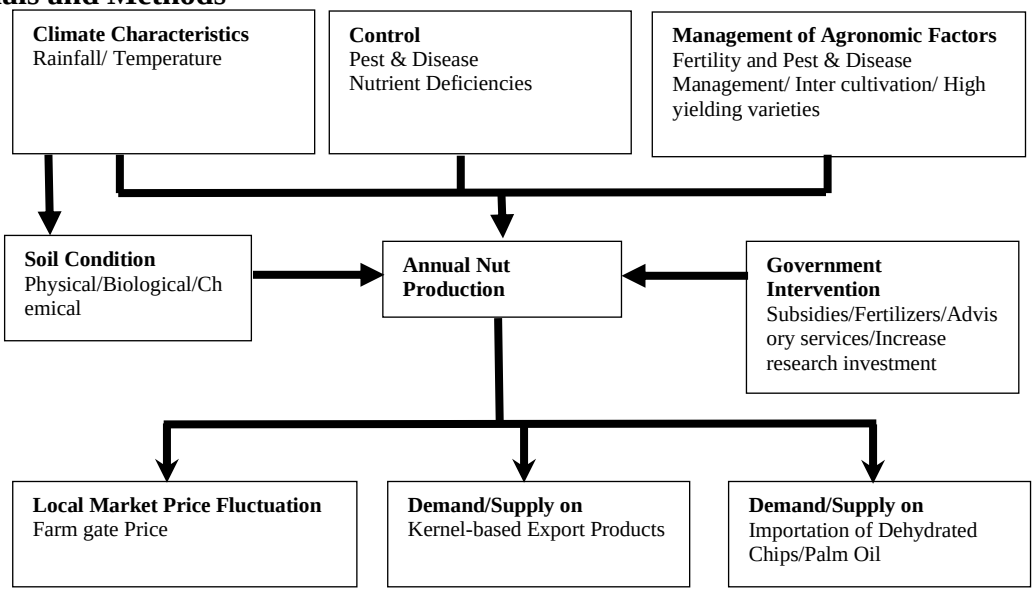

Figure 1. The conceptual framework of the study

The conceptual framework and methodology for this study were developed according to the information gathered in the literature survey and preliminary focus group discussions held with key experts attached to the coconut industry (Figure 1). Primary data were collected by interviewing coconut-based (Kernel) exporters, palm oil importers, and dehydrated chips importing millers who were registered under the Coconut Development Authority of Sri Lanka. In this study, six products with a total of 172 companies/mills formed the population that was undertaken for the investigation. The sample size was determined using a formula developed by Mugenda (2008). Accordingly, 120 respondents were selected for this study using a stratified purposive sampling technique. Three questionnaires five point-Likert scale questions were employed for three categories of above mentioned foreign traders. Moreover, the respondents were encouraged to share their knowledge of the industry at the beginning with any relevant comments in an open-ended format at the end of each questionnaire.

The production data of 20 years of coconut production of Sri Lanka were collected from the Marketing Development & Research Division of the Coconut Development Authority of Sri Lanka. In addition, time series Met data (Rainfall) for the period of 20 years from 2000 were obtained. The data on production of coconut in Sri Lanka for last 20 years were used for forecasting coconut production with ARIMA (Auto Regressive Integrated Moving Average) model. The ARIMA model is a method of analysis that uses only past observations of the variable of interest to explain the behavior of a time series data set and predict future values.

3. Results and Discussion

To fit an ARIMA model, it requires a sufficiently large data set. In this study, six tentative ARIMA models were used obtaining the production data of coconut in Sri Lanka for the period of 2000 to 2020. The general notation ARIMA (p, d, q) refers to the model with p-order of autoregressive (AR) terms, d is the order of non-seasonal differences and q, the order of moving average terms (MA). From that ARIMA (2,1,1) model was selected which has the minimum P value and MS Value (Table 1).

Table 01. Models and component order (p, d, q)

Model	AR	I	MA	P value	MS
Model1	1	0	0	0.029	56425
Model2	1	1	0	0.013	98134
Model3	1	1	1	0.031	59690
Model4	2	1	1	0.023	38312
Model5	2	1	2	0.111	29919
Model6	2	1	0	0.123	55955

The ARIMA (2,1,1) model was used to see if nut production in Sri Lanka would fluctuate between 2500-3000 in the next 5 years. Final estimates of forecasting parameters were reported as 2626.47, 2832.58, 2978.02, 2849.67, and 2760.92 million of nuts for the years 2021, 2022, 2023, 2024, and 2025 respectively.

A normality test was done to identify whether data were normally distributed. Consequently, non-parametric tests were applied to analyze the primary data. Thereafter, to find out the significant difference among tested statements, the Friedman test was performed.

Table 02. Results of Friedman test

Question	Chi-square Value
Kernel-based products (Exports)	
1	410.504**
2	47.276**
Impact of Dehydrated chips Importation	
1	142.376**
3	193.402**
Impact of Palm oil Importation	
1	2.667
2	13.780**
3	5.182

**significant at 0.05

Multiple comparisons of the selected questions were done by the Wilcoxon sign rank test (Probability adjusted by Bonferroni method) test. Accordingly, significant differences could be found among the pair of questions. However, there are no significant differences among questions in the Sri Lankan palm industry and among questions in the sustainability of final product supply. Therefore, multiple comparisons were not conducted for those question sets. There is a significant difference among the opinions on the export market of kernel-based products. Most of the respondents are (80.65%) strongly agreed with getting quality raw materials. Statistical analysis has reviled that; a significant difference ($P<0.05$) is found among statements that are related to the final product supply of kernel-based. Significantly highest number of respondents are strongly agreed with ensuring the quality of the final product (98.39%) and supply of the final product in the required demand (96.77%).

A significant difference could be found among statements on the impact of dehydrated chips/kernel importation. The effect of the decline in annual nut production on raw material supply from Sri Lanka is significant. All the respondents strongly agreed with the statement of consideration about the quality. Accordingly, a significantly higher number of persons (65.9%) are strongly agreed that the oil requirement would be complete by importing the raw materials. Samarajeewa and Gunathilake (2002) argue that local market demand for coconut oil is very likely to be affected by the presence of these replacement vegetable oils. Agreeing with the fact, in relation to the impact of palm oil importation, approximately 60% of the respondents have approved the import of crude oil while 40% have approved the import of refined palm oil. Most of the respondents are of the opinion that if crude oil is imported, it can be rejected and sent back to the same countries. The response rate for the questionnaire sent to Palm oil importers was 38.46%. According to 38.46% of the respondents, when importing palm oil, they are concerned about the local market demand and the quality of the palm oil.

4. Conclusions

According to the ARIMA model, the production volume of nuts for the next five years is also between 2,500 and 3,000 million nuts. Based on the current demand for nuts in the country, the coconut industry in Sri Lanka needs about 3,600 million nuts to work smoothly. Hence, a decline in nut production would be seen in Sri Lanka over the next 5 years. As most of the current annual coconut production goes to the export company without systematic distribution, it is difficult for the coconut oil millers to obtain the coconut required to produce coconut oil.

Therefore, the tendency to import dehydrated chips has increased. In addition, there are problems regarding the import of palm oil in Sri Lanka due to the recent concern raised on Aflatoxin. However, importing quality palm oil and dehydrated chips will help to meet the local oil demand as well as boost the industry. Further studies must be carried out to investigate whether there is an impact of the decline in the production of coconut in Sri Lanka on farm gate prices and taxes and impact of changes of tax and prices on coconuts in Sri Lanka.

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Building resilient in cut flower value chains through managing postharvest losses

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1. Introduction

Floriculture is a global industry, with main markets in Europe, USA, and Japan, and consider as a high income generating agribusiness sector in Sri Lanka (Padmini & Kodagoda, 2010). Demand in both local and the international market has been rapidly increasing since the last few decades in the floriculture sector. However, the floriculture industry in Sri Lanka is still a small and medium category enterprise (Rathnayake & Rathnayake, 2019). Main floricultural products comprise cut flowers, ornamental foliage, aquarium plants, landscaping plants, seeds, and tissue culture plants (Rathnayake & Rathnayake, 2019). Though, export-oriented floriculture industry was established during the 1970 period; still considered as an emerging sector in the Sri Lankan economy (Weeraratne et al., 2012).

Major production regions in Sri Lanka are central, western, and some districts in north-western province. Among these areas, particularly upcountry region is the most appropriate for the cultivation of varieties of cut flowers such as Gerbera (*Gerbera sp.*), Roses (*Rosa sp.*), Madonna (*Lilium candidum*), Chrysanthemum (*Chrysanthemum frutescens*), Aster (*Aster dumosus*), Dhalia (*Dahlia pinnata*), Baby's breath (*Gypsophila* sp.), etc (Padmini & Kodagoda, 2010). The climatic conditions, geographical distribution, labor force, planting inputs provide some favorable impact for floricultural production in Sri Lanka. However, still the floriculture agro-business and export has been limited as the supply chain actors directly influence the total functions floriculture industry (Padmini & Kodagoda, 2010). Therefore, this study was mainly focused on identifying the loss hot spots of the floriculture supply chain and developing postharvest chain management practices to upgrade the current supply chain to achieve an effective and efficient floriculture industry within the country and export market.

2. Materials and Methods

Mixed method approach was principal to investigate the Orchid and Anthurium value chains. Both qualitative and quantitative data were instrumental to identify loss hot spots and develop best practices. Respondents were value chain actors of both Orchid and Anthurium value chain: from grower to consumer.

The selected sample for the study was 55 individuals encompassing all the supply chain actors; growers, collectors, wholesalers, agents, and exporters who are actively involved in the cut flower industry. Data collection was preceded in the Western province (Gampaha and Colombo), Uva (Badulla), Sabaragamuwa (Rathnapura), and North western provinces (Puttalm) where the cut flower industry established. Primary data were collected by focus group discussions in main grower areas, consumer hubs as well as local collectors. Focus group discussions were useful to obtain the overall shape of the value chain, identify key players, opportunities and problems. In-depth interviews with key informants, and interviewer administered questionnaire were facilitated the primary data collection process. Secondary data

were collected from the annual reports of the Export Development Board (EDB), Department of Agriculture, and Department of Census and Statistics Descriptive analysis along with qualitative techniques were instrumental in deriving the outcomes.

3. Results and Discussion

Both Anthurium and Orchid value chains are short with Few nodes horizontally. Upstream of the value chain composed of input suppliers (planting material, fertilizer, agrochemicals, garden tools, equipment, protected agriculture systems, irrigation systems, pots and potting media, etc). Growers (about 95% small holders), local collectors, traders, wholesalers, exporters, importers, retailers and customers. Actor concentration is dense in both ends of the value chain where large number of growers and customers. Countable number of mid chain actors govern the chain. Out of the sample, majority of respondents (46%) were wholesalers and actors were growers (8%), collectors (21%), exporters (17%) and retailers (8%) respectively. Among the growers (20%) have been practiced by-back system and they have made agreements with the companies or individuals regarding buying plants and re-selling operations. Most of the growers considered were independent growers who sell their products at home and sales outlets adopting narrowed marketing methods.

Throughout the value chain, post-harvest losses occurred due to varied reasons and losses recorded as approximately 1-2% for every stage and the total post-harvest losses were 5%-7%. Information asymmetry weakens the relationships among value chain actors. Growers were less aware on end market requirements and ill prepared to cater the need of diversified market segments. In general end market requirement of high quality product with exact color, shape, health and also with shelf life were unmatched and returns were poor for upstream of the value chains. Postharvest losses mainly occur during the transportation where unavailability or limited availability of logistic supplies, and cold chain management were key points. Transportation with improper cool storage facilities, poor road facilities, improper packing has been identified main reasons for reduction of flower quality. Most of the farmers are still far away from the modern techniques such as cool storage and pulsing techniques to minimize the losses and increase the vase life. Grower's literacy on postharvest management of flowers was weak and limited supplies hinder their performance. Unexpected weather and climatic change, pest and diseases problems, pre and post-harvest handling practices worsen the situation.

The majority of cultivators were small scale home growers who have earned profit, by selling in the local market and there were few large growers who engage in export. Although growers have distributed in Badulla, Kurunaegala, Matale, Kandy, Galle and Kaluthara rest of the value chain actors were based on the western province. Therefore growers were unable to supply their products for the specific supplier who valued their products and losses were increased due to poor transportation. Poor returns discourage growers to engage in the business and lead to give up the cultivation. Since they were unable to obtain satisfied income. Higher initial investment, inadequacies of inputs, poor extension, infrastructure support and insufficient marketing avenues were the primary reasons for low productivity in the grower's stage.

Poor communication and coordination among the value chain actors has created the scattered value chain. Hence, it creates shortage of suppliers, considerable post-harvest losses, supply inconsistency, improper price mechanism, and quality deterioration and finally reduces business returns. For the mitigation of the above drawbacks well established value chain network is essential and the each stage of the value chain should be well equipped with the modern technologies and the management practices. Most of the flower exporting firms and some local florists maintain their own farms to produce flowers of required quality as a cost effective strategy since post-harvest losses and the inefficiencies of the value chain. Unment demand of high end local market and export market link with business returns.

Building resilient floriculture value chains require capacity building and empowering the small scale growers along with best practices and postharvest literacy. Smooth information flow from downstream to upstream and establish value chain linkages will help to manage postharvest losses. Build up producer clusters and organization through intervention of the government or private sector companies to increase the skills, knowledge and market access of the grassroots level producers with modern marketing strategies to win the local and export market.

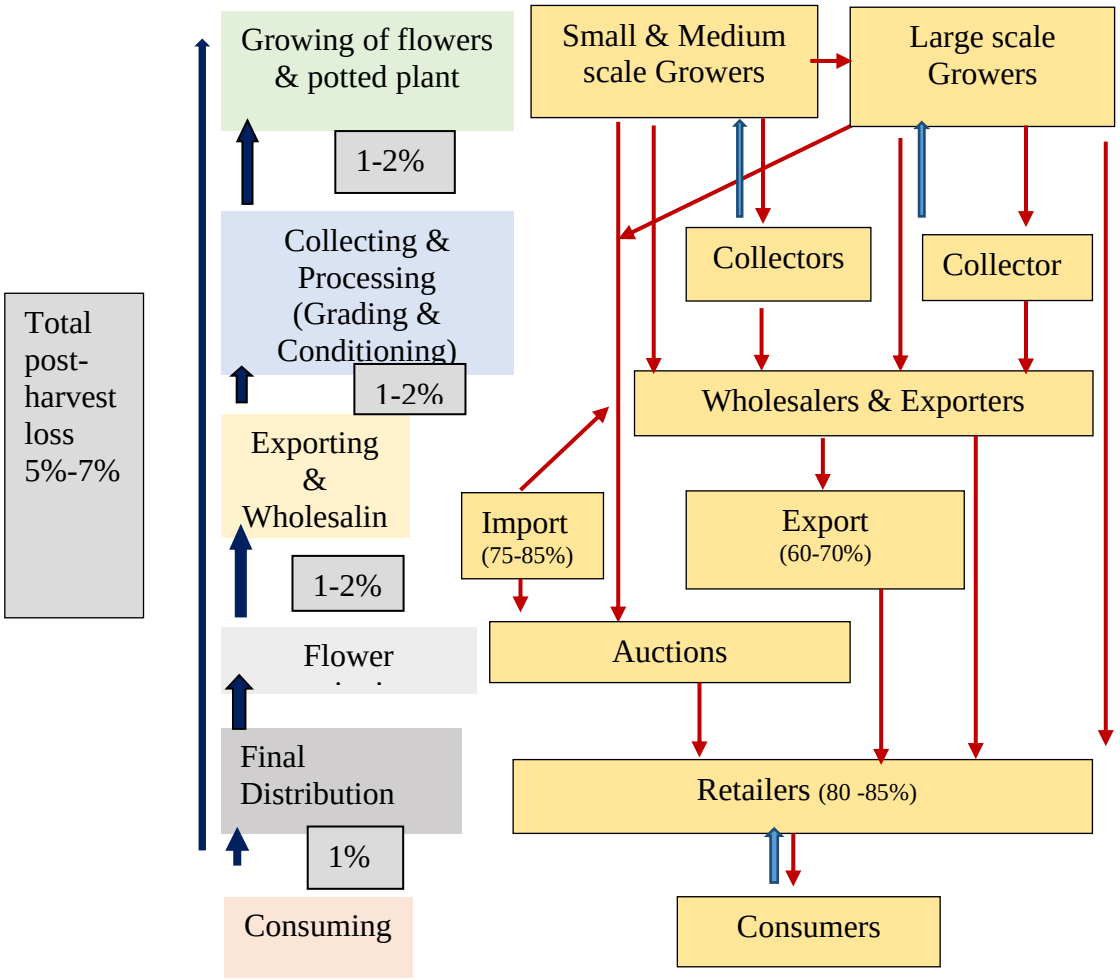

Figure 1. Value chain of orchid and anthurium

4. Conclusions

This end market research investigates the current Orchid and Anthurium value chain; especially referring to identify loss hot spots of post-harvest chain and approaches to minimize losses and maintain quality. Unmet demand of the consumers negatively effect on returns to the value chain members as well as local industry. There's an essential need in building capacity of small holders on quality flower production, postharvest literacy and cater the demands of end users. Therefore introducing techniques such as grading, pulsing, packing using polythene envelops, cool storing, developing of extension and infrastructure, new technology application, policies and legislations will strengthen the each level of the supply chain actors and will be able to explore the new opportunities in the export market.

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Determinants of the willingness to use a mobile application for market participation by fishers: A case study in Western province Sri Lanka

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1. Introduction

Fishing has been the oldest yet the most important livelihood among the coastal community in Sri Lanka since ancient times (Dayalatha, 2020). Fisheries as an Industry contributed 1.3% to the Gross Domestic Product (GDP) in 2019, of which 1.1% is from marine fishing (MFAR, 2020). Despite the importance, the growth of the sector is hampered by the poor connection between the value-chain actors (Gestsson et al, 2010), which has ultimately led to information asymmetry between value-chain actors and lower efficiency. One of the ways to strengthen the connection between value-chain actors is the use of mobile-based tools for market participation. In addition to enhancing the connection between value-chain actors, the use of mobile-based tools enables to increase the efficiency of the market participants and provide greater access to new markets. Against that backdrop, the present study was conducted to assess the willingness of fishers to use mobile applications for market participation and determinants of their willingness. The results of this study aid mobile-based tool providers to assess their market and targeting the customers.

2. Materials and Methods

A primary survey was conducted among fishers those who unload fish in four harbours, Negombo, Dikkowita, Beruwala and Panadura, in the Western Province. Multistage cluster sampling was used as the sampling technique. Beruwala, Dikkowita and Negombo Fisheries Harbours, were selected for the study. Lists of fishers contact details were gained through respective fisheries harbour offices. Then, convenience sampling was used to select fishers for the sample. The sample included 27 fishers from Beruwala harbour and 25 respondents each from the other two harbours. Data were collected using a pretested questionnaire administered through telephone interviews.

The study used Firth logistic regression model to identify the determinants of willingness to use a mobile application to participate in the market by fishers.

The decision to participate in the market using mobile based tools depends on the socio-economic characteristics of the farmer, resource endowment and institutional factors (Moono, 2015: Nwafor, 2020). Thus, the following independent variables were chosen for the analysis. Experience in fisheries (D1), availability of additional income (D2) and scale of operation proxied by the type of fish boat (Dayboat or Multiday boat-D3) were used as socio-economic determinants. Being a member of Community Based Organization-CBO (S1) was used to indicate the influence of institutional factors. The influence of technology was measured by ICT literacy (T1) and awareness on online business (T2).

The specified logit model was as follows,

$$y \begin{cases} y_{ki} = \beta_{k0}D1 + \beta_{k1}D2 + \beta_{k2}D3 + \beta_{k3}S1 + \beta_{k4}T1 + \beta_{k5}T2 + \varepsilon_t \\ 1, \text{ if respondents intend to participate market through mobile applications} \\ 0, \text{ if respondents do not intend to participate market using mobile applications} \end{cases}$$

3. Results and Discussion

Descriptive data showed that the highest percentage (34%) of respondents of the marine fisheries community in the study sample belongs to the age group 50-60 years. Income diversification was observed among 4% of the respondents. The other income sources they engaged in included the import of fishing baits, restaurants ownership, retail shops, agriculture – growing cinnamon and acting as middlemen.

Fishers have formed community-based organizations that some of which are state-aided while others are not. The objective of the establishment of these CBOs is to improve the welfare of the fishing community and engage in social security-related activities (Amarasinghe, 2006). All the respondents had at least one ICT device including a mobile phone. Fifty-seven percent of the respondents had high ICT tool usage. Further, 51% of the respondents were having high ICT literacy.

As per the results obtained, 83% of the respondents had high awareness of the existence of online businesses (the buying and selling that happens through a digital platform). The majority (68%) of the respondents were willing to use a mobile application to access and participate in the market while the rest were having the opposite response.

The results of the logit analysis (Table 01) indicated that fishers who have diversified their income, members of CBOs and have awareness of online businesses have a higher willingness to use mobile-based tools for market participation.

Table 01. The result summary of binary firth logit regression

Independent variables	Coefficient
Years of experience in fisheries (D1)	-0.020 (0.038)
Availability of other income sources (D2)	2.731** (1.000)
Type of fish boat (D3)	-0.515 (0.870)
Membership in CBO (S1)	3.241** (1.031)
Online business awareness (T1)	4.121** (1.215)
ICT literacy (T2)	1.464 (0.892)
Constant	-9.978**
Number of observations	77
Wald chi2(6)	15.41 (0.0173)

Standard errors are stated within parenthesis. ** Indicates significance at 5%

As shown in Table 01, the Wald chi-square is 15.41 and the probability value is 0.0173 with 5% significance that implies model fit is good. According to the coefficients of the analysis, the willingness to use a mobile application for market participation is high among the respondents with another income source as compared to the fishermen who rely on fisheries to gain an income. The awareness of online businesses (T1) has a positive coefficient, indicating the ones with an awareness of online businesses are more willing to use a mobile application

for market participation compared to those without awareness of online businesses. Members of Community Based Organization (CBO) were also found to be more willing to use mobile-based applications for market participation than non-members.

The effect of ICT literacy (T2), years of experience in fisheries (D1) and type of fish boat (D3) on willingness to use mobile-based tools for market participation is insignificant. The major constraints faced by fishers are the unavailability of a mechanism to access daily market prices, high fluctuations of fish price and receiving a lower share of the retail price.

4. Conclusions

The study reveals that a great majority of fishers (68%) are willing to use mobile applications for market Participation. The results suggest that there is a greater potential to introduce or promote mobile-based ICT tools among fishers. Furthermore, to promote ICT tools, fishers' awareness of the online business and their ICT literacy need to be scale-up. This can be done through CBOs. The study also shed light on the target market for mobile-based tools.

Furthermore, the marketers can use this result to introduce and promote mobile applications among fishers addressing the aforementioned constraints while facilitating their market participation.

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Factors affecting the adoption of mechanization technologies in tea plantations: A systematic literature review

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1. Introduction

The tea sector plays a key role in Sri Lankan economy, being the third largest source of foreign exchange and the fourth largest tea producer in the world. Tea accounts for about 0.6% of gross domestic production (GDP) (Central Bank, 2020)**.** The current tea extent of Sri Lanka is approximately 204,600 ha and the total tea production in 2020 was 278.5 million kg (International Tea Committee, 2020). The tea industry currently faces many challenges domestically and globally. Among them, low productivity, high cost of production, and worker scarcity are crucial challenges. Workforce employment for field operations represents over 60% of the production cost (Wijeratne, 2012). Statistics show that the number of workers employed in the plantation sector has fallen drastically by more than 40% over the past three decades (Shyamalie et al., 2020). Adoption of mechanization in tea lands is found one of the remedies in this regard (Ongonga et al., 2013). The use of tea harvesting machines saves costs that interfere with the performance of the plantations (Kirui, 2020). Although stakeholders show different perceptions of the adoption of mechanization technology (MT) in the country, there are some success stories behind the scene. However, the emerging competitive market within the industry emphasizes the importance of the adoption of MT in the long run. Therefore, there is a serious need to reveal the factors that hinder the adoption of mechanization among the tea plantations in Sri Lanka. It is important to find out what are the determinants of the adoption of mechanization technology in tea plantations.

The main objective of this study is to conduct a systematic literature review to discover the determinants of the adoption of mechanization technology in tea plantations

2. Materials and Methods

For this study, the national and international research papers related to adoption of MT in tea have been reviewed in English only. Based on the review process reported by Webster & Watson (2020), four electronic databases: Google Scholar, JSTOR, Elsevier and Science Direct were used to find research articles. Articles for this review were gathered using different combinations of keyword sets as search strings while maintaining the same meaning.

Search strings used are “factors affecting mechanization technology adoption in tea ”, “factors influence machine adoption in tea”, “factors hinder the machine implementation in tea”, “ determinant of mechanization technology adoption in tea”, “drivers of mechanization adoption in tea”, “factors affecting mechanization technology adoption in Agriculture” and “drivers of machine adoption in agriculture”.

The research papers available for the adoption of MT in the tea sector were extremely limited. It was therefore realized that the review should be expanded to other agricultural sectors to identify the factors influencing the adoption of MT without being limited to the tea industry. Subsequently, the research documents were filtered by selecting only published empirical studies relevant to the objectives of the review. Instead of the keyword “tea” keyword “agriculture” was used combined with other relevant keywords as search strings. After

filtering, 38 research papers were reviewed to examine factors influencing the adoption of MT adoption in tea plantations and other agricultural sectors.

3. Results and Discussion

An attempt was made to search for literature on the adoption of MT in the tea sector worldwide. The research papers on this subject are very limited in the context of Sri Lanka and globally. After carefully analyzing the titles, abstracts, and conclusion sections of papers, only 14 relevant research papers in the tea sector and 24 papers in other agriculture sectors were filtered which are aligned with keywords.

The literature review emerged with results in different countries with different research titles converging towards adopting MT. The quantitative approach and Logit / Probit analysis are predominant in these studies. The response-dependent variable defined in the reviewed studies appeared in various forms while maintaining the same meaning in research titles (Adoption of MT).

In accordance with the conceptual foundation of the technology adoption models, the complexity of the innovation adoption process is demonstrated by the range of variables of technological adoption revealed in the review**.** The summary presented in figure 01 demonstrates the drivers of MT adoption identified by the review. The results indicate that many of the determinants of innovation dissemination that were looked at in other agricultural sectors were missing in the literature relevant to the tea sector.

This systematic review revealed that 24 explanatory variables were addressed in the literature concerning the process of adoption of MT in tea plantations. As shown in table 01**,** the response variables found in the literature review were categorized based on the well-known theories of technology adoption (Rogers, 1983; Venkatesh & Davis, 2003)**.** Roger's DOI theory was chosen as a root model for adoption theories based on co-citation analysis (Oorschot, 2018) and The UTAUT theory was chosen as the theory developed through chronological order (Venkatesh & Davis, 2003).

The demographic factors, social influence, facilitation condition, relative advantage, effort expectancy, performance expectancy, compatibility (features related to technology), voluntariness of use are the most commonly identified innovation diffusion determinants (attributes and predictor variables) in theories. However, the low frequency of repeated validation of these determinants in technology uptake studies was found to be the main gap in the literature in tea and this may be one of the reasons for the relatively slow rate of uptake of technologies in tea. In addition, very few studies examined multiple determinants of the adoption process, and most focused heavily on assessing the impact of a few determinants. It is also noted that constructs related to cultivation and resources have not been conceptualized in adoption theories though it has already been validated by recent past studies. Therefore this appears as a gap in adoption theories related to agriculture. Gaps in literature are shown in the Table 01.

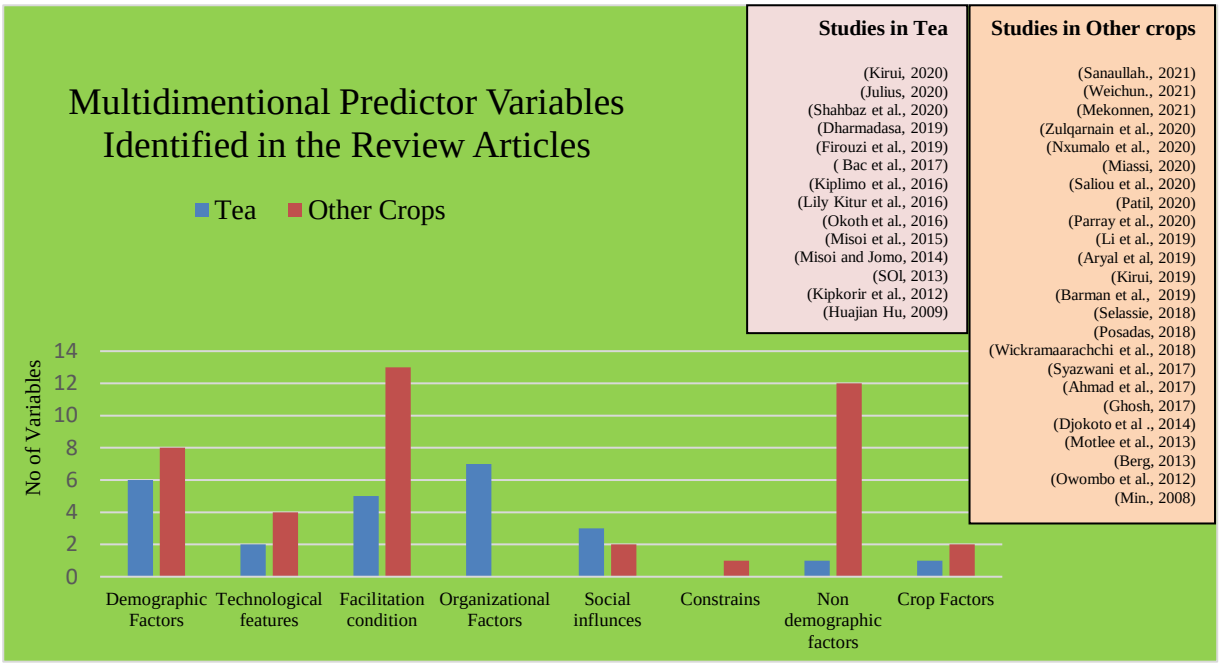

Figure 1. l Multidimensional predictor variables identified in the review articles

Table 01. How the response variables found in the literature review are consistent with well- known theories about technology adoption

Determinants of technology adoption identified through literature review- Tea Sector	Categorization of Determinants according to already established Adoption Theories
1.Demographic & Non-demographic factors- Gender, Experience, Age, Education, Managerial skill, workers daily earning, Skill of workers	Moderator variables (Rogers, 1983; Venkatesh & Davis, 2003)
2.Social influnnce- Employee Resistance, Employee perception, Customer perception	Social influence as construct/ variable (Venkatesh & Davis, 2003)
3. Facilitation conditions- Information access, Training , Credit facilities, Practice of other technologies, Access to machine	Facilitation condition as constructs (Venkatesh & Davis, 2003)
4.Technological features- Effectiveness, Hazard condition	Performance expectancy as construct Variable (Venkatesh & Davis, 2003)
5. Crop factors - Planting system	Not yet established by theories
6.Organizational Factors - Firm size, Land size, Labour availability , Operation cost, Plantation ownership, Owner pressure perception, Fear of job loss	Not yet established by theories
Validation of the Variables for tea sector has not been done through studies	Effort expectancy Triability Visibility Compatibility voluntariness of use (Rogers, 1983, Venkatesh & Davis, 2003)

4. Conclusions

The results show that many of the determinants of innovation diffusion that were looked at in other agricultural sectors were missing from the review of the literature relevant to the tea sector. As Roger pointed out in 1983, Voluntariness, compatibility, and ease of use which play important roles in the persuasion process, do not show in the findings as validated variables. Non-demographic factors do not appear to a high degree in studies of the tea sector as moderator variables. (Venkatesh & Davis, 2003). Theoretical gap in the failure to develop multidimensional constructs is noted (Edwards, 2001; Seckin, 2015)**.** Therefore, it can be concluded that a comprehensive study on factors affecting the adoption of MT in Sri Lanka has not been undertaken with an empirical focus on the most relevant explanatory variables.

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Present status and future prospects of coconut kernel-based industries in Sri Lanka

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1. Introduction

Sri Lanka is the fifth largest coconut producing country in the world which yields 2,500-3,000 million nuts per annum. In general, two third of the production consumes locally as fresh nuts and the rest, dedicates to agro-industries. From 2015 to 2019 an upward trend for coconut based products were clearly visible with a earning of US $609.77 million foreign exchange and a contribution of 7.42% to the GDP of the agriculture sector in 2019. Kernel-based products were the most popularized and dominant category compared with non-kernel. Coconut grown in Sri Lanka has unique characteristics since it delivers favourable kernel taste. Therefore, Sri Lanka has a competitive advantage over coconut in the world market. However, as a result of low productivity, adverse climatic conditions, land fragmentation for housing purposes along with the gradual increment in domestic consumption has created a critical shortage of nuts for industrial use (Jayewardene, 2018; Pieris & Kularathne, 2015). Simultaneously, industrial usage of coconut has also increased as a result of ample opportunities in international markets. This attracted many new entrants recently into the industry seeking more prospects (Pathiraja et al., 2015). However the central question focuses, whether these agro-industries are sustainable enough to cater the flourishing demand and ready for the next leap in the sector creating favourable prospects. In light of this, it is pivotal to understand the real context of the coconut kernel-based industry and its nature. Hence, study attempted to explore the current status, constraints and opportunities in the coconut kernel-based industries in Sri Lanka.

2. Materials and Methods

A total of 50 registered coconut kernel-based industries representing the areas of Kurunegala, Puttalam and Gampaha, where nearly 70% of the cultivation and industries concentrated were randomly selected from a list provided by the Coconut Development Authority. Both primary and secondary data were collected. Primary data collection was done using pre-tested structured questionnaire from kernel-based industry representatives, key informant interviews from responsible officers (i.e. officers of the Coconut Cultivation Board, Coconut Development Board, Coconut Research Institute, divisional coconut development officers and agricultural research and production assistants of the relevant areas) and through case study analysis in order to ensure the information richness. This enables to include a variety of settings, situations and participants, including negative cases or extreme cases to obtain rich data (Moser & Korstjens, 2017). Primary data mainly focused on coconut production and marketing aspects, kernel-based product types, export volumes, roles and responsibilities of private and public parties, constraints and opportunities within the industry and hence, cascaded under both qualitative and quantitative nature. The survey was implemented in August to September 2019. Secondary data were gathered from various secondary sources such as relevant institutional documents, websites, other national and international journal articles, periodicals and reports. Descriptive statistical measures (frequency, central tendency, dispersion and position) were used to analyse the data. A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis was also deployed to assess the industry.

3. Results and Discussion

A significant portion of coconut properties in Sri Lanka (nearly 75%) belonged to smallholders (less than 20 ac.) and the rest to the estate sector where both private and government companies hold ownership. The contribution of the smallholding sector to the total annual coconut production was 70%. There were 547 registered coconut based products exporters around the country in 2018 and 80 – 85 percent contribution originated from the coconut production triangle. Currently, there were around 50 mega scale coconut based product manufacturers around the country and Silvermill Group of Companies (Giriulla Mills Limited) holds the market leadership in the industry. Mega players approximately consumed 100,000 – 150,000 nuts in an average per day. Jafferjee Brothers, Hayleys Group, Jacobi Carbons Lanka (Pvt.) Ltd. and Canro exporters were also major players in the industry. Further, 17 brokers and 237 coconut estate dealers were registered in 2018. A total of 37 coconut based products are exported annually and 18 comprised of kernel-based (Cocount Development Authority, 2018). Coconut oil, virgin coconut oil, desiccated coconut, coconut cream, milk, milk powder, copra, fresh nut and seed nut are considered the most popular products.

The leading constraint (27%) of the manufacturing industries was the prevalence of relatively unstable market for products. As a result, both producers and manufacturers suffered severely. This has a direct impact on the market share of both local and international levels. Next, was the low demand for local desiccated (16%) industry due to poor quality products. The third one was the labour shortage (12%) for processing and other activities and this ultimately lead to increased cost of production. Limited supply and unplanned allocation of raw materials were also a constraint in the industry. This diluted commercial level planning process creating major lapses in the industry. Heavy market competition (4%) and climatic change (4%) were also identified as constraints. In addition, ad-hoc tax changes, low profit margins, higher production cost, inability of applying for higher standard certifications, adulterations and use of chemicals were also mentioned as minor constraints.

Figure 1. A SWOT Analysis for the Coconut Kernel-Based Industry

Coconut based production industry is an ideal industry for the rural development through encouragement of small and medium scale agribusinesses around the country (Abeysekara et al., 2020). However, in order to expand industrial prospects, it is essential to increase the production and productivity (19%) simultaneously in plantations. Study emphasised that, the productivity of coconut production in Sri Lanka was much lower compared to other South-Asian counterparts. Adoption of good management practices are required to overcome this

issue. Similarly, manufacturers highlighted the need of modern technological know-how (19%) in the processing sector in order to maintain high standards. This is a vital aspect when meeting international market requirements. Increased productivity requires increased product manufacturing to retain market stability. It has been suggested to restrict the importation of palm oil (9%). However, a total ban of palm oil is not plausible. There should be a proper mechanism and policy procedures on importation of palm oil. Upgrading of desiccated coconut mills (9%) was also suggested. These mills require new machinery to increase production efficiency. Upgrading old mills is worthwhile with increased market prospects. The promotion of small scale production and coconut home gardening (6%) was emphasised in order to strike a balance between household and industry consumption.

4. Conclusions

Considering the coconut kernel-based industries, Sri Lanka has reached a transitionary stage where it has to cater to vast demand for both processed products and fresh nuts. Industrial growth could be propelled through giving more emphasis on industries like virgin coconut oil, fresh king coconut, coconut cream and coconut milk. Upgrading the technology of small and medium sector local desiccated industries is must to enhance the standards of manufacturing in order to compete with global markets. Proper mechanism has to be identified to convert the wastage of household fresh coconut consumption into industrial usage. Widening quality assurance by accrediting Quality Assurance Methodology like ISO 22000:2005 Food Safety for the coconut kernel-based products is essential to enhance the quality and standards of the products.

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Exploring the potential of colorants extracted from refuse green tea as a food applicant

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1. Introduction

Color is the first sensory parameter that meets the eye of the consumer. It plays an important role in determining the overall sensory appeal of a food product (Rajapaksha et al., 2017). Food colorant can be defined as any substance added to food or beverages to change its initial color and to enhance its appearance (Hewamalage et al., 2016). Recently, the use of synthetic food colorants has garnered much attention due to the staggering amount of research done related to the negative health impacts of synthetic food colours. Hence, the demand for the natural food colorants has increased over time. At present, tea extracts have gained popularity as raw material for developing food colorants (Bydoon, 2016). Further, in green tea processing, a considerable amount of wastage is created in the form of refuse tea. A higher percentage of this refuse tea is discarded without making any use of it, despite its potent chemical and therapeutic value. Therefore, this study focuses on developing a natural food colorant from refuse tea generated during green tea manufacturing. The specific objectives of the study are to determine the optimum conditions for extraction procedure; to analyze the stability of the colorant against pH, concentration, and temperature–time combination; to determine the physicochemical parameters of the developed colorant, namely polyphenol content, antioxidant activity, and caffeine content. This could be identified as a novel, low cost and sustainable valorization approach. Also, Sri Lankan tea market can use this method to convert waste materials into cash.

2. Materials and Methods

Refuse tea obtained from Raja-Ela green tea manufacturing factory, Gampola, Sri Lanka was used as the major raw material. Samples were obtained directly from the factory premises. Proximate analysis of the raw material was done according to the AOAC 2000 standard methods on dry weight basis. Extraction was done using the hot water-bath and sonication techniques. For extraction, 5 g of each tea sample was mixed with 25 ml of distilled water. Extraction using the sonication technique was done at room temperature for different time intervals. Extraction using the water-bath was carried out at for different time- temperature combinations as 50 ºC, 60 ºC and 70 ºC for 20 minutes, 30 minutes and 40 minutes respectively, which were determined over a preliminary study. Filtrates were taken using Whatman no: 01 filter paper.

The color intensity and absorbance values of filtrates were measured using KONICA MINOLTA Colorimeter and CT-6400 UV/Vis spectrophotometer at 572nm respectively. Based on the b* values and the absorbance values obtained, sample with highest yellowness and highest absorbance was selected. Afterwards, the selected sample was concentrated until the brix value of the filtrate reached up to 9^0 Bx. Carrageenan (1 - 3 %) was added upon the requirement to enhance the thickness and to stabilize the colorant. Carrageenan samples were collected from Euro food tech, Colombo. Finally, the product was stored in cleaned and dried glass containers at normal refrigerator condition.

The isolated colorant was incorporated with lime juice in different concentrations (1, 1.5, 2, 2.5, 3 % v/v) and structured sensory evaluation with nine point hedonic scale was carried out to study the consumer preference for the colorant. The sensory attributes tested were aroma, taste, colour, appearance, after taste preference and overall acceptability. Sensory data were

analyzed using MINITAB 17 statistical package according to non-parametric Friedman test at 5 % level of significance.

The Stability of the selected colorant was determined against concentration (3, 2.5, 2, 1.5, 1, 0.5, and 0.3 % v/v), pH (3, 4, 6, 8, 10, and 12), and time- temperature combinations (30 ºC, 60 ºC and 100 ºC for 3 minutes, 6 minutes, 9 minutes and 12 minutes) and the resulted colors were compared with Munsell color chart. Antioxidant activity (Free radical scavenging activity against DPPH), polyphenol content (ISO 14502 – (1) method), and caffeine content (method described by Jenway bibby scientific) of the colorant were determined.

3. Results and Discussion

According to the results of the proximate analysis, the initial refuse tea sample contained 8 % moisture, 5.58 % ash, 15.51 % crude fiber, 2.06 % fat and 19.68 % of protein. As per the Sri Lanka Tea Research Institute, the moisture content of the sample was well within the limit (Balasooriya et al., 2019). According to the proximate composition, it is evident that refuse tea could be identified as a desirable raw material which could be further improved to be used in various food applications.

Based on the colorimeter values and absorbance values obtained, from both extraction techniques, three samples were selected with the highest yellowness (b* value) and are listed in table 01 and table 02.

Table 01. Results of the sonication extraction technique for refuse tea-based colorant

Time (Minutes)	L^*	a^*	b^*	Absorbance (572nm)
25	31.14	-0.31	3.44	1.424
30	30.88	-0.45	4.13	1.234
35	30.77	-0.21	3.3	1.264

Table 02. Results of the water bath technique for refuse tea-based colorant

Time (Minutes)	Temperature °C	L^*	a^*	b*	Absorbance (572nm)
40	50	29.56	1.08	3.86	1.836
30	70	30.61	0.53	4.29	1.825
40	70	30.29	1.2	4.3	1.76

Among them, using the absorbance value, the sample with highest concentration was identified. Accordingly, water bath extracted sample for 40 minutes in 50 $^{\circ}$C was selected as it had the highest absorbance value. Afterwards, 3 % carrageenan was added and finally, gel form of the colorant was obtained.

The sensory profile of refuse tea based colorant is shown in figure 1, According to the results of the sensory evaluation, treatment 472 had higher total scores than other treatments. Addition of the colorant did not have a significant impact on taste and aroma of the food products. However, the use of 2.5 % v/v of the developed colorant was observed as the most suitable amount to be used as a colorant for beverages.

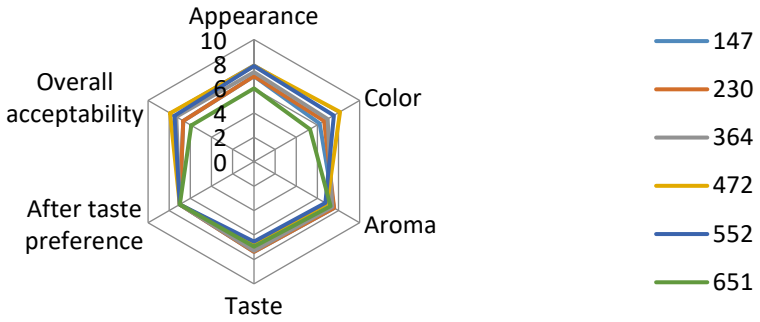

Figure 1. Web diagram of the sensory evaluation for refuse tea-based colorant

pH value	colour	Munsell color code	Concentration% v/v	colour	Munsell color code
3.0		5Y 8/10	0.3		5Y 8/8
4.0		5Y 8/12	0.5		5Y 8/12
6.0		2.5Y 7/10	1.0		2.5Y 8/6
8.0		7.5YR 7/10	1.5		2.5Y 8/8
10		5Y 6/8	2.0		2.5Y 8/10
12		5Y 6/10	2.5		7.5YR 7/8

Figure 2. Stability of colorant against pH and concentration

According to the figure 2, colorant showed yellow hues from 0.3 to 2 % v/v concentration level. Furthermore Yellowness (5 Y8/10 to 5 Y8/12) could be expected in the 3 to 4 pH range in the colorant and there is no significant change in the color from pH 3 to pH 4. Therefore it is intended for food products like Jam, concentrated fruit juice, confectionary food products having an acidic environment. Above pH 8, colorant resulted in hues approximate to commercial caramel color. Within those pH levels, colorant could be used for bakery products which are in high pH conditions.

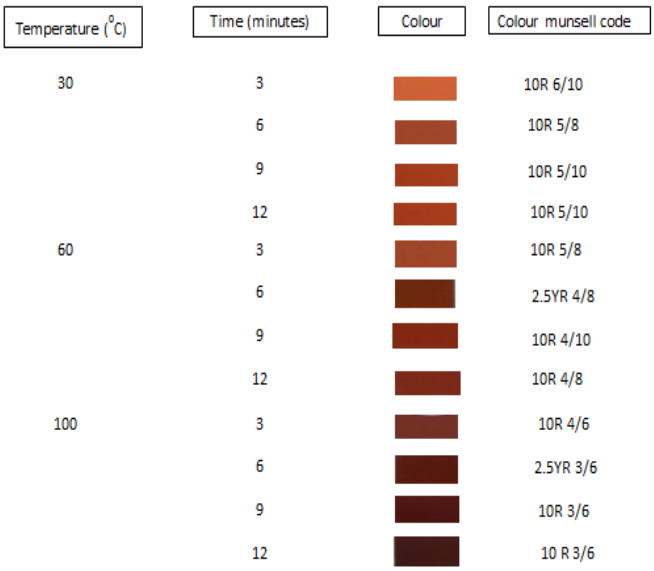

Figure 3. Stability of colorant against Time-Temperature

According to the figure 3, it was observed that the temperature and time harshly affected on the color and with the increase of the temperature darkness of the colorant significantly rises, especially from 60 °C and above, which resulted in a hue approximated to caramel black. Therefore, the colorant could be deemed most suitable for bakery products and confectionery products.

Table 03. Results of the physicochemical analysis

Parameter	Amount
Polyphenol content	192±4.5 mg/100ml
Antioxidant activity	83.24±1.69 µg/ml
Caffeine content	782.8±6.9 ppm

According to table 03, the colorant is found to possess a considerable amount of polyphenol, antioxidant, and caffeine contents. The detected values are in agreement with the values of green tea extracts (Hajiaghaalipour et al., 2016; Reto et al., 2007). Therefore, it can be concluded that colorant possesses a therapeutic effect and health promoting effect against human body. Since refuse tea is a waste product, developed colorant could render positive benefits toward health promotion.

4. Conclusions

According to the results, isolated colorant could be best used in food products in an acidic environment (pH 3-6) which are stored at room temperature or below. Furthermore, the colorant has considerable levels of polyphenol, antioxidant, and caffeine contents. However, further studies are required to improve the stability of the developed colorant.

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Chitin extraction from shrimp shell waste using pineapple crude enzyme

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1. Introduction

Chitin is the second most abundant biopolymer on the planet after cellulose, consisting of antifungal, antibacterial, antioxidant, anti-inflammatory and anti-hypersensitive properties. It is broadly used in different industries; including food, agriculture, wastewater treatment, cosmetics, and pharmaceuticals (Tolaimate et al., 2003). Chitin can be found in 15-40% of the exoskeleton of crustaceans including shrimp shell waste. Three steps followed in the chitin production are deproteinization, demineralization and decolorization. Deproteinization is the process used to separate proteins from shrimp shells. The pretreatment of deproteinization of chitin uses either partially purified or purified proteolytic enzymes. The cost of chemical methods and commercially available proteolytic enzymes in chitin pretreatment is most of the time unprofitable. As a result, an easily reached, cost-effective and plant-derived crude proteolytic enzyme was used in the pretreatment processing of chitin. Bromelain is an abundant protease enzyme found in pineapples and it breaks down cysteine peptide linkages in proteins. This study determines the efficiency of bromelain of the unpurified pineapple crude enzyme of the commercial cultivar on chitin extraction from shrimp shell waste.

2. Materials and Methods

Three selected pineapple cultivars were purchased and kept under the room temperature. The crude bromelain extraction was done using a method described in Mohan et al. (2016).

Deproteinization and chitin extraction

The clean and sun-dried shrimp cell waste was blended with distilled water in a ratio of 1: 4 (W/V). The deproteinization reaction was performed by mixing the extracted crude bromelain with the blended samples in a ratio of 1: 20 (v/v) at an optimum condition for the enzymatic activity (53 ℃, pH 7) for 24 hours. After the completion of the enzymatic reaction, samples were heated at 90 ℃ for 10 minutes to deactivate the enzyme. The insoluble fraction was separated from the supernatant by centrifugation at 4000 rpm for 45 minutes at 28 ℃.

The precipitate was used to perform the decolorization process by using acetone in a ratio of 1:4 (W/V) for 48 hours in the absence of light, at room temperature. Filtered samples were then demineralized by using 8% HCl solution in a ratio of 1:30 (W/V) for 30 minutes. After demineralization, samples were washed with distilled water until they became neutral. The extracted chitin was dried at 60 ℃ for 18 hours and stored in a desiccator.

The extracted bromelain enzyme and chitin biopolymer were characterized by powder X-ray diffraction (PXRD) and Fourier transform infrared (FT-IR). PXRD and FT-IR data were collected on a Bruker Phaser 11 diffractometer (30kv, 10 mA, Cu K-alpha radiation) and Bruker TENSOR 27 FT-IR spectrophotometer respectively.

3. Results and Discussion

According to the extracted chitin PXRD results (Figure 1), 5 major crystalline reflections were observed at ~9, 19, 20, 23 and 28 and the results are agreed with the α-chitin crystalline reflections observed for chitin extracted from organisms such as crabs, shrimp, and insects in literature (Liu et al., 2012, & Jang et al., 2004).

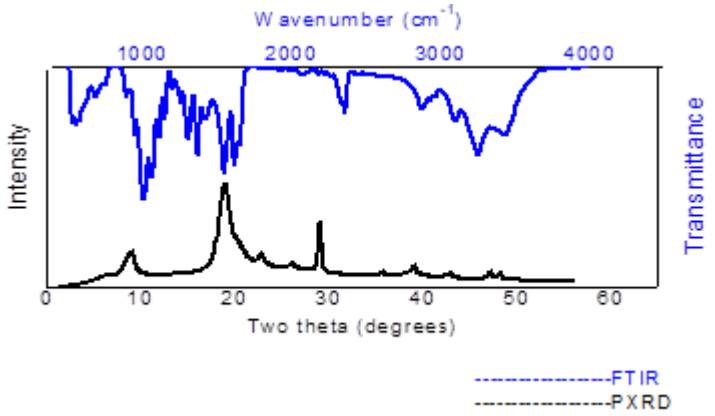

Figure 1. PXRD diffractograms and FTIR spectrum of extracted chitin

FTIR spectra (Figure 1) observed for chitin extracted in the present study has shown doublet at amid 1 band (~ 1620 cm^{-1}) and revealing that the extracted chitin is in the α form as reported in literature (Sajomsang, & Gonil, 2010). Peaks near 1650, 1620, and 1550 cm^{-1} of the chitin polymer correspond to the following functional groups; C=O secondary amide stretching (Amide I), N-H bending, and C-N stretching (Amide II), respectively (Jang et al., 2014). Other peaks observed at 3400 cm^{-1}, 3100-3200 cm^{-1}, 2900 cm^{-1}, 1500 cm^{-1} , 1400 cm^{-1} , 1300 cm^{-1} 1150 cm^{-1}, 1110 cm^{-1}, 1070 cm^{-1}, 1000 cm^{-1}, 950 cm^{-1} and 900 cm^{-1} are the result of O–H stretching, N–H stretching, aliphatic compounds, amide II, CH_2 bending, CH_3 deformation, CH bend and CH_3 sym. deformation, CH_2 wagging, asymmetric bridge oxygen stretching, asymmetric in phase ring stretching mode, saccharide rings, C–O asymmetric stretch in phase ring, along chain and saccharide rings respectively for chitin.

The price of commercially available Sigma Aldrich chitin per kilogram ranges between € 800-807 per kilogram (http://www.sigmaaldrich.com/european-export.html; accessed13th December 2021), whereas the cost of chitin prepared by our enzymatic based method ranges between € 440 - 450 per kilogram and will be an economically important potential method.

4. Conclusions

The present study has shown an effective chitin production method from shrimp shell waste using an unpurified pineapple crude enzyme called bromelain. The FTIR and PXRD analysis has confirmed the extracted chitin in the α form as reported in literature. Hence, it is possible to assess that the chitin extraction method using pineapple crude enzyme is a cost effective and economically important potential method in comparison to other chemical methods available.

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Contribution of home gardening for achieving food and nutrition security during covid-19 pandemic; Study on Gonapinuwala DS division

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1. Introduction

The COVID-19 pandemic has had an impact on all aspects of life. People have been forced to stay inside their homes due to quarantine, resulting in a "new normal" of living and adaptation. Countries had to follow prevention guidelines such as travel restrictions, the physical distancing of at least one meter, mandatory use of face masks when outside at home, and community lockdowns for prevention to spread. Those guidelines affected day-to-day activities all over the world (Sunga & Advincula, 2021). The COVID-19 pandemic has affected food insecurity in urban areas due to disruptions in the food supply chain, aggravation of physical and economic barriers to food access, and labor shortages.

Due to limited or non-existent international transactions, countries will have to rely on their own food and resources in such a situation. When considering Sri Lanka, imports a significant amount of food and the country has a trade deficit. As a result of that, Home gardening raised in popularity, both in rural and urban areas in Sri Lanka.

Food and nutrition security describes when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for active and healthy life (Hannah & Pieters, 2013). Home gardening is an important strategy for increasing access and ensuring food security at the household and community levels (Lal, 2020). This study focuses on the Relationship between home gardening and food and nutrition security during the COVID-19 pandemic.

2. Materials and Methods

This study employed the deductive approach. The survey was used as a research strategy to provide a solution to the research problem. A Self-Administrated questionnaire and structured interview conducted to obtain these primary data by visiting the household.

According to the census from the Sri Lanka Department of Census and Statistics, There are 6167 households in the Gonapinuwala Divisional Secretariat (DS) division, which is divided into 19 Grama Niladari (GN) divisions. Clusters are defined at the of GN divisional level. Then, based on the ratio of the household population in each of the three GN Divisions, Simple Randomly selected three GN divisions from the total of 19 GN divisions and obtained 100 households.

This Study uses Descriptive Statistics, Chi-square test, Frequency Analysis, Graphically illustration, and Scoring Method. SPSS 21 Version was used for data analysis. The US HDDS Scoring Method used for assessing the status of food secure or food insecure. The respondent was asked to recall all food (including snacks) and drinks consumed at home within 24 hours prior to the interview. HDDS consisted of a list of 12 food groups. When those households consume less than six food categories can introduce as food insecure, and when more than six food categories can introduce as food secure. The total possible score was 12 (Ene-Obong et al., 2017).

3. Results and Discussion

The Gonapinuwala DS Division was Food Secure in the accessibility dimension, according to the HDDS method. According to the HDDS method, 68% of households were food secure, while the remaining 32% were food insecure. The Gonapinuwala DS Division Food Security score was 7.4 as compared to the average HDDS indicator. As a result, the area was designated as a food secure zone. If household food is secured, those households had High Dietary diversity.

The frequency analysis is used to evaluate the household's home gardening status. Among 100 households, 79% maintain a home garden and 21% do not maintain. Out of the 79% of households that have a home garden, 18% are regularly maintained home gardens and 61% are irregularly maintained. Out of the 79% of home garden owners, 46.80% initiated their gardens during the COVID-19 pandemic, while the remaining 53.20% maintained their gardens prior to the COVID-19 pandemic.

Dependent variable	Independent variables	P value	Degree of freedom	value	Cramer's V value
Status of Food and Nutrition Security	Maintenance of Home Gardening	0.008	1	7.131	0.267

Figure 2. Chi-square test Results

There are two Hypotheses;

H0: There is no Relationship between maintenance of Home Gardening and Food and Nutrition
Security in Households.

H1: There is Relationship between maintenance of Home Gardening and Food and Nutrition Security in Households.

P value is less than 0.05. The null hypothesis was rejected. Cramer's V value is (0.267) between 0.2-0.3. There is a moderate relationship between maintenance of Home Gardening and Food and Nutrition Security in Households. When increasing home garden cultivation cause to improving households food Security (Dioula et al., 2013).

4. Conclusions

This study was done to Study on Relationship between home gardening and food and nutrition security during COVID-19 pandemic. The average HDDS indicator score was 7.4. As a result, it is possible to conclude that the Gonapinuwala DS Division is a food secure zone. When it comes to home garden maintenance, 76% of households do it. Out of them, 46.80% initiated their gardens during the COVID-19 pandemic; while the remaining 53.20% maintained their gardens prior to the COVID-19 pandemic. There has the significant relationship between maintaining home gardens and food security.

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Factors influencing the adoption of productivity enhancement practices in pepper cultivation in Sri Lanka

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1. Introduction

Sri Lanka is popularly known as the "Spice Island" and acquainted with the "Spice Route" from East to West for many centuries. Pepper is known as "King of the Spices" since it is widely used and extensively demanded spice around the globe. Pepper is generally attributed to as "Black gold" due to its luxurious nature and used as commodity money (Ministry of Minor Export Crop Promotion, 2014).

Sri Lanka ranks fifth concerning the pepper cultivated extent and seventh in production, with a world market share of around 5% (SLEDB, 2019). The Sri Lankan Export Development Board (SLEDB) statistics show that the country exported nearly Rs.11.5 billion worth of pepper in 2018, estimated as Rs.12.7 billion in 2017. Pepper fetches a sizable foreign exchange to Sri Lanka annually. Nevertheless, it has been reported that pepper productivity in Sri Lanka is comparatively low. Compared to the average export by Sri Lanka during the last decade, pepper export declined by 31% in 2019 (IPC, 2020). Nevertheless, Sri Lanka plays a crucial role in the world market under the 'Ceylon Spice' trade name due to its inherent superior quality. Taking this advantage to negotiate the intense competition in the world market, improving the productivity of the pepper will undoubtedly open up the way for Sri Lanka to explore high-end markets in USA and EU while enhancing the per capita income of the pepper farmers.

However, it seems that the application in the field is not following the recommendations. In order to explore the problems in the field, the effort needed to accelerate the adoption of the productivity enhancement practices, it is necessary to carry out a study by observing farmers' cultivation directly in the field and interviewing them. This study aims to explore the factors influencing the adoption of productivity enhancement practices by pepper farmers in Sri Lanka.

2. Materials and Methods

In Sri Lanka pepper cultivations are prominently found in Matale, Kandy, Kagalle, Kurunegaleand Nuwara Eliya districts (IPS, 2017). Kurunegala is one of the potential districts for pepper cultivation that contributed around 9% of the pepper production in the whole Island was selected for this study. In consultation with the department of export agriculture (DEA)-Kurunagala office, three major pepper cultivating DS divisions namely Rideegama, Alawwa, and Narammala were selected for the data collection. Multi stage purposive random sampling technique was employed and a total of 224 farmers were identified and interviewed with a pretested structured questionnaire. Multi stage sampling implies the divisional secretariat (DS) division, agriculture instructor (AI) division and grama niladhari (GN) divisions respectively. The collected primary data were entered in a spread sheet and the outliers were dropped from the sample during the data gleaning process. The effective sample size was 194. The data were analysed within the frame work of Ordered Probit Regression Model (Gujarati, 2003). Ordered Probit models explain variation in an ordered categorical dependent variable as a function of typically more than two independent variables.

The respondents were grouped into three categories, namely low, medium and high adoption levels based on the mean adoption score and standard deviation of the 'Productivity Improvement Practices Adoption Index' (PEPAI). Here the dependent variable in the Ordered Probit Model was coded as 1, 2 and 3 for low-level adopters, medium-level adopters and high-level adopters, respectively. The response variable here is trichotomous. Based on the literature, gender, age, and years of education of household head, household size, nature of farming, the extent of pepper cultivation, number of vines, age of the vine, market distance, access to the extension service, access to credit and crop yield index were included as the explanatory variables in the model.

3. Results and Discussion

Descriptive statistics disclosed that the mean age of the pepper farmers are 53 years and the majority of them, 82% are males. Only 18% of the farmers surveyed for the study depended on pepper as their main source of income. Many farmers interviewed in Kurunegale district have grown pepper for years, ranging from 8 to 50 years. Much of the knowledge and skills related to pepper farming have been transferred through generations. Mean years of experience in pepper cultivation was 30, and this indicates the most of the farmers possess an appreciable amount of experience in growing pepper. Most of them grow pepper in their small plots of land. According to the survey, the extent of land ranged from 0.25 to 4 acres, with a mean of 0.94 acres. The estimated production enhancement practices adoption index (PEPAI) ranged from 42.86% to 57.14%, with a mean of 55.52%. This indicates that more than 50% of the productivity improvement practices are already being adopted by the pepper farmers. Nevertheless, the maximum percentage of the adoption index was merely 57%. Primarily it was seen that selecting the planting material is one of the important follows under productivity enhancement practices.

Most farmers in the Kurunegala district are missing the commercial dimension of pepper farming by simply skipping the critical practices like going for improved clones and application of inorganic fertilizers and could be the prime reasons for low productivity.

Prob > chi2 is the probability of getting a small p-value from the Wald test, < 0.00001, which would lead the researchers to conclude that at least one of the regression coefficients in the model is not equal to zero. This implies that there is a significant relationship exist between the explanatory variables and the PEPAI. The Pseudo R2 = 0.2103 means model outperform the baseline model by 21%. In qualitative response regression model analysis, marginal effects use model prediction for interpretation because it can better interpret the model on the scale that makes more sense.

The results (Table 1) revealed that the age, years of education of the farmer and number of vines in the farm were positively correlated with the PIPAI and found to be significant at 1% ($P>|z|=0.001$) and 1% ($P>|z|=0.004$) and 5% ($P>|z|=0.038$) α level respectively. On the other hand, the extent of pepper cultivation, age of the vine and crop yield index was negatively correlated with PIPAI and found to be significant at 5% ($P>|z|=0.033$) and 5% ($P>|z|=0.038$) and 1% ($P>|z|=0.000$) α level respectively.

Table 01. Ordered Probit Regression STATA 13.1 Out-put

Variable	(dy/dx)	Std.Err	Z	P>|z|
Gender	0.0031	0.0681	0.05	0.963
Age	0.0166	0.0050	3.35	0.001**
Household size	-0.0086	0.0213	-0.41	0.685
Years of education	0.0361	0.0126	2.87	0.004**
Nature of farming	-0.0785	0.0916	-0.86	0.392
Extent of pepper	-0.3287	0.1540	-2.13	0.033*
Number of vines	0.0005	0.0002	2.08	0.038*
Age of vines	-0.0108	0.0052	-2.08	0.038*
Distant to market	0.0071	0.0173	0.41	0.680
Access to credit	0.0620	0.1492	0.42	0.678
Crop yield index	-0.6702	0.1536	-4.36	0.000**
Number of observations	194			
Wald chi^2 (11)	39.76			
Prob > chi^2	0.0000			
Pseudo R^2	0.2103			
Log pseudolikelihood	-92.0612			

dy/dx Average Marginal Effect ***significant at 1% level & **significant at 5%level

Figure 1 depicts the gender effect on the income generated from pepper farming with respect to farmers' educational levels. With the higher levels of formal education, farmers have more opportunities to secure a white-collar job or position in the private sector. Though this opportunity can be viewed as a risk reduction and income diversification strategy, it is found that it does not favour a good harvest in pepper, especially for female farmers. Generally, it was found that females with higher educational levels are taking up another job and not performing well in their farming activities. This is mainly due to their double fold responsibility both in the workplace and at home. The socio-economic and cultural setting of Sri Lanka shifts most of the household responsibility to females.

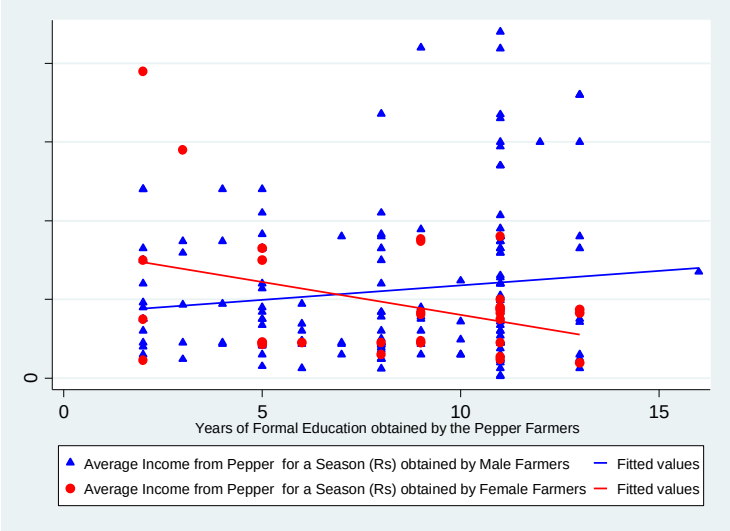

Figure 1. Income from pepper farming & Years of education and Gender Relationship.

Since they have a reasonable commitment towards their family and job, they may not keep up the farming phase. However, the male farmers, along with their job, seem to manage their farm well and could generate an appreciable income from it.

4. Conclusions

Age and education of the farmer are positively associated with adopting productivity enhancement practices. Farmers who are interested in practising crop intensification are also motivated to adopt more productivity enhancement practices. Contrarily farmers who own a larger extent of land and have older pepper vines and those who have attained a higher crop yield index have shown less incentive in adopting the productivity enhancement practices. Though education is generally favouring the adoption of productivity improvement practices for pepper farmers, it seems to be causing inefficiencies and affecting the returns from pepper farming for female farmers. Thus, special attention has to be paid to prioritizing the needs and constraints of the female farmers in formulating any policy to upgrade pepper production. In order to shift the pepper farmers in Kurunegale district more towards commercially oriented, the insufficiency in the adoption of productivity enhancement practices in pepper cultivation must be addressed immediately. Farmers have to be clearly explained the benefits of adopting the productivity enhancement practices and the spill over effect, probably through the extension efforts.

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Institutional support, readiness and relative perceptions in addressing sustainability challenge of agro-based SMEs in the competition: Evidence from Sri Lanka

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1. Introduction

Small and Medium Enterprises (SMEs) can be entitled as the pioneer force of attaining a sustainable development in any economy under the globalized economic conditions (Prasanna et al., 2019). Therefore, it is equitable to designate them as the backbones of both developed and developing countries. Similar to those countries, the SME sector in Sri Lanka has been named as the key driver for acquiring a strong economy, regional development, reducing unemployment and poverty. But, due to the feckless ability to face the three competitive challenges - sustainability challenge, global challenge and technological challenge (Auwal et al., 2020), compete, survive and succeed in the intensified competition have become infeasible for SMEs. Specially, the increased failing rate of a large number of firms within a few years of their commencement is identified as a distinctive issue (Shihadeh, et al. 2019). Among the above-mentioned competitive challenges, many scholars proposed sustainability challenge as one of the key hurdles of the SME sector, which becomes the main focus of this study. The changes in the global business and natural environments challenge the sustainability of SMEs. Hence, the institutional support and readiness is recognized as a key element for SMEs to be sustained in the intensified and globalized economic conditions. Involvement of SMEs in agriculture secures the country's food security. Therefore, the main objective of this study to investigate the support and readiness of local institutions, and their officers' relative perception on institutional support towards SMEs in facing sustainability challenges, and to address the noticeable lack of research work by taking agro-based SMEs in Sri Lanka as a case.

2. Materials and Methods

A qualitative, case study-based methodology was used for the study by concerning the special nature of the cases to be investigated. Specially, to enable the researchers to investigate and identify new areas and scopes, possibly dropped by previous studies. All the primary data were collected via conducting in-depth interviews. As conducting interviews are renowned as one of the most effective data collection procedures in case study-based research methodology, a series of key informant interviews were conducted to gather data by using a pre-tested interview guide, mainly consisted open-ended questions. Data were gathered from thirteen respondents representing thirteen local institutions related to the Sri Lankan agri-business sector. The purposive sampling method was used in selecting the sample respondents to permit that respective officer have at least more than a year of experience in working with agro-based SMEs in the field. Therefore, it could be assumed that they have considerable amount of experiences and knowledge to express and comment on their perspective on the SMEs confronting sustainability challenge and nature of institutional support. The interviews lasted for about fifty minutes on average and the respondents were contacted via face-to-face meetings or over the phone. All the interviews were recorded with the consent of the respondents. An in-depth thematic area analysis was adapted to analyze the data collected from the interviews and identified five key sustainability challenges faced by SMEs.

3. Results and Discussion

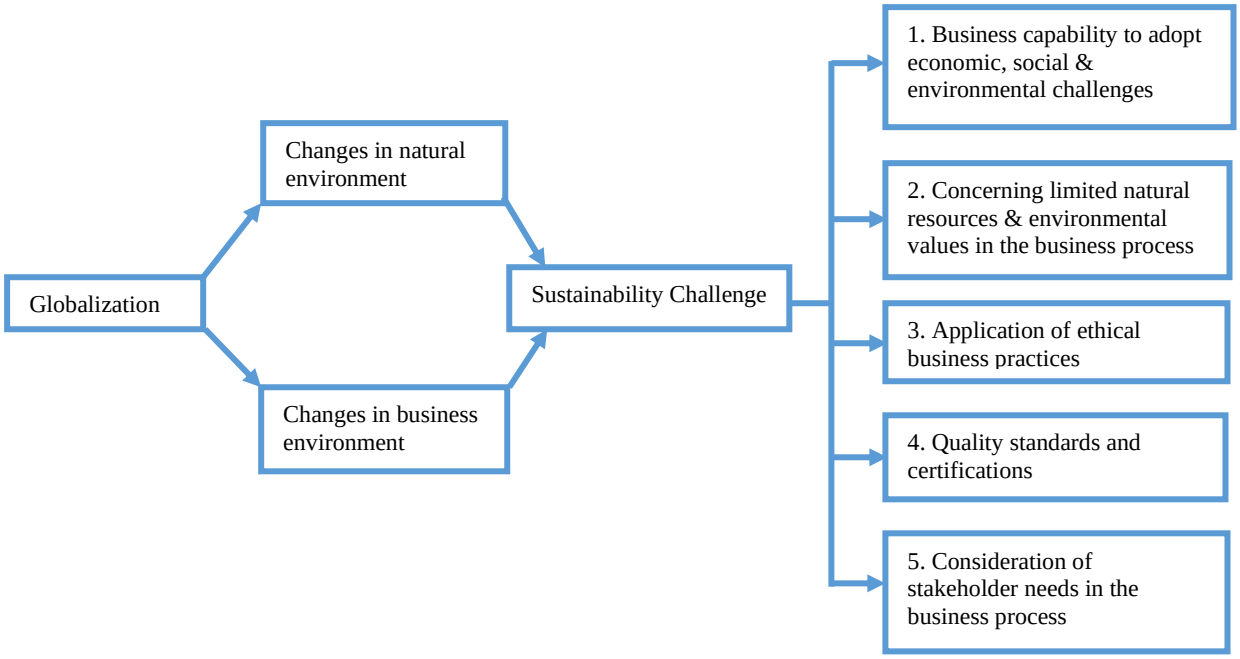

Figure 1. Relationship of SMEs' sustainability challenges

First, the study recognized the importance of having the potentiality of firms to identify and adopt socio-economic and environmental changes. Therefore, the study proposed the importance of both policy level and institutional level discussions over probable modifications in above mentioned changes and thereby legislature mediation to permit the financial security, environmental security and social security to reach a sustained SME growth across the country *"Entrepreneurs do not go to many government banks because the systems of those banks are not favorable for them".* It also shows the importance of nourishing the entrepreneurship mindset, attitudes and values in the curriculum of state educational institutions comprising technical and vocational programs to bring forth job creators rather than employment seekers.

With regard to environment values and limited natural resources in the business process, the research highly peels the importance of establishing and improving recycling systems and focus SMEs' attention on material flow analysis and strengthen their responsibility arrangements regarding the laws and regulations *"Most of them don't even know about the Environmental Protection License (EPL). We conduct training sessions for those entrepreneurs with the participation of the Central Environmental Authority to aware them about those environment-related matters".* Therefore, institutions need to perform a significant role to develop easily acquirable and simple solutions, which allow the SMEs to achieve their business targets in a more environmentally friendly perspective, by acquiring consumer demand and attraction for sustainably and environmentally friendly produced products.*".*

In-depth discussions with respondents revealed that the policy reforms initiated by many successive governments undoubtedly show their dedication towards forming an ethically competitive economy, combined with sustainability. But some cases reveal the unawareness of SMEs on practicing environmentally friendly production technologies and green growth opportunities. Some cases show the areas which required the government interventions in terms of enforcing the human resource of such institutions. As study reveals, government intervention is an essential strategy to the areas where, are influencing by policy, financial discipline, human

capital, technology, quality, education training and price control. "*With less human resources in the Department it's difficult to promote such things".*

The study emphasized the importance of simplification of applying procedures to certifications and quality standards, making appropriate and timely technology decisions, providing financial support, initiating national awards for quality services and products, and linking SMEs with large scale and multinational companies in achieving the sustainability challenge of producing quality products and services. The availability of condescending and skilled officers is economical when guiding SMEs towards certifications and quality standards and organizing knowledge sharing sessions with large firms and multinational companies generate opportunities to proliferate quality assuring practices among SMEs.

The study reveals the attempts of institutions is relatively successful in consideration of stakeholder needs of SMEs in the business process. Thus, initiating strong networks, platforms and links between stakeholders and SMEs such as exhibitions would guide the SMEs to a success. Moreover, the study emphasizes the importance of creating closer connections and linkages between research institutions and SMEs. This approach would promote industry relevant applied researches and it would ease off SMEs to anticipate market competition changes and implement appropriate shifts. Also, the study recognized the importance providing financial strength to institutions when developing SMEs' leadership, shared vision and strategy is necessary.

4. Conclusions

The essence of the study has highlighted the importance of establishing a single coordinating institutional body with the participation of both government and private sector, with enough, strong human resource to coordinate and answer SME related matters. Government should provide incentives for SMEs and continuously invest on the industry. The services provided by institutions should be enhanced with SMEs' willingness to get support and it should avouch efficacious solutions to their problems. The issues and constraints identified throughout the study are mostly unique to SMEs. Therefore, future researchers should explore these identified issues deeply which could use to familiarize with the institutional support services and sustainable development of SMEs.

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The diversity and dynamics of shifting cultivation in the dry-zone of Sri Lanka

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1. Introduction

Shifting cultivation, under its diverse forms of slash and burn system, is a traditional method of cultivating tropical upland soils, mostly for subsistence purposes. During the rest or fallow periods intervening between crops, the natural fertility of the soil is restored for renewed utilization in a subsequent period of crop growth. This traditional system of cultivation is in ecological balance with the environment and does not irreversibly degrade the soil resource, provided a sufficient length of fallow is allowed for soil restoration (Ediridhingha & Herath, 2017). Shifting cultivation, locally referred to as *Chena* cultivation, in general, a system of farming in which fields are prepared by cutting down the natural vegetations, letting it dry and burning it off. This technique serves to clear the field and enrich the soil with nutrients from the ash. Traditionally, this form of cultivation is characterized by a mixture of crops a long fallow period and minimal use of agro-chemicals. During the fallow period soil fertility improves and the land once again becomes suitable for growing crops However, it takes about 10–15 years for the fallow lands to restore the fertility of the soil (Anuradha et al.2019). This traditional practice of Shifting agriculture has been a means of livelihood for many farmers worldwide. However, recent decades, substantial literature highlighted that the Shifting cultivation and the people who practice it are often negatively stereotyped (Waner, 1991). Therefore, aim of this study is to systematic review of present Chena cultivation practices in the Dry Zone of Sri Lanka in economic and ecological point of views.

2. Materials and Methods

This study applied mixed approach both quantitative and qualitative research methods. The emphasis on 'lived experience' in qualitative research means that the methods are ideally suited to uncovering the meanings that people associate with events, processes and structures of their lives by way of perceptions, suppositions and preconceptions (Thrupp et al, 1997). The study used focus group discussions and key informant interviews with the help of questionnaires and checklist to meet objectives. Content analysed was used to analysis the qualitative data. This research aimed to analyse the current management practices and existing indigenous aspects of the dry Zone shifting cultivation (Chena cultivation) system from the economic viewpoint of farmers who are the main stakeholders of the system. The study completed the pilot survey in Anuradhapura, Kurunegala and Monaragala districts and made 24 focus group discussions in 24 villages. Each district covered 8 focus group discussion and one group represented more than 10 farmers. Hence this discussion depends survey and enormous literature survey on Chana cultivation. Information were analysis with the help of thematic analysis under seven steps. Income, expenditure and related market information were analysis using descriptive statistics.

3. Results and Discussion

Ninety-five percent of sample farmers were practicing Chena cultivation on government-owned lands and balance 5% farmers cultivate on their owned lands. More than 90% of households practice Chena agriculture on one land plot and 7% farmers were practicing two separate land plots and only 3% farmers were engaging their Chena practices using more than two land plots. In wet season (*Maha* season), farmers commenced land preparation in August,

cultivate crops in September/October and harvest between December and February. Mean age of the responded farmers was 58 years and majority of farmers were (78%) above 50 age category and only 5% were below 30years old. In respect to education of sample farmers, more than 62% farmers have studied up to ordinary level and 21 % have completed advance level examination. Balance 17% have completed grade 5 examination.

According to quantitative survey, average monthly gross income of Chana cultivation very from Rs. 60,000 to 250,000 per ha per season. The farmers who applied modern seed varieties, commercialized crops, inorganic fertilizer, pesticide and new technology with man-made water sources have recorded higher gross income of shifting farming. However, the farmers who have cultivated commercialized crops with inorganic fertilizer and pesticide with new technologies have depicted substantially higher cost of production with lower profit margin. The average net income is around Rs 62,000 per ha per season including imputed cost. Major cost component of the study area was recorded as labour (59%), inputs (26%) and machinery (15%) out of the total cost. More than 95% farmers cultivated Maize, Sesame, Kurakkan, Watermelon and Vegetables. Wild life attacks, mainly wild elephants, legal issues on lands. Pest and diseases and marketing issues were highlighted as major problems faced by the farmers in the study area.

Shifting farmers in the study area use a variety of modern inputs. More than 69% of sample farmers have used organic fertilizer, 62% have been used tractors on their shifting cultivation and more than 79% farmers have used agrochemicals with their cultivation practices. Out of total labour usage, more than 62% have used family labour and balance were hired and aththam labour specially during the period of land preparation and harvesting. Very few farmers, less than 10% who practice shifting cultivation away from village. More than 65% of sample farmers were repeatedly cultivated same land during last five years and only 23% farmers have changed their land annually since they have separate plots for cultivation. Only 12% of farmers kept the land uncultivated for at least one-year period. For farmers cultivating the same land every year, the follow period is around six months which is the between two cultivation seasons. It is also due to lack of rain water, legal issues and personal problems. According to content analysis, more than 87% of sample farmers were facing elephants' attacks for their crops during last two years.

4. Conclusions

The study revealed that agricultural land use patterns in traditional dry zone villages have changed in major ways over the last few decades. Such changes included the transition from a shifting-cultivation mode of farming to a fixed sequential mode of farming, the expansion of the per capita cropping area, and the disappearance of communality in agricultural land use patterns. The features, stages and lengths of cycles of shifting cultivation have changed over time. In the Dry zone of Sri Lanka, for example, fallow times historically were as long as 10 years, but are now an average of one years, well below the time required (10 years or more) to allow soil fertility to recover in a fallowed site and this is the main reason for Elephant human conflict. At the same time, shifting cultivators generally have been intensifying their land use practices over time, in many cases through the introduction of new crops and technologies.

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Entrepreneurial orientation and farm business performance: the moderating role of farm diversification and farm and farmer characteristics of cinnamon farmers in Galle district

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1. Introduction

Cinnamon is the most important and valuable spice among all the other spices in Sri Lanka. Ceylon cinnamon plant called "*Cinnamomum zeylanicum Blume*" is indigenous to Sri Lanka which generates 85% of the world production. Sri Lankan Cinnamon accounts for 60% of the total spice export earnings in 2018 (Tridge, 2020). As a primary spice of Sri Lanka, cinnamon creates unexploited opportunities for all the value chain actors including cinnamon farmers. Due to the high demand for Ceylon cinnamon, there is a high tendency to enter the cinnamon industry. Value-added Ceylon cinnamon products hold a competitive advantage due to the quality of local cinnamon. However, there is limited upgrading in the cinnamon value chains especially upstream value chain actors such as farmers have failed to capitalize on this opportunity. Most likely due to lack of entrepreneurial spirit and inability to mobilize their entrepreneurial capabilities to develop the farm business performance.

In this context, it is worthwhile to examine the entrepreneurial orientation of cinnamon farmers by investigating key entrepreneurial dimensions such as innovativeness, risk-taking, and proactiveness (Grande et al., 2011). Entrepreneurially oriented farmers have a high potential to achieve better performance both financially and non-financially (Veidal & Flaten, 2014). Therefore, this study aims to undertake a detailed analysis of the EO-performance relationship from a cinnamon farmer's perspective as well as to understand the moderating effect of on-farm & off-farm diversification and farm and farmer characteristics on the EO-performance relationship.

2. Materials and Methods

A survey was carried out in the Galle district covering 100 cinnamon farmers selected by using a stratified random sampling technique. The four strata came from four GN divisions of Gonapinuwala, Karandeniya, Ambalangoda, and Welivitiya- Divithura. 25 each cinnamon farmers were randomly selected from the strata based on a list of farmers provided by the divisional Agrarian Service Center.

Primary data were collected by using interviewer-administered questionnaires. The dependent variable was farm business performance that encompassed both financial and non-financial performance indicators. Farm diversification, farm and farmer characteristics were considered as moderator variables to the EO-Performance relationship. EO dimensions considered included innovativeness, risk-taking, and proactiveness. Socio-demographic factors, farm size, access to financial resources and other resources, and external networks were used as dimensions of farm and farmer characteristics. On-farm & off-farm diversification dimensions were crop diversification, agro-tourism, and other business activities.

Descriptive analysis was used to profile the characteristics of the farmers and farms. Structural Equation Modeling (SEM) was employed to test the relationships among the variables used in the study. SEM is useful for establishing inter-relationships among multiple variables through a series of single and multiple regressions. The effects of moderator variables were analyzed by specifying the interaction effects of the SEM. AMOS 23 version (statistical software for SEM), and SPSS 22 version was used for the analysis.

3. Results and Discussion

The internal consistency of measures used was evaluated using Cronbach's alpha coefficients. EO and the non-financial performance had Cronbach's alpha coefficients of 0.935 and 0.739. Therefore, EO had an excellent level of reliability, and the non-financial performance had an acceptable level of reliability. Figure 01 depicts the SEM path diagram that includes estimate regression weights.

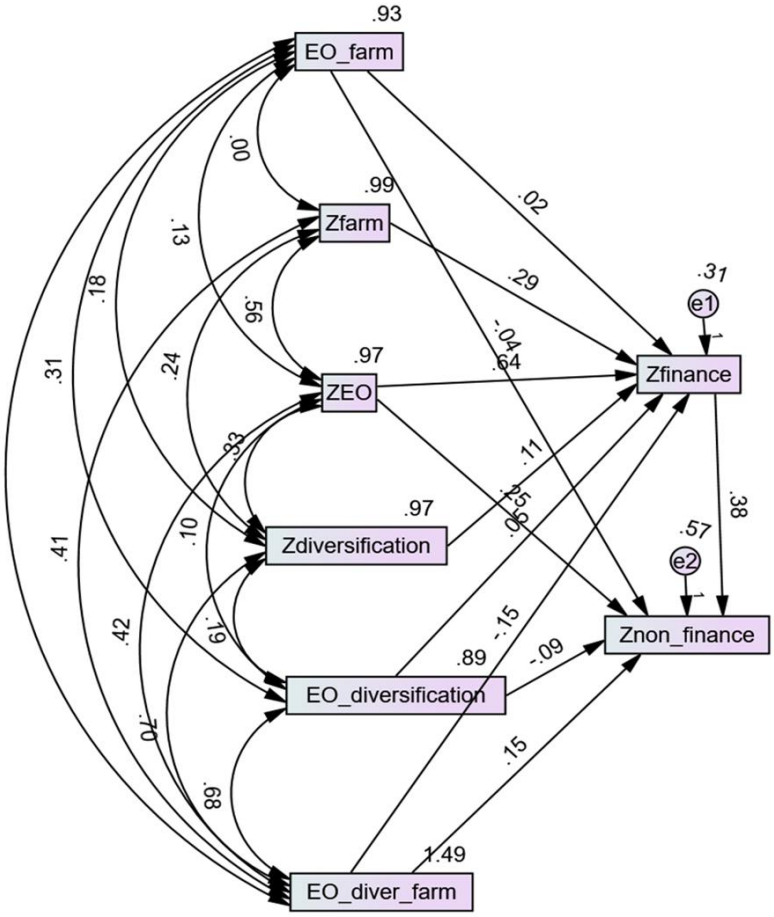

Figure 1. SEM path diagram

Default model fit values are GFI = 0.980, CFI= 0.984, NFI= 0.977, and CMIN/DF= 2.808. Both GFI, CFI, NFI values are higher than 0.9. If CFI and NFI values are higher than 0.9 it implies satisfactory fit (Forza & Filippini, 1998). CMIN/DF value is between 1 to 5 which means an acceptable fit.

Table 01. Structural equation model (SEM) path coefficients and significance levels

Path	Estimate	S.E.	C.R.	p-value
Finance performance <····· EO	0.644	0.073	8.841	0.000***
Non-financial performance <·····EO	0.247	0.131	1.888	0.059
Finance performance <····· EO-farm diversification interaction effect	0.049	0.079	0.624	0.532
Non-financial performance <····· EO-farm diversification interaction effect	-0.092	0.103	-0.901	0.367
Finance performance <····· EO-farm and farmer characteristics interaction effect	0.017	0.063	0.276	0.783
Non-financial performance <····· EO-farm and farmer characteristics interaction effect	-0.037	0.085	-0.436	0.663
Finance performance <····· EO-farm diversification- farm and farmer characteristics 3- way interaction effect	-0.148	0.075	-1.968	0.049**
Non-financial performance <·····EO-farm diversification- farm and farmer characteristics 3- way interaction effect	0.147	0.083	1.758	0.079

The relationship between EO and financial performance estimate value was 0.644 and it was significant at the 5% level implying that EO has a positive effect on financial performance. The EO and non-financial performance relationship was not significant at the 0.05 level implying that EO has no strong influence on non-financial performance. This could be attributed to high expectations of entrepreneurial farmers as the non-financial performance was measured in terms of farmer satisfaction with achievements related to their farming enterprise.

EO-farm diversification interaction effect on financial performance and non-financial performance was not significant. This is because farmers were likely to engage in entrepreneurial activities if there was a good demand and high price for their cinnamon products. Therefore, farm diversification does not moderate EO- performance relationship.

EO- farm and farmer characteristics interaction effect on both financial performance and non-financial performance was not significant at the 5% level. This implies that the interaction effect does not influence financial and non-financial performance. This is because most of the conventual farmers who engaged in traditional cinnamon farming do not have the mindset and the right attitudes to engage in entrepreneurial activities.

The result of the 3-way interaction effect on financial performance is negatively significant at the 5% level (Table 1). However, the 3-way interaction effect on non-financial performance is not significant. When farmers have good farm & farmer characteristics (e.g., good education, good network, and access to resources) they are inclined to involve in on-farm & off-farm diversification activities (e.g., other business, doing a job). They give less priority to cinnamon

cultivation due to lack of time. This was confirmed by the positive covariance between farm diversification and farm & farmer characteristics and thus explains the negative 3-way interaction effect on financial performance.

4. Conclusions

This study concluded that EO influences financial performance thus entrepreneurially inclined farmers perform well. However, they fail to achieve non-financial performance due to their higher level of expectations. Farm diversification does not moderate the EO-performance relationship because when they engaged in diversification activities, they pay less attention to cinnamon cultivation due to time constraints. The 3-way interaction effect of EO, farm diversification, farm and farmer characteristics weaken the EO-financial performance relationship. Given the poor entrepreneurial ecosystem in the study area to support cinnamon farming and value addition activities those farmers with good entrepreneurial traits and good farm characteristics move out of cinnamon cultivation and engage in other farm diversification and off-farm activities. The findings suggest the need to create a conducive entrepreneurial ecosystem to keep entrepreneurial oriented farmers in the cinnamon enterprise as well as to attract young entrepreneurially oriented youth to the cinnamon industry.

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Factors prompting in technology adoption of cashew farmers: Case of Eastern dry zone of Sri Lanka

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1. Introduction

The economy of Sri Lanka continues to be dominated by small holder-agriculture and is highly dependent on the import-export economy. Presently, Cashew has gained the status of a commercial crop through technological advancements concerning propagation, production management and mechanized processing. Cashew produced in Sri Lanka is not sufficient to meet local consumption as well as export. The annual production of Cashew is estimated to be around 10000MT – 12000 MT (Sri Lanka Cashew Corporation, 2016). Cashew is imported in large quantities from India and is re-exported with value addition to address the inadequacy. It is expedient; therefore, existing plantations have to be managed efficiently for increased productivity, and fresh plantations have to be established to increase production substantially. Thus, new technology and management practices must be adopted to enhance the productivity of plantations. Cashew Corporation introduces new technology and management practices extensively.

In Sri Lanka, cashew is observed to thrive and flourish in significant ground stretches in the Dry and Intermediate Zones. Cashew cultivation is prominent in Puttalam, Kurunegala, Anuradhapura, Hambantota, and Batticaloa. As far as Sri Lanka is concerned, removing the obstacles in increasing the productivity, enhancing the knowledge and skill of the farmers, and eliminating the hindrances in adopting technology in the industry, the quantity of cashew produced could be increased substantially.

Hence, this study considered determining the extent of technology adopted relevant to cashew cultivation and identifying the socio-economic and demographic factors influencing the adoption of the technology in the Eastern dry zone of Sri Lanka.

2. Materials and Methods

Researchers obtained details of cashew cultivators in the Batticaloa district, which is one of the potential districts in Sri Lanka. Those who were in the commercial dimension were chosen purposively, and relevant information was elicited. Commercial dimension is defined as the possession of a minimum of two acres of cultivation. Data were collected by administering a pretested structured questionnaire from the 236 selected respondents. Collected data were entered into a spreadsheet, and the outliers were dropped. The resulting 220 samples were analysed using descriptive statistics and Linear Probability model. Technology adoption features of the cashew farmers were calibrated considering the practices adapted relevant to the aspects ranging from Establishment of the plantation, Fertigation, Irrigation, Land utilization, Training and Pruning, Plant protection, Harvesting to Value addition. Based on the technology adoption index of the farmers, they were categorized either into the technology adopters or non-adopters' category. The adoption index for individual farmers is calculated as the technology score for individuals divided by the total technology score. The average adoption index is calculated as the sum of all individual adoption indexes divided by the number of samples (Obisesan, 2014). The dichotomous nature of the dependent variable suggests the suitability of the Logistic regression model for the data analysis (Gujarati, 2003; Wooldridge,

2010). Scientific literature, especially within econometrics (Gujarati, 2003, Wooldridge, 2010), commonly illustrates the Logit model in the following form Li = ln (Pi/1-Pi) = $\beta 1 + \beta 2Xi + \varepsilon i$. Here, Li is the log of odds ratio, and Pi is the probability that the ith farmer's decision to adopt the innovative cultivation practices was equal to 1 and 0 otherwise. Linear Probability Model assumes that Pi is linearly related to Xi. The Logit model assumes that the odds ratio is linearly related to Xi. $\beta 2$, the slope, measures the change in L for a change in Xi. $\beta 1$ is the Y – Intercept, and εi is the stochastic error term. The data were analysed using the econometric software STATA 13.1. Interpretation of the data was made based on the marginal values of significant variables resulted from Logistic regression analysis.

3. Results and Discussion

The overall significance (Prob > chi2 = 0.0162) of the Logit model (Table 1) implies that the relationship between the adoption of technology and the socio-economic characteristics of cashew growers in the Batticaloa district were significantly correlated. The results showed that the years of education, household size, the extent of the cashew plantation and the degree of exposure to the mass media are significant and positively associated with technology adoption of the cashew farmers at 5%, 5%, 5% and 10% α levels respectively.

Table 01. Logistic regression output

Variables	Coefficient	Std.Err	Z	P > |z|	dy/dx
Gender	0.14788	0.4529	0.33	0.743	0.29577
Age	0.00838	0.0318	0.26	0.792	0.00168
Years of education	0.16738**	0.6644	2.80	0.005	0.03348**
Farming experience	0.01015	0.2072	0.49	0.623	0.00203
Household size (medium)	1.56960*	1.1089	1.78	0.075	0.27035*
Household size (small)	2.19763**	1.1346	2.55	0.011	0.39726**
Extent of plantation	0.43880*	0.2411	1.91	0.056	0.08776*
Output	-0.00212	0.0013	-1.65	0.100	-0.00043
Price of output	-0.00009	0.0036	-0.03	0.980	-0.00002
Extension services	0.50698	0.4725	1.09	0.274	0.10139
Mass media exposure	0.98174**	0.4214	2.53	0.012	0.19635**
Irrigation	0.21500	0.7571	0.28	0.776	0.04300
Fertilizer application	-0.11571	0.6258	-0.18	0.853	-0.02314
Number of observations	220				
Wald chi2 (14)	20.46				
Prob > chi2	0.0162				
Pseudo R^2	0.1558				
Log pseudolikelihood	-70.2170				

dy/dx for factor level is the discrete change from the base level- Marginal effect.
**significant at 5% level, *significant at 10% level.

It could be seen that more the educational level of the farmer better the adoption of technology in cashew farming. Education improves one's capability and understanding of the benefit of technology and may help them make correct decisions. It enhances one's ability to perceive and understand innovations and information and apply the same in their cultivation practices. This result is consistent with Nhantumbo et al., 2017 and Uhunamure et al., 2019. In the total sample, 60% of respondents had above average years of education within that 48.83% of males and 19.17% were female cashew growers.

It was found that medium and smaller household sizes favouring the adoption of technology in cashew farming. This may be due to the fact of labour substitution. In Sri Lanka, the fraction of agricultural workers in the labour force is decreasing yearly, and thus it is becoming more expensive (CBSL,2018, 2019 & 2020). For this reason, smaller farm families are keener to go for new technologies and innovations that would help them substitute the labour. Particularly the labour-saving technologies, for instance, farm mechanization, would be more attractive to them. In contrast, larger families often have more family labour to support the farming, and due to this reason, they may not be much attracted to the modernization of their plantations.

The extent of cashew plantation is also played a crucial role in fostering the adoption of technology. More extensive plantations seem to be doing quite well and capable of supplying a sizable portion to the market. Since larger plantations are fetching more returns, farmers are mainly involved and occupied with their plantations and paying more attention to the management and maintenance aspect of their plantations. Higher returns always motivate the farmers to know about the innovations and technology introduced in cashew farming. Larger farmers are mostly more market-oriented and thus giving them comparatively higher access to the information. They are more up to date and enthusiastic. This nature could be favouring the adoption of technology. Beshir (2014) and Mwangi and Kariuki (2015) also got the same results and arrived the similar conclusions.

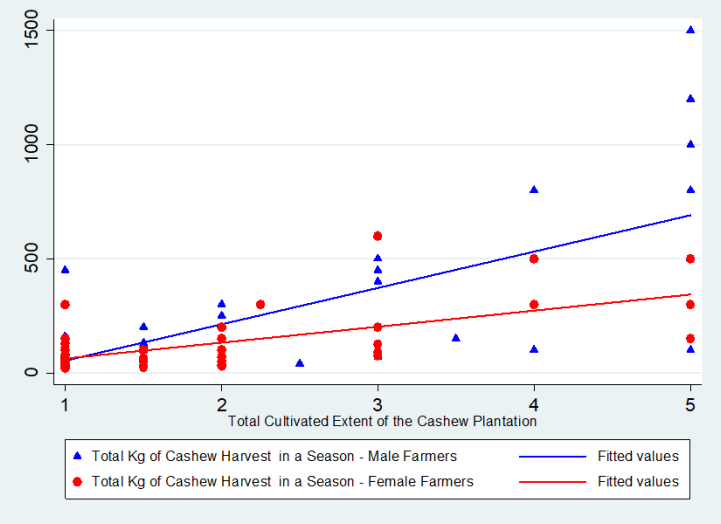

Figure 1. Extent of Cashew plantation (ac), Output (kg) and Gender relationship

Moreover, gender seemed to play a crucial role in the performance of the cashew plantations in the Batticaloa district. It was observed (Figure 1) that with the increased extent of the plantation, male farmers seem to perform well and can reap a higher production than female farmers. This may be because female farmers have more household responsibilities than men. This may hold them back to manage their plantations to a certain extent. It is seen in the above figure that the yield difference is get widened when the extent of the plantation gets larger.

Logistic regression revealed the significant contribution of mass media exposure in the adoption of technology in cashew cultivation. The more exposure, the greater the technology adoption was observed. Many other researchers, Singh et al. (2011); Anusuya et al. and Vishakha Yadav et al. (2020), reached the same conclusion. When farmers have a chance to watch the television programs relevant to new technology or read the printed materials

distributed by the department of agricultural extension or Cashew Corporation played a crucial role in convincing the farmers to opt for new technologies.

4. Conclusions

The results showed that the years of education, household size, the extent of the cashew plantation and the degree of exposure to the mass media are significant and positively associated with the technology adoption of cashew farmers. Therefore, the policy options that promote rural extension education services, access to mass media and factors of production, precisely land, are pertinent to enhance the adoption of improved agricultural technologies by the Cashew farmers in the Batticaloa district. Special attention and extension support can be extended to the female farmers to increase their productivity, especially those managing to greater extents.

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The impact of ICT in large scale agricultural producers' productivity; evidences in Kandy district

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1. Introduction

In this rapidly developing modern world, Information and Communication Technology (ICT) plays a significant role in every single aspect of human life. ICT tools can play a vital role in uplifting the standards, accuracy and efficiency in every industry. ICT includes a broad range of converging technologies, including smart devices, Geographic Information Systems, remote sensors, satellites etc. (Corpin, 2021). There is already an increasing trend towards adapting to ICT in almost every sector. Agriculture sector is no exception. The agriculture sector significantly contributes to the country's economy. Being the backbone of the economy of Sri Lanka, agriculture sector contributes 8.36% to the country's GDP (O'Neill, 2021). The agriculture sector is facing major challenges in increasing productivity at a time when natural resources required for production are declining. However, increasing demand for agricultural products also provides opportunities for producers. The agriculture sector faces a number of significant challenges especially in developing countries due to price shocks, climate change and the continuing lack of infrastructure (Das, 2013). Today digital devices are being extensively utilized by agricultural producers in providing solutions

In Sri Lankan context, majority of the producers are small scale farmers, but the sector is dominated by the less number of Large Scale agricultural producers (LSAP). They play a vital role in Sri Lankan agriculture sector while contributing to the country's economy significantly.

In general, the adaptation to ICT tools is less prominent in the Sri Lankan agriculture sector, still LSAP utilize ICT in their business context compared to small scale farmers/ producers. Use of ICT helps LSAP to deal with suppliers and consumers, to determine the potential markets, to monitor and regulate their stocks, prices, quantities depending on demand fluctuations and to do various predictions on the entire process. The purpose of this study was to examine the impact of ICT on productivity of LSAP.

2. Materials and Methods

The methodological approach for this study was the descriptive quantitative method which collects data from the LSAP to make interpretations in a numerical way. In this quantitative research, the researcher has used a survey as the research strategy. Data were collected via a questionnaire distributed among the LSAP in Kandy district.

The researcher has identified 3 variables to measure the impact of ICT on LSAPs productivity. Therefore, convenience, accuracy, and efficiency were defined as the independent variables whereas productivity was the dependent variable.

When considering the dependent variable, productivity, it is about achieving the best output using the available inputs (Jona-Lasinio, Haskel & Corrado, 2021). The convenience of a particular agri-business is a judgment made by users/business owners themselves according to their sense of control over the access and the use of the service. Increased convenience of the firm operations enhances the productivity of the entire firm (Farquhar & Rowley, 2009). Accuracy is described as the level of measurement that yields true and consistent information (Wilkerson & Lang, 2003). According to Wilkerson & Lang, 2003, accuracy of data is a crucial

component in measuring productivity. Agriculture sector, being a hard-to-predict sector compared to other sectors in the world of business, requires more accurate and precise data in order to make appropriate decisions and to make predictions. The concept of efficiency is closely related with the productivity. Input-output relationships are greatly bounded with both these concepts. For instance, if a company is obtaining a maximum output from a least input within a least time period, it is identified as an efficient process.

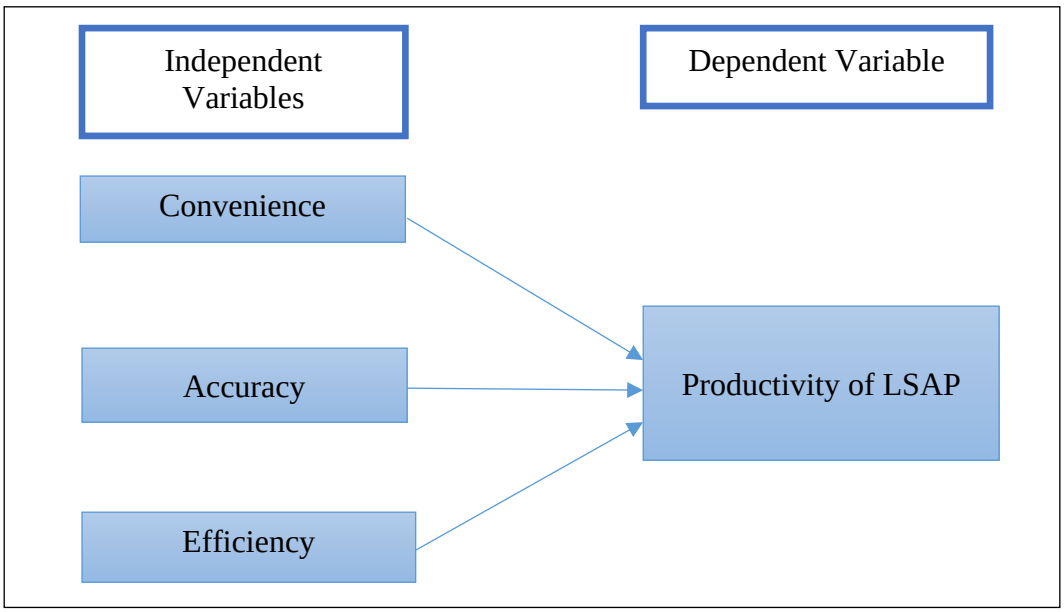

Figure 3. Conceptual framework (developed by the authors - 2021)

The total population of the study was all the LSAPs in Kandy district. The researcher was unable to find the exact population in the study since there were few obstacles that occurred while finding the exact population. Because of that the researcher used the convenience sampling method which is a non-probability sampling method. Therefore, the researcher selected 50 companies representing different natures of agribusinesses which are LSAP in Kandy district which report a high annual average output and which gives a significant contribution to the export sector, as the sample. This study was mainly based on primarily collected data from the selected sample; therefore, questionnaires were the main instrument of data collection. First part of the questionnaire consisted of demographic questions. Five point Likert scale was used in the second part of the questionnaire. The researcher additionally used secondary data from company profiles in gathering information on utilization of ICT, financial information, and production.

3. Results and Discussion

The researcher analyzed the collected data by using the SPSS analytical tool. Reliability and validity are the concepts used to evaluate the quality of the research. Hence, the researcher has used internal consistency method to test the reliability of the questionnaire. According to the reliability test coefficient alpha (α) values were 0.783, 0.758, 0.736, 0.707 for convenience, accuracy, efficiency and productivity respectively. Therefore, all the independent and dependent variables were considered as reliable since all the values were above 0.7. Validity is defined as the extent to which a concept is accurately measured in a quantitative study. The researcher mainly focused on construct validity to measure the validity of the questionnaire.

Data was analyzed using two statistical techniques; descriptive statistics and inferential statistics. Descriptive statistics are used to analyze demographic factors to describe the basic

features of the sample of the study. (Mean, mode, median, standard deviation, variance and skewness). The study revealed that the most respondents are from the LSAP of tea sector, while being the highest output provider too. LSAP in cocoa (chocolate) sector marked the highest number of employees owned within the sample. Also, average utilization of ICT-related devices was highest in the cocoa sector as well. Inferential statistics allows making predictions from collected data and making generalizations about the population.

According to Pearson correlation coefficient analysis the relationship between convenience and LSAP productivity has a positive relationship with a value of 0.433. The p value is 0.000 which shows a significant relationship between convenience and productivity. It implies that the convenience level gained by utilizing ICT devices in firm operations, positively affects the productivity of LSAP. As a sector dealing with a tremendous amount of statistical data, it's difficult to engage in manual calculations of data. Therefore, the study reveals that utilizing ICT in such operations makes it more convenient to enhance its productivity. The relationship between accuracy and LSAP productivity has a positive relationship with a value of 0.524. The p value is 0.001 which shows a significant relationship between accuracy and productivity. It demonstrates that the accuracy of the digitalized data of a company leads to obtain a higher productivity. Because, accurate data ensures accurate decision making and predictions on agriculture sector. The relationship between efficiency and LSAP productivity has a positive relationship with a value of 0.478. The p value is 0.000 which shows a significant relationship between efficiency and productivity. This illustrates that efficiently acquired data, through utilization of ICT tools and knowledge on ICT enhances the productivity. All three independent variables showed a significant positive relationship with productivity. Also, above values illustrate that accuracy has the strongest relationship with the productivity of LSAP. This can be further explained as follows; large scale agricultural production sector deals with an immense amount of data based on many farming operations that are tough to handle manually. Hence, the accuracy of such data and processed information is questionable. Adaptation of ICT helps reaching accurate decisions through accuracy of data. Therefore, accuracy shows the strongest relationship.

Regression analysis was used to determine the relationship between the dependent variable and one or more independent variables. The researcher used a multiple regression analysis to measure the hypothesis of this study. According to the results, Beta (ß) values were 0.123, 0.547, 0.149 for convenience, accuracy and efficiency respectively. Only accuracy and efficiency were significantly related and p values were 0.000 for both variables. Convenience took 0.749 for the p value which showed insignificant relationship with the dependent variable.

The coefficient of multiple regression analysis indicates the percentage of variation in a dependent variable explained by the combination of all independent variables. It indicates the goodness of fit of the model. The r2 value for the current study was 0.581 which represent that the 58.1% of the variance in the dependent variable is explained by the independent variables.

4. Conclusions

The main objective of this research was to investigate the impact of ICT on LSAP. Therefore, the researcher collected information randomly from 50 LSAP. This study concluded that convenience, accuracy and efficiency gained by utilizing ICT have a positive relationship with LSAPs productivity while accuracy having the highest relationship with productivity. In conclusion, although adaptation to ICT tools is less prominent in Sri Lankan agriculture context, this study revealed that ICT imposes a positive impact on the productivity of LSAP. The study lays a basis for other agricultural producers to improve productivity with the use of ICT.

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Livestock and Aquaculture

Increase of altered nuclei in peripheral erythrocytes of *Oreochromis niloticus* following exposure to sub lethal concentrations of crude oil

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1. Introduction

Crude oil includes a variety of components, such as poly aromatic hydrocarbons (PAHs), nitrogen–oxygen mixtures and heavy metals which are the major elements of petroleum hydrocarbon pollution in aquatic ecosystems. Different PAHs can have dangerous consequences due to oxidative biotransformation, which produces highly DNA-reactive metabolites that are known carcinogenic and mutagenic chemicals (Djomo et al., 2004; Oliva et al., 2012). Genotoxic potency of these metabolites is expressed in fish due the relatively low metabolic rate of biotransformation of PAHs and has been confirmed by different studies (Baršiene et al., 2006; Çavaş & Ergene-Gözükara, 2005; Kanthi et al., 2015; Kanthi & Jayaweera, 2021). Micronuclei assays and other erythrocyte nuclear abnormality (ENA) assays are most common and promising biomarkers for assessing genotoxicity in fishes (Baršiene et al., 2004). In recent years, several investigations have shown the existence of nuclear abnormalities (NAs) other than micronuclei in cells of fish exposed to genotoxic chemicals could be used as effective tool for assess genotoxicity (Ayllon & Garcia-Vazquez, 2000; Baršienė & Andreikėnaitė, 2007; Çavaş & Ergene-Gözükara, 2003; 2005). Among those erythrocyte abnormality types, altered nuclei (AN) have been identified as a type of ENA which consisted with several nuclear lesions which are readily available in exposed fish peripheral blood erythrocytes (Kanthi et al., 2015). Furthermore, altered nuclei are a combination of blebbed nuclei, notched nuclei, lobed nuclei, and kidney shaped nuclei (Çavaş & Ergene-Gözükara, 2003). Analysis of AN is used for in situ genotoxicity assessment in aquatic media (Hose et al., 1987; Al- Sabti & Hardig, 1995; Al-Sabti & Metcalfe, 1990). Since fish often respond to toxicants in a manner like higher vertebrates, they can be used to screen for chemicals that have the potential to cause teratogenic and carcinogenic effects in humans. The aim of this study was to investigate the frequency trends of altered nuclei over the exposure period in the fish species *Oreochromis niloticus* treated with sub lethal concentrations of crude oil under controlled conditions.

2. Materials and Methods

Forty-day laboratory experiment was carried out using advanced fingerlings of (*Oreochromis niloticus*) (n=9 per tank; two replicates) which were exposed to sub lethal crude oil concentrations (T1 = 3ppm and T2 = 15ppm, v/v% in freshwater) and the effects were compared with a control group (C) not exposed to crude oil. Water and crude oil exposure renewal was done after each 5 days of exposure. Water quality (Temperature, pH, Salinity, Total ammonia) was monitored regularly throughout the experimental period. Feeding was done as once per day and daily fecal matter removal procedure was carried out.

Peripheral blood sampling (n = 10 per group) was carried out on the 5^{th}, 10^{th}, 20^{th} and 40^{th} day of the exposure period to prepare blood smears. For the blood collection, randomly selected fish were anaesthetized by using benzocaine solution. Blood samples were obtained by caudal vein puncture (2 slides per fish), directly smeared on the slide, and air-dried overnight. The air-dried blood smears were fixed using absolute methyl alcohol (Methanol) before the staining of the smears. Then slides were stained with 10% Giemsa solution for 60 minutes. Then slides were rinsed with distilled water and air-dried at room temperature overnight. Counting of

altered nuclei was done on each slide, areas with a uniform spread in monolayer without overlapping cells according to the classification key introduced by [Figure 1] (Çavaş & Ergene-Gözükara, 2003).

Different altered nucleus types were enumerated while counting up to a total of 5000 RBCs (per fish) and Frequency of total AN (per 1000 RBCs per fish) was calculated. The trends of frequency of AN were statistically analyzed by using Kruskal-wallis test and Mann-whitney U test for pairwise comparisons between sampling dates (SPSS ver.16) and represented with graphical illustrations.

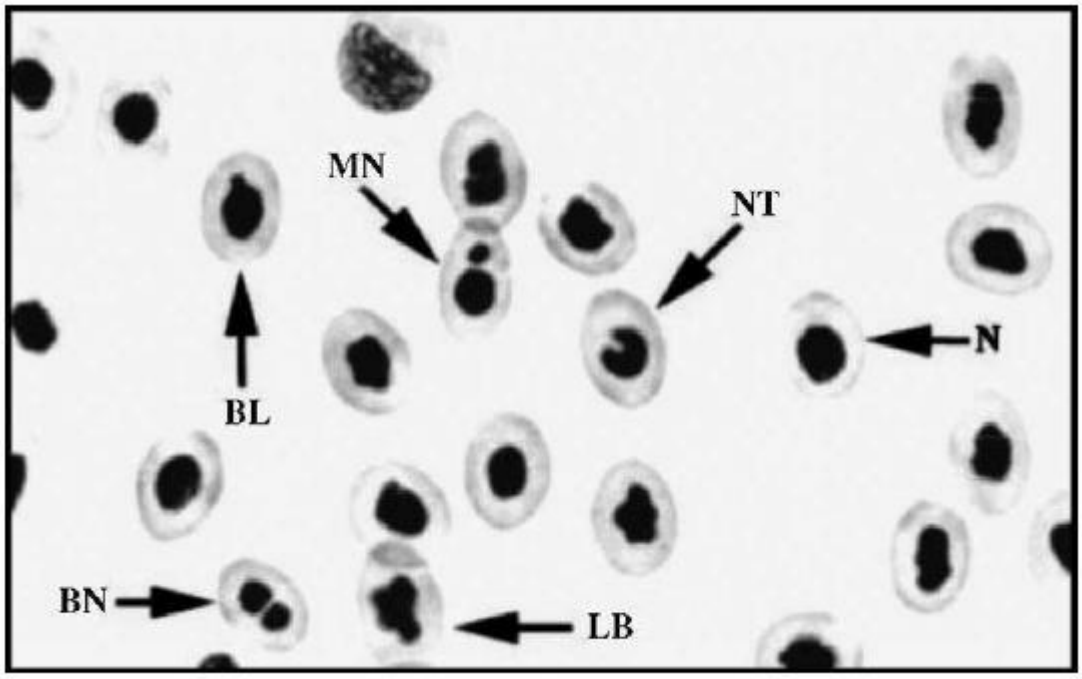

Figure 1. The micrograph adapted from Cavas et al., (2003) to be used as the guidelines for identify different altered nuclei, N: Normal red blood cell, BL: blebbed nuclei; LB: lobed nuclei; NT: notched nuclei/ kidney shaped nuclei in peripheral blood erythrocytes of *O. niloticus*

Table 01. Summary description statistics of altered nuclei in peripheral blood of O. *niloticus* among four sampling times over 40-day exposure period in experimental groups (Mean ± SD calculated from 10 fish per group). Results from Mann- Whitney U test for comparison between pairwise are indicated by the superscript letter (a, b, c, d), where shared letter within rows indicate homogeneity

Sampling date / Exp. group	5th day	10th day	20th day	40th day	P value
Control	0.52± 0.329^{a}	2.10±2.104^{b}	0.56± 0.350^{a}	0.44± 0.263^{a}	0.018
Treatment 1 (3ppm)	2.26±1.181^{ab}	2.09± 1.908^{ab}	1.60±0.805^{abc}	1.02±0.537^{d}	0.054
Treatment 2 (15ppm)	3.40±2.268^{a}	5.18± 2.292^{ab}	2.74±1.095^{acd}	2.56±1.061^{acd}	0.034
P value	< 0.001	< 0.001	< 0.001	< 0.001	

3. Results and Discussion

There was no significant difference ($P > 0.05$) within each experimental group among different sampling points for selected water quality parameters. Therefore, the quality of water in control and treatment tanks did not vary significantly during the experimental period, except for the suspensions of oil droplets in treatment groups because of the water-soluble fraction of PAHs in crude oil.

Normal red blood cells were observed to have a spherical, clearly demarcated nuclear surrounded by cytoplasm (Figure 1) and normal RBCs were highly prevalent in the control group. Blebbed nuclei, notched nuclei, lobed nuclei, and kidney shaped nuclei were observed as altered nuclei on each sampling date in all experimental groups. Kidney shaped altered nuclei type was highly available in treated groups than in control group. In each sampling date there was a significant difference in altered nuclei among the experimental groups ($P<0.001$) [Table 1]. According to the pairwise comparison (control vs. treatment 1control vs. treatment 2/ treatment 1 vs. treatment 2) on each sampling date between control and treated groups, significant mean frequencies of AN were perceived in each comparison except between control and treatment 1 on the 10^{th} sampling date [Table 1]. The mean frequency of AN was high in the treatment 2 (15ppm) group compared to the treatment 1 (3ppm) group throughout the exposure period [Figure 2].

According to the statistical results for comparison of mean frequencies of AN among sampling dates of each group, control and treatment 2 groups showed significant ($P < 0.05$) variation of altered nuclei counts with respect to exposure period [Table 1]. In the control group, though the frequencies were low in counts compared to treated groups, a substantial number of altered nuclei were observed on 10^{th} sampling date. Moreover, after the 5^{th} day of the experiment, there was considerable upwelling of AN till the 10^{th} day. Afterwards, a decline was observed (Figure 2).

The erythrocytes of fish exposed to 3ppm crude oil (Treatment 1 group) concentration exhibited the highest frequency of AN at the 1^{st} sampling date. After that the trend of appearing of abnormality type was gradually reduced, but the amount of AN was higher than that of the control group at the endpoint of the exposure. However, the fish of the treatment 2 group (15ppm crude oil) revealed a trend of development of altered nuclei in their erythrocytes in a similar way to the control group. Even so, the frequency of AN was highest on each sampling date among the groups [Figure 2].

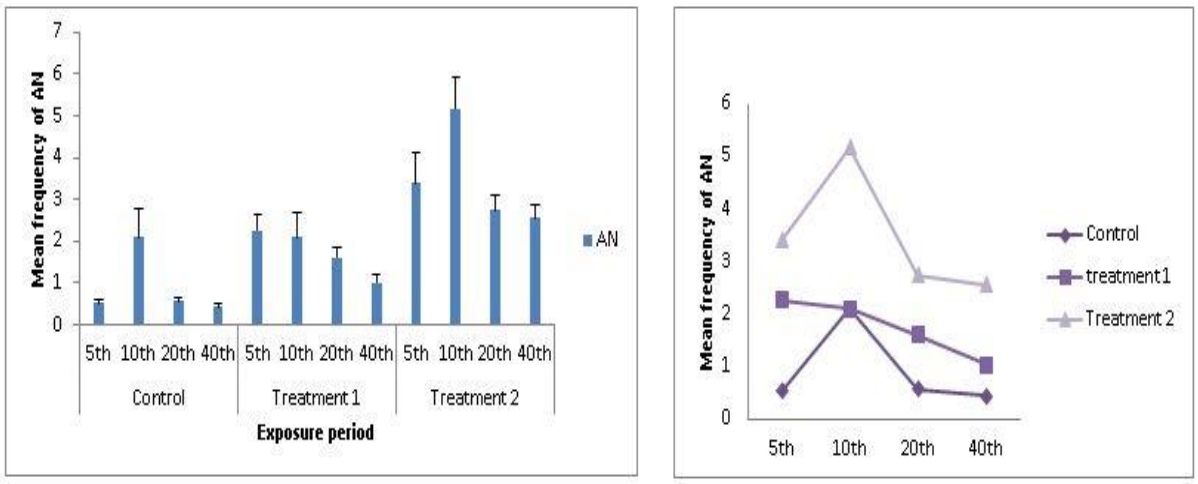

Figure 2. Indication of and trends of altered nuclei (AN), over 40-day exposure period (Mean ± SE calculated from 10 fish per group.)

According to Bolognesi et al., 2006, the application and justification of a sensitive biomarker susceptible to the effects of chemical mixtures is important in bio monitoring aquatic pollution. The present study exhibits the genotoxic effects of sub lethal concentrations of crude oil on *Oreochromis niloticus* peripheral blood. According to the results obtained, there was a significant induction of altered nuclei in peripheral blood which were exposed to crude oil, which has been considered as a reliable approach in assessing the genotoxic effects of certain compounds in crude oil (Ferraro et al., 2004; Hoshina et al., 2008).

When considering about the genotoxic effect of different concentrations of crude oil on fish, the present study showed that there was a significant induction of nuclear abnormalities in fish exposed to a 15ppm concentration of crude oil than in fish exposed to a 3ppm concentration of crude oil. Scientists also discovered this finding for varying amounts of crude oil and other xenobiotic chemicals in fish under controlled settings (Özkan et al., 2011), (Baršienė & Andreikėnaitė, 2007). The observed trend of abnormalities with exposure time also reported by several studies (Gökalp Muranli & Güner, 2011). Scientists argue that fish can generally maintain a consistent concentration of red blood cells under normal conditions through a dynamic equilibrium between fresh erythrocyte production (erythropoiesis) and erythrocyte breakdown, which results in homeostasis. As a result, new erythrocytes enter the circulation at a constant pace, and altered erythrocytes are eliminated at the same rate (Van der Oost et al., 2003). This phenomenon was demarcated with the decreasing trends of AN in all groups after 10^{th} day of exposure. Venier et al. (1996) pointed out same effect, that the treatment with 0.3 and 3 μgl–1 benzo[a]pyrene induced a significant increase in DNA strand breaks in mussel hepatopancreas after one day of exposure, followed by a gradual decrease in strand breaks after 3– 6 days, and after 12 days the frequency of DNA strand breaks returned to the control level. According to that trend, we can argue that the genotoxic effects of fish peripheral blood do not always increase with exposure to crude oil or any other toxic compounds within short term period.

However, there were small number of altered nuclei in the control group throughout the exposure period, but it wasn't a significant amount when compared to exposure groups. Therefore, these findings justify the use of nuclear abnormalities other than micronuclei in fish erythrocytes as a sensitive model for testing the mutagenic activity of chemical substances in the laboratory conditions. Furthermore, the trend suggests that the genotoxic effect of these xenobiotic compounds depends on both time and dose. However, further research is needed to

understand the process of these nuclear abnormalities' development, as well as to study their genotoxic origins.

4. Conclusions

According to the results and observations of the present study, concluding remarks could be kept as the toxic compounds in crude oil are responsible for the development of a significant quantity of altered nuclei in fish erythrocytes with respect to exposure dose and the trends of those abnormalities indicate the association with time of disclosure.

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Isolation and identification of *Vibrio* species from *Macrobrachium rosenbergii* cultured in selected five reservoirs in Uva and Southern provinces in Sri Lanka

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1. Introduction

Macrobrachium rosenbergii (Giant Freshwater Prawn/GFP), residents in the tropical freshwaters adjacent to brackish water areas are more popular among the culture of crustaceans due to their rich taste and profitability. *M. rosenbergii* culture is now an emerging sector in Culture-Based Fishery in perennial and non-perennial reservoirs, Sri Lanka. Though it is profitable business, at present, *M. rosenbergii* production in Sri Lanka is low in both quality and quantity. Most devastating threat is the presence of disease-causing agents and among the diseases causing agent, microbes play an important role. Bacteria, especially the *vibrios* have a significant impact on *M. rosenbergii*.

Most of the studies have identified disease causative bacteria on GFP with frequently encountered *Vibrio* species. *Vibrios* are Gram-negative, rod-shaped, facultative anaerobes, (family Vibrionaceae), abundant in warm, brackish water and they lead to the devastating disease; *vibrio*sis. Even though there are non-pathogenic *vibrios*, about 12 species cause infections in humans by consumption of *Vibrio* contaminated seafood, water, and by wound exposing to water containing *Vibrios*, hence the zoonotic *vibrio*sis. Among the diverse disease out come in aquaculture species by *vibrios*, luminous *vibrio*sis, fouling disease, blackening of gills, brown spots and white muscle disease are some significant infections in prawn culture.

Though there are reports at global level, there is hardly any report on the *vibrios* associated with *Macrobrachium rosenbergii* in Sri Lankan reservoirs. Hence this study aimed to enumerate total bacteria and *vibrios* present in *Macrobrachium rosenbergii;* collected from five reservoirs, in Uva and Sothern provinces and also to isolate and identify *Vibrio* species associated with *M. rosenbergi.* Further studied the sensitivity of the *Vibrio* isolates to commonly used antibiotics.

2. Materials and Methods

2.1 Sample collection

Seventeen prawn samples were collected from three reservoirs (Urusita wewa, Muthukandiya, Handapanagala wewa) from Uva Province and two reservoirs (Ridiyagama, Bandagiriya) in Southern Province.

2.2 Sample preparation

Prawn samples were weighed, washed and homogenized in a stomacher (BagMixer 400cc, France). Homogenized samples were used for further study, enumeration of total bacteria and *vibrios*. Also, the samples were used for the isolation of *vibrios* as described in the Isolation and Identifications (2.4)

2.3 Enumeration of total bacteria and *Vibrios*

Enumeration of total bacteria and *Vibrios* present in the *M. rosenbergi* was done by using the spread plate method. Samples were serially diluted in sterilized distilled water and cells were enumerated by using the spread plate method using Plate Count Agar (Total Bacterial count), and in TCBS Agar (Vibrio yellow and green colony count). Colonies were enumerated (automated colony counter; as Colony Forming Units per gram/CFU/g).

2.4 Isolation and identification

Homogenized samples were enriched (APW); streaked in TCBS plates. Selected green and yellow colonies from TCBS were grown in LB broth. For identification of *vibrios*, battery of biochemical tests was done using Alsina`s key (1994) and Food and Drug Administration (FDA) bacterial analytical manual (BAM) as the table below.

Table 02. Biochemical tests

Test	Result
Motility test	Cloudy growth from stabbed line
Salt tolerance(0%,2%,6%,8%NaCl) Growth at 4°C,35°C,40°C	Cloudy growth
Amino acid decarboxylation	Positive- Purple colour
Indole test	Positive-Pink ring
Citrate test	Positive – Blue colour
Oxidase test	Positive- Blue colour
Catalase test	Positive- air bubbles
ONPG test	Positive- yellow colour
TSIA slant test	Positive- yellow butt Negative- orange/red butt
Caseinase test Gelatinase test	Positive-clear zones
VP test	Positive-Red layer
Urease test	Positive- Magenta
Oxidation/Fermentation test	Positive-Yellow colour
Grams staining	Gram negative

2.5 Antibiotic Susceptibility Test (ABST)

Antibiotic sensitivity test was performed by using the Kirby Bauer disk diffusion method (Bauer et al., 1966). ABST was performed for 9 Vibrio isolates with five commonly used antibiotics viz, Chloramphenicol (C30), Ciprofloxacin (CIP30), Tetracycline (TE30), Gentamicin (GEN30), and Ampicillin (AMP10) (Himedia, India). Diameters of inhibitory zones were compared with a standard chart that shows the performance standards (CLSI 2017).

3. Results and Discussion

Enumeration of Total Bacteria and *Vibrios*

The highest number of total bacterial count was present in Bandagiriya (9.32 ± 2.2 log CFU/g of prawn) whereas the Handapanagala reservoir has the lowest (7.02 ± 0.14 log CFU/g of prawn). The total number of *Vibrio* (yellow) colony counts was greater in every reservoir than Vibrio (green) colony count and the highest number of total Vibrio (yellow) colony counts was resulted in Bandagiriya wewa (6.64 ± 0.63 log CFU/g of prawn) while the lowest number was resulted in Muthukandiya (4.5 ± 1.31 log CFU/g of prawn). The highest number of total Vibrio (green) colony counts were in Bandagiriya (5.72 ± 0.73 log CFU/g of prawn) whereas the Muthukandiya wewa has the lowest (3.86 ± 0 log CFU/g of prawn) (Figure 4).

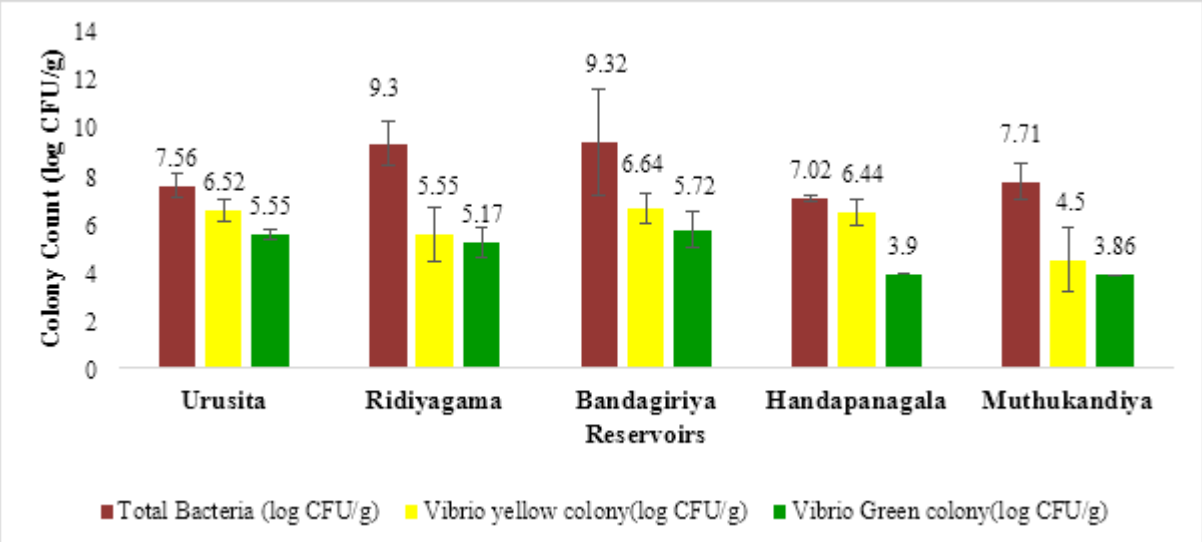

Figure 4. Enumeration of bacteria and *Vibrios* in *M. rosenbergii* collected from five reservoirs

A study done by Phatarpekar et al. (2002) is in line with the current study having a different distribution of bacteria and the *vibrios* among the different locations. Liu et al. (2020), concluded that there is an effect of the surrounding environment on microbial colonization in *M. rosenbergii* strongly agreed with us as we also had different colonization from different locations.

Forty-one isolates were identified as *Vibrios* and among them, 13 isolates were identified up to species level; *Vibrio parahaemolyticus, V. anguillarum, V. cholera, V. vulnificus, V. mimicus, V. alginolyticus, V.damsela, V. gazogenes, V. natriegens, V. metschnikovii.*

The species identification of *M. rosenbergii* done by Prakash and Karmagam (2013), has used TCBS to isolate *Vibrios* and a battery of tests as we used. As in the current study, *Vibrio alginolyticus, Vibrio cholera, Vibrio mimicus,* and some other *Vibrios* have identified in a study in Vietnam by Oanh et al. (2001). Different strains of *V. cholera* cause negative effects on hepatopancreas (Gao et al., 2019) and cause White Faeces Disease (WFD) in prawns. Disease investigation caused by *Vibrio alginolyticus* has recorded histological alterations in hepatopancreas, gills, muscle, and heart and lower the quality of prawns causing cloudy musculature, loss of appendages, and focal necrosis of the hepatopancreas (Ajadi et al., 2019).

All the identified isolates were resistant to Ampicillin 10µg while all the isolates were sensitive for Ciprofloxacin 30µg except *Vibrio cholera*. *V.damsela*, and *V.cholera* were resistant against Chloramphenicol 30µg where the others were sensitive. Only *V.anguillarum* and *V.cholera*

were shown a resistivity for Tetracycline 30µg. For Gentamicin, *V.anguillarum, V.alginolyticus,* and *V.gazogenes* were sensitive, while *V.mimicus, V.damsela, V.metschnikovii, V.vulnificus,* and *V.natriegens* were intermediate resistant and only *Vibrio cholera* was resistant. Overall, *Vibrio cholera* was resistant to all five antibiotics (Table 2).

Table 02. Antibiotic sensitivity of *Vibrio* spp isolated from *M. rosenbergii*

	Antibiotics Inhibition zone diameter in mm				
Vibrio isolate	CIP (30µg)	GEN (30µg)	TE (30µg)	C (30µg)	AMP (10µg)
Vibrio anguillarum	SEN	SEN	RES	SEN	RES
Vibrio mimicus	SEN	IR	SEN	SEN	RES
Vibrio damsela	SEN	IR	SEN	RES	RES
Vibrio cholera	RES	RES	RES	RES	RES
Vibrio metschnikovii	SEN	IR	SEN	SEN	RES
Vibrio vulnificus	SEN	IR	SEN	SEN	RES
Vibrio gazogenes	SEN	SEN	SEN	SEN	RES
Vibrio alginolyticus	SEN	SEN	SEN	SEN	RES
Vibrio natriegens	SEN	IR	SEN	SEN	RES

CIP: Ciprofloxacin, GEN: Gentamicin, TE: Tetracycline, C: Chloramphenicol, AMP: Ampicillin.
SEN=Sensitive,RES=Resistant,IR=Intermediate resistant

There are several studies showing antibiotic resistance in line with findings of the current study. Amalina et al, 2019 reported the resistant of *vibrios* isolated from groupers to Ampicillin while all of them were sensitive to Tetracycline. Rahman et al, 2020 revealed that *vibrios* isolated from *Penaeus monodon* were sensitive for Ciprofloxacin, Chloramphenicol, and Tetracycline. There are ample of reports showing different sensitivities by *Vibrio* spp isolated from aquatic animals.

4. Conclusions

This study concluded that there is a variation of total bacteria and *Vibrios* present in *M. rosenbergii* and there is a diversity among identified *Vibrios*. Moreover, it concluded that there is a resistance development by *Vibrios* isolated from *M. rosenbergii* to commonly used antibiotics, this is an alarming message derived from this study.

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Morphological identification and comparative growth of tubificid worms in culture media supplemented with different feed types

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1. Introduction

Aquaculture has been considered one of the main food-producing sectors to date, as it provides protein and other essential nutrients for people from low- to high-income countries worldwide. Despite its success, nutritional management, including balanced feeding, has been a significant challenge for sustainable aquaculture production (Dawood, 2021). Since the formulated feeds are species-specific, their conventional use in aquaculture might be less effective. Inappropriate formulation, nutrient leaching, less efficiency as a larval feed due to inefficient digestion, and static nature lead to finding more sustainable, cost-effective diets in aquaculture (Gamboa-Delgado, 2014). Microscopic plankton, micro, and macro aquatic invertebrates, i.e., Rotifers, *Artemia*, Moina, Daphnia, Chironomid larvae, are important live feed organisms in aquaculture. Live feeds contain high nutritional components that tend to be called "living nutritional capsules" (Kandathil Radhakrishnan et al., 2020). The oligochaete worm (*Tubifex tubifex*) is attributed as a cost-effective live feed (also as a processed diet) rich in polyunsaturated fatty acids (PUFA) and protein especially suitable for juvenile and brooder fish (Panikkar, 2002; Velasco- Santamaria, 2011; Saravana et al., 2015; Mandall et al., 2018). Despite the success as a potential live feed, numerous drawbacks, i.e., overexploitation, contamination due to pathogens, lack of knowledge, ineffective culture strategies, etc., in the Sri Lankan context, caused underutilization of the oligochaete worm. Thus, this study was mainly focused on identifying the available sites, species-level identification, and finding a cost-effective feed type for mass production of *T. tubifex*.

2. Materials and Methods

The *T. tubifex* samples were collected from definite sites covering Nuwara Eliya and Colombo districts. Firstly, GPS coordinates were taken and mapped using ArcGIS software. The species-level identification was done referring to external morphology, i.e., body length, number of segments, and the presence of setae using light and scanning electron microscopes. Subsequently, the identified species were used for the culture experiment providing three different feeds, i.e., Black soldier fly larvae leachate (T_1), coconut poonac meal (T_2), and poultry blood meal (T_3) based on their feeding behaviour and the nutrient requirements.

Nine (09) plastic trays (L x W x H; 40 cm x 30 cm x 7 cm) were used for the culture experiment, and every treatment was included of three culture trays as replicates (r=3). Initially, sixty grams (60 g) of live worm sample was placed in each tray together with soil sample collected from their natural environment as the substrate. The first feeding was 210 g on day 01, and subsequently, 42 g was added every week until the end of the experimental period (42 days). Gentle aeration was provided during the experimental period, and the water quality parameters, including temperature and pH, were measured. The weight of the worms was taken on the 28th, 35^{th,} and 42nd days respectively.

Table 01. Experimental design of the feeding experiment; Culture media as BSFL leachate (BSFLL), Coconut poonac meal (CPM), and Poultry blood meal (PBM)

Trt. (T) / Rep. (R)	T_1 (BSFLL)	T_2 (CPM)	T_3 (PBM)
R1	Tray 1	Tray 2	Tray 3
R2	Tray 4	Tray 5	Tray 6
R3	Tray 7	Tray 8	Tray 9

3. Results and Discussion

Tubificid worms are naturally found in sewage pits, drainage canals near slaughterhouses, hospitals, livestock farms, etc. Tubificid worms were commonly found in such areas in Colombo district; however, human-linked activities, including uncontrolled capture, have resulted in the rapid decline and even disappearance from their natural habitats. We found few locations in Colombo district where the worms can be seen, including Rathmalana, Mulleriyawa South, and Belagama areas; however, population decline has been noticed at an alarming rate. Currently, Nuwara Eliya district is the central location for supplying tubificid worms, yet the supply is not sufficient enough to meet the growing demand. However, most collection sites are highly contaminated with human effluents, mainly due to industrial wastes. Moreover, continuous disturbances for their natural habitats could also be a reason for the total disappearance of these worms from these locations.

Identifying *T. tubifex* using morphological characters often misleads for various reasons such as similarity that specimens bear with several other oligochaetes, phenotypic plasticity (i.e., key morphological characters) change due to environmental factors, age of the specimen, etc. Therefore, PCR based molecular approach (e.g., DNA barcoding/gene sequencing) can solve this identity crisis.

The standing biomass (cumulative mean weight) of tubificid worms in three different culture media is presented in Figure 1. At the end of the experimental period, the highest standing biomass of 212.98 ± 1.17 g was observed in T_3, which poultry blood meal was given as the feed. The standing biomass of all the tested treatments was significantly different ($p<0.05$) at 35^{th} and $42^{nd,}$ days respectively. It also showed that there was a significant difference ($p<0.05$) between T_1 (BSFLL) and T_3 (PBM) on the 28^{th} day. Overall, the highest significant growth of tubificid worms was achieved in poultry blood meal throughout the feeding experiment.

In contrast, the treatment used black soldier fly leachate as the feeds had the least growth. The highest yield of worms fed with poultry blood meal could be due to the high dietary protein (crude protein) of 93.8 % (DM basis). A high level of worms inoculum 50 mg/cm^2 might have grown and propagated quickly in protein-rich media that seemingly plays a crucial role in maturing and reproduction, leading to increased biomass (Hasan et al., 2019). According to Agustinus (2016), the use of chicken manure as culture media significantly influences the population density of Tubifex worms (*Tubifex* sp.) than other media such as rotten lettuce media, chicken feed, etc. The earlier studies conducted by Brinkhurst and Kennedy (1965) and Kosiorek (1974) could culture *Tubifex* in captivity using mud enriched with organic matter. According to Marian and Pandian (1984), tubifex-fed cow dung showed higher growth and fecundity than that fed with lettuce (Lactuca sativa). Barman (1986), Mollah and Ahmed (1989; 1992), and Hossain et al. (2011; 2012) found that mustard oil cake (MOC) was the most suited feed for Tubifex than wheat bran (WB), soybean meal (SM), or cow dung (CD). Islam et al. (2015) used poultry blood as a wetting media and found a higher worm yield than rice gruel.

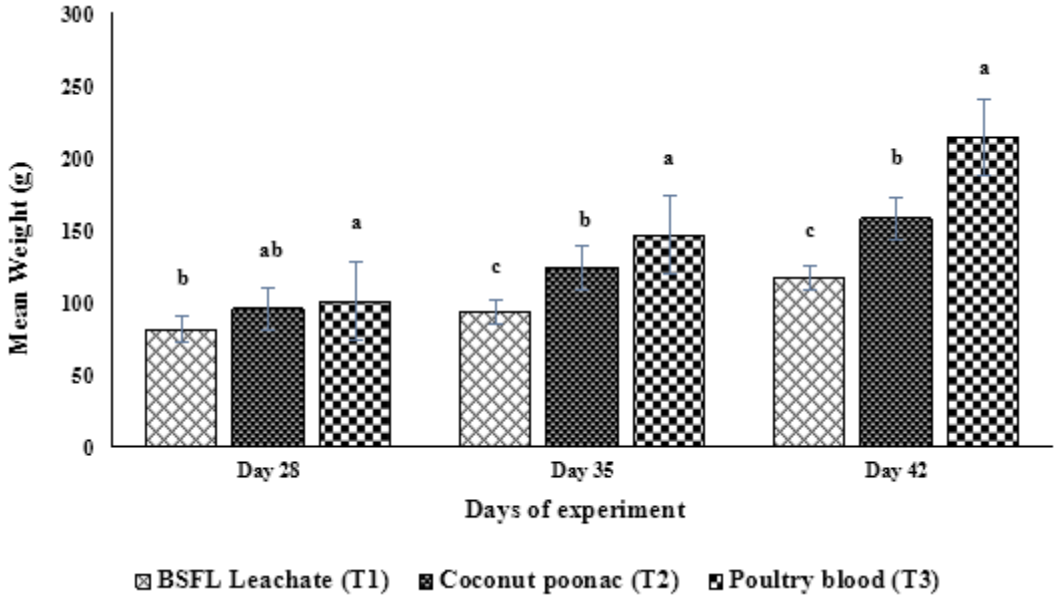

Figure 1. Tubifex worms mean weight (g) at 28th, 35th, and 42nd days after being fed with three feed types. The bars indicate standard errors. Significant ($p<0.05$) differences are indicated with different letters

4. Conclusions

This study found that identifying tubificid worms using morphological characters' might not be the accurate method. Hence, a molecular-based identification method should be performed for precise identification. We have noticed that overexploitation and other related issues have resulted in declining the existing populations. The feeding experiment revealed that poultry blood is the best feed for Tubifex. Captive breeding could be the best way to conserve this valuable live feed for continuous production to meet the increasing demand.

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Shapes, substrates, and monsoon patterns that affect live rock culturing among the coastal communities in Southern Sri Lanka

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1. Introduction

Marine live rock culture can be identified as an alternative livelihood method to the unsustainable marine ornamental fishing industry in Sri Lanka that is almost depending on the wild catch with bad practices and overexploitation (Dhanasundara et al., 2020). Although breeding marine ornamental fishes in captivity is difficult than freshwater fish breeding (Cato and Brown, 2008), marine live rock culturing could be identified as one of the simplest processed commodities, but also have higher demands in the global market (Parks et al., 2003). Live rocks are live specimens of invertebrates, algae, coralline algae, and other microbiota attached to a rock that are not included in the Convention on International Trade in Endangered Species (CITES) appendices and which are transported in moist conditions (CITES, 2000). Due to their biological and aesthetic roles, they are important in the ornamental aquaria industry. Therefore, it is necessary to culture instead of harvesting them from natural marine environments. Since the southern coastal zone in Sri Lanka is rich with rocky shores, fringing coral reefs ecosystems, and high biodiversity (Rajasuriya, 2009), there is a copious possibility to culture live rocks by enriching them with naturally occurring marine algae and invertebrates with attractive colours in order to add them higher ornamental values. Through this study, important factors such as the season, growth period, shape, substrates, and locations on culture of live rocks are investigated. The knowledge acquired can be utilized for the implementation of live rock cultures for commercial purposes by abolishing the baseline limitations.

2. Materials and Methods

Rounded, semi branched and branched shaped cement structures were made by using different sized particles (substrate) as very coarse sand (1-2 mm), very fine gravel (2-4 mm), and fine gravel (4-8 mm) respectively. Those nine types were marked with their Shape and Particle size as S1P1, S1P2, S1P3, S2P1, S2P2, S2P3, S3P1, S3P2, and S3P3 respectively. These structures were firmly placed on specially designed holding structures made of concrete bases and metal mesh covered wooden frames ensuring uniform height from the bottom in different study locations; Dondra, Madiha, and Ahangama reefs along the southern coast. When selecting the above locations, criteria such as least disturbances to fisherman, least disturbances to tourism and recreational activities, easy accessibility, available spaces, protective environment, and surrounding biodiversity were considered. Forty-five structures as five structures of each nine types (9*5=45 types) were attached on one holding structure and three of such setups (45*3=135 types) to cover the maximum extent of the site were placed for one growth cycle at a monsoon period in a location. Cup-shaped cement structures were used as controllers. Thus, four cycles were completed as covering four monsoon patterns; 1st Inter Monsoon (March-April), Southwest Monsoon (May-September), 2nd Inter Monsoon (October-November), and Northeast Monsoon (December-February) during 2020-2021. Percentage of biota attachments were analysed by image analysis and counting after every 03 months and 06 months growth period. Sensory evaluation by 100 independent responders was performed after 06-months growth period as relevant to all types of live rocks and locations for different monsoon patterns.

3. Results and Discussion

The rapid attachments of microcolonies such as macroalgae, fungi, and lichen covering the cement rock structures were prominent after installing them at all three study locations. However, macro-organisms such as macroalgae, seagrass, cnidarians, molluscs, and echinoderms were attached at a higher rate after the 03 months (Table 01).

Table 01. Levels of attachments of different biota to rock structures after 03 months and 06 months period concerning four different culture cycles at different monsoon patterns in different study locations.

Study location	Initiated monsoon	Summary of the observations of all types of live rocks	
		Approximate percentage (%) after 03 months period	Approximate percentage (%) after 06 months period
Dondra	1st Inter Monsoon	Microcolonies: 50% Macro-organisms: 0% Total: 50%	Microcolonies: 75% Macro-organisms: 20% Total: 95%
	Southwest Monsoon	Microcolonies: 60% Macro-organisms: 20% Total: 80%	Microcolonies: 55% Macro-organisms: 45% Total: 100%
	2nd Inter Monsoon	Microcolonies: 60% Macro-organisms: 25% Total: 85%	Microcolonies: 60% Macro-organisms: 40% Total: 100%
	Northeast Monsoon	Microcolonies: 50% Macro-organisms: 5% Total: 55%	Microcolonies: 65% Macro-organisms: 15% Total: 80%
Madhiha	1st Inter Monsoon	Microcolonies: 55% Macro-organisms: 5% Total: 60%	Microcolonies: 50% Macro-organisms: 50% Total: 100%
	Southwest Monsoon	Microcolonies: 70% Macro-organisms: 20% Total: 90%	Microcolonies: 70% Macro-organisms: 30% Total: 100%
	2nd Inter Monsoon	Microcolonies: 60% Macro-organisms: 40% Total: 100%	Microcolonies: 40% Macro-organisms: 60% Total: 100%
	Northeast Monsoon	Microcolonies: 65% Macro-organisms: 5% Total: 70%	Microcolonies: 80% Macro-organisms: 10% Total: 90%
Ahangama	1st Inter Monsoon	Microcolonies: 50% Macro-organisms: 5% Total: 55%	Microcolonies: 60% Macro-organisms: 40% Total: 100%
	Southwest Monsoon	Microcolonies: 60% Macro-organisms: 30% Total: 90%	Microcolonies: 40% Macro-organisms: 60% Total: 100%
	2nd Inter Monsoon	Microcolonies: 60% Macro-organisms: 35% Total: 95%	Microcolonies: 45% Macro-organisms: 55% Total: 100%
	Northeast Monsoon	Microcolonies: 50% Macro-organisms: 10% Total: 60%	Microcolonies: 60% Macro-organisms: 20% Total: 80%

*** Macro-organisms attached over microcolonies were countered to the macro-organism percentages.

In some cases, these attachments caused changes of the original shape of the placed live rocks. Fish species of family Gobiidae and fish larval stages of family Pomacentridae, were inhabitants in or on some live rock structures which were covered by macro sessile organisms

and sediments after 03 months' period. The attachment nature of micro and macro biota to artificial rock structures after 03 months and 06 months periods differed significantly ($P < 0.05$) with initiated monsoon patterns and study locations. All together 20 macro species in Dondra, 26 macro species in Madiha, and 25 macro species in Ahangama have been recorded on live rock structures after 06 months' growth period. A higher amount of nutrient runoff with the southwest monsoon to the coastal water of the southwestern zone (Silva et al., 2005) is strongly suggested as the cause for the higher attachment rate of microalgae, macroalgae, and other biota to the live rock structures. Loading of those nutrients at the end of the southwest monsoon period and the calm sea condition may highly affect the rapid growth of those biota on top of the artificial rock structures which subsequently showed the lowest growth period than in any other monsoon pattern. Further reduction of nutrients levels due to lower amount of terrestrial runoff during the Northeast monsoon and the 1st inter monsoon, may cause to longer growth period observed on live rock structures during those seasons. When comparing study locations, Madiha showed a relatively higher growth rate and higher number of species attachments followed by Ahangama and Dikwella. Madiha is situated closer to the Nilwala river mouth, which would be the reason to show a higher growth rate with the help of terrestrial nutrient runoff by the river. Subsequently, Ahangama location is closer to Koggala lagoon mouth which may loading nutrients to the coastal area.

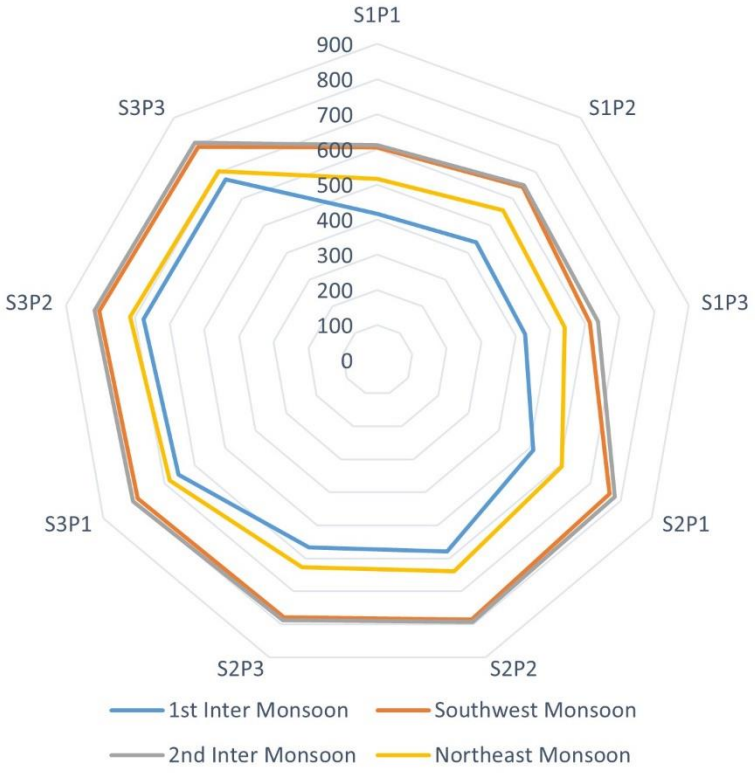

Figure 1. The radar chart shows the sum of the ranks performed by the Friedman test. 90 volunteer responder's preferences on live rock structures after 06 months period grabbed through the 0-10 ranking system concerning four different culture cycles at different monsoon patterns for the sensory evaluation are visualized.

Responder's insights were also more or less coincided with the level of biota attached to different types of live rocks (Figure 01). Most preferences were received for branched typed rocks followed by semi branched and rounded types. Cement structures made by very fine gravel (2-4 mm) substrate had the highest preferences followed by fine gravel (4-8 mm) substrate and very coarse sand (1-2 mm) substrate. Sequentially, culture cycles initiated with the 2nd Inter Monsoon, Southwest Monsoon, Northeast Monsoon, and 1st Inter Monsoon have obtained the preferences of responders.

Branched rocks made with very fine gravels (2-4 mm) and cultured during the 2nd Inter Monsoon period had the heights preferences while rounded rocks made with very coarse sand (1-2 mm) and cultured during the 1st Inter Monsoon period had the lowest preferences by the sensory evaluation.

4. Conclusions

Marine live rock culturing can be performed easily without higher knowledge on aquaculture and techniques at any reef or rocky shore environment of the southern coast during any period of the year. However, the biota attachment (growth rate) depends on the monsoon pattern, location, shape, and the substrate of the initial rock structure placed. Therefore, this can be introduced as an alternative livelihood to the coastal community who are suffering from issues of resource utilization due to overharvesting, climatic changes, anthropogenic factors, and natural effects.

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Initial success of captive breeding and larval rearing of endemic fresh water food fish *Systomus spilurus* (Günther, 1868) in Sri Lanka

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1. Introduction

Systomus spilurus (olive barb or "Mas Pethiya") is an endemic fish to Sri Lanka, distributed in rivers, streams, reservoirs and irrigation canals of south western, Mahaweli, dry and transitional ichthyological zones. This species was previously described as *Puntius sarana* (Hamilton, 1822), native to South and South East Asia (Pethiyagoda et al., 2012, Sudasinghe et al., 2020). However, recent nomenclature updated the name to *Systomus spilurus* redescribing it as an endemic species to the country Sri Lanka (Pethiyagoda et al., 2012, Sudasinghe et al., 2020). *S. spilurus* has been a popular food fish species across the country, reaching an average size of 600 g and included in the group of minor cyprinids in fishery subsector reports. This group alone contributed a catch of 11,260 MT in 2019. With the local perception as a nutritive fish species. *S. spilurus* has a considerable harvesting pressure on its existing stocks, leading to population. Though the systematically review made species data confusion for past records, it is assumed that the species is under heavy fishing pressure, as of many freshwater fish species (Goonatilake et al., 2020). Hence, stock enhancement via captive breeding programs is necessary to be implemented, yet, no previous efforts are made in this regard. Therefore, present study was aimed at developing captive breeding and larval rearing protocols for *S. spilurus*.

2. Materials and Methods

This study was conducted at the National Aquaculture Development Authority of Sri Lanka (NAQDA), Aquaculture Development Center (AQDC); Dambulla. (7.8726˚ N, 80.6299˚ E). Wild caught *S. spilurus* was acclimatized in 6 x 4 x 0.5 m tanks in a flow through system. During acclimatization, adaptation and behavioural changes were observed in the morning and evening. Natural feeds were supplied first and gradually replaced with formulated diets (38% Crude Protein) fed at 2-3% of the body weight. With the onset of rains, stage of maturity of both the males and females was examined, and the water quality parameters were recorded. Matured adults were selected and a commercial hormonal mixture of sGNRHa and Domperidone was administered at the rate of 0.4 ml per kg for females and 0.2 ml per kg of male as per Chakraborty et al. (2007). They were then introduced into a 3m x 1.5m x 0.45m cement tank with coconut leaves as substrate, at 1:2 female/male ratio.

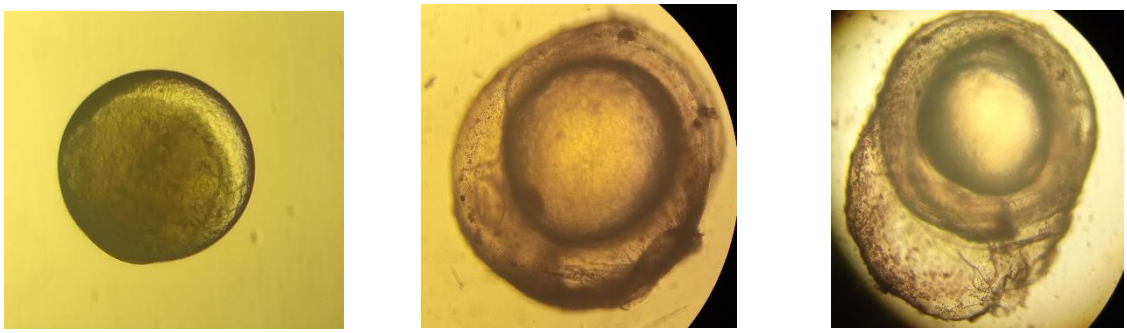
Brooders were removed after laying completed, and embryonic development was photographically recorded. The first feeding was done for 60 hours post hatch free swimming larvae using blended chicken egg mixture and continued for five days. This was followed by *Artemia* nauplii for another five days. Post larvae were then stocked in cement tank 3m × 1.5m.

at the water depth of 0.2m. were fed with daphnia, followed by formulated powered fish feed contained 38% of Crude Protein (CP) for 12 days. Water quality was measured using portable test kit, Milwaukee® (Romania).

3. Results and Discussion

This study was the first of its kind to breed *S. spilurus* under captive conditions in Sri Lanka, and to provide a successful larva rearing protocol. Broodstock fish in the acclimatization showed signs of final maturation by the time of 8th week. Mean values of water quality parameters during the acclimatization were Dissolved Oxygen (DO) 7.8 ± 0.21 ppm, pH 7.8±0.29 and temperature 27.4±0.42 ^{o}C. Markedly high levels of DO and slightly low temperature might be mimicking the rainy conditions, stimulating final maturation of the fish. When the maturity of the fish was observed with the females having bulging abdomen and swollen vulva, and males having whitish milt oozing at a gentle press of the abdomen, they were used for induced breeding induction. Matured *S. spilurus* was sexually dimorphic, where males were bright olive-green dorsally side and silver colour ventrally. They also have slender body with rough pectoral fins and operculum.

Hormone administered brooders developed typical signs of breeding by accelerated swimming, chasing each other and aggressive movements evident after about 6 hours of injection. After about a 7 hr and 45 min latency period, spawning was observed for a period of approximately 45 minutes. Once the brooders were spent, they were removed to post-spawning tanks. Most of the eggs were attached to the coconut leaf substrate, but some were spread over the tank floor. They were spherical in shape, and fertilized eggs were ranged 1.3-1.5 mm in diameter. Unfertilized eggs were about 0.9-1.1 mm in diameter. Average estimated production per female was 32030 eggs. While in the coconut leaf substrate eggs were then transferred to adjacent cement tank (1.3 m x1.5 m x 0.45m), wherein a flow through system was maintained. Eggs started to hatch after about 16 hours, resulting larvae of 3-3.5 mm length. Plate 1. shows sequential development of embryonic stages of *S. spilurus.*



(A) (B) (C)

Figure 1. embryonic development of *S. spilurus* (A) 2 hours after fertilization (B) 06 hours after fertilization (C) 12 hours after fertilization.

Water quality parameters during larval rearing were pH.7.4± 0.24± 0.21, DO 7.9±0.29 mg/l and temperature 27± 0.32 ^{0}C. Yolk-sac absorption of the hatchlings was completed by 45-60 hours Blended whole chicken egg was fed to free swimming larvae at 3 hours' interval during daytime, 4 hours interval during night and continued for five days. *Artemia* nauplii were fed at the same frequency for another five days. Then the larvae were thinned to a density of 1500 per 3m x 1.5m x 0.2m cement tanks. About 20500 larvae were successfully recovered by this method of culturing. *S. spilurus* post larvae attraction to feeding was comparatively high with 10th day of the feeding. Then feeding was followed by daphnia and formulated powdered feed.

From 12th day onwards, adult colours were appearing as light green colour on the dorsal side. From the same day onwards, larvae were fed with artemia, daphnia and formulated powder feed with 42% CP.

4. Conclusions

Present study provides first evidence of successful captive breeding of *S. spilurus* using sGnRH and domperidone, at the rate of 0.4 mg/Kg for females and 0.2 mg/kg for males. It further provides a larval rearing protocol for successful nursing of their larvae, suggesting a possible application of captive breeding and larval rearing of this species for conservation or commercial purposes.

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Enrichment of egg yolk lipids with Conjugated Linoleic Acid (CLA) by feeding bitter melon (*Momordica charantia*) seed fat to layer chickens

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1. Introduction

Chicken egg is considered as a main dietary source of protein, fat, and other nutrients in human diet. It is made up of approximately two-thirds white and one-third yolk. The yolk contains lipids, vitamins, minerals and carotenoid pigments (Álvarez et al., 2004).

As consumer demand for health-promoting foods increases, a great interest has been created on production of value-added nutritious animal products such as eggs, milk and meat. Furthermore, scientists as well as industry are also keen to explore novel methods to incorporate health-promoting nutrients into the eggs. One of the successful examples is the creation of eggs enriched with omega-3 fatty acids, which are now available in Sri Lankan market. Thus, incorporation of fatty acids with health promoting effects into the egg yolk lipids has been proved as a feasible task. Conjugated Linoleic acid (CLA), a group of isomers of linoleic acid (18:2, 9c, 11t and 10t, 12c) reported with numerous health benefits such as anti-cancer, anti-obese and anti-diabetic actions by a minute level in our diet. Especially 9c, 11t isomer has been reported to exert anti-cancer properties and 10t, 12c isomer is more potent in anti-obese actions (Cherian et al., 2002).

Natural sources of CLA are found in milk and meat from ruminants. It has been reported that a conjugated trienoic fatty acid named alpha-eleostearic acid (ESA; 18:3: 9c, 11t, 13t), which is present in bitter melon (Karawila; *Momordica charantia*) seeds is metabolized into 9c, 11t isomer of CLA *invivo* and deposited in various tissue lipids in animals such as rats (Jayasooriya, 2000; Jayasooriya, 2017). Thus, this study was designed to determine whether the ESA derived from fat obtained from bitter melon seeds is incorporated into a poultry layer feed is converted in to CLA in bird's body and deposited in egg yolk lipids.

2. Materials and Methods

Twenty five weeks (25 weeks) old Hy-line strain white Leghorn laying hens reared on deep litter in a closed house system were selected randomly for the study. Ninety birds (90) (1.296 ± 0.478 kg) were allocated in a completely random design (CRD) with three groups (n=30 per group) and each group consists of replicates (n=10 per replicate). Thus, three experimental groups with three (03) replicates were used for the study. The regular layer ration, which was available commercially was used for the control group (C) without adding any extra fat whereas, 1.5% (w/w) desiccated coconut was added to the layer ration and used as treatment 2 (B). It was used to compare the effects of conventional feed fat source with bitter melon seed

fat on laying hens' production. Furthermore, 1.5 % (w/w) bitter melon seed powder was added to layer ration to incorporate bitter melon fat and was used as the treatment 1 (A). Water was given as *ad libitum* and specific experimental feeds were supplied according to average daily feed consumption (115 g/hen/day). All hens received 16 hours light per day throughout the experimental period. Room temperature was controlled close to 28^0C. The experiment was conducted for 12 weeks.

Hen house production, egg yolk color, egg weight and the body weights of the birds were measured throughout the experimental period. Fatty acid profiles of lipids extracted from egg yolk using standard methods were analyzed by Gas chromatography. Individual fatty acid peaks including the CLA peak (9c, 11t) were identified using an authentic standard. Proximate analysis of the three feed samples was carried out using standard protocols. The ANOVA with repeated measures was utilized to compare the CLA levels in egg yolk lipids and $P < 0.05$ was considered for the determination of statistical significance. All data were analyzed using statistical software Graph Pad Prism 7.0.

3. Results and Discussion

The results revealed (Fig. 1) that at the end of the 12 weeks experimental feeding, there was a cumulative deposition of CLA (CLA 1: cis-9,trans-11) in the egg yolk of the treatment 1 group (A) compared with the control group (C) and the group fed with added desiccated coconut diet (treatment 2: B) . This was also evident in the 6th week and those effects were statistically significant ($P < 0.05$) compared with other dietary groups (B & C). The other CLA isomer (CLA 2: trans-10, cis-12) was not detected in any of the egg yolks of the other 2 groups throughout the experiment.

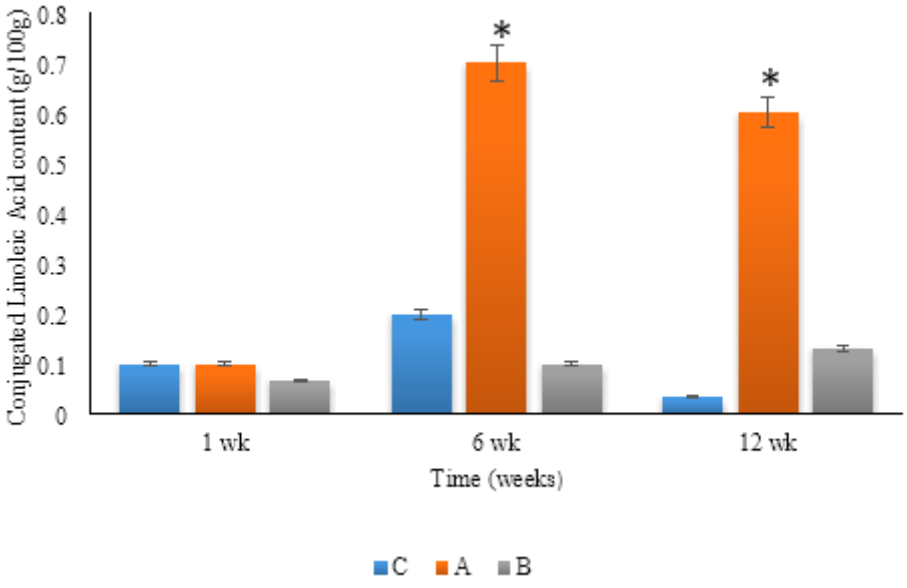

Figure 1. The amount of CLA accumulated in the egg yolk of three experimental groups at different time points of the feeding trial (A: Treatment 1(Bitter melon seed powder), B: Treatment 2 (Desiccated coconut), C: Control), *P<0.05.

The egg production and the body weight of the birds were not significantly different among experimental groups. However, the egg weights were reduced with the time and treatment 1 group showed the lowest egg weight at the 12th week, while control group showed the highest weight. Thus, the feed intake of treatment 1 group was reduced and feed conversion ratio was

lower than the control group. The analysis of fatty acid profiles of three feed types showed that neither CLA1 nor CLA2 was present in the experimental feeds.

A previous research conducted has shown that feeding Tung oil that contains 80% ESA at 1% dietary level has resulted in a deposition of CLA in egg yolk lipid and adipose tissue (Lee et al., 2002). These results also clearly indicated the fact that dietary ESA is effectively converted in to CLA and readily deposited in body lipids. Though the ESA in Tung oil readily converted to CLA and deposited in egg yolk lipids, however it could exert toxic effects on human and animals (Lee et al., 2002). In the current study the ESA source is bitter melon seed fat, which contains relatively low level of ESA and nontoxic to animals and human subjects. Thus, it can be considered as a safe ESA source.

It has been reported that the hens fed with 1.6% CLA, egg-laying and feed conversion ratio were lower than the control group (Shang et al., 2004; Xuelan et al., 2017). Furthermore, some other factors such as oestrogen has been shown to promote follicular growth, while cortisol reduces egg production (Zhu 2003). Thus, the negative effect of cortisol which was significantly higher in the 1.6% CLA group might have hindered the positives effect of thyroid hormone and oestrogen (Xuelan et al., 2017). However, Cherian et al (2002) has reported that CLA-supplementation did not affect feed consumption, daily egg production, feed efficiency, or egg weight. The reason for the reduction of egg weight in group A (Treatment 1) could be due to a hormonal change that might have occurred in those birds due to feeding of ESA rich bitter melon seeds. This might be due to the negative effect of cortisol which was significantly higher in the 1.6% group, which offsets the positive effect of thyroid hormone and estradiol (Xuelan et al., 2017).

Overall, the results of this current study reflects the fact that dietary ESA is effectively converted in to CLA and readily deposited in egg yolk lipids in the treatment group. This concept can be effectively used for a value addition to the eggs.

4. Conclusions

The alpha-eleostearic acid (ESA) present in locally available bitter melon seed fat added to layer ration (1.5% w/w seed powder is added to the diet) is converted to CLA *in vivo* in poultry layer birds and deposited in egg yolk lipids at a significant level. The current study suggested a method of enrichment of natural CLA into a food item (chicken egg) using a fat source from a locally available vegetable seed (Bitter melon /Karawila; *Momordica charantia*).

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Isolation and characterization of lactic acid bacteria (LAB) from forage silage to be used as an inoculant for ensiling forage

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1. Introduction

Sri Lanka produced 46.5 million liters of milk which meets only 38% of the national requirement. Thus, imported 93,749 metric tons of milk powder in 2019 (Central Bank of Sri Lanka, 2019). Dairy cows largely fed on poor quality forage included guinea grass (*Megathyrsus maximus*) resulting in low productivity. Weather independent, corn and sorghum silage production at commercial scale can ensure year-round supply of good quality forage for improved dairy herds in Sri Lanka. Good quality corn and sorghum silage (35-40% DM and 28.4 DM/kg, respectively) are highly palatable, digestible (71.9 and 64.3 %, respectively) and energy rich (10.8 and 8.9 MJ/kg DM) roughage for dairy cattle rations (Feedipedia, 2012-2020). During forage ensiling, number of organic acids (lactic acid, acetic acid, butyric acid, succinic acid, formic acid) and ethanol are produced by bacteria and yeast. Lactic acid production is preferred for ensiling forage due to rapid pH drop. *Lactobacillus, Pedioccous* and *Lactococcus* species dominate the fermentation process in ensiling forage. However, the abundance of epiphytic lactic acid bacteria (LAB) is inadequate to ensure rapid production of lactic acid during incubation (Soundharrajan et al., 2020). The LAB used as an additive, can ferment forage and produce abundant lactic acid. The LAB inoculants could increase the lactic acid content thereby assure rapid pH drop. Further, they improve the fermentation profile of silage and enhance feed quality (Muck et al., 2018). The potential of isolation of LAB from high quality silages and their application to improve the fermentation quality of alfalfa has been recently demonstrated (Peng et al., 2021). The objective of the current study was to isolate and characterize the LAB from good quality forage silage to be used as an inoculant for silage production.

2. Materials and Methods

Maize, sorghum and guinea grass silage samples (10 g) were blended in sterile distilled water (100 mL) and inoculated (1 mL) into de Man, Rogosa and Sharpe (MRS) broth for enrichment at 40ºC for 48 hours. Bacterial isolates were recovered by serial passage on MRS agar at 40ºC. They were characterized by Gram's staining followed by biochemical tests (catalase, TSI, citrate, urease, indole, gelatin hydrolysis, motility, oxidase) according to Van den Berg et al., (1993). Additionally, sugar fermentation tests were performed using 1% (w/v) sugar solutions (arabinose, galactose, glucose, mannitol). The genomic DNA of the isolates were extracted using BactoSpin D extraction kit (CEYGEN Biotech (Pvt.) Ltd., Sri Lanka) following manufacturer's instructions. The DNA sequence analysis of the 16S rRNA gene was performed using the 63f (forward) and 1387r (reverse) primers (Julian et al., 1998; Janda & Abbott, 2007). The NCBI data base and BLAST search were used to identify the isolates at species level. The potential of the isolated LAB species for anaerobic sugar fermentation was assessed by

inoculating into sterilized lactose solutions separately and incubating anaerobically for 30 hours at 40º C. Sterilized lactose solution without LAB inoculant was considered as the control. The variation in pH and percentage titratable acidity (TA) were measured at 0, 18 and 30 hours during the incubation. The data was subjected to analysis of variance (ANOVA) followed by Duncan's multiple range test (DMRT) at $P<0.05$.

3. Results and Discussion

A pure culture of Gram-positive rods was isolated from each sample. The colonies were white, round and with entire margins. Cell morphology of bacterium isolated from maize, sorghum and guinea grass silage were curved short pleomorphic rods, curved long pleomorphic rods and short pleomorphic rods, respectively. All the isolates were non-motile and non-spore forming and negative for catalase, TSI, citrate, urease, indole, gelatin hydrolysis, and oxidase tests. Further, they were able to ferment arabinose, galactose, glucose and mannitol.

The DNA sequencing confirmed that the *Lactobacilli* isolated from maize, sorghum and guinea grass silage were *Lactobacillus plantarum*, *Lactobacillus rhamnosus* and *Lactobacillus oris*, respectively. Further, the query cover was 98% for all the species. The percentage identity for *L. plantarum, L. rhamnosus* and *L. oris* were 91.69, 89.83 and 92.52 %, respectively.

The effect of *Lactobacillus* species isolated from forage silage and incubation period were significant ($P<0.05$) on variation of TA percentage and pH of lactose solution (Table 1). At 18 hours incubation, a significant ($P<0.05$) TA percentage was observed only when lactose solution was inoculated with *L. plantarum* (0.43%). Although, the TA percentage was greater ($P<0.05$) in all the solutions at 30 hours (0.48-0.66%) compared to that at zero hours (0.17%), the highest ($P<0.05$) percentage was recorded when the solution was incubated with *L. plantarum* (0.66%). Following the gradual increase of TA percentage, a reduction of pH ($P<0.05$) was observed in all the lactose solutions. However, the reduction of pH was rapid ($P<0.05$) when the lactose solution was inoculated with *L. plantarum* compared to other treatments (5.85 vs 6.29-6.64 at 18 hours). Literature shows that the use of facultative heterofermenter *L. plantarum* in combination with obligatory heterofermenters is more beneficial in silage production (Santos et al., 2019).

4. Conclusions

The study confirmed greater potential of *L. plantarum* isolated from maize silage to be used as an inoculant for ensiling forages. Further research is recommended to study the potential of *L. plantarum* in combination with *L. rhamnosus* and *L. oris* as an inoculant of forage silage.

Table 1: Effect of *Lactobacillus* species isolated from maize, sorghum and guinea grass silage on the variation of and titratable acidity and pH

Bacteria species	Percentage titratable acidity (TA)[1]			pH[1]		
	0 h	18 h	30 h	0 h	18 h	30 h
L. plantarum	0.17 ± 0.01^{aC}	0.43 ± 0.04^{aB}	0.66 ± 0.01^{aA}	6.76 ± 0.01^{aA}	5.85 ± 0.19^{bB}	4.70 ± 0.09^{bC}
L. rhamnosus	0.17 ± 0.01^{aB}	0.24 ± 0.03^{bB}	0.64 ± 0.02^{aA}	6.76 ± 0.01^{aA}	6.29 ± 0.07^{aB}	4.79 ± 0.19^{bC}
L. oris	0.17 ± 0.01^{aB}	0.23 ± 0.02^{bB}	0.55 ± 0.06^{abA}	6.76 ± 0.01^{aA}	6.34 ± 0.01^{aB}	5.07 ± 0.13^{bC}
Control	0.17 ± 0.01^{aB}	0.20 ± 0.01^{bB}	0.48 ± 0.01^{bA}	6.76 ± 0.01^{aA}	6.64 ± 0.03^{aB}	5.75 ± 0.01^{aC}

[1], Mean ± SE.

Within a column means followed by different lower-case superscripts are significantly different ($P<0.05$).

For each parameter, means within a raw followed by different upper-case superscripts are significantly different ($P<0.05$).

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A comparison between colourimeter and computer vision system in colour evaluation in broiler chicken meat

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1. Introduction

Meat colour is an important quality attribute that primarily determines consumers' intent to buy meat. This is mainly due to surface discolouration is associated with product wholesomeness and, any condition that negatively affects the visual appearance of a product will influence the purchasing decision, resulting in economic loss. The meat quality defects associated with meat tenderness, water holding capacity, and other quality attributes can be indicated by the meat colour. Mainly, two meat quality defects are known as Pale Soft Exudative (PSE), and Dark Firm and Dry (DFD) develops in meat as a result of genetics, ante-mortem, and post-mortem stressors including environmental temperatures, transportation, preslaughter handling practices, and chilling. Due to its inherited characteristics, meat colour can be varied such as PSE meat get pale colour (L* (Lightness) ≥53) than the normal meat colour and DFD meat gets darker (L*≤48) than the normal meat colour (Lesiow and Kijowski, 2003). The determination of meat colour can be performed subjectively and objectively. Subjectively, consumers perform sensory evaluation such as visual appearance while Colourimeters (CL), and Computer Vision System (CVS) are used for the objective measurements of the meat colour (American Meat Science Association, 2012). A comparison of the meat colour assessment methods has not been evaluated in detail locally. Hence, this study aimed to compare the colourimetric assessment methods used to evaluate the broiler meat colour.

2. Materials and Methods

Twenty-two broiler chicken breasts were purchased at local supermarkets and butcher shops. Each breast muscle was cut into samples 4x5x4 cm, coded with random three-digit numbers, placed flat on a uniform on-glare black background, and allowed to bloom for 30 minutes. Colourimeter (CR-10 plus, Konica Minolta) was used to take three sets of measurements from different areas of each broiler breast meat sample and average values of L* (lightness), a* (redness) and b* (yellowness) were calculated for each sample. The CVS measurements were taken as the method described by Tomasevic et al., (2019). Briefly, the surface of the samples was photographed using a digital camera (Canon, DSLR-6D marks ii camera) with a 26.2 Megapixel full-frame CMOS sensor. Based on the measured L*, a*, b* values by both methods colour chips were generated using Adobe Photoshop CC (2020) software. According to Ramirez-Navas and Stouvenel, (2012), the colour chips were selected. The colour chips were compared against the photographs of the meat samples and those were presented as an online questionnaire. Further, 344 respondents were facilitated to choose their answers with multiple options. Student t-test was used to determine the differences in L*, a* and b* obtained through colourimeter and CVS. The Chi-square test (X^2 one-sample test) was used to determine the colour similarity between the generated colour chips and the photographs of the broiler breast

meat sample through a consumer assessment. The SAS (2002) software version 9.1 was used and *p*-values below 0.05 were used as the decision criterion for statistical significance.

3. Results and Discussion

The results revealed that (Table 01) the L* a* and b* values of broiler meat samples which were obtained by CVS and colourimeter were significantly different ($p<0.05$). The colour difference was even additionally noticeable as a result of it had been not targeted in only one dimension however instead, considerably totally different values between the CVS and colourimeter were observed for all three dimensions (L*, a*, b*). Similar findings were observed in Tomasevic et al., (2019).

Table 01. The comparison between CVS and Colourimeter (Mean + SE)

Parameter	Method		Pr > |t|
	CVS	Colourimeter	
L*	46.41 ± 1.49^{a}	51.03 ± 1.22^{b}	0.0277
a*	4.72 ± 0.47^{a}	1.04 ± 0.12^{b}	<.0001
b*	1.66 ± 0.46^{a}	8.93 ± 0.41^{b}	<.0001

[a] and [b] mean values were significantly ($p < 0.05$) different within the row across methods

The highest number of respondents (86.53%) were found that the broiler meat colour generated by the colour values obtained through CVS were similar to the actual colour of meat samples. Similar findings were obtained by Girolami et al., (2013); Tomasevic et al., (2019) and the authors indicated that the highest percentage of the respondents/panellists were chosen the CVS-generated colour chips as compared to the colourimeter-generated colour chips. This may be as a result of, the meat does not have a homogeneous surface because of its structure, connective content, and intramuscular fat. Hence, the enlargement of the measured area would possibly include fat and connective tissue, thus yielding unreliable measures. Hence, it is hard to take the measurements using the colourimeter because it causes multiple reflections and refractions where optical discontinuities are present, resulting in a diffusion of light and using the colourimeter can be calculated only one point or of a reduced area such as the area spotted by the colourimeter. But the CVS can be estimated the overall colour of the sample and its heterogeneity, as well as this system, offers the possibility of analysing the entire surface of the meat and its characteristics and defects (Girolami et al., 2013). As of that CVS can be measured the entire surface colour of the meat, thus the CVS-generated colour could be more similar to the actual meat.

4. Conclusions

The computer vision system (CVS) is more appropriate to evaluate the colour of the broiler chicken meat as it generates colour chips that are more similar to the actual meat colour.

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Effect of incorporation of finger millet (*Eleusine coracana*) on proximate composition, sensory and microbiological properties and shelf life of drinking yoghurt over refrigerated storage

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1. Introduction

Yoghurt has identified as a suitable carrier for integration of dietary fibre sources in foods. Several research studies revealed consumption of fibre enriched yoghurt may prevent or reduce diabetes, hypercholesterolemia, obesity, cancer, colonic diverticulosis and constipation, ulcerative colitis, whereas promote intestinal micro flora and gastrointestinal immunity. In addition, dietary fibres are capable of improving rheological properties and reducing syneresis in yoghurt (Dabija et al., 2018).

Cereals, fruits, vegetables and nuts are good sources of dietary fibres which are absorbed by small intestine and fermented by large intestines. Among cereals, *Eleusine coracana* (Finger millet) is an excellent source of dietary fibres occurring about 15-20%. However, it is an underutilized cereal in tropical regions, but having an immense potential in the food market due to its nutritional and medicinal values (Göksel Saraç & Dogan, 2016).

Further, previous studies demonstrated prebiotic fortification of adding dietary fibres in yoghurt, butter and buttermilk. It is notable that such fermented dairy products were only produced with traditional starter cultures. Thus, it is necessary to produce fibre-enriched yoghurt inoculated with probiotic cultures because it improves gut microbial flora and gastro intestinal immunity. It has been evident by many clinical studies that *Lactobacillus acidophilus* and *Bifidobacterium animalis* subsp. *lactis* BB-12® exhibited beneficial health effects in terms of improved gastrointestinal health and immune functions. Therefore, the aim of the study was to evaluate the effect of addition of finger millet powder on physiochemical properties and microbiological quality of drinking yoghurt.

2. Materials and Methods

Good quality finger millets were cleaned and sopped in distilled water for 1-2 minutes. The selected grains were subjected to sun drying for 3 hours under aseptic condition and then roasted at 110 ºC for 10 minutes and cooled up to room temperature. Grains were ground to 200 µm of particle size, subsequently, powder were packed and stored at room temperature.

Yoghurt was prepared as described by Prasanna et al. (2013). Probiotics cultures (*Lactobacillus acidophilus, Bifidobacterium animalis* subsp. *lactis* BB-12®) and starter cultures (*Lactobacillus delbruckii* spp. *bulgaricus, Streptococcus thermophilus*) were used. After successful fermentation, coagulum was disturbed and divided into four parts. Finger millet powder were then added at the level of 0%, 2%, 5% and 6% w/w respectively. Finally, samples were stored at 4 ºC for further analysis.

The proximate analysis, caloric value, pH and titratable acidity of yoghurt samples were tested according to AOAC (2000). Sensory attributes were evaluated by eighteen semi-trained assessors. Samples were evaluated using a 9-point hedonic scale (1 = unlike extremely, 9 = like extremely). The sensory parameters tested were the appearance, aroma, texture, taste, consistency and overall acceptability. Total number of coliform bacteria and yeast and mould

counts were determined as described by SLS 393, 2016. Finally, the shelf life of yoghurt samples were tested at 14, 28 and 42 days of storage. Finally, data were analysed using the ANOVA procedure of SAS, version 9.2. All experiments were replicated in two times and the test of significance was done at 5% probability.

3. Results and Discussion

In terms of chemical composition, protein, ash and moisture contents of finger millet powder (FMP) incorporated drinking yoghurt samples were in the range of 6.20-6.28%, 2.09-2.15% and 82.5-83.5% respectively. As results revealed 5% finger millet powder fortified yoghurt samples shown the highest percentages for all components than those of other treatments. However, no significant differences observed among treatments with respect to proximate composition except ash content ($p<0.05$). All components were significantly decreased during storage period ($p<0.01$). Caloric values of all samples were shown a steady trend and fallen within the range of 207.94-212.72 kcal/kg. However, control samples exhibited lower caloric values than other treatments during storage period of 42 days.

The pH of FMP incorporated yoghurt samples significantly decreased while increasing level of addition of FMP. At the end of 42 days, pH of control samples reached to 4.22 due to over acidification. Regarding titratable acidity, significant difference was observed among treatments ($p<0.05$). During the 42 days of storage period, titratable acidity of all samples were between 0.47±1.19 to 0.73±1.19%, however, control sample recorded higher acidity than FMP incorporated samples. Kneifel et al. (1993) reported a similar trend for yogurt, in which, titratable acidity of the yoghurt samples increased during storage at 6°C due to the production of lactic acid and other organic acids by lactic cultures.

As per the microbial results, the count of coliforms were zero in all the samples until 42nd day which indicates the manufacturing of drinking yoghurt satisfied good manufacturing practices (GMP). Samples gave positive results with significant count of yeast and mould count during the 42nd days. Regarding total yeast and mould counts, 2% fortified FMP yoghurt samples fulfilled the requirements established by SLS standards for yoghurt until 42 days of refrigerated storage. The primary reason for inhibition of yeast and moulds may be due to the anti-microbial activity of finger millet or lower acidity of yoghurt (Devi et al., 2014). Further, the shelf life of yoghurt and fermented milk products are generally limited to one to three weeks.

Significant differences observed among different treatments ($p<0.05$) with respect to sensory attributes, in particularly, colour, texture, taste, consistency, flavour and overall acceptability. The highest scores for texture, consistency, colour and overall acceptability were recorded for 2% FMP drinking yoghurt. Addition of finger millet flour had a significant ($p<0.05$) influence on organoleptic properties of the product. The preference was given to yoghurts with less concentration of FMP.

4. Conclusions

In the conclusion, the addition of finger millet flour to the drinking yoghurt significantly influenced the physicochemical properties, composition and sensorial properties of drinking yoghurt. The results of this study showed that drinking yoghurt samples containing 2% and 5% finger millet flour maintained the physiochemical properties. As per the results, yoghurts with different incorporation of FMP gave negative results to coliforms that indicating the good manufacturing practices. According to the proximate, sensory and microbial results, 5% FMP incorporation level was better than other treatments during 28 days of refrigerating cold storage.

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Effect of cooling temperature and time on physicochemical and organoleptic properties of commercial cooked sausages

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1. Introduction

Sausages are made by the assemblage of proper ingredients with meat in the right proportion coupled with a structured cylindrical design and undergoing a controlled process. Cooked sausages are ready-to-serve products and the required cooking process is done by using an oven, grill, and deep fry after filling (Essien, 2003).

The sausage industry has been facing to increasing cost of raw ingredients (Jochen et al., 2010). Incorporation of non-meat ingredients such as dairy, eggs, plants, and microorganisms into the meat products to reduce the cost of products (Xiong, 2012; Yadav et al., 2013). Mechanically deboned poultry meat, usually used in sausage production due to fine texture, functional properties, and low-cost ingredients. But gives a negative effect on the texture giving a soft or mushy texture to the final cooked products (Daros et al., 2005; Pereira et al., 2011).

After the cooking of the sausages undergoes the cooling process. Water immersion is a traditional cooling method widely used in the processing of cooked meat products (Feng et al., 2014b). The cooling process reduces the product temperature as quickly as possible and helps to prevent shrinkage and wrinkling of the product casing (USDA, 1999).

The primary objective is to determine the effective water immersion cooling temperature for the commercial cooked sausages to reduce the weight of damages, to determine effective water immersion holding times to reduce the weight of damages and also to investigate the effect of water immersion cooling temperature and holding times on the sausages physicochemical properties and organoleptic properties.

2. Materials and Methods

Cooked sausages were made using Mechanically Separated Meat (MSM), Bread crumbs, Wheat flour, Skin and vegetable oil, ice, salt, and spices. MSM and Skin were minced. Ingredients were bowled chopped by 3750rpm in 4^0C for 5minutes according to the recipe. Stuff, filled into the 15mm cellulose casing. Sausages were cooked in oven 5^0C and 50% humidity and for 35–45 minutes until core temperature reach the 72^0C–73^0C temperatures and 95% humidity.

A field experiment Complete Randomized Design (CRD) was conducted replicating each treatment three times and samples were prepared according to the method described above.

Ten batches were separated before cooling and one batch of the weight of the sausage is 100 Kilograms. Four different treatment temperatures (5 ^{0}C, 10 ^{0}C, 15 ^{0}C, 20 ^{0}C) water and two immersion periods (10 minutes, 15 minutes) were used for the cooling of the sausages. Room temperature water (25-26 ^{0}C) was used as the control for all treatments. Each treatment is performed at two different water immersion cooling periods (10 minutes, 15 minutes).

The moisture content was determined by the oven-dry method (AOAC, 1990). In this three cylindrical gel (Φ15mm×10mm) from one representative sausage that has been used in the

measurement of moisture content. The water holding capacity (WHC) of the cooked sausages was determined by the modified centrifugal method described by (Cheng & Sun, 2006b). Damaged sausages were separated and weight expresses as per batch (100 Kg). Thirty untrained panellists were used for the evaluation of sensory parameters including appearance, colour, smell, flavour, texture, and overall acceptability. Nine points hedonic scale method used to rank for organoleptic attributes.

3. Results and Discussion

Water holding capacity (WHC) of commercial cooked sausages with the 10 minutes and 15 minutes immersion time

The following figure illustrated that five water immersion temperatures treatments (5^0C, 10^0C, 15^0C, 20^0C, 25^0C) against the water holding capacity of the commercial cooked sausages. And also two water immersion times (10 minutes, 15 minutes) are used to treat the commercial cooked sausages.

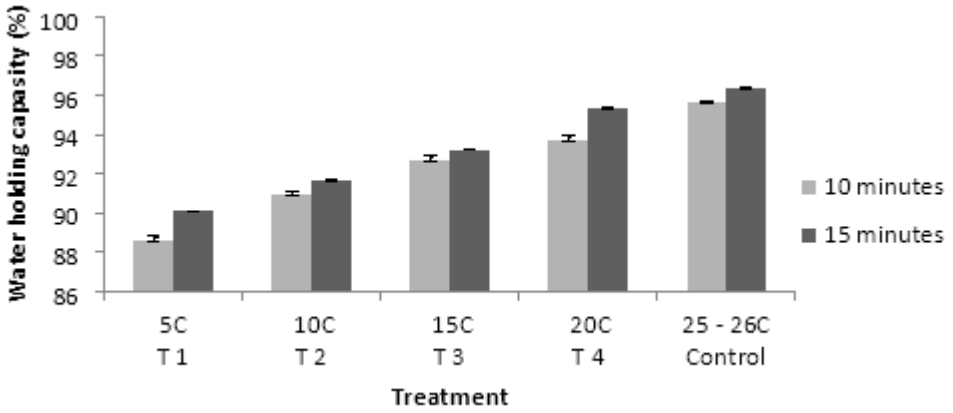

Figure1. Water holding capacity (WHC) of cooked sausages with immersion time

If comparing the water holding capacity of all 10 minutes treatments with all 15 minutes treatments, except T5 10 minutes and T4 15 minutes all other treatments significantly differ on water holding capacity.

Water immersion time and temperature were significantly affected ($p<0.05$) to the water holding capacity of the commercial cooked sausages. There is an interaction effect from the water immersion cooling temperature and time in the water holding capacity. Ma et al., (2020), have reported that the water holding capacity of the sodium-reduced pork sausages treated with 15-20^0C water immersion cooling temperature is significantly higher ($p<0.05$) than that cooled by 0-10^0C treated sausages.

The moisture content of the commercial cooked sausages with the 10 minutes and 15 immersion time

The following table indicates the figures of moisture contentment and weight of damaged (Kg) per 100Kg batch of the commercial cooked sausages treated with five temperatures including control (5^0C, 10^0C, 15^0C, 20^0C, 25^0C) and two water immersion times (10 minutes, 15 minutes).

Table 01. Moisture content and Weight of damages per 100 Kg of the commercial cooked sausages with the 10 minutes and 15 minutes immersion time

Treatment with Immersion time		Moisture content (W/W) %	Weight of damages(Kg) per 100Kg batch
T1 (5^0C)	10min	50.65 ± 0.8909	2.328 ± 0.0196
	15min	52.88 ± 0.4833	1.870 ± 0.0368
T2 (10^0C)	10min	53.15 ± 0.6585	2.284 ± 0.0529
	15min	49.82 ± 0.8095	2.481 ± 0.0344
T3 (15^0C)	10min	53.87 ± 0.4888	3.7467 ± 0.0508
	15min	54.25 ± 0.3174	3.270 ± 0.0225
T4 (20^0C)	10min	54.47 ± 0.2730	5.046 ± 0.0475
	15min	55.39 ± 0.2922	4.438 ± 0.0640
Control (RT)	10min	54.12 ± 0.3161	5.405 ± 0.0332
	15min	54.39 ± 0.4741	5.825 ± 0.0278

T1 10 minutes immersion time and T2 15 minutes immersion time samples were not significantly different ($p>0.05$). T1 10 minutes immersion time moisture content was significantly different ($p<0.05$) from the T1, T3, T4, and Control. Moisture content has no significant difference ($p>0.05$) between T1 10 minutes immersion time and T2 15 minutes immersion time.

The water immersion cooling temperature was significantly affected ($p<0.05$) to the moisture content of the cooked sausages. Feng (2013) reported that there is no significant effect from the moisture content to the cooling method of jumbo plain sausages. But the water immersion time was not significantly ($p>0.05$) affected the moisture content of the cooked sausages. There is a significant effect ($p<0.05$) from the interaction of water immersion cooling temperature and time according to the experiment.

The weight of the damaged cooked sausages per batch (100Kg) with the immersion time

Water immersion cooling temperature and time have significantly affected ($p<0.05$) the weight of damaged cooked sausages per batch (100 Kg). There is no significant effect of the interaction of the water immersion cooling temperature and time on the weight of the cooked sausages.

There is a positive Correlation between water holding capacity and the weight of damaged cooked sausages ($p<0.05$) with 10 minutes of water immersion time. The correlation is +0.96209. The intercept of the linear regression is +84.861.

There is a positive correlation between water holding capacity and the weight of the damaged cooked sausages with 15 minutes immersion time is +0.97713. The linear regression interception is +87.61.

Impact of water immersion cooling temperature with immersion time on the organoleptic properties of the cooked sausages

In the comparison of water immersion cooling temperature with 10 minutes and 15 minutes immersion time with the control, the appearance and color of the samples were significantly affected ($p<0.05$).

In the comparison of water immersion cooling temperature treatment with 10 minutes and 15 minutes, immersion times on the smell, flavour, texture, and overall acceptability with the samples were not significantly affected ($p>0.05$) by any of the water immersion cooling temperature treatments.

4. Conclusions

Overall findings express that, water holding capacity and weight of damages of commercial cooked sausages per 100 Kg batch were reduced when the reducing water immersion cooling temperature. According to the experiment increasing water immersion time is increasing the weight of damages per 100 Kg batch and water holding capacity. Reduction of water immersion cooling temperature was improved the organoleptic characters such as appearance, colour, texture, and overall acceptability except for smell and flavour. 5^0C water immersion temperature and 10 minutes immersion time treated commercial cooked sausages sample was performed lowest damages and most preferred sample in the sensory evaluation.

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Decontaminating effect of *Neolitsea cassia* leaves extract on broiler chicken meat contaminated with *Salmonella typhimurium* and *Escherichia coli*

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1. Introduction

Unsafe food leads to severe losses, estimating 600 million foodborne disease cases annually at global scale due to the consumption of contaminated foods with 420 000 deaths/year. Foodborne diseases are mainly associated with the consumption of meat and meat products contaminated with pathogenic microorganisms such as bacteria, viruses and parasites. *Salmonella* spp., *Campylobacter, Listeria* spp., *Clostridium* spp., *E. coli* and *Staphylococcus* spp. are the most common bacteria leading to foodborne disease outbreaks affecting millions of people annually. These outbreaks leads wide range of symptoms from severe to fatal outcomes. As the treatment options, antimicrobials are used and they are also used in sub-therapeutic levels to maintain animal and human health. This indiscriminate use of antimicrobials has resulted in a global threat, i.e. emergence of antibiotic resistant. More importantly, resistant bacteria can be transmitted to human through the food chain. In order to address this globally important threat of antibiotic resistance, scientists are in search of alternatives for antibiotics. Use of natural antimicrobial agents has received much attention as it is one of the best solution for the above problem. Therefore, application of plant based natural antimicrobials could be better option for the synthetic antibiotics and hence reducing the development of antibiotic resistance. *Neolitsea cassia* is a plant of Lauraceae family and known to have some beneficial effect such as antifungal, antioxidant and etc. However, there are hardly any researches so far on investigating the antibacterial properties, antioxidant properties, anti-biofilm properties, cytotoxicity of *N. cassia*. Hence this study investigated the decontamination ability of aqueous extract of *N. cassia* leaves on broiler chicken meat contaminated experimentally with *Salmonella* Typhimurium and *E. coli.*

2. Materials and Methods

Decontamination ability of the aqueous extract of *N. cassia* leaves on broiler chicken meat contaminated experimentally with *S.* Typhimurium (ATCC 14028) and *E. coli* (ATCC 25922) was investigated according to the method described by Madhushanka et al. (2018). Bacterial cell suspensions were prepared at 1.0×10^7 colony forming units per ml (CFU/ml) following the McFarland 0.5 turbidity standard. Aqueous extract of *N. cassia* was collected by passing through sterilized cheese cloth under aseptic conditions and this extract was used for meat decontamination. Chilled chicken meat samples (each sample weighing, 2.5g±0.2 g) were sterilized using sterilized distill water and subsequent UV treatment. Meat samples were artificially contaminated with the concentrations of 10^7 CFU/g of *S.* Typhimurium and *E. coli* under sterilized conditions and then were shaken in an automatic shaker for 30 minutes at 100 rpm/minute. Meat samples without contamination with *Salmonella* and *E. coli* were used as the uncontaminated control to see the sterility of meat samples. Three different concentrations (500mg/ml, 250mg/ml, and 125mg/ml) of aqueous extracts of *N. cassia* were used as treatments. Meat samples that were contaminated with bacteria were separately dipped in

different concentrations of aqueous solutions for two dipping times as 15 and 30 minutes in mechanical shaker at 100rpm. Contaminated meat samples without treatment of aqueous extract was taken as the positive control. Each treatment had six replicates. Decontaminated meat samples were homogenized and serially diluted and enumerated on Hektoen enteric agar (for *Salmonella*) and McConkey agar (for *E. coli*) plates using spread plate method. Following the incubation at 35±2°C for overnight, colonies were counted using automatic colony counter. Data were analyzed using the SAS statistical software.

3. Results and Discussion

This study investigated the decontamination effect of N. cassia extract on meat contaminated with S. Typhimurium (ATCC 14028) and *E. coli* (ATCC 25922).

3.1 Effect of *Neolitsea cassia* on chicken meat contaminated with *Salmonella* Typhimurium (ATCC 14028)

This study revealed a higher reduction of S. typhimurium count in meat samples dipped at higher concentration (500mg/ml) of the N. cassia than that of meat samples dipped in lower concentration (250mg/ml) for the both the dipping times (15 and 30 minutes). Percentage reduction of *S.* Typhimurium in the meat samples dipped at the concentration of 500mg/ml concentration level was 54% and 62.9% respectively for 15 and 30 minutes dipping time when compared to the concentrations of 250mg/ml and 125mg/ml. Percentage reduction of *S.* Typhimurium was 50.8% & 58.8% in the meat samples dipped at the concentration of 250 mg/ml and it was 125 mg/ml concentration levels 13.8% and 30.6% for15 minutes and 30 minutes dipping time respectively (Table 01).

Table 01. Effect of different concentrations of aqueous extract of *Neolitsea cassia* on count of *Salmonella typhimurium* in contaminated meat samples

Treatments	15 minutes		30 minutes	
	Average colony count in log 10	% Reduction	Average colony count in log 10	% Reduction
Positive control	5.169^{g} ± 0.01	0	5.216^{i} ± 0.02	0
500mg/ml	4.832^{h} ± 0.02	54.0	4.785^{k} ± 0.02	62.9
250mg/ml	4.861^{h} ± 0.02	50.8	4.830^{k} ± 0.02	58.8
125mg/ml	5.102^{g} ± 0.06	13.8	5.056^{j} ± 0.03	30.6

*Data were presented as the mean ± standard deviation. Means with different superscripts in the same column are significant differences at ($p \leq 0.05$)

Findings of Tabak et al. (1999) also in line with the results, as the concentration of the *N. cassia* at 125mg/ml may be supply enough nutrients for microbial survival but low enough to exert an inhibitory effect on *S. typhimurium*. The results prove that with the increment of concentration of *N. cassia* aqueous extract, the colony count reduction has been increased. This can be proved through the findings of the Piskernik et al. (2010).

3.2 Effect of *Neolitsea cassia* on chicken meat contaminated with *E. coli* (ATCC 25922)

The experiment of meat contamination with *E. coli* (ATCC 25922) also exhibited reduction of the bacterial cell numbers by 59.4% and 63.4% in the meat samples which were immersed in the 500mg/ml concentration of *N. cassia* extract for both dipping times 15 & 30 minutes respectively. The second highest percentage reduction of *E . coli* cell number was at 250mg/ml concentration and the reduction percentages was 57.7% and 59.6% respectively for both

dipping times and the lowest percentage reduction of bacterial cell numbers was by 125mg/ml and the reduction was 37.5% and 47.5% respectively for both the dipping times (Table 02).

Table 02. Effect of different concentrations of aqueous extract of *Neolitsea cassia* on count of *E. coli* in contaminated meat samples

Treatments	15 minutes		30 minutes	
	Average colony count in log 10	% Reduction	Average colony count in log 10	% Reduction
Positive control	5.204^{a} ± 0.01	0	5.247^{d} ± 0.02	0
500mg/ml	4.813^{c} ± 0.01	59.4	4.810^{f} ± 0.02	63.4
250mg/ml	4.830^{c} ± 0.02	57.7	4.853^{f} ± 0.01	59.6
125mg/ml	5.000^{b} ± 0.06	37.5	4.966^{e} ± 0.03	47.5

*Data were presented as the mean ± standard deviation. Means with different superscripts in the same column are significant differences at ($p \leq 0.05$)

A study done with cinnamon extract against *E. coli* has been shown the possibility of controlling the *E. coli* by these natural compound (Bharath et al., 2016) and it further supports the findings of this study too.

Phytochemical analysis had been proved that dried mucilaginous material of *N. cassia* contained with carbohydrate, monosaccharide, tannins, flavonoids and alkaloids (Kusunmala et al., 2017; 2019). But aqueous leaf extract has been contained with arabinose and xylose together with small amount of other sugars. The high viscosity of the *N. cassia* aqueous leaf extract is having due to water soluble arabinoxylan (De Silva & Kumar, 1986). Therefore, mucilaginous material which is contained in *N. cassia* leaf extract is shown antibacterial effect on S. typhimurium and *E. coli* treated chicken meat as above result.

Further this study revealed that the percentage reduction was not significantly affected ($p<0.05$) by dipping time but there was biological effect with elevated dipping time; some increment of percentage reduction was at 30 minutes dipping time in all three concentration levels in both the bacterial species used.

Uncontaminated control (sterile meat samples without contamination and without treatment with extract) did not exhibit the growth of microorganisms as it was free from microorganisms of concern.

4. Conclusions

This study concluded that there was a significant decontamination effect in aqueous extracts of *N. cassia* against *Salmonella* and *E. coli* at varied levels of concentration.

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Effect of the use of *Hermetia illucens* larvae to replace fish meal on the growth performances of *Labeo rohita* post-larvae

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1. Introduction

Black soldier fly (BSF) is an insect species that has received much concern in the animal feed industry, including aquaculture. Since BSF is a dipteran with a complete life cycle, the larval stage was already identified as a possible feed ingredient for animals (Bosch et al., 2019). Searching for alternative protein sources for expensive fishmeal, led nutritionists to find many possible sources including soybean meal, corn gluten meal, rapeseed meal and cotton seed meal like plant sources. Availability of anti-nutrient factors and imbalanced amino acid profiles of plant nutrients made them unreliable for use in aqua-feed industry (Daniel, 2018). Animal protein sources such as insects (i.e., yellow meal worm, BSF larvae), have been identified as alternative sources and however, still research is being conducted over different fish species, since the literature evidenced that the reliability of insects were extremely species dependent (Priyadarshana et al., 2021).

Therefore, the present study investigated the effect of BSF larva as a feed ingredient for *Labeo rohita*. *L. rohita* was considered the foremost fish species that thrives Sri Lankan freshwater bodies, since it was demanded as a major food fish species among Sri Lankans (Pushpalatha, & Chandrasoma, 2018). Since, Indian carps including *L. rohita* were not capable of being bred naturally in the Sri Lankan waters, National Aquaculture Development Authority (NAQDA) was performing the breeding activities. Captively bred *L. rohita* larvae were kept in tanks until they were released into the reservoirs, and consequently, a good quality and a low-cost feed was indispensable. Therefore, this study has evaluated the effect of BSF larva as a feed ingredient for the post-larval stage of *L. rohita*.

2. Materials and Methods

Experimental diets and feeding trial

A meal from BSF larva was processed by partially defatting, drying and grinding the harvested larvae. Four feeds were prepared to be iso-caloric (3100 kcal/kg), iso-lipidic (10%) and iso-proteic (35%) manner, by incorporating different feed ingredients i.e., rice bran, coconut poonac, maize, fishmeal, BSF larval meal, fish oil, L-lysine, DL-Methionine, Vitamin-mineral premix. BSF larva meal was used to replace over fishmeal at 04 different levels i.e., 0%, 25%, 50% and 75% to prepare 04 experimental feeds.

Four days old *L. rohita* post-larvae were introduced into cement tanks at a stocking density of 75 post-larvae per tank (tank volume=0.2 m^3). Fish were fed to apparent satiation, thrice a day and tanks were cleaned by syphoning with a frequency of once in two days.

Growth performances

Body weight (BW), body length (BL) measurements of post-larvae were obtained at the beginning and the end of the feeding trial. Water quality parameters (temperature, pH and dissolved oxygen) were measured with a frequency of once a week. Mortality of the fish was recorded daily and survival rates of each treatment group was determined separately at the end of the experiment.

Statistical analysis

IBM SPSS Statistics (version 21.0) software and One-way ANOVA was used to analyse data where the mean comparison was performed using, Duncan's Multiple Range Test ($p<0.05$).

3. Results and Discussion

The results implied that the incorporation of BSF larva meal, did not affect the growth performances up to 25% inclusion rate, since growth performances were significantly higher ($p<0.05$) in 0% and 25% BSF larva diet groups where the BW gain, BL gain and specific growth rate (SGR), values in 0% and 25% BSF larva diet groups were 0.164±0.004 g and 0.163±0.003 g, and 1.579±0.052 cm and 1.578±0.03 cm, 18.015±0.301 % day^{-1} and 17.958±0.101 % day^{-1} respectively. However, the growth performances were seriously affected over 25% inclusion. Body weight gain, BL gain and SGR values were negatively correlated with 50% and 75% BSF diet groups. Similar results were observed in African catfish, *Clarias gariepinus* (Talamuk, 2016), Siberian sturgeon *Acipenser baerii* (Caimi et al., 2020) and Rainbow trout *Oncorhynchus mykiss* (St-Hilaire et al., 2007). BSF larva meal 0% and 25% diet groups showed the highest Protein Efficiency Ratio (PER) values (2.235±0.06 and 2.339±0.037 respectively) whereas 50% and 75% exhibited the lowest (1.965±0.074 and 1.713±0.059 respectively). Since, PER is a reflection of the quality of the proteins (Muin et al., 2017), 0% and 25% feeds might comprise of high-quality proteins. Feed Conversion ratio (FCR) values of the 0% (1.705±0.046) and 25% (1.629±0.026) dietary groups were also significantly lower ($p<0.05$) than those of 50% (1.941±0.074) and 75% (2.226±0.079). A feeding study performed with *Chanos chanos* revealed that diets with poor nutrients and energy deficits as the possible reasons for poor FCR values (Icamina, 2012). As supported by the most of previous studies, chitin was found as the possible cause for growth retardation at higher incorporation levels of BSF larva meal (Kroeckel et al., 2012). Since, chitin is an indigestible polysaccharide for most of the organisms (Rahman & Koh, 2014), digestible energy deficits of the feeds could be possible, though the gross energy values of the feeds in this study seemed equal. Since, chitin a nitrogenous polysaccharide, the apparent crude protein contents of the diets might be lesser than the actual value. Consequently, the protein to energy ratio might not be at optimum levels, and therefore, the proper utilization of energy might not be achieved by the fish. Therefore, further studies are required to clarify this matter.

The survival of post-larvae was not affected ($p<0.05$) by the experimental diets and were within the range of 87.56%±0.76 – 89.33%±3.52. Water quality parameters also remained consistent within the treatments throughout the experimental period; since, the removal of faecal matter and feed residues were done frequently.

4. Conclusions

Black Soldier Fly larva in the diets of *L. rohita* post-larvae do not affect the growth performances up to 25% incorporation level. However, the growth performances have been subsided at 50% and 75% incorporation levels. Therefore, the maximum level of 25% BSF

larvae meal could be incorporated as the protein source in *L. rohita* post-larvae diets to retain optimum growth and survival rates.

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Influence of the dietary protein and fat contents on the growth performances of *Xiphophorus maculatus*: A preliminary study

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1. Introduction

Ornamental fish culture has been a hobby and a commercial industry since 1930's in Sri Lanka. The geographical location and the climatic conditions were also being beneficially affected on the ornamental fish industry in Sri Lanka. Even though Sri Lankan fish enthusiasts have paid their attention towards keeping of goldfish and koi carps, guppies, swordtails and platies were the foremost species in Sri Lankan export trade. Fish exporters used to collect the required quantity of guppies, swordtails and platies through a buy back system, in which the contact farmers grow the demanded fish species in cement tank or mud pond systems. However, platy (*Xiphophorus maculatus*) was such a demanded ornamental fish species, who had given a low priority in the sense of culturing for exports (Wijesekara & Yakupitiyage, 2000).

Sri Lankan ornamental fish growers were facing a lot of difficulties throughout the rearing period, where unavailability of a targeted, cost-effective and quality feed is the major problem. Thus, developing an economically viable, good quality feeds to match different ornamental fish species would be essential for further development of the industry (Heenetigala, 2012). However, development of a feed has to be done with a proper way, with the use of appropriate crude protein and crude fat levels while balancing the energy levels for outstanding overall performances in the fish.

2. Materials and Methods

Experimental Diets

Four treatment diets i.e., T_1: Crude protein (CP)-35% and crude fat (CF)-6%, T_2: CP-35% and CF-12%, T_3: CP-40% and CF-6%, T_4: CP-40% and CF-12%, were prepared to comprise 02 crude fat levels (6% and 12%) and 02 crude protein levels (35% and 40%).

In the preparation of diets, properly sieved dry feed ingredients i.e., coconut poonac, rice bran, wheat flour, fishmeal, vitamin-mineral mixture, L-lysine and DL-methionine, were uniformly mixed with fish oil and water at appropriate ratios. Then the prepared mixture was minced using a 4 mm mesh sized mincer. After that, the minced mixture was oven dried at 50 ^{0}C for 24 hours until the moisture content reaches 8-10 %. Finally, the particles were grounded and sieved using a 0.4 mm mesh sized net.

Feeding trial

One day old *X. maculatus* fry were introduced into glass tanks (Length =2 ft, width =1ft and water height =6 inches) which were arranged in triplicates, with a rate of 50 fries per tank. Fish in each tank were acclimatized for a week before the feeding trial. Fish were fed to apparent satiation, 03 times per day.

Growth performances

Body weight (BW) and body length (BL) of fish were measured at the beginning and after 30 days. Water quality parameters (temperature, pH and dissolved oxygen) were regulated at appropriate levels. Fish mortality in each tank was recorded at the end of the feeding trial.

Statistical analysis

Data was analysed using IBM SPSS Statistics (version 21.0) software and Two-way ANOVA. The mean comparison was done using, Duncan's Multiple Range Test.

3. Results and Discussion

To our knowledge this was the first attempt ever made to evaluate the growth performances of *X. maculatus* with reference to the different dietary protein and lipid levels. A significant ($P<0.05$) effect was observed in between the two test factors i.e., crude fat content and crude protein content, on the growth performances of *X. maculatus* nurselings. Evaluation of individual treatments evidenced that the T_3 (0.056±0.004 g) group had the highest body weight gain than those of T_1 (0.036±0.004 g), T_2 (0.030±0.004 g) and T_4 (0.029±0.001 g) where the body length gains also showed the self-same (T_3- 0.819±0.081 cm, T_1- 0.577±0.051 cm, T_2- 0.524±0.069 cm, T_4- 0.520±0.043 cm).

At the 40% dietary protein content, the specific growth rate (SGR) was highest at 6% fat content (9.533±0.268 % day^{-1}), whereas, the SGR was negatively affected at 12% fat content (8.067±0.119 % day^{-1}). At 35% dietary protein content, SGR was not affected by different dietary fat contents i.e., 6% (8.492±0.303 % day^{-1}) and 12% (8.171±0.297 % day^{-1}). However, with reference to the all four diets, T_1 had the best SGR. The feed conversion ratio (FCR) was proven to be best at T_3 (2.435±0.172) than those of T_1 (3.455±0.450), T_2 (3.897±0.483) and T_4 (4.093±0.209). Compliance with the results of this study, Kruger et al. (2000), also experienced poor growth performances in *X. helleri* juveniles, at high lipid levels (over 6%) where the protein contents were comparatively low (below 38%).

Feed intake (FI) was highest at 6% dietary fat content, at 40% protein content (0.135±0.001), followed by 35% protein content (0.122±0.001), whereas the FI was extremely impaired at 12% fat content among 35% (0.116±0.001) and 40% (0.117±0.001) crude protein containing dietary groups. This effect was evidenced by Li et al. (2011) for Snout bream (*Megalobrama amblycephala*), where the FI showed a huge variation with the dietary fat content. A proper balance in between dietary protein and energy contents was requisite for an efficient protein intake. Unless the protein and energy were balanced in a diet, "sparing effect"; a phenomenon in which the body protein deposits forced to breakdown, due to poor availability of dietary carbohydrates, would be possible (Steffens, 1996).

Velasco-Santamaría, and Corredor-Santamaría (2000) found that the protein requirement of the finfish could be varied specifically in relevant with the kind of species and growth stage. Compliance with the available literature, the results of this preliminary study implied that the growth performances of *X. maculatus* nurselings were best in the diet where 40% dietary protein content combined with 6% fat content.

4. Conclusions

A combination of high protein content together with a low-fat content in *X. maculatus* nurseling diets would be ideal for an effective utilization of the proteins and the optimum growth performances thereof. A well-balanced protein and energy content in a diet was also a prerequisite to avoid body protein degeneration and a better growth thereby.

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Constraints faced by ornamental fish farmers in the Kandy district during the COVID-19 pandemic

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1. Introduction

The ornamental fish industry has a long history in Sri Lanka. The presence of tropical climatic conditions with abundant natural water resources has enabled fish farmers to engage in the breeding and culturing of various exotic and endemic ornamental fish species. Currently, the ornamental fish farming industry is present in many parts of the country. Sri Lanka exports freshwater, brackish water, and marine species, collected from the wild as well as from farms. Currently, over 5000 fish farmers and suppliers are engaged in this industry, making it a lucrative business venture. United States remains the major buyer of ornamental fish products with a value of over 4 million US dollars (Alexander, 2021).

The coronavirus (also known as COVID-19) pandemic that first appeared in China by the end of 2019, has affected most of the countries worldwide including Sri Lanka. Global value chains got interrupted which connect producers across multiple countries (Kalogiannidis, 2020). Sri Lanka reported its first locally transmitted COVID-19 patient on March 11, 2020, leading to a series of lockdowns and other measures, affecting the smooth functioning of businesses including the ornamental fish industry. Effects of COVID-19 on the aquaculture sector varies widely. Fish farmers facing difficulties in selling their products, maintaining large quantities of live fish that need to be fed due to restrictions in market accessibility, closure of international markets and difficulties of trading brood stock are few of the many challenges faced by ornamental fish farmers (FAO, 2020).

This pandemic is a major threat to the Sri Lankan economy (Manawadu & Wijeratne, 2020). The Kandy district located in the central province of the country is one of the many areas where ornamental fish farming is present. Fish farmers in this area were affected due to restrictions to contain the virus thus, hindering their sales. The present study emerged from the need for information to understand the impact of COVID-19 on the ornamental fish farming in Kandy district as there are no similar published studies present.

2. Materials and Methods

The study was carried out from February 2021 to June 2021. A structured questionnaire was used for data collection from ornamental fish farmers. Among the total of 120 ornamental fish farmers registered with the National Aquaculture Development Authority (NAQDA) in the Kandy District, 80 individuals were selected for this study. The questionnaire was used to collect basic data from fish farmers including experience in the industry, monthly income, and available workforce. Production problems and marketing-related problems faced by the fish farmers during the COVID-19 pandemic were also considered. Data related to the challenges faced by the fish farmers in the study area were also collected. Collected data were tabulated and analysed in SPSS statistical package (version 25) and MS Excel.

3. Results and Discussion

Most of the fish farmers in the study area (44.44 %) earn less than Rs. 10,000 per month and 29.63 % of farmers earning above Rs. 50,000. Hence, it is evident that most fish farmers face difficulties in increasing their monthly income.

Most of the farmers have 1-5 years of experience in ornamental fish farming (48.75 %) with only 13.75 % having experience of over ten years. Chi-square test results showed that there is a significant difference between the experience in ornamental fish farming and monthly income ($p < 0.05$, $df = 9$, $\chi^2 = 33.723$). Among the respondents, 81.82 % of fish farmers who have been engaging in the business for more than ten years have reported the highest income of above Rs. 50,000 per month.

Above 75 % of the farmers use only one laborer to maintain their fish farms, possibly due to limited production and other constraints. Only less than 2 % of farmers reported employing six laborers in their farms. Among the individuals, 13.58 % reported that they have recruited two laborers.

Most of the fish farmers in the study area have obtained some form of training in ornamental fish farming (81.48 %). Among the farmers who earn the highest monthly income (above Rs. 50,000), 87.5 % have obtained training in ornamental fish farming. However, there was no statistically significant difference between the participation in training programs and the monthly income ($p > 0.05$, $df = 3$).

Problems faced during COVID-19

The majority of the farmers reported various problems in continuing ornamental fish farming due to the COVID-19 impact. Among the respondents, 72.8 % of farmers reported difficulties in receiving aquaculture feeds. Also, some farmers reported difficulties in receiving medicines, difficulties in breeding the fish, difficulties in cleaning the farm, difficulties in maintaining the product quality, difficulties in finding quality breeding fish, and disease infection.

All the farmers reported facing a lack of workforce in their farms for daily maintenance of the farms. Due to travel restrictions, many faced a lack of labor supply. Among the individuals, 92.59 % faced transportation-related issues to send their fish to the market while 80 % reported a reduction in the number of customers. Other marketing-related problems included no stable price in the market, lack of potential sellers and middlemen in the marketing chain.

Only 36 % of farmers used different forms of strategies to manage the losses faced during the pandemic such as reducing the frequency of feeding, limiting breeding activities, restricting the use of different feed types for different stages of fish, preparing their own feed, obtaining assistance from the government and other organizations, obtaining financial support, making changes in production systems and species and change the market channels.

All the farmers agreed that they need to adopt new marketing strategies to sell their products as well as high maintenance costs incurred due to the COVID-19 pandemic.

Most farmers (75 %) agreed that increasing feed prices have a major impact on their production. Among the respondents, 37 % mentioned that they faced difficulties in entering the export market due to lack of communication between farmers and exporters. Majority of farmers (83.33 %) who reported difficulties in reaching export markets had the lowest monthly income of less than Rs. 10,000. All the farmers in this study agreed that their income would be reduced due to the above-mentioned problems.

4. Conclusions

The ornamental fish farmers in the Kandy district have been facing several constraints and challenges that have adversely affected them in the past. This situation has become more complicated due to the recent COVID-19 outbreak. Many farmers have experienced a decline in monthly income during recent times. The spread of the pandemic has led to problems in production, marketing, supply, and logistics. Challenges in entering the export market have also been reported.

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Unprocessed household fish consumption and COVID-19 - evidence of negative effects: A case study

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1. Introduction

Most of the Sri Lankans consume fish either as fresh or processed form (Komahan & Sivarajah, 2018). About 70 % of the animal protein requirement is met by the people of Sri Lanka by consuming fish (Devadawson et al., 2015). The per capita fish consumption in the household sector was 11.8 Kg/year in 2016 (Ministry of Fisheries, 2020).

The novel coronavirus, commonly known as the COVID-19 pandemic first started in Wuhan city, Hubei province of China in December 2019 (Sun et al., 2020). Since then, the pandemic has spread to many countries, affecting many aspects including the global trade. The first local case of novel coronavirus in Sri Lanka was reported on 27 January 2020 (Epidemiology Unit, 2020). The COVID-19 has severely impacted various sectors in Sri Lanka including food security. The first wave of COVID-19 lasted from January to October 2020 followed by the second wave. The second wave affected the fisheries sector by the emergence of a cluster based on Peliyagoda fish market.

National level studies on the impact of COVID-19 on local fish consumption are not abundant thus, highlighting the need for similar studies. Being a country with a considerable proportion of fish consumers as well as fishing communities, this study aims to provide evidences of COVID-19 impact on local fish consumption in three Grama Niladari (GN) divisions. The study also aims to understand the attitude towards fish consumption among the residents of the selected study areas.

2. Materials and Methods

This study was conducted using structured questionnaire targeting the residents in the following GN divisions: Batakeththara north in Colombo district, 34B Poddiwala in Galle district and Gatamanna north in Hambanthota district. Higher fish consumption pattern and fish production (Ministry of fisheries, 2020) can be found in 34B Poddiwala and Gatamanna north GN divisions due to their close proximity to the coastal area. The Batakeththara north GN division consists many households that consume fish from the Peliyagoda fish market. A sample size of 150 residents from each GN division was selected using random sampling technique. The study period lasted from 14th of February 2021 to 16th of May 2021. The study period included the first and second waves of COVID-19 pandemic in the country.

The questionnaire was based on the socio-demographic aspects of the residents, their economic status, attitude towards fish consumption, species of fish consumed, sources used to purchase fish and frequency of fish consumption. The study also focused on fish consumption pattern by the residents during the COVID-19 pandemic and their attitude towards the impact of pandemic on fish consumption. The residents' preference for alternative protein sources was also considered in this study. Primary data required for this study was collected from the residents by interviews and online-based surveys. Data analysis was performed using MS Excel and IBM SPSS statistical package (version 25).

3. Results and Discussion

Fish consumption pattern among the respondents

Most of the participants in all three GN divisions (97.60 %) were regular fish consumers. The distribution of residents who consume fish were almost equal across the three divisions as follows: 96.18 % in Batakeththara north, 98.68 % in 34B Poddiwala and 98.01 % in Gatamanna north.

Among the respondents, majority of them (60.65 %) purchased fish from fish mongers, while others purchased fish from sources such as fish markets and supermarkets. Most of the individuals stated that they preferred to purchase marine species (62.17 %) over freshwater species. A considerable proportion of respondents (34.57 %) stated that they purchased both species. Most respondents consumed fish twice a week (63.76 %), followed by 25.33 % consuming fish throughout the week and only 10.48 % once a week. Most of the participants in the study stated that they consume above 1 kilograms of fish per week (48.25 %) while only 7.64 % purchase less than 500 g per week. This purchasing trend is dependent on the number of family members. Most respondents spend less than Rs. 1000 per day for fish consumption (95.40 %) followed by 4.60 % spending between Rs. 1000 and Rs. 2000. There was a significant difference between the per day expenditure for fish consumption and monthly income of the respondents in the study ($\chi^2 = 12.644$, $p < 0.05$). When inquired about the reasons to consume fish, most of the respondents (85.84 %) stated that they consume fish to obtain nutrition. Furthermore, 99.78 % stated that fish is expensive to purchase, although it is a good nutritional food source.

Awareness of COVID-19 and fish consumption during COVID-19

Majority of the respondents (60.35 %) were aware of COVID-19 pandemic in contrast to only 1.31 % having no awareness of the disease. Among the individuals, 28.32 % mentioned moderate awareness. Surprisingly, 98.69 % of respondents consumed fish during the first wave of coronavirus pandemic in Sri Lanka. However, most of the individuals (70.31 %) avoided consuming fish (98.1% in Batakeththara North, 98.0% in 34B Poddiwala and 12.7 % in Gatamanna north) during the emergence of Peliyagoda fish market cluster in the country. Among the respondents, 18.56 % continued to consume fish even during the presence of the cluster.

Majority of respondents (74.35 %) did not purchase fish due to fear of COVID-19 spread in fish markets. However, most of the individuals did not consider economic difficulty as a reason to stop purchasing of fish (93.26 %). Majority of the respondents utilized alternative protein sources (80.22 %). Among the respondents in the study, 58.70 % believed that local fish consumption was affected by COVID-19. Inferential statistics revealed that there was a significant difference between the per week consumption of fish before and during COVID-19 pandemic ($\chi^2 = 421.81$, $p < 0.05$).

4. Conclusions

The findings of this study give an understanding of the impact of COVID-19 in fish consumption pattern in the above mentioned GN divisions. Although the first wave of the pandemic did not affect the fish consumption, the emergence of fish market cluster led to reduced demand for unprocessed fish. Consumers showed interest towards consuming alternative protein sources. Further studies in other parts of the country are required to understand the impact of the pandemic on local fish consumption.

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Outbreak of Lumpy Skin Disease (LSD) in cattle – A recent epidemic in Jaffna district

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1. Introduction

Lumpy Skin Disease (LSD) is an economically devastating disease in cattle caused by Lumpy Skin Disease Virus (LSDV). The principal mode of transmission is by haematophagic arthropod vectors such as flies (*Stomoxys calcitrans*), mosquitoes (*Aedes aegypti*) and hard ticks (*Rhipicephalus* and *Amblyomma* species) (Sprygin et al., 2019). LSDV is host specific that affects only cattle and buffaloes with a high morbidity rate (Hasib et al., 2021) and a low mortality rate between 1-3 % (Rahman, 2020). All the cattle populations irrespective of breed, age and sex are susceptible to LSDV (Salib & Osman, 2011). The first case of LSD was identified in Zambia in 1929. Earlier LSD was confined to African continent only. However, it was spread to Asian and European countries later (Rahman, 2020).

LSD is manifested by cutaneous nodules, fever, anorexia, salivation, rhinitis and oedema of different parts of the body. The major economic impacts of LSD are mastitis, reduction in milk yield, abortion in pregnant animals and mortality. Therefore, LSD is enlisted as a notifiable disease by the World Organisation for Animal Health (OIE) due to its trans-boundary spread, threat to animal health and economy (Hasib et al., 2021). There is no published information available about the LSD outbreak in this region. Therefore, this study reports the clinical features and impacts of LSD in cattle.

2. Materials and Methods

The study area, Jaffna, is a district that belongs to Northern province, Sri Lanka. This region was totally free from previous LSD outbreaks. The present study was conducted on 235 cattle presented to the Veterinary Surgeon's Office with the characteristic clinical signs of LSD. These animals were clinically examined and relevant details such as breed, sex, age and physiological status were gathered using a pre-structured questionnaire. The data were analysed and presented as the percentage of infected cattle.

3. Results and Discussion

The infected cattle showed the characteristic signs such as cutaneous nodules (Figure 1-a), salivation, rhinitis, anorexia, fever, and swelling of limbs, brisket, ventral abdomen and subcutaneous tissue at the early stage of the disease. The significant commonality found in the majority of the affected population was cutaneous nodules which were distributed randomly all over the body. They initially appeared in small sizes and later developed into large nodules in different sizes (10-50 mm in diameter) and number range from a few to hundred. In few animals, some nodules were coalesced into large irregularly circumscribed nodules. Nodular lesions were hyperaemic and painful which involved skin, subcutaneous tissue and musculature depending on the severity of the illness.

In severe cases, these lesions persisted for two weeks and with the disease progression, considerable number of nodules became necrotic with a deep scab formation. However in some cases, the nodules were ulcerated and prone to secondary bacterial infection (Figure 1-b). Oedema of limbs, brisket, dewlap and subcutaneous tissue was a prominent feature observed

in the affected cattle resulting in lameness and difficulty in lying down. Ruptured swellings with oozing of pus attracted flies and ended up in myiasis.

Figure 1. Clinical signs of the cattle affected by LSD; (a) Skin nodules and (b) Well-circumscribed ulcers on skin

The study found that cattle belong to different breeds, ages and sexes were affected with LSD which was also evidenced in other studies conducted in different countries (Salib & Osman, 2011). Lactating cows were the highly affected group (58.7%) in this study, which could be due to the physiological changes and affiliated immunosuppression in dairy cows (Ingvartsen & Moyes, 2015; Rahman, 2020). This subsequently resulted in dropped milk yield which was a detrimental impact to dairy farmers. The prevalence of LSD was low in bulls with 4.3% of the study population. This finding is in line with a study conducted in Bangladesh which reported that the lowest prevalence was observed in bulls of 5% (Hasib et al., 2021). The calves, heifers and dry cows were infected with 17.9%, 8.5% and 10.6%, respectively (Table 01).

Table 01. Classification of LSD infected cattle according to age and sex

Category	Percentage (%)
Calves	17.9
Heifers	8.5
Lactating cows	58.7
Dry cows	10.6
Bulls	4.3

4. Conclusions

Cattle under the study showed skin lesions as a marked sign with salivation, rhinitis and oedema of body parts. All the cattle regardless of age, sex and breed were infected with similar clinical presentation. The lactating cows were mostly affected while a low incidence was noticed in bulls. Lameness, milk reduction and mortality were the economic impacts encountered in the studied population. Early detection of the disease is pivotal to implement preventive measures like movement restriction, vector control and vaccination programs which could decelerate the spread of the disease and downgrade the adverse consequences of LSD in livestock sector.

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Impact of the X-Press Pearl ship fire on domestic marine fish consumption in Western, North Western and Southern provinces: A case study

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1. Introduction

Fish has been consumed by Sri Lankans for many centuries. Fish provides protein for humans not otherwise available (Burger & Gochfeld, 2006). According to statistics, more than 400 000 metric tons of fish have been produced by the marine fisheries sector and 90 000 metric tons by inland fisheries and aquaculture sector (Ministry of Fisheries, 2020).

On the 20th of May 2021, X-Press Pearl, a 186 meter-long Singapore-registered container ship caught fire while anchored off the coast of Sri Lanka, near the capital city of Colombo (Oceanswell, 2021). The vessel was carrying many containers of bunker fuel oil, gas oil, nitric acid, lubricating oil, chemicals, cosmetics, millions of plastic pellets, and shopping bags. The leakage of dangerous compounds such as nitric acid, sodium dioxide, copper, and lead raised concerns. Carcasses of dead marine animals were frequently reported soon after the incident. Dead fish washed up with bloated bellies and plastic pellets.

This marine accident caused a major blow to the livelihoods of fishermen in the country. Many fishing families lost their income overnight and were forced to find alternative sources of income. Additionally, fish consumption among the general public was affected due to various claims of potential oceanic pollution. This disaster had a major impact on the livelihoods of people residing in the western province, north western province, and southern province. However, no studies have been published yet to understand the impact of the X-Press Pearl disaster on domestic fish consumption. This study aims to provide an insight into this by studying the fish consumption patterns of the people living in the western province, north western province, and the southern province before and after the disaster.

2. Materials and Methods

The study was carried out from June 2021 to July 2021. Questionnaires were distributed among the individuals residing in the western province, north western province, and southern province, the major provinces affected by the disaster. A total of 1255 individuals responded to the questionnaire provided. Individuals in this study represented the study areas as follows: 533 (42.47%) in the western province, 322 (25.66%) in the north-western province, and 400 (31.87%) in the southern province.

The questionnaire was used to understand the awareness levels of the X-press pearl ship fire among the residents in the study areas and changes in fish consumption patterns. In addition to this, data related to monthly income, knowledge on fish landing sites and preferred species for consumption were collected. Collected data were analysed using SPSS statistical package (version 23) and MS Excel.

3. Results and Discussion

Monthly income level and fish consumption pattern

The monthly income level of the respondents showed a majority of them (38.17 %) earning above Rs. 50,000 per month. A smaller proportion of the respondents earned a monthly income of less than Rs. 10,000 (14.50 %). Among the 1255 individuals, the majority (93.86 %)

consume fish very often while only 4.78 % of them consume fish once a month. It was evident that most of the respondents are regular consumers of fish.

Knowledge about the fish landing site and preference of species

When inquired about the location of fish caught, most of the individuals (54.82 %) have awareness about the landing site of the fish they purchase. Most of the respondents (66.14 %) prefer to consume marine fish species while 32.11 % prefer both freshwater and marine species.

Reasons for fish consumption

Data collected from the respondents proved that most of them were aware of the nutritional benefits associated with fish consumption. A majority of the respondents (83.43 %) consume fish to obtain protein and other nutrients. Only a smaller proportion of individuals reported that they consume fish for habitual reasons (33.63 %).

Awareness regarding the X-Press Pearl disaster and subsequent behaviour in fish consumption

Among the individuals considered for this study, most of them responded that they have a clear understanding of the recent X-Press Pearl ship fire (90.04 %) followed by 9.40 % of respondents reporting a moderate level of awareness regarding the incident. Less than one percent (0.56 %) were unaware of the ship fire. Most of the individuals did not consider consuming fish due to associated risks of contamination by the ship fire (Figure 1).

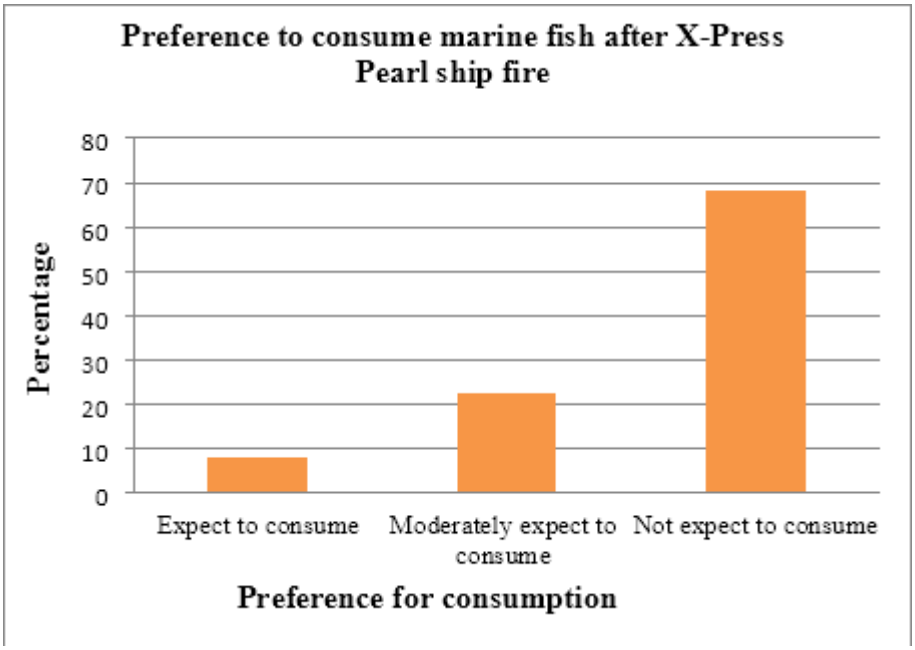

Figure 1. Preference among the residents regarding consumption of marine fish after the X-Press Pearl ship fire. Most respondents (68.29 %) did not expect to consume marine fish, indicating a negative impact of the ship fire in local fish consumption.

Perception towards impacts of X-Press Pearl disaster on fish consumption

When inquired about the impact of the X-Press Pearl incident on fish consumption among the residents of the western province, north western province and the southern province, 90.6 % of respondents agreed that this incident will affect fish consumption. Among the respondents, 88.69 % believed that consuming fish will lead to adverse health effects. Furthermore, 78.01

% of respondents believed that this marine disaster will lead to changes in the nutritional value of the food fish. A majority of respondents (90.99 %) believed that the incident will affect the future market demand for food fish. In addition to this, a considerable number of individuals (79.13 %) believed that the demand for alternative protein food sources will rise in the future. Among the respondents having awareness of the accident, 68.29 % did not expect to consume fish. Inferential statistical analysis revealed that there was a significant relationship between the awareness of the X-Press Pearl disaster and preference for consuming fish ($\chi^2 = 72.633$, $p < 0.05$).

4. Conclusions

Due to the widespread belief that consuming fish during this marine disaster may lead to adverse health effects and lead to changes in the nutritional value of the food fish, the majority of people in western province, north western province, and southern province have decided not to consume marine fish. The majority of them had an awareness of the X-Press Pearl ship fire and it led to increased negative perception towards fish consumption.

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Student Forum

Effect of different calcium sources on yields and quality of groundnuts (*Arachis hypogaea* L.) in Thihawa, Kumbukwewa

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1. Introduction

Groundnut is cultivated in the dry and intermediate zones of Sri Lanka mainly in the Maha season and in paddy lands during Yala season. According to the Department of Agriculture DOA (2006), the application of calcium is important for proper kernel development in groundnut. Calcium carbonate, a source of calcium, is slow releasing due to less solubility compared to gypsum. Therefore, gypsum ($CaSO_4.2H_2O$) can be used at flowering to ensure the adequate availability of calcium in the fruiting zone to enhance pod development. Gypsum application to the soil reduces erosion due to improving soil aggregates by increasing the ability of soil to soak up water after precipitation whereby it improves soil aeration and water percolation through the soil profile. The application of gypsum to soils low in calcium increased the percentage of oil in all peanut cultivars; with less nitrogen content. The application of gypsum to groundnuts grown in Georgia increased germination and reduced aflatoxin contents by 40 percent (Davidson et al.,1983). Chapman et al. (1993) reported that the low calcium in the pegging zone causes low peg formation. The groundnut pegs and pods treated with gypsum had significantly less pod rot than the untreated (Chapman et al., 1993). Farmers in the Dambulla area apply 60-350 kg ha^{-1} of gypsum for their cultivations and obtained a yield of 2500kg ha^{-1}. The yield of groundnut is around 750 - 1000 kg ha^{-1} in Thihawa, Kumbukwewa. Hence, the objective of this study was to evaluate the effect of gypsum and calcium carbonate on groundnut in Thihawa, Kumbukwewa.

2. Materials and Methods

This study was conducted at the Thihawa, Kumbukwewa in Kurunegala district, which belongs to IL3 agro-ecological region. This was conducted in Maha season in October 2019 and variety Thissa was used. The recommended fertilizer rate is 30 kg ha^{-1} nitrogen, 45 kg ha^{-1} phosphate (P_2O_5), 45 kg ha^{-1} potash (K_2O) (DOA,2006) and there was no recommendation for gypsum or calcium carbonate. The experiment was laid according to Randomized Complete Block Design (RCBD) with four treatments with three replicates. The treatments were: DOA recommendation (control) (T1), DOA recommendation + 200 kg ha-^{1} of gypsum (T2), DOA recommendation + 200 kg ha-^{1} of calcium carbonate(T3), DOA recommendation + 100 kg ha^{-1} of gypsum + 100 kg ha^{-1} of calcium carbonate (T4). Soil pH, cation exchange capacity (CEC), and electrical conductivity (EC) were measured at the planting, 5 days after application (5 DAA) at the pegging stage and harvest. The number of pegs per plant was calculated by selecting five plants randomly and the pods' fresh weights (g), pods' dry weight (g), kernel weight of fifty pods (g), and shell weight of fifty pods were measured (g). The quality of the kernel was assessed visually by sorting and grouping the seeds according to the size of the kernel of 50 pods into large, medium and small. Data were analyzed using the analysis of variance (ANOVA) procedure by statistical analysis system (SAS) and mean separation was done using Duncan's Multiple Range Test (DMRT) at p= 0.05.

3. Results and Discussion

Initial pH, CEC (cmol kg-1) and EC (micro-Siemens cm^{-1}) values showed the soil was in the acidic range and it was below the recommended pH range. The initial stage pH varied from 5.4 to 5.5, CEC varied from 6.0 cmol kg^{-1} to 6.5 cmol kg^{-1} and EC varied from 200 µS cm^{-1} to 220 µS cm^{-1}. 5 days after application (5 DAA) at the pegging stage, pH varied from 5.4 to 6.0, CEC varied from 7.2 cmol kg^{-1} to 7.8 cmol kg^{-1} and EC varied from 230 µS cm^{-1} to 270 µS cm^{-1}. At harvesting pH varied from 5.4 to 6.0, CEC varied from 7.1 cmol kg^{-1} to 7.7 cmol kg^{-1} and EC varied from 210 µS cm^{-1} to 260 µS cm^{-1}. Warren (2011), observed that gypsum improve the pod filling without changing the soil pH and explained that a good soil EC level was somewhere above 200 µS cm^{-1} and 1200 µS cm^{-1} (1.2 mS cm-1) while any soils < 200 µS cm^{-1} have not enough available nutrients to the plant and a sterile soil with minimum microbial activity and EC above 1200 µS cm^{-1} indicate that of high salt fertilizer or perhaps a salinity problem due to lack of drainage.

When plant performance is considered; treatment T2(20) with gypsum revealed the highest peg formation whereas the least was in (T1) and (T3). The results showed there was no significant difference between (T1) and (T3), but there was a significant difference in (T2) compared to the control (T1). The highest mean pod fresh weight was in (T2) (23.3g/ plot) and the least was in (T1) (20.5 g/plot). The T2 treatment showed a significantly higher yield compared to other treatments. (T1) without gypsum showed a significantly lower yield than other treatments. Therefore, (T2) with 200 kg ha^{-1} of gypsum could be identified as the best treatment to obtain higher yields. When the yield is considered, kernel weight and 100 pod weight showed a significant difference ($p< 0.05$) among treatments (Table 1). The treatment (T2) (2800 Kg/ha) showed a significantly higher kernel yield and a good quality appearance compared to other treatments. The treatment (T1) (2458 Kg/ha) gave the lowest yield with half-filled nuts. Therefore, according to the results, the treatment (T2) with 200 kg ha^{-1} of gypsum was the best treatment to obtain a higher kernel yield. The results showed that the individual seed weight was not significantly different ($p > 0 .05$) among treatments (Table 1).

Table 01. The Yield, kernel dry weight, individual seed weight, 100-kernel weight, 100 pod weight and mean pod weight

Treatment	Yield (Kg/ha)	The dry weight of kernel (g)/plot	Individual seed weight (g)	100 kernel weights (g)	100 pod weights (g)	Mean Pod weight (g)
T1	2458^{d}	12.7^{b}	0.40^{a}	39.83^{b}	113.8^{b}	1.14^{b}
T2	2800^{a}	13.1^{a}	0.41^{a}	40.83^{a}	116.7^{ab}	1.17^{ab}
T3	2550^{c}	13.2^{a}	0.41^{a}	41.32^{a}	118.1^{a}	1.18^{a}
T4	2694^{b}	13.2^{a}	0.41^{a}	41.36^{a}	118.2^{a}	1.18^{a}

*Values within a column followed by a common letter are not significantly different at P=0.05, according to DMRT

According to Salke et al. (2010), gypsum application increased the number of nodules per plant and the dry weight of nodules per plant. When considering the quality of seeds, in (T1) the percentage of the large-sized kernel, medium-sized kernel and small-sized kernels are 20%,30% and 50% respectively and in (T2) the percentage of the large-sized kernel, medium-sized kernel and small-sized kernels are 60%,30% and 10% respectively.

The results showed that the quality of the kernel of 100 pods was significantly different ($p<0.05$) among treatments. The T2 treatment gave a better kernel size compared to other treatments with the application of 200 kg ha^{-1} of gypsum. However, all the treatments with the application of calcium showed an improvement in kernel size. As same as the present study, it

appeared due to gypsum's positive effect on soil chemical characteristics, especially around the rhizosphere increased the number of peg in groundnut (Salke et al., 2010).

4. Conclusions

It is evident from the results that adding gypsum with DOA recommendation increased the groundnut yield. The treatment with DOA recommendation + 200 kg ha^{-1} of gypsum increased the nut yield from 2458 to 2800 kg ha^{-1} with better quality kernels in pH 4.4 soil at Thihawa, Kumbukwewa. A significant effect was found on yield when applying DOA recommendation + 100 kg ha^{-1} of gypsum + 100 kg ha^{-1} of calcium carbonate, but no significant effect was found on 100 kernel weight. Thus, with the application of 200 kg ha^{-1} of gypsum, groundnut produces a higher number of pegs per plant and increased kernel weight.

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Impact of climate change on paddy yield: Case studies in Mahailluppallama and Batalagoda, Sri Lanka

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1. Introduction

With the increment of temperature and the changes in rainfall pattern, the growth and the yield of many crops are severely affected worldwide. Especially, the yields of key crops including rice and maize are expected to decline due to the climate change in the tropical region (Karunaratne et al., 2015). Previous studies have shown that the increment of temperature has an adverse impact on paddy yields in Sri Lanka's subhumid areas (Zubair et al., 2015). Paddy is the staple food of Sri Lankans, thus understanding the impacts of climate change on paddy production is important.

Since paddy is cultivated as rainfed cultivation in most parts of Sri Lanka, it is important to understand the impact of changes in rainfall on paddy yield. In this case, traditional agronomic experiments take time and are not economical. Therefore, crop models are one of the best methods to study the impact of climate change on crop yield (Holzworth et al., 2014).

A high-density, well-distributed, and consistent projected climatic data is critical for crop simulations (Baron et al., 2005). Depending on the General Circulation Model (GCM) used for simulation, the yield can be varied. Therefore, the objective of the study was to assess the impact of climate change on the yield of two major paddy cultivars (BG300 and BG358) in Mahailluppallama and Batalagoda, using a crop modelling approach. Pre-tested Agricultural Production Systems Simulator (APSIM) model (Holzworth et al., 2014) was used for yield simulation under 3 GCMs.

2. Materials and Methods

Mahailluppallama (in low country dry zone, 8.1095°N, 80.4631°E) and Batalagoda (in low country intermediate zone, 7.6593°N, 80.5007°E) were selected as the study area. Two improved, medium-duration and high-yielding local rice varieties, BG300 (three months duration) and BG358 (three and half months) were selected as the most prominent cultivars in the area. The Oryza model of (APSIM model) (Holzworth et al., 2014) was used for the simulation.

Observed daily rainfall, minimum and maximum temperatures for 1990–2015 (baseline) period were collected from the Meteorological Department of Sri Lanka while solar radiation data were obtained from NASA POWER database (https://power.larc.nasa.gov). Bias-corrected daily climate data (rainfall, minimum and maximum temperature and solar radiation) for the period of 2040–2065 were downscaled using 3 GCMs; CMCC_CMS, GFDL_ESM2M, MPI_ESM_MR. Future climate data were downscaled from the Consultative Group for International Agricultural Research (CGIAR) Program on Climate Change, Agriculture and Food Security (CCAFS) database under Representative Concentration Pathway (RCP) 8.5 scenario (http://ccafs-climate.org/).

The genetic coefficients for the simulations were obtained from (Zubair et al., 2015). Other crop parameters in the model were set to default. The published data on management practices (plant density, sowing dates, fertilizer applications) were collected from Wimalasiri et al., (2020). Direct seeding was selected as the planting method and the number of plants per seed bed was set as 350 (Zubair et al., 2015). The period between 01 November and 28 February was considered as the growing period. Rice yield for the *Maha* season was simulated for baseline (1990-2015) and future (2040-2065) climates.

3. Results and Discussion

Growing seasonal climate in the baseline period (1990-2015)

In Mahailluppallama, the maximum and minimum temperature for the growing season in the baseline period was 30.1°C and 21.6°C respectively. The total average growing seasonal rainfall of Mahailluppallama was 659 mm for the same location. The maximum and minimum temperatures in Batalagoda were 30.4°C and 21.8°C, respectively, while the total average rainfall was 630 mm.

Growing seasonal climate in mid-century (2040-2065)

The projected climate data in Mahailluppallama showed an increment of average maximum temperature with 1.4°C, 0.9°C and 1.1°C for CMCC_CMS, GFDL_ESM2M and MPI_ESM_MR GCMs compared to 1990-2015 period while, 1.8°C, 1.5°C and 1.5°C increment in Batalagoda.

The average minimum temperature also has increased compared to baseline for both locations; 2.6°C, 2.1°C and 2.6°C for Mahailluppallama and 2.4°C, 1.8°C and 2.3°C for Batalagoda from CMCC_CMS, GFDL_ESM2M and MPI_ESM_MR GCMs respectively. These results are consistent with previous studies, which showed that temperature would increase in the mid centuries (2040-2065) relative to the baseline period (1990-2015).

For Mahailluppallama, CMCC_CMS and MPI_ESM_MR GCMs showed an increment of total average rainfall (50 mm and 47 mm) relative to the 1990-2015 period and for Batalagoda 92 mm and 82 mm increment in respective GCM. While The GFDL_ESM2M showed a reduction of total average rainfall in Mahailluppallama and Batalagoda with 149 mm and 52 mm respectively.

Paddy yield for baseline climate data

The average yield in Mahailluppallama was 3457±342 $kgha^{-1}$ and 4304±340 $kgha^{-1}$ for BG300 and BG358, while for Batalagoda 3352±411 $kgha^{-1}$ and 4189±479 $kgha^{-1}$. In Mahailluppallama, the highest yield was 4418 $kgha^{-1}$ for BG300 and 5084 $kgha^{-1}$ for BG358 respectively (reported in the year 1990). In Batalagoda it was 4316 $kgha^{-1}$ and 5056 $kgha^{-1}$ for BG300 and BG358 which were reported from the same year.

Rice yield under future climate

APSIM simulations showed different responses with the changing climate for all three GCMs (Table 1).

Table 03. Simulated rice yields in mid- centuries for Mahailluppallama and Batalagoda

Location	Variety	Average Yield (kgha^{-1})		
		CMCC_CMS	GFDL_ESM2M	MPI_ESM_MR
Mahailluppallama	BG 300	3171±336	3274±340	3125±343
	BG 358	4069±429	4229±391	4026±453
Batalagoda	BG 300	3180±356	3274±262	3156±349
	BG 358	4070±420	4244±246	4040±436

The statistical analysis for comparison of the GCMs and locations with average yields was not significant ($p>0.05$) for both variables. Compared to the baseline period, the rice yield change is fluctuated for selected three GCMs with different magnitudes for the *Maha* season (Figure 1).

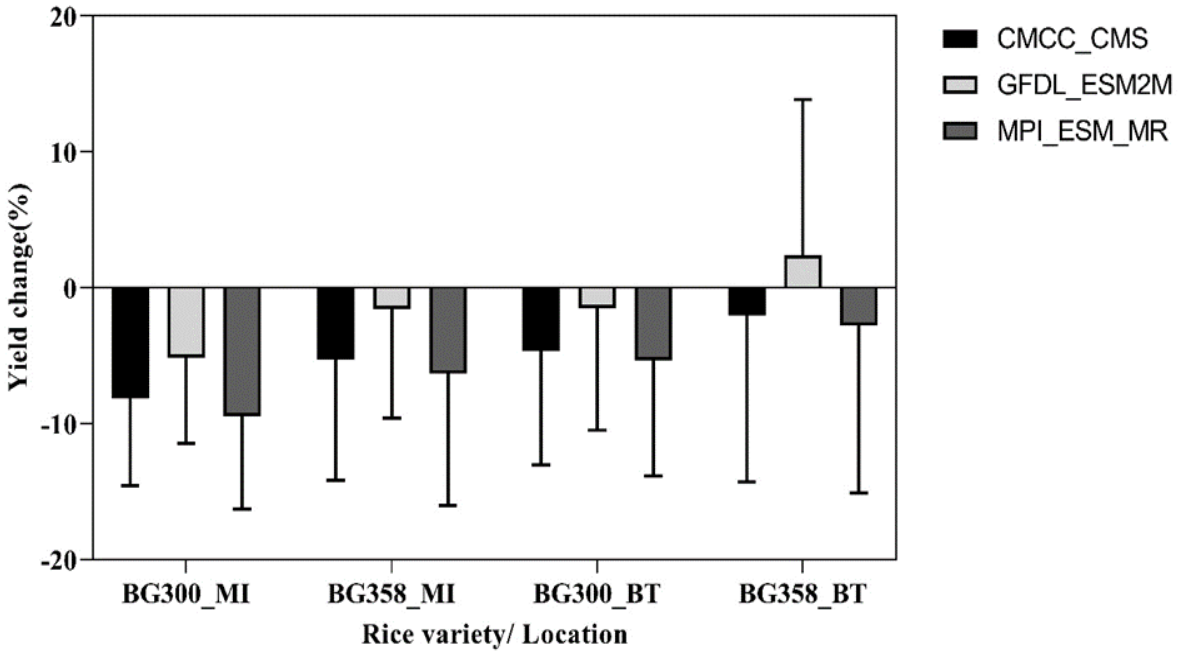

Figure 5. Rice yield change of selected GCMs for BG300 and BG358 in Mahailluppallama (MI) and Batalagoda (BT) compared to the baseline period

The highest yield reduction, compared to the 1990-2015 period was recorded by BG300 (5.7%) cultivar while, BG358 showed the lowest (2.6%) ($p<0.05$). Compared to the baseline period, a significant yield reduction was observed for CMCC_CMS, GFDL_ESM2M and MPI_ESM_MR GCMs as 5.05%, 1.5% and 5.9% respectively ($p<0.05$). The highest yield reduction was observed for the MPI_ESM_MR (5.9%) GCM. The findings are in accordance with previous studies, which has shown rice yields would decrease (Zubair et al., 2015).

4. Conclusions

The impact of projected climate data on rice yield in Mahailluppallama and Batalagoda was analysed in the study. The temperature has increased in considered all three GCMs for *Maha* season for both locations. Under the projected climate, the APSIM model simulations revealed a significant reduction of yield relative to the baseline period. Also, the yield changed with the future climate model and the cultivar used. Out of two cultivars, BG358 showed the lowest yield reduction (2.6%) compared to the 1990-2015 period. Therefore, proper adaptation strategies are essential in order to minimize climate change impacts on paddy cultivation in Sri Lanka.

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Causality relationship between CO_2 emission, energy intensity and economic growth in Sri Lanka

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1. Introduction

With continuous industrialization and increasing population pressure with significant change in lifestyle, the threat of global warming and climate change is rapidly increasing in recent time period. The carbon emission level is expected to be increased for many of the economies, resulting further towards global warming. As World Bank data shows, for the decade ended from 2015, CO_2 (Carbon Dioxide) emission in Sri Lanka has risen 0.608mt per capita to 1.14mt per capita. This continuous pace of growth has been caused by fast industrialization, accelerated growth of the service sector and has resulted in a high consumption of fossil fuel, massive destruction of natural resources, and rapidly increasing level of pollution of air and water. In addition to these factors, now Sri Lankan economy has been increasingly integrated to the outside world with active involvements of labour migration, tourism, and export of goods and services, these activities are expected to contribute significantly towards a high economic growth.

The main objective of this study was to evaluate the relationship between economic growth, energy consumption and carbon emission (which is considered as a proxy variable for environmental quality). The study mainly focused on the effect of the economic growth when carbon emission and energy consumption changes.

According to Uddin et.al., 2016 it has found the relationship between carbon emission, energy consumption and economic growth in Sri Lanka in between the time period of 1971 – 2006, and thereafter there were no any literature on this field found and therefore it is timely important to conduct with updated data for the current scenario of the country by following the same statistical tools.

2. Materials and Methods

Data source of the study was World Development Indicator 2019, published by the World Bank. The variables under consideration for the study are, carbon emission (C), energy consumption (E), real income (Y), and trade openness (T). For further analysis, these variables have been converted to logarithmic form. The relationship between variables can be shown in the following manner:

$$Ct = \alpha + \beta\ 1Et + \beta\ 2Yt + \beta\ 3Ot + \varepsilon t$$

where, εt is error term. Logarithmic transformation of the above equation and inclusion of a trend variable would leave the equation as follows:

$$LCt = \alpha 0 + \alpha t + \beta\ 1LEt + \beta\ 2LYt + \beta\ 3LOt + \varepsilon t$$

where, T is the trend variable, LC is the log of carbon emission; LE is the log of energy consumption; LY is the log of real GDP per capita; and LO is the log of trade openness ratio as a proxy for foreign trade. In the analysis, we applied multivariate Granger methodology to identify direction of causation among the variables of interest using Granger (1969) method. The estimation procedure begins with testing the time series properties of data.

3. Results and Discussion

Stationarity of the time series data were checked by using augmented Dickey–Fuller (ADF) in all the Differenced variables, the P value is lesser than the 5% and 10% critical values, and null hypothesis is rejected. Therefore, there is no unit root in those variables; then we stated that the series is stationary.

The co-integration test is warranted for checking whether the variables are co-integrated. If the variables in the present case are found to be co-integrated, they are said to have maintained a long-term relationship. Johansen co-integration test was used, and the null hypothesis was "there is no co-integration" and the alternative hypothesis was "there is co-integration among variables". In this case in the zero rank or the null hypothesis, the trace statistic (83.7965) is higher than the critical value (47.21), so the author had to reject the null hypothesis. Only in the maximum rank 3 is having trace statistic (2.0030) lower than critical value (3.76), so the author stated that there were three co-integrating equations. This state that the four variables were co-integrated. By further calculations using Vector Error Correction model (VECM), the error term in the variables was able to remove and made them non co-integrated.

It's mostly accepted that many of the macro variables are related in a way that sometimes it is difficult to understand the nature of such relationship between those variables. Therefore, we applied Granger causality test, which is widely used to understand the direction of causality between variables. Null hypothesis was "there is causality between variables", and the alternate hypothesis was "there is no causality between variables".

Table 01. Granger / Wald test for the variables

Variables	Carbon emission	Energy consumption	Real GDP	Trade openness
Carbon emission	-	0.6553	0.3331	0.4371
Energy consumption	0.4323	-	0.6624	0.7460
Real GDP	0.0052	0.0069	-	0.7156
Trade openness	0.8897	0.6548	0.9919	-

As shown in above table, the results for Sri Lanka reveal that there are existing unidirectional causality running from economic growth to the change in carbon emission, energy consumption and trade openness in the short run, which is found to be significant at 5% and 10% significance levels. Carbon emission shows higher P values than the significant levels in other variables after testing for causality, therefor null hypothesis cannot be rejected which showed there is causality between carbon emission and the rest of the variables. There are only two times the null hypothesis got rejected in the table and it stated that there is unidirectional causality between all the variables. Causality analysis exposed that Real GDP and Energy consumption are interdependent with each variable. There was bidirectional causality found between Energy Consumption and Carbon emission variables. The joint long-and-short runs causality analysis also supports the empirical findings for long run as well as short run.

4. Conclusions

This study investigated the dynamic relationship between Carbon emission, energy intensity and economic growth in Sri Lanka. For this purpose, author applied, the VECM Granger causality to test the direction of causal relationship between the variables. The results indicated that the variables are co-integrated for long run relationship. The empirical evidence showed that energy intensity increases carbon emissions and economic growth is a major contributor

for that situation. The causality analysis exposed the bidirectional causality between energy intensity and carbon emissions. The unidirectional causal relation is found running from economic growth and energy intensity to Carbon emissions. This suggests that carbon emissions can be reduced at the cost of economic growth or energy efficient technologies should be encouraged to enhance domestic production. Sri Lankan policy makers, should use supplementary policies when using the carbon emission reduction policies, since carbon emission and economic growth have positive relationship between them, if those policies were made to decrease carbon emission that can create negative impact on economic growth. Future research can be conducted by investigating the relationship between renewable energy consumption, non-renewable energy consumption.

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A study on the effectiveness of tea replanting subsidy scheme on tea production in Thawalama DS division in Galle district

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1. Introduction

The tea sector in Sri Lanka plays a vital part of the country's socio-economic development. Many governments have introduced different subsidy schemes and policies for sustainable development of the tea sector in the country. Tea replanting subsidy scheme is such an intervention which had been introduced by the government in 1979 in order to increase the productivity of low yielding and old seedling tea fields (TSHDA, 2018). Every government of Sri Lanka has spent a huge sum of public money for this subsidy scheme. Therefore, it is very important to study the effectiveness of this programme to know whether it benefited economically as well as socially which is expected by governments. A previous study which had undertaken to find out the effectiveness of tea replanting subsidy scheme was basically based on quantifying the impact of the subsidy scheme on tea production according to various geographical elevations of tea cultivating lands in the country. However, there is no study had done previously to quantify the effectiveness of this subsidy scheme by investigating the tea growers' point of view. Therefore, this study was aimed at identifying the existing gap by analysing how significance of the subsidy scheme on tea replantation and thereby for tea production in the selected area based on tea growers' opinion. The results revealed that tea growers' involvement for replantation has increased due to the impact of subsidy scheme. Also, tea growers' responsiveness on the existing subsidy scheme process and the satisfaction of the subsidy scheme has influenced to increase the effectiveness of the subsidy scheme.

2. Materials and Methods

Study population was the tea growers who had done replantation by obtaining the replanting subsidy scheme. The control sample was the tea growers who had done replantation without obtaining the subsidy scheme. Galle district was selected purposefully because it contributes nearly 25 % of the country's total tea production (DCS, 2005). Out of 19 Divisional Secretariat (DS) divisions, Thawalama DS division was selected due to its higher tea production. Within the division 100 tea small holders from 5 Grama Niladhari divisions out of 36 were selected randomly based on the name list of beneficiaries who received the subsidy scheme for replantation.

Personal interviews were conducted with tea smallholders by using interviewer administered structured questionnaire to collect primary data. Secondary information was collected from the sources such as journal articles, reports and web sites such as TSHDA, Tea Board, Department of Census and statistics, Central Bank of Sri Lanka etc.

By reviewing the literature, three variables were identified as "tea grower's involvement", "Implementation performance" and "tea grower's satisfaction" to measure the effectiveness of subsidy scheme. Behaviour of tea grower's involvement was identified by analysing the data on changed yield due to replantation with the replanted land extent and number of times done replantation using subsidy scheme. The changed yield due to replantation was eliminated by

taking the difference of data on tea yield after replantation and before replantation collected through the survey. Implementation performance of the subsidy scheme was analysed by using data on receiving subsidized instalments on time with the recommended amount. Tea grower's satisfaction has identified by likert scale analysis.

3. Results and Discussion

The demographic characteristics of respondents in the sample revealed that average tea small holders who've obtained 'tea replanting subsidy scheme' were middle aged male landowners who have done replantation in the average land extent of 0.5 acres. Among 100 of respondents in the sample 54 mainly depend on the income from tea while the remaining 46 are employing in other sectors too such as in government, semi-government or private sectors while doing tea cultivation. In the sample 43% whose main income source of tea cultivation is having some other agricultural crops such as pepper, cinnamon and coconut as the secondary income generating sources. Around 28% of small holders have done the replantation when the age of tea bushes became more than 20 years old while 59% have done it between the ages of 15-20 years old. Remaining 13% had done it within 10-15 years old when they had revealed the yield was getting lowered. The respondents within the sample who've done the replantation in each year are shown in the following figure 1.

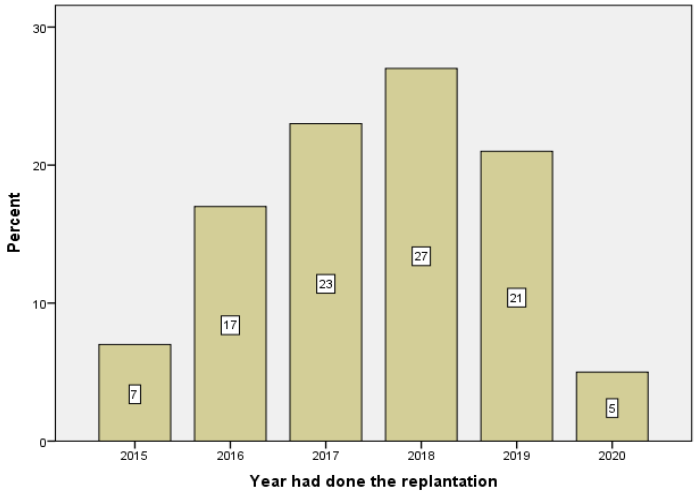

Figure 1. The respondents who've done the replantation in fields respected to the year

The first objective of assessing how replanting subsidy scheme is significant on tea production is analysed by using the variable "tea growers' involvement" with the aid of three indicators. Pearson's correlation tool is employed firstly between the extent of replanted land and changes in the yield after replantation. The null hypothesis is 'there is no relationship between replanted land extent and changes in yield after replantation'. The alternative hypothesis is 'there is a relationship between replanted land extent and changed yield after replantation'. The results revealed that null hypothesis is rejected at 0.05 level of significance and therefore has identified a relationship between variables. Correlation of the test is 0.707 and thus there is a strong positive relationship between two variables being tested. Secondly, correlation is done between 'number of times done replantation obtaining subsidy scheme and changes in yield after replantation'. The null hypothesis in here also rejected at 0.05 level of significance and thus revealed that there is a relationship between the two variables that has been tested. Correlation result of this is 0.357 and it has been identified a low positive relationship between two variables.

The second objective was assessed by using the variable of 'implementation performance' with the aid of two indicators. Analysing the first indicator, it was revealed that 78% of the beneficiaries of the subsidy scheme have received subsidized instalments on time while the remaining 22% haven't received it on relevant time period. Analysing the second indicator revealed that only 8% haven't received the recommended number of subsidized instalments while 92% have received it as recommended.

The third objective of tea grower's satisfaction on subsidy scheme was tested using correlation analysis with the use of related variables which are subsidy scheme 'helps to improve living standards', 'should be continued in the future', 'reapplying subsidy scheme', 'recommending someone else'. Correlation of all variables with satisfaction of subsidy scheme are significant at 0.05 level of significance. Hence, all variables have a relationship with the satisfaction level of the subsidy scheme'.

Table 01. Responses about TSHs for not receiving subsidized instalments timely and as per recommended amount

Reasons for not receiving the subsidized instalments on time		Reasons for not receiving the recommended number of subsidized instalments	
Reasons	%of TSH	Reasons	% of TSHs
Failures in the process	12%	Inefficiency of the system	4%
Didn't comply with the requirements stated by TSHDA	5%	Government policies and regulations on subsidy scheme	2%
Didn't inform on time to the tea inspector to supervise the lands	2%	Malpractices in the authority	1%
Others	3%	Others	1%

Suggestions provided by TSHs	% of TSHs
Provide an advancement or low interest soft loan scheme to initialize the field task of replantation	63%
Appoint sufficient number of officers for field supervision for a region	69%
Establish an extension service to make aware TSHs about the subsidy scheme process starting from the filling of applications correctly.	77%
Provide quality inputs throughout the replantation period for a repayment basis	71%
Reduce the period of soil rehabilitation and introduce alternatives for that	68%

4. Conclusions

Results revealed that when replanted land extent and replanting frequency increases, yield that can be harvested also increases. Thus, it has motivated the tea grower's involvement for tea replantation. Therefore, it has improved the effectiveness of replanting subsidy scheme and ultimately for the tea production in the area. According to the majority of responses, it revealed

that existing subsidy scheme is performing well by issuing the subsidized instalments timely as well as the recommended amount. Also, can be concluded that subsidy scheme has acquired the tea grower's satisfaction except for some features and therefore suggests government should continue this subsidy scheme to the future according to the tea grower's suggestions.

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Socio-economic factors affecting for the urban consumers' awareness toward the organic food

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1. Introduction

Organic food consumption is becoming more popular among consumers across the world because of the environmental and health benefits associated with organic food production. Organic farming produces healthy and quality food without using synthetic chemicals (Alizadeh et al., 2008). According to Willer and Yussefi (2009), global demand for organic products is increasing over five billion US dollars per year. Awareness and knowledge have become decisive factors in changing the attitude and behaviour of consumers towards organic foods. Consumers' awareness level on organic food depends on various factors. Previous studies have investigated that social formations, demographic profiles, food buying behaviour, and knowledge of consumers are likely to affect the level of awareness and purchasing decisions on organic foods (Gracia & Magistris, 2008; Millock et al., 2004). As consumer knowledge and awareness is an essential drive for growth of the organic food market, there is an urgent need to investigate the consumers' awareness on organic food and their purchasing behaviour towards organic foods. Information about consumer awareness is an essential element for farmers, producers, and marketers to successfully plan their production and grab the existing opportunities. Also, researching in this regard in Sri Lanka is timely essential since marketers, researchers, and marketing analysts may consider such significant variables to capture their organic products' market share. Therefore, this study aims at analysing the awareness of consumers on organic food products, specifically examining the socio-economic factors affecting consumer awareness on organic food, and their purchasing pattern.

2. Materials and Methods

This study was conducted in the main cities of six urban districts (Rathnapura, Colombo, Gampaha, Kandy, Kurunegala, and Galle) in Sri Lanka. The main cities were purposively selected for the study, as organic markets are mainly available in these locations. Four supermarkets that are selling organic food items were selected from each city. Then the target group was obtained by selecting 25 customers who did shopping in these supermarkets and also who were willing to answer the questionnaire. Finally, the data were collected from 24 supermarkets having some organic food items (four supermarkets from each city), and thus sample size was 600 customers (100 from each city). Before data collection, a pilot study was conducted with ten consumers using a quick survey to check the relevancy of the questionnaire. Subsequently, a market survey was conducted using the pre-tested questionnaire in the chosen six cities, from November 2018 to May 2019.

In the questionnaire survey, respondents were asked information related to socio-economic characteristics and awareness about organic food. In data analysis, these responses were analysed using frequencies and percentages. Multiple linear regression analysis helped to assess the factors affecting consumers' awareness on organic food, and data analyses were accomplished using the SPSS version 21 statistical package.

Hypothesis stated

H_{01}; Respondent's age does not significantly affect their awareness on organic food.
H_{02}; Respondent's gender does not significantly affect their awareness on organic food.
H_{03}; Respondent's marital status does not significantly affect their awareness on organic food.
H_{04}; Respondent's education does not significantly affect their awareness on organic food.
H_{05}; Respondent's family size does not significantly affect their awareness on organic food.
H_{06}; Respondent's monthly income does not significantly affect their awareness on organic food

3. Results and Discussion

Consumer awareness of organic food

Most of the respondents (74.8%) knew that organic food is something free from chemicals and its importance for human health. However, a considerable percentage (25.3%) of customers had no idea about organic food because they have no updated knowledge about the organic farming, and the associated perceived benefits are not well-known. Therefore, it will take time for its importance to become common knowledge. According to these results, a better market for organic food will have to be established in Sri Lanka to encourage organic food production in the future.

Table 01. Model summary of regression analysis

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.617[a]	.381	.338	.330

Table 02. Socio-economic factors and consumer awareness towards organic food

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	H_0
	B	Std. Error	Beta			
(Constant)	1.530	.295		5.177	.000	
Age	-.094	.064	-.132	-1.468	.146	Do not reject
Gender	.151	.072	.187	2.108	.038*	Reject
Education	-.097	.024	-.366	-4.145	.000*	Reject
Marital status	.394	.119	.302	3.315	.001*	Reject
Family size	.009	.051	.015	.176	.860	Do not reject
Monthly income	-.162	.064	-.225	-2.527	.013*	Reject

*significant at 95% confidence level; dependent variable: consumer awareness

As per the results of Table 02, out of the variables analyzed, gender, education, marital status, and monthly income were significantly influenced on consumer awareness towards organic food as the *p* values are lower than the 0.05 at 95% confidence interval. Among them, education is a highly significant factor for consumer awareness on organic food because of the lowest *P*-value. When reviewing the literature, Krishnakumarea and Niranjan (2017) and Ranasinghe et al. (2015) have also reported that some socio-economic factors of consumers' age, gender, education, household income, and the occupation affect the awareness on organic food. According to Eriksen et al. (2018), an increase in social knowledge, education level, and improvements in consumer income levels have been effective in increasing organic food consumption. The positive and significant impact of education on awareness about organic food revealed a strong connection between education and consumer awareness on organic food

increases with more education. Furthermore, regression analysis shows that gender and marital status of consumers were significant factors for making awareness about organic food. This can be proved further with the fact that most respondents in the selected sample were females, and the majority of them were married. As discussed with the respondents, the main reason for this is the concern about the health of children by mothers. Previous studies have investigated experimentally that demographic factors and knowledge on the nutrition of consumers are likely to affect the level of awareness and purchasing decisions of organic food (Gracia & Magistris, 2008; Lockie et al., 2002).

Consumer purchasing pattern of organic food

Although the most of the respondents (75.2) have purchased organic food, 25.3% of them have been purchasing organic food since only 2-3 years. While only one-fourth of the respondents buy organic food continuously, most of them (76.4%) have been purchasing organic food rarely. Respondents mentioned that organic foods are costly and difficult to find real organic food in the market. The most important motive was the expected positive health effects because consumers believe that they are pesticide-free and safe than conventional food. Other benefits mentioned by the consumers were environmentally friendly methods of production and support given for local farmers. Furthermore, reasons to purchase organic food were because they are fresher and have a better taste when compared with non-organic foods. The unavailability of organic foods in the market and lack of trustworthiness about the label of organic food are the main reasons for not buying organic food. Also, almost all the consumers stated that price as a barrier for them to buy organic food.

4. Conclusions

Urban consumers' awareness on organic foods has significantly influenced by their education, marital status, gender, and income. Consumers with a lower level of education and income were least likely to buy organic food. The majority of respondents rarely purchase organic foods, and they mentioned the high price of organic food, unavailability, and the lack of knowledge about the benefits of organic food are the main reasons. Therefore, these socio-economic characteristics should be considered when making efforts to expand organic food markets successfully. The level of interest and concern varies significantly among consumer segments. The existing level of awareness about the organic foods must be further enhanced. The government, agriculturists, and health organizations must involve in the process of improving consumer responsiveness and conducting effective educational programs and promotional campaigns. Results from this study provide valuable information on consumers in Sri Lanka, which the policymakers can use in promoting organic farming at the local and national level.

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An analysis of consumer awareness and preference of eco-labels in Galle district

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1. Introduction

A healthy environment is essential for the survival of all living creatures. We should treat the environment around us as if it were our mother. It also provides us with nurturing. The Earth supplies us with a wealth of natural resources for our health and growth. Nonetheless, as we grow older, we become more egoistic and harm our environment. Environmental pollution has become a serious concern as a result of environmental degradation. Rising carbon pollution poses a risk of natural disasters. However, different nations throughout the world are responding to these tragedies in the most effective way possible. As a result, the concept of the eco-label came up. Eco labels are marks placed on product packaging or in e-catalogs that can help consumers and institutional purchasers quickly and easily identify those products that meet specific environmental performance criteria and are therefore deemed "environmentally preferable" (EPA, 2021). Accordingly, when compared to other similar items, eco-labelling seeks to identify and promote products that have a minimal environmental effect. It is a worldwide voluntary system of environmental performance certification and labelling that relies on the cooperation of three sectors. Such as industry, consumers, and the eco-labelling authority. It will help to achieve sustainable development in the country. Hence, the main objective of this investigation was to recognize consumer awareness and preference of eco-labels. The paper's conclusion investigates what factors can affect consumer awareness and preference of eco-labels in the Galle district.

2. Materials and Methods

This research was conducted exclusively for Galle district consumers to test their awareness and preference of the eco-label. Simple random sampling technique was instrumental in collecting data from the Galle district, which included 240 consumers. Both primary and secondary data was used in this investigation. Primary data were gathered from the selected sample over a three-week period in August 2021 via a Google form questionnaire. Various published and unpublished research, journals, books, newspapers, and internet sources were considered for secondary data. A quantitative research approach was used to conduct the research, and the data was analyzed using the binary logistic technique. Raw data were collected and organized in a Microsoft Excel spreadsheet before being fed into the SPSS software to identify the factors associated with the stated preference for eco-label. Data were examined using descriptive methods, and correlation coefficients and levels of significance were produced for future explanations.

3. Results and Discussion

According to the collected data, 55% of the respondents were male and the rest were female. Among those participants, 24 years could have been selected as the most responsive. Therefore, more than half of the respondents were single. Around 54% of respondents were studying, while 32% were working full-time. Nearly half of the respondents had a monthly household income of LKR 20 000-40 000.

Likewise, 86% of respondents were aware of the eco-label. Further, 66% became aware through social media platforms. 85% of respondents had used products with an eco-label at least once, but 27% had rarely used them. Under awareness factors, 20% of respondents had good knowledge and 7% of respondents didn't know about the benefits of the eco-label. More than half of those polled concerned about the environment.

A logistic regression analysis was performed using the awareness of eco-label as a dependent variable (yes=1, no=0). And independent variables were gender, occupation, and education, income, knowledge about environmental benefits, and age. When considering the model summary, the R square valued represents how much variation in the outcome was explained by the model. The explained variation of the dependent variable based on the model ranges from 24% to 43.5% with reference to the Cox & Snell R-square and Negelkere R-square values, respectively. According to the omnibus of model coefficients, the column was the probability of obtaining chi-type statistics when the zero assumption was considered true. In other words, this was the probability of obtaining these chi-type statistics (126.373) if the independent variables taken together did not have an effect on the dependent variables. In this case, the format was important because the p-value was less than 0.01 and would have been statistically significant for the overall model.

Accordingly, table 01 depicts the relationship between dependent and independent variables. The p-value could be used to measure the probability that an observed difference could have occurred just by random chance. Among the predictor's variables, monthly household income, knowledge about environmental benefits and education were statistically significant because their p-values were less than 0.01 and 0.05 respectively. However, gender, age, and occupation were not significant because their p-values were greater than of 0.05. Likewise, the sign of a regression coefficient ("+" = positive relationship, "-" = Negative relationship) indicates whether each independent variable and the dependent variable had a positive or negative relationship. Among the significant variables, education had a positive coefficient and others had a negative coefficient. Hence, the positive coefficient implies that the mean of the dependent variable continues to rise as the value of the independent variables increases. The Exp (B) shows that males are 1.873 times more likely than females to be aware of eco-labels ("yes" category). Accordingly, the following regression equation could be derived from the available data to predict the dependent variable from the independent variable.

Ln [p/ (1-p)] = 7.191 (constant) + 0.493 **Education - 1.805*** Knowledge about environmental benefits - 0.604***Income

Table 01. Factors affecting to the consumer preference of eco-label

Factors	B	P-value
Gender (1)	.628	.216
Occupation	.085	.799
Education	.493	.042
Income	-.604	.001
Knowledge about environmental benefits	-1.805	.000
Age	.013	.575
Constant	7.191	.000

4. Conclusions

This study suggests that a person who cares about the environment is more likely to buy a green product if they are aware of its eco-friendly properties. In fact, in situations where people are required to evaluate the environmental characteristics of a product they intend to acquire, eco-labels will undoubtedly be the deciding factor in their decision. Expanding the sample size up to 1000 individuals by incorporating citizens all over the country will aid in obtaining a generalized outcome. Also, the researchers would like to emphasize the importance of taking the necessary actions by the bodies responsible for conducting public awareness programs about eco-labels.

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Factors affecting the consumption of confectionery products among the Youth: A case of Maharagama divisional secretariat division

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1. Introduction

Obesity is a significant public health challenge faced by majority of Sri Lankans. Another significant point is the increased nutritional and health concern in recent years. The effect of the relationship between nutrition and health on confectionery items has increased recently. Confectionery products are the official product classes that distinguishes the chocolate and other sugar confectionery. Sri Lankan bakery and confectionery industry is one of the largest industries in the food industry. The complexity of the consumer purchasing pattern has made the understanding of consumer behaviour a tremendous issue. Social-economics factors such as gender, age, educational level, perception, nutritional level are examples for this. This study only focused on a few products such as biscuits, chocolate, candies, and snacks for the convenience of analysing the results. The urban population is more inclined toward the consumption of confectionery compared to its rural counterparts. People most commonly consume confectioneries just for taste, convenience, and as snacks. But altogether the excessive consumption of confectionery products roots different types of non-communicable diseases. (Yakunina et al., 2021). On the other hand, the adult generation should avoid consuming these types of food because it has the power to create health issues. Therefore, this research aimed to analyse the consumer habits towards the confectionery food items and their choice among the four selected products. The main objective of the study was to identify the factors influencing the consumption of confectionery products such as biscuits, chocolates, candies, and snacks among the demography of Maharagama area. Lack of related studies in the area highlights the importance of current research to the industry.

2. Materials and Methods

Maharagama DS division of Colombo district was selected as the research location for this study. The research approach was deductive approach and the study was conducted mainly based on primary data. The sample consisted of 240 demographic groups and data collecting tools were questionnaires, focus group discussions, and in-depth interviews. The questionnaire was designed to identify and quantify the factors that influence the customers for their consumption of confectionery products. Socioeconomic factors like income level, family status, and social status were taken into consideration. Simple random sampling technique was instrumental in gathering data for the study. Focus group discussions were conducted in each village of the Maharagama DS division by participating 5-10 respondents. Secondary data were collected from journals, reports, and internet. Data were analyzed using binary logistic regression and descriptive statistics. SPSS version 19.0 IBM software and descriptive statistics were used to examine the frequency of different variables. Logistic regression was used to calculate the relationship between a dependent variable and other variables. The variables evaluated included age (categorical), gender, brand, nutritional level, income level (continuous), taste, non-communicable diseases, and package.

3. Results and Discussion

The data were analysed using binary logistic regression. The analysis was performed only on complete datasets, and the number of analysed questionnaires were reduced to 200. From the participants 34% were female. The average age of the respondent were 25 years (continuous variable) which is very close to the population mean. 43% percent of the respondent were fully employed, 17.8% were part-time employed and 18% are still studying. 13% of the sample were unemployed. Majority of respondents in Maharagama DS division recorded a mean household income of Rs. 40 000.

A logistic regression was used to identify the factors affecting for the consumption of confectionary food among youth. Results revealed that there is a relationship between the factors (independent variables: age, gender, taste, package, nutritional level, income level and educational level and the dependent variable ‘’Do you consume confectionery food ‘’ (Yes-1, No-2)”. Omnibus test of model coefficient table indicated that probability of obtaining Chi-square statistic was 43.080. The variable gender (0.000) was highly significant in this case according the table and there could be gender preferences towards the consumption of biscuit and confectionery foods like chocolate. According to the table 01 the variable taste (0.006) was significant at α=0.10 and it suggested that the people considered the taste of the product before purchasing it. The independent variable age (0.062) was also significant at α=0.10. However, the variables such as the presence of non-communicable diseases, nutritional level income level of the family did not seem to be significant and young people do not pay attention on those factors when they purchase confectionaries. But the consumers paid attention for the package and the brand name of the particular product (table 01). Brand name of the product was significant at the α=0.10 and it reveals the effect from brand name on the purchasing behaviour. The factor packaging (0.072) of the product also affected for the purchase of the food. It was significant at the level of α = 0.10. All significant factors indicated that increasing the influence increased odds of consumption. Age as an important demographic factor in this study, revealed that age group 16-18 years of age consumed confectionery items more than the rest of the age groups (78%). It is important to know which age group pay more attention on confectionery items to deciding their purchasing habits. International brands such as Ferrero Rocher, Pringles and Mars recorded higher preference than local confectionery brands. Preference for the local brands were only 20% and the international brands were 80%.

Table 01. Variables in equation

	B	S.E.	Wald	df	Sig	Exp(B)
Gender	.579	.271	4.567	1	.000	1.785
Income level	-.077	.174	.193	1	.660	.926
taste	.489	.565	.750	1	.006	1.631
Age	.154	.083	3.475	1	.062	.857
Nutritional level	-.140	.285	.241	1	.624	1.150
Presence of non -	.131	.297	.193	1	.661	1.139
Brand	.725	.392	3.427	1	.064	2.065
Package	.559	.410	1.864	1	.072	1.750
Constant	2.045	2.081	.966	1	.326	7.731

4. Conclusions

The estimated model was statistically significant with the chi –square =43.080 p<0.001 and df =8. Factors affected to the consumption of confectionery foods were gender, taste, age, package and brand. Factors nutrient content, probability of getting non-communicable diseases and income level did not affect the consumption of confectionery foods. Participants preferred consuming international brands such as Ferrero Roccher, Pringles and Mars, than the local brands. The respondents demonstrated more willingness to consume chocolate products than biscuits and candies. With the current trend of youth moving into healthy food habits, an island wide survey on the same subject area would be beneficial for the Sri-Lankan confectionery manufacturers.

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Most preferred beverage between fruit nectar and fresh juice among the university students

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1. Introduction

Consumers intended to purchase fruit beverages over the carbonated beverages because they are perceived to be healthier (Kothalawala & Jayasinghe, 2016). So the fruit juice segment is expected to witness increased demand in terms of both value and volume as the overall market return is mainly from Asian and Latin American countries (Kothalawala & Jayasinghe, 2016). The General Codex norms (CODEX STAN 247-2005) defines a fruit juice as the unfermented but fermentable liquid derived from the edible part of healthy fruits which have reached the appropriate degree of ripening fresh or preserved under healthy conditions in accordance with relevant provisions of Codex Alimentarius Commission (Maicas and Mateo, 2005). Some fruit beverages including Kist, MD, Smak etc. received a higher demand with respect to the other categories as they were well aligned with the consumer perceptions. Also consumers develop higher psychological ownership towards the products they select to purchase (Kothalawala & Jayasinghe, 2016). Studying the consumer perceptions that drives the purchasing decisions is beneficial to well align the products to fulfil the consumer perception, adaptation of new marketing strategies and to increase the sales. Since number of fruit nectar brands are available in Sri Lankan market, current aimed to identifying the most preferred beverage between fruit nectar and fresh juice among the University students who are covering all the districts in Sri Lanka. Findings of the study support the fruit beverage industry to align their products well with the consumer requirements to sustain their business operations.

2. Materials and Methods

The aim of the current study was to search the most preferred beverage and factors that influence for the consumption that selected fruit beverage type. The primary data was collected from 200 government university students from 21 to 28 years age group representing all the district in Sri Lanka. The sampling framework was decided as the university students. And they include the young educated group who could make better decisions about their food consumption for a healthy lifestyle. The sample was selected through the convenient sampling technique by adapting pre tested structured online questionnaire survey.

The questionnaire included the questions regarding the respondents' preference and perception towards both fruit nectar and fresh juice. The questionnaire made up with both qualitative and quantitative questions for collect the required information. Choice experiment method was adopted in calculating the results of selected attributes and nine choice cards were used in questionnaire (Yue & Tong, 2009).

3. Results and Discussion

Table 01 indicate the results and discussion according to the most preferred beverage between fruit nectar and fresh juice among the university students.

Table 01. Estimated parameters for the maximum likelihood

	B	SE	Wald	df	Sig.	Exp(B)
Fruit Nectar						
HS	-2.358	.280	70.988	1	.000	.095
MS	-1.039	.263	15.618	1	.000	.354
LS			.	0[a]	.	
Fresh Juice	2.294	.292	61.553	1	.000	9.912
HN						
MN	-.007	.382	.000	1	.985	.993
LN			.	0[a]	.	
Price						
P1	.439	.273	2.596	1	.107	1.552
P2			.	0[a]	.	

a. Degree of freedom reduced because of constant or linearly dependent covariates

b. Constant or Linearly Dependent Covariates LS (Low sugar) = 1 – HS (High sugar) – MS (Medium sugar); LN (low nutrient) = 1 – HN (high nutrient) – MN (medium nutrient) ; P2 (Rs.100/=) = 1 - P1 (Rs.80/=)

According to the test result table, the coefficient that were provided in the variables in the equation table are used to evaluate the contribution of the individual covariance to the overall model fit. Fruit nectar was the part worth utility (Estimated coefficient) for high sugar content is -2.358 and for medium sugar content is -1.039, when the part worth utility for the variable status quo is structural zero. According to the students' preference in fruit nectar, the students most preferred beverage category was the "low sugar containing" fruit nectar rather than other sugar levels (De Oliveira Pineli et al., 2016). Here the first attribute of fruit nectar proved that medium sugar and also high sugar levels are highly significant at level $\alpha = 0.01$. High nutrient and medium nutrient were tested against the status quo when students preference about the Fresh juice. The high nutrient of Fresh juice was the most preferred one over both medium nutrient and the status quo. High nutrient level was significant at $\alpha = 0.01$ and medium nutrient proved insignificant even at the $\alpha = 0.10$ level. The price's status quo is "P_2" which indicate the level as 100.00 lkr. "P_1" mean was 80.00 lkr and it indicated 0.439. Where, P_1 is the value that is over the status quo and also P_1 is insignificant at $\alpha = 0.10$ level.

4. Conclusions

The highest percentage of university students highly prefer the fresh juices than fruit nectar. When buying fresh juice, students more concern on high nutrients and when buying fruit nectar, they more concern on medium sugar level. When considering the reasons for buying fresh juices, students concern more about their freshness, natural taste and also zero artificial added chemicals. Most of students suggested that low artificial chemicals, low sugar level and also high nutrient content from the fruit nectar are the key characteristics they consider in purchasing the preferred beverages.

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Next-Gen smart value chain for cottage industry: A case of Kithul value chain

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1. Introduction

Kithul industry can be described as an established cottage industry in Sri Lanka. The sap extracted from the inflorescence of the Kithul tree is used as raw material for various products. Among them, Kithul treacle, jaggery, toddy, flour, vinegar, and timber are considered important ones. Currently, the ethnic niche consumes Kithul products in the European market despite a long history of Kithul trade with Great Britain, Belgium, Germany, France, and the Netherlands as shown by Customs' records of colonial 'Ceylon'. The value chain of Kithul contained few horizontal nodes and more vertical linkages. Information asymmetry and issues of the governance mechanism disturb the smooth flow of products from upstream to downstream. Performances of the Kithul value chain are badly affected by inherited human resources issues, especially the lack of trained tappers, traditional processing technology, poor market access, and the lack of coordination among value chain members. The lack of knowledge on information and communication technology of Kithul manufacturers also seems to be a reason for the decline in this cottage industry. Although some aspects of the value chain of the Kithul industry are challenging, technology collaborations and decentralized characters can be used to overcome the various problems faced by manufacturers and to give real value to Kithul products (Parthiban, Bandyopadhyay, & Basak, 2018) Therefore, this study was conducted to investigate the Kithul value chain, identify its structure, functions, and profiles of value chain actors, and to discover the structure of information and communication technology-driven, actor to actor collaborative, decentralized, value chain for the Kithul industry.

2. Materials and Methods

The study was carried out in Deniyaya, Kalawana and Elpitiya areas of the wet zone of Sri Lanka where the Kithul industry is established traditionally. Case Study Approach was used to collect qualitative data from the 50 respondents and respondent groups were Kithul tappers, processors and traders who are involved in the Kithul value chain. Qualitative data were converted to Quantitative data by using Microsoft Excel and analysed by IBM SPSS22 software. Non-availability of a data base on Kithul value chain, informal methods were instrumental to identify the value chain actors and collect the primary data. Data collection begins with storytelling exercise with selected Kithul value chain actors. Open ended discussions were conducted individually and audio records were used to store the information shared. Further, in-depth interviews were performed with same value chain actors with an interview guide. The key thematic areas of questions were on product portfolio, volume and values, cost of production, processing knowhow, and functions and roles of value chain actors. Moreover, field observations were used to monitor the work of each value chain actor, identify the technology they used, processing methods, issues, problems, and coping strategies to meet the market requirements. The knowledge and experience on mobile technology, social media and online sources were identified to develop ICT led future Kithul value chain.

3. Results and Discussion

Value chain begins with Kithul trees growing in home gardens, and wet zones forests where rural tappers produce sap. Upstream of the Kithul value chain consists with Kithul tree owner, Kithul tapper, and processor. Traditional knowledge, techniques, equipment are common in tapping and processing various products. Short value chain has few horizontal nodes and more vertical links. Downstream begins with local collectors, traders, processing companies, exporters and both local and foreign customers. The role of experienced tapper is vital to start the process and prepare the inflorescence. About one week period is needed to prepare the tree for the first tapping and the cost is around LKR2000-3000. The sap harvest depends on the quality of treatments used and the maintenance process. Basically, they sell their products to local collectors and a few of them were selling directly to the customers of village fairs. In contrast, Kithul toddy business exists within the village area and regular buyers were the main target. Farm gate price of one bottle of Kithul treacle was around LKR 800 and its market price was around LKR 1000-1200 and Kithul jaggery was priced at 450-600LKR/Kg., and in the market intermediaries selling those products for about 650-700 LKR/Kg.

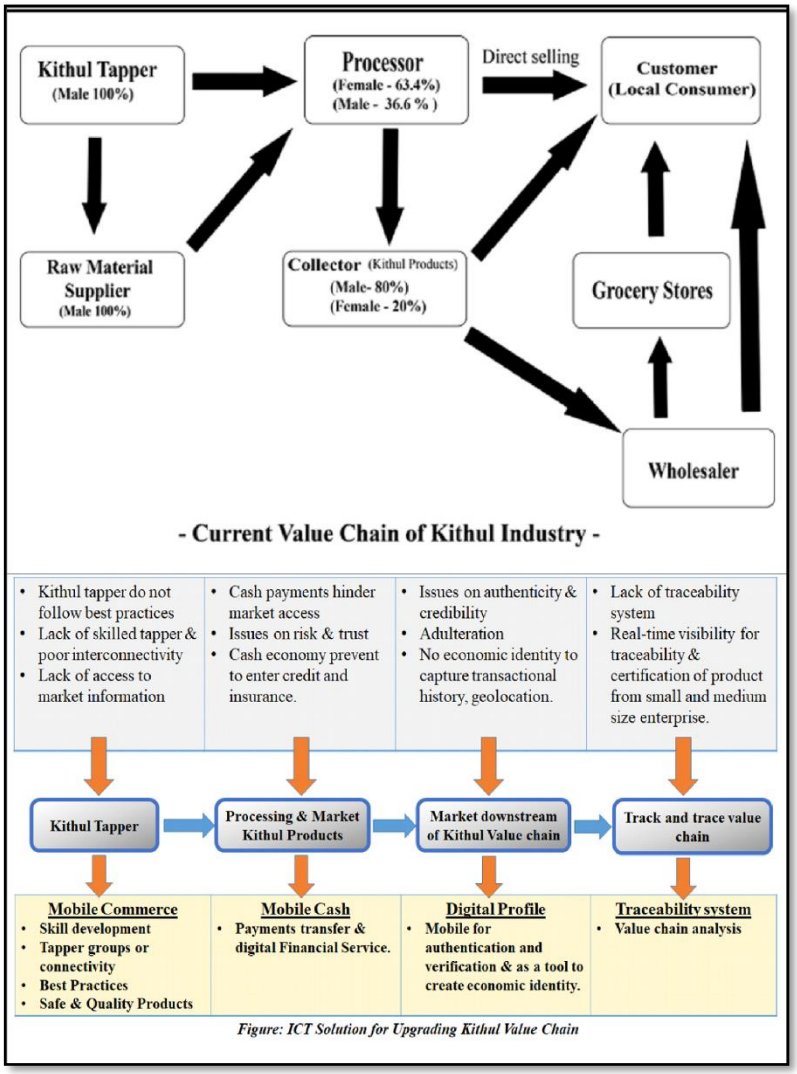

Figure 1. ICT solutions for upgrading Kithul value chain

Findings were able to identify potentials and drawbacks of the Kithul value chain. Due to the intervention of intermediaries in the value chain of Kithul products from the manufacturer to

the consumer, damage to the quality of Kithul products shows a decline in consumer taste. (Seneviratne & Dissanayake, 2016)The study showed that the Kithul tapper lacks the necessary defensive tactics, skilled manpower, coordination among value chain members, a collaboration between actors and the knowledge about the role they are supposed to play. The study revealed that the majority of those involved in the Kithul industry are elderly people due to their poor literacy on mobile technology and ICT they were ignored from the market orientation. Moreover, poor institutional involvement, as well as the lack of interest of members excluded them from modern value chains.

Taking into account the findings of the study, need for an ICT Next-Gen smart value chain aimed at overcoming the challenges of the present Kithul value chain and giving real value to the producer can be pointed out. Based on this new concept, ICT can be used to bridge the gap between actors in the current value chain, smooth flow of information, especially pricing and quality concerns and intensify the relationship between producers and consumers. This can be done through media such as online marketing, e-commerce, social media platform and mobile application which are widely used in today's society and high value Kithul related products can be marketed not only in the local market but also in foreign markets. In addition, the Next-Gen smart value chain highlights the need for public or private sector intervention to create new jobs. This will enable Kithul manufacturers to market their products directly to consumers through a digital platform.

4. Conclusions

Present Kithul value chain comprised of few nodes, short in length but network structure. Information asymmetry, poor market information on pricing, quality, and needs and wants of consumers badly affect the value chain performance. Digital identities have the potential to help farmers build pride in their profession, feel more informed, connect to new markets or buyers, access digital financial services and reduce their financial risk and act as a key enabler for digitizing the Kithul value chain and extending a wide range of services to rural users and enterprise customers. In the long-term, this will help lead to improved farming practices, increased digital and financial inclusion, and higher productivity.

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Factors contributing to organic food consumption: A case of Balangoda area

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1. Introduction

Nowadays food consumption patterns are rapidly changing towards organic food products for various reasons. Agricultural products are grown without chemical synthetic pesticides, bioengineered genes, or any artificial fertilizers are called organic products. In Sri Lanka, there are many organic products available such as rice, fruits, vegetables, tea, spices, coffee, cashew, and coconut-based products and those organic products are exported to foreign countries as well. The price of organic products is varying according to consumer preferences and satisfaction while compared with conventional foods that are remarkably higher than the actual price in all parts of the production sites of organic foods. Organic food products are expensive among both organic and non-organic produce consumers. (Narmilan & Sugirtharan, 2015) According to studies, organic food provides many advantages and nutritional value for humans such as nutritional and health benefits, safer than other chemical residue products, etc. (Gopalakrishnan, 2019 Jun- May,pp.242-245).

Several previous studies have examined issues related to the characteristics and consumer behaviours of organic food in the world. The broader objective of this study is to identify the factors that contribute to the consumption of organic foods in the Balangoda area. This study was important to identify consumer knowledge level, influence on organic food consumption, and whether they are environmentally conscious while consuming organic foods. And also increase awareness than current awareness.

2. Materials and Methods

Balangoda is located in the Rathnapura district of the Sabaragamuwa province. The questionnaire started with a brief introduction. That described the aims of the survey, Random Sampling Method was used to identify the factors that are most engaged when buying organic food products. The questionnaire had three sections. The first section of the questionnaire was designed to obtain information about the socio-economic background of respondents such as age, gender, employment, income, education, marital status, and family size. The second section was designed to get information about the consumer knowledge about organic foods. The final section was designed to obtain an idea about consumer preferences for organic food items. The sampling frame for this study was male and female consumers in the Balangoda area with various ages ranging above 21 years old. Through Researcher administered questionnaire, respondents are directly asked questions regarding factors that are mostly considered when buying organic foods. A sample of 220 consumers was interviewed in the market and retail shops in the Balangoda area and the statistical package SPSS was used to analyze the data.

Regression analysis was used as the analysis method of this survey to estimate demand function.

The Demand Function.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Dependent Variable

Y = Average quantity of monthly consumption of organic foods.

Independent Variables

X_1 = Size of household

X_2 = Consumer Knowledge

3. Results and Discussion

3.1 Socio-economic factors of consumers

Within the scope of this study, variables that are thought to impact consumer behaviors such as Age, Gender, Main income source, Education, Average monthly household income, Marital status, and Size of household are taken into consideration. Among the participants 122 were female and 98 were male. And the majority of the participants have obtained their higher education, 24 respondents have completed the primary education and 88 have completed advanced level education, and also 81 have obtained a diploma or a degree. Among 220 respondents 27 have a degree and above. Regarding the income level, the average income level was Rs.55,000.00 and the maximum was Rs. 200,000.00. And the average age of respondents was 36 years. Most participants (60.5%) are married. More participants are employed in the private sector (35%) than any other. Moreover, 88 (40%) of respondents have attained a higher level of education and 108 respondents hold a diploma, degree, or above. This may be considered as a sign that consumers of organic food have higher education levels. Gender is also considered among the factors affecting organic food consumption. Questionnaire results indicate that 55.5% of respondents are women, while 44.5% were men. More women participated in this study than women. Factors leading to women being more informed than men about organic foods.

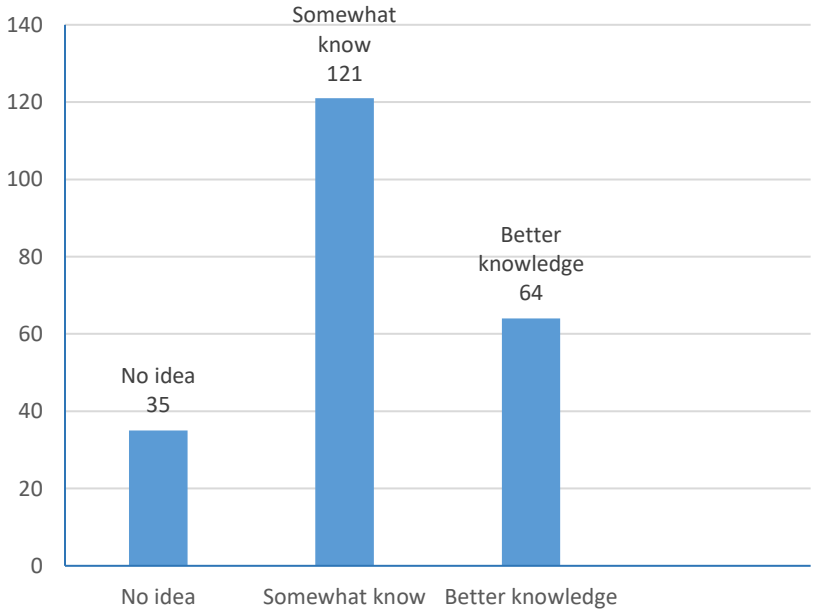

Figure 1. Consumer Knowledge about existing organic products in the market

a. Consumer Knowledge about existing organic products in the market

According to findings, 185 respondents have considerable knowledge about the existing organic products in the market.

3.3. Multiple regression results and Demand Function

A multiple linear regression model was applied to estimate factors affecting organic food consumption. (Table 1) Regression results showed that the two variables considered, size of household and consumer knowledge was significant at a probability level of 0.05.

According to the coefficient table, the Size of household have a positive β value and consumer knowledge have a negative β value. It means when the size of the household increased by 1-unit average quantity of monthly consumption of organic foods goes up at 508.262 % because those have positive values. When consumer knowledge increased, the average quantity of monthly consumption of organic foods goes down at 937.318% because those have negative values. Then demand function can be estimated as,

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Where,

Average quantity of monthly consumption of organic foods = 2514.483 + 508.268 + (-973.318) + ε

According to the Model summary (Table 2) $R^2 = 0.018$, taken as a set, the predictors (X_1 & X_2) account for 1.8% of the variable in the Average Quantity of monthly consumption of organic foods.

Table 01. Multiple Regression results

Model	β	St. Error	t	Significant
Constant	2514.483	2071.587	1.214	0.226
Size of house hold	508.268	239.543	2.122	0.035**
Consumer knowledge	-973.318	476.690	-2.042	0.042**

** - Significant at 0.05 (95% Confidence Interval)

a). Dependent Variable is the Average quantity of monthly consumption of organic foods.

Table 02. Model summary table

R^2	Adj R^2	Sig. F
0.045	0.018	0.134

According to the majority of the public, high prices of organic foods are due to the production cost and the less amount of production drives the high price. So, the majority of consumers could only purchase a few organic foods because of the high price and lack of market supply.

4. Conclusions

This survey helps to increase consumer awareness and knowledge about organic food consumption than the current awareness and also it helps to increase organic food consumption and increase farmers' income. As a result, the organic food consumption market can grow furthermore. According to the finding in the Balangoda area, there is a considerable demand for organic food products, but there is not enough supply to the market. Also, highly educated people are more concerned about organic products and they tend to purchase organic vegetables. Increasing awareness or education about these organic products can increase organic vegetable consumption in the Balangoda area.

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A study of undergraduates' perception of organic-only agriculture and organic foods in Sri Lanka

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1. Introduction

This study was focused on the students' understanding and appreciation towards organic agriculture and organic food products. Questions were prepared to gather information on the definition of organic agriculture, quality and other differences between organic and conventional foods, availability of organic products, respondents' preference to purchase organic foods, and their perception towards promoting organic agriculture and certification requirements in Sri Lanka.

Organic farming is a long-standing tradition in Sri Lanka. Traditional planting strategies (astrology, various forms of biodynamic applications, particular time schedules, pest and disease management methods: "Kem" approaches, etc) were once trusted by local farmers. To provide a long-term remedy, the Sri Lankan government established the 'Vasa Visa Nethi Ratak' national program in 2016, intending to rid the country of poisonous agrochemicals and, as a result, poisoned or polluted food items such as rice, vegetables, and fruits (Malkanthi, 2020).

According to the Sri Lankan government's new policy decision, the country is moving towards an environmentally friendly, long-term agricultural system by supporting organic farming. Hence, the government published Gazette Extraordinary No. 2226/48 on May 6, 2021, banning the importation of chemical fertilizers and pesticides (Kumara, 2021).

Organic food demand is rising worldwide due to the numerous health issues that consumers are experiencing. Organic food purchasing behavior is expanding not only in developed countries but also in developing countries, and as a result, the organic food market is widely recognized as one of the most potentials in the food sector (Wijesinghe & Aththanayaka, 2021).

2. Materials and Methods

For this study, 264 students enrolled in various Agricultural sciences and allied sciences faculties at Selected government universities in Sri Lanka, were randomly sampled. The distribution and demographic characteristics of respondents and their relationship with Organic agriculture and Organic food awareness results are shown in Table 1. There were 81 male students and 183 female students in the group. Female students make up around a quarter of the total number of students enrolled in these faculties. All of the participants completed two sections of the questionnaire. Whereupon covered general demographic information, such as age, gender, degree program, academic year, and work status. And respondents' perceptions about organic agriculture furthermore organically produced foods. Definition of organic agriculture, quality and other perceived distinctions between organic and conventional foods, availability of organic products, respondents' preference for either, certification requirements, and readiness to purchase organic foods were among the questions asked. The Google form and MS Excel were used to record and analyse all of the data obtained, and the results were presented descriptively as frequencies and percentages.

3. Results and Discussion

According to the results, the majority of the respondents were female (69.3%) while the male respondents accounted for 30.7%. There were about 71.2% of respondents who belonged to the 20-24 age group and the majority were following their degrees in the Agricultural allied faculties (36.7%) and the second-largest (33.3%) of respondents were from the Faculty of Agricultural Sciences of Sabaragamuwa University of Sri Lanka presented the highest respondents' percentage (35.2%). Among all the universities, the majority were second-year students 38.2% and the third-year, first-year, and fourth-year students were responded to the questionnaire amounting to respectively 28%, 18.2%, and 13.3%. Only 7.6% of respondents were engaging employment would have been the 2.2% of postgraduates who are having employment.

When asked to define organic agriculture 40.5% of respondents said it was "Use of organic inputs for production" 17.4% thought "It takes into consideration the welfare of the environment" The majority of the students' respondents (37.8%) got their knowledge through school/university. Others were all minor sources.

Approximately, 65.2% of students stated that they would not purchase expensive organic foods. The price of organic foods is the major obstacle in their purchasing decision. And also 3.7% of less percentage mentioned low prices as a reason for preferring Organic Foods. The vast majority (95.8%) of the students responded that Organic foods are healthier. This finding indicates that a significant proportion of the respondents are more concerned about their health

The respondents were asked if they thought organic agriculture should be promoted among farmers. 96.5% thought that encouraging organic agriculture was significant. The key reasons for encouraging organic agriculture were that it is environmentally friendly (24.5%) and promotes good health (18.3%).

Consumers are considered in the certification program with a high average of 89.4%. The female (88%) and males (92.6%) who answered the awareness question were approximately equal.

The awareness of Organic agriculture was typically high with an average of 95.5% among 264 respondents. The female (96%) and male (95%) percentage who answered the awareness question was approximately equal. When considering the faculty of studying, an appreciable percentage was amounted by the Faculty of Agricultural Sciences, Faculty of Agriculture and Plantation Management, and Faculty of Agriculture. Almost all the students from the fourth year, third year, second year, and first-year had (averaging 96.3%) a similar level of understanding about Organic Agriculture. There was no considerable difference in the knowledge of students of different age groups and levels of studies (Table 01).

Organic food awareness was high, with an average of 98.1% among the 264 respondents. The ratio of females (97.8%) and males (98.8%) who answered the awareness question was nearly equal. When considering the faculty of studying, Faculty of Agricultural Sciences, Faculty of Agriculture and Plantation Management, Faculty of Agriculture contributed a significant percentage (98.8%). Almost all fourth-year, third-year, second-year, and first-year students showed a similar level of awareness of Organic Agriculture (averaging 97.8%). There was a higher percentage of awareness about organic food in the 20-24 and 25-29 age groups (Table 01).

Table 01. Familiarity of respondents towards organic agriculture and organic food

	Are you familiar with the term "organic agriculture"?				Have you heard about organic foods?			
Factor	Yes	No	Total	Yes%	Yes	No	Total	Yes%
Gender								
Male	77	4	81	95.06	80	1	81	98.77
Female	175	8	183	95.62	179	4	183	97.81
Total	252	12	264	95.45	259	5	264	98.11
University								
Sabaragamuwa University of Sri Lanka	93	0	93	100	93	0	93	100
University of Peradeniya, Sri Lanka	27	2	29	93.10	29	0	29	100
University of Ruhuna, Sri Lanka	26	1	27	96.29	25	2	27	92.59
Uva Wellassa University of Sri Lanka	54	5	59	91.52	57	2	59	96.61
University of Rajarata, Sri Lanka	29	3	32	90.62	31	1	32	96.88
Wayamba University of Sri Lanka	23	1	24	95.83	24	0	24	100
Total	252	12	264	95.45	259	5	264	98.11
Faculty								
Faculty of Agricultural Sciences	97	0	97	100	97	0	97	100
Faculty of Agriculture	82	6	88	93.18	85	3	88	96.59
Faculty of Animal Science and Export Agriculture	50	5	55	90.90	53	2	55	96.36
Faculty of Agriculture and Plantation Management	16	1	17	94.11	17	0	17	100
Faculty of Livestock, Fisheries and Nutrition	7	0	7	100	7	0	7	100
Total	252	12	264	95.45	259	5	264	98.11
Age of students								
20-24	180	8	188	95.74	184	4	188	97.87
25-29	59	3	62	95.16	61	1	62	98.39
30-34	8	1	9	88.89	9	0	9	100
More than 34	5	0	5	100	5	0	5	100
Total	252	12	264	95.45	259	5	264	98.11
Level of study (Year)								
First	47	1	48	97.92	45	3	48	93.75
Second	95	6	101	94.06	101	0	101	100
Third	69	5	74	93.24	72	2	74	97.29
Fourth	35	0	35	100	35	0	35	100
Postgraduate	6	0	6	100	6	0	6	100
Total	252	12	264	95.45	259	5	264	98.11

4. Conclusions

Organic agriculture and organic foods have great potential in Sri Lanka to improve the agriculture sector, according to this study's results. Producing organic agricultural products necessitates a strong knowledge. Nevertheless, there is a significant need to raise awareness of the socioeconomic, health, and environmental benefits of organic farming and organic foods. If the agricultural production is promoted as a purposeful government policy and also by educational institutions, notably in the agriculture sector, organic agriculture will make a great success. Because it is said that producing organic agricultural products necessitates a strong knowledge.

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Consumer awareness on misinformation linked with consumption of broiler chicken meat: A case of Kandy district - Sri Lanka

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1. Introduction

The current poultry industry is proficient in producing broilers weighing around 2 kg or more at the end of its 6-7-week production phase (Maurer, 2003). Vigorous genetic selection and improved nutrition are the key reasons for these large sized broilers. Moreover, comfort environment and efficient management practices also assist in overall growth of the birds.

Several hormones such as 17-β-Estradiol, Progesterone, Testosterone and their anabolic substances (e.g. Clenbuterol and Zeranol) are used in livestock production for fattening purpose (Hirpessa et al., 2020). However, these substances have found to generate genotoxic, mutagenic, carcinogenic, immunotoxic and teratogenic effects on human (Hirpessa et al., 2020). Therefore, government regulations have been imposed worldwide prohibiting the use of hormones in livestock and poultry production (Hirpessa et al., 2020).

However, as highlighted by the most social media the myth of the fact that 'the broiler chickens are fed with hormones to produce more meat' has popularized globally (Esquivel-Hernandez et al., 2016) though hormones for broiler chickens are not available commercially. This imprecise information brought unintended consequence on the poultry industry while creating fraudulent health concerns (e.g. cancers, obesity and early puberty in adolescence girls) among the public (Esquivel-Hernandez et al., 2016). However, limited systematic studies have been conducted in Sri Lanka to investigate the public awareness about broiler chickens with no added hormones. Therefore, the present study was carried out to explore misinformation exist among the public community in Kandy district - Sri Lanka pertaining to consumption of broiler chicken meat.

2. Materials and Methods

Research approach was deductive and the study was based on both primary and secondary data. Kandy district was selected purposively for the study (i) for having higher numbers of poultry farms (11,156) in this area (ii) for being ranked the 5^{th} and 11^{th} positions, respectively when considering the total number of poultry farms and total number of broiler farms in Sri Lanka and (iii) for being a district belonging to the Central province where the chicken meat industry is prevalent (Alahakoon et al., 2016; Census and Statistics, 2020). Primary data collection tools included an interviewer administered questionnaire and field observations. The sample consists with 460 randomly selected participants in Kandy district. Questionnaire was designed to identify the consumer perception, buying and consumption behaviours of consumers. The secondary data were collected from the Ministry of Livestock and Rural Community Development, Department of Census and Statistics and Central bank reports. Data were analyzed using SPSS (Statistical Package for Social Sciences) version 22 software and Microsoft Excel 2016 software. To analyze the collected data descriptive statistics, such as frequencies, percentages, Chi square analysis were used.

3. Results and Discussion

Socio economic background of the respondents of the study presented that the majority of them are male (52.6 %), frequent age group is 18-30 years who are living in rural areas (54.6%), the most of them are educated up to the higher education level (Graduates and post graduates) (48.9 %), majority of their income level is distributed between Rs.25,000-50,000 per season/per month and the majority of respondent's profession has been recorded as 'other' category (41.1%).

The results revealed that the majority of the respondents (85.4%) consume broiler chicken. Unpalatability (41.9%) is the major reason outlined by those who do not prefer broiler meat. Considering buying behaviour, the majority of the respondents (64.6%) purchase broiler meat from small scale retailers and consume in a frequency of once or few times per week (46.6%).

When considering the perception toward the hormone usage in broiler chicken production, 85.9% of the sample thinks that the hormones are used for broiler chicken at the production level and these substances impose health risk (83.7%) in human. They also believe that (76.7%) eating broiler meat frequently during childhood leads to earlier onset of puberty in adolescent girls. Moreover, the majority of the respondents (75.7%) do not aware on the fact that the use of hormones (anabolic steroids such as Oestradiol, Testosterone, Stilbene, Estrogen, Progestogens *etc.*) in broiler production is banned in Sri Lanka (Gazette No. 1,292, 06.06.2003) and they do not have any idea whether there is any illegal use of hormones in broiler production in Sri Lanka. According to the chi-square analysis, there is a positive correlation exists between the gender and the chicken consumption (P = 0.014) and therefore the null hypothesis has been rejected. Moreover, there is a positive relationship between the income level and the consumption frequency (P = 0.000012). No relationship exists between the education level and the perception of hormone usage in broiler chicken production and no relationship exists between the profession and the perception of hormone usage to gain rapid growth in broiler chicken production (Table 01) (P = 0.153).

Table 01. Chi square test results

Education level x Perception on hormones usage in rapid weight gain in broilers	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	0.624[a]	2	0.732
Likelihood Ratio	0.678	2	0.713
Linear-by-linear association	0.005	1	0.943
N of valid cases	460		

[a.] 1 cell (16.7%) has expected count less than 5. The minimum expected count is 3.11.

This study also revealed that the misinformation about hormone usage has perceived from the general public (36.2%). Moreover, the majority of the respondents (81.3%) have agreed to change their mindset if there is any proof or certification for no added hormones in broiler chicken meat.

It is well known that the consumer satisfaction on meat and their products is set primarily by the numbers of criteria such as safety guarantee, provision of precise information, quality assurance of the product, convenience and attentiveness in animal welfare (Alahakoon et al.,

2016). Therefore, the public awareness should be accelerated rationally to abolish currently existing misbeliefs among the public and change their negative attitudes about broiler chicken meat.

4. Conclusions

The present study concluded that the myths of (i) using hormones to gain rapid growth rates in broilers, (ii) the hormones assumed to be present in broiler meat can impose health risk in human and (iii) frequent broiler meat consumption during childhood has an impact on earlier onset of puberty in adolescent girls exist. Though the majority of the sample represents higher educated professionals, these myths were based on the information gathered from the general public. Provision of valid certification with no added hormone in broiler meat will change the mindset of public. Therefore, improving the public awareness on legal background of hormone usage and product labelling with correct information are warranted.

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Do misconceptions affect chicken egg consumption pattern among the public community? A case of Western province-Sri Lanka

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1. Introduction

Eggs are considered the most low-cost, highly nutritious and highly bioavailable dietary protein source. The egg's role as a source of food for human was known from prehistoric era (Ravindran, 2017). Current Sri Lankan egg industry focuses mainly on the domestic market, providing eggs to a population of 21.8 million (Census and Statistics, 2021). Of the total poultry population (39.26 million) in 2019, the annual average layer population and back-yard poultry population in Sri Lanka were represented by 16.11 million and 0.93 million, respectively. Moreover, the mean total egg production was 2630.74 million where the per capita availability was reported as 120.23 (Livestock Statistical Bulletin, 2019).

However, it is well known that the reputation of chicken eggs among the general public in Sri Lanka suffers from numbers of misconceptions. One major misconception circulating is that existence of life in farmed eggs. Since Sri Lanka is multi-ethnic and multi-religious country, this sort of myths might negatively affect egg consumption pattern. Second, the consumers might refrain from eating eggs, due to the fear of health issues (Eg. Hypercholesteremia) though the current dietary guidelines recommend to consume an egg (180 mg cholesterol/per egg) per day since an average less than 300 mg cholesterol intake per day is widely acknowledged (Ravindran, 2017). However, limited systematic studies have been conducted in Sri Lanka to investigate the various misconceptions based on chicken eggs and their impact on egg consumption pattern. Therefore, the present study was conducted to investigate misconceptions exist among the community in Western province - Sri Lanka in relation to consumption of chicken eggs.

2. Materials and Methods

The present study was carried out in the Western province where a higher number of commercial (3114) and backyard (25635) poultry farms are available and for ranking the 2nd place based on the total number of registered poultry farms in this province (Livestock Statistical Bulletin, 2019). Research approach was deductive and the study was obtained both primary and secondary data. The sample consisted with 690 respondents selected from the Western province using simple random sampling technique. The key data collecting tool was a pre-tested interviewer administrated questionnaire. Questionnaire was designed to identify the consumer perception and buying behaviours of purchasing chicken eggs and surveyed consumer's awareness on egg's nutritional profile, fertility, health benefits or health risks associated and socio-economic factors affecting egg consumption frequencies and pattern. The secondary data were collected from the Ministry of Livestock & Rural Community Development and Department of Census & Statistics. Data were analyzed by using SPSS (Statistical Package for Social Sciences) version 22 software and Microsoft Excel 2016 software. The collected data were analysed using descriptive statistics, such as frequencies, percentages and Chi square analysis.

3. Results and Discussion

Of the total respondents, 52.3% were in the Colombo district. The majority of them were female (51.7%) whereas the frequent age group is 18-30 years who are living in urbanized areas (60.9%). Most of them are educated up to higher education level (Graduates and post graduates) (52.8%) with income level distributed between Rs.50,000-100,000/per month (40.1%). The majority of respondents were from the private sector (48%). Moreover, 80.4% of respondents are Buddhists and 89.7% are Sinhalese.

The results revealed that the majority of the respondents (95.8%) consume chicken eggs as their main protein source where the eggs were purchased mainly from the retail shops and supermarkets. Majority (65.9%) consume both the village chicken eggs and commercial chicken eggs in a frequency of 3-5 eggs per week per person. The present study proved that the egg consumption frequency has been increased tremendously over the years from 2015 to 2021 from 1-2 per week to 3-5 per week, respectively (Wickramasinghe et al., 2015). There is a relationship between age and the frequency of chicken egg consumption (Table 01). With aging, the respondents believe at least they need to consume 3-5 eggs weekly for proper nutrition.

When considering perceptions towards chicken eggs purchasing, they aware (53.4%) the facts that commercial chicken eggs are (i) infertile (ii) do not carry embryo and (iii) the female birds are reared sex separated in layer operations. Moreover, they believe the fact that village chicken eggs are more nutritious and safer to eat than commercial chicken eggs. This is in an agreement with the finding of Wickramasinghe et al. (2015) who found that the majority of the community is aware about the fact that commercial eggs do not carry embryos and less nutritious than village chicken eggs. No relationship has been observed between age, profession or education level and the belief that village chicken eggs are more nutritious and safer to eat than commercial chicken eggs. Of the total respondents, 95.4% do not believe the fact that brown eggs are more nutritious than white eggs. However, 53.5% of respondents prefer to eat brown eggs instead of white eggs.

Table 01. Chi square test results

Age*How often you eat chicken eggs	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	24.741[a]	12	0.016
Likelihood Ratio	20.842	12	0.053
Linear-by-linear association	2.173	1	0.140
N of valid cases	668		

[b.] 9 cells (45.0%) have expected count less than 5. The minimum expected count is 0.57

Further, in contrast to the findings of Wickramasinghe et al. (2015), the majority of the respondents (46.2%) in the present study believe that daily consumption of chicken eggs causes high blood cholesterol levels increasing the risk of coronary diseases. However, fear of high blood cholesterol level has negatively impacted on their buying decision and to limit egg

consumption (14.1%). According to Mizrak et al. (2012), fear of high blood cholesterol level has been identified as the second most common reason to limit egg consumption (33.3%) in Turkey, next to the medical advice (41.7%). The misconception of the fact that pregnant women should not prepare or eat commercial chicken eggs was not accepted by 52.5% while 36.4% of respondents did not have an exact idea. However, 11.2% of the total respondents were in an agreement with this misconception. All these believes on chicken egg consumption and purchasing decisions are mainly depending on the information that they gathered from the general public and social media platforms. Further, 77.4% are willing to change their mindset if it is confirmed or certified with the fact that both village chicken and farm chicken eggs are equally nutritious, white and brown eggs are equally nutritious, safe to eat daily, and are infertile.

4. Conclusions

The present study concluded that two misconceptions: (i) village chicken eggs are more nutritious than commercial eggs and (ii) daily consumption of chicken eggs causes high blood cholesterol levels while increasing the risk of coronary diseases, do exist. However, the colour of the chicken eggs does not have any impact on their buying decision. The majority of respondents from the Western province are aware of the fact that commercially reared chicken eggs are not fertile, not carrying embryos and reared sex separate. Though majority of the sample represents higher educated professionals, majority of respondents are relying the information of general public and social media for purchasing decisions. Organizing promotion campaigns to make well inform the community about the nutritional value and health benefits of eggs is warranted.

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An assessment on attitudes on antibiotic usage and knowledge regarding antibiotic resistance among the general public in Sri Lanka

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1. Introduction

The emergence and spread of antibiotic resistance have become a significant burden worldwidein recent decades (WHO, 2014). Antibiotics referred to the medicines formulated to treat and prevent bacterial infections which are administered to patients based on a certified health care professionals' prescription (Ajibola et al, 2018). Antibiotic resistance leads to increased healthcare costs, limited drug options for treatment, and longer hospital stays (World Health Organization, 2015).

In Sri Lanka, Anti-microbial resistance is a key challenge that has been faced by the health care sector. A study conducted at NHSL in 2014 has shown that almost all bacterial pathogens which are responsible for Ventilator-Associated Pneumonia were multidrug resistant. A similar study was carried out in teaching hospital Anuradhapura which has identified 70% of clinically significant Acinetobacter spp., to be having resistance to two or more antimicrobial agents (Liyanapathirana and Thevanesam, 2016). The data reveal the need for a potent action that can address the occurrence of antibiotic resistance in Sri Lanka. Antibiotic resistance is known to be associated with incomplete courses, inadequate dosing, and counterfeit drugs. The improper use of antibiotics may arise from a complex interaction between numerous factors, such as diagnostic uncertainty, prescribers' knowledge, perceptions of patients to the patient-doctor interaction, andinsufficient patient education by physicians. In addition, other factors include patients' knowledge, beliefs, and attitudes towards antibiotic use, self-medication, and patients' experience with antibiotics (Ajibola et al, 2018). Therefore, this study aimed at investigating into the burden from patients' aspect by evaluating their attitude and knowledge of Antibiotic resistance towards antibiotics usage.

2. Materials and Methods

The survey was conducted during the period from May to July 2021. The Sample size was 600 which comprised of students below 21 years of age, salaried employees, non-salaried employees, and unemployed personals. A literature review was conducted to identify potential items for the study instrument from similar previous studies. Based on the literature search, the study questionnaire was adapted from validated surveys (Awad et al, 2015). Data were collected anonymously via a self-administered online questionnaire form, which was randomly distributed among the community.

Close-ended questions were included in the first section that recorded the respondents' socio-demographic characteristics. Section two to seven consisted of the practice of antibiotic use, self-medication, knowledge, and attitude about antibiotics, doctors' habits, and the patient-doctor relationship. Section eight consisted of 10 statements to evaluate respondents' knowledge about antibiotic resistance with a five-point Likert scale.

3. Result and Discussion

According to the demographic characteristics of 600 individual respondents, 67.7% were femalesand 85% were between the 21-29 age category. Most of the respondents were well-educated, having 81% above the Advanced level, with 72.5%, undergraduates and 9%, possessing postgraduate qualification. Table 01 shows the self-medication pattern of the respondents.

Table 01. Self-medication pattern of respondents

	Practice	Frequency n	Percent %
Reasons for self-medication	*To save time due to busy schedule*	476	45.51
	Ability to purchase drugs easily from pharmacies	230	21.9
	High costs of visits to doctor	109	10.4
	Less severity of the disease	225	21.51
	Lack of trust toward doctors	6	0.57
Locations for obtaining medications	*pharmacies*	480	55.7
	supermarket pharmacies	208	24.15
	from home (previously purchased)	132	15.33
	borrow from friends	41	4.76
From whom get advice	*pharmacist*	382	62.52
	family members	142	23.24
	Friends	87	14.24
factors considered for selection of antibiotics	*Type of antibiotic*	415	31.58
	Brand of antibiotic	182	13.85
	Price of antibiotic	141	10.73
	Indication for use	192	14.61
	Adverse reactions	215	16.36
	Availability	169	12.86
Dose determination	*Consulting doctor*	418	40.38
	Consulting pharmacist	300	28.9
	Family members	48	4.63
	Internet	100	9.6
	Media	2	0.19
	Previous experience	156	15.0
	Guessing	11	1.06

Out of all participants, 457 (76.2%) self-medicated themselves with antibiotics as shown in table 1. Regarding the reasons for self-medication (n=421, 42.5%) because it is convenient due to their busy schedules, most of the participants selected antibiotics for self-medication on basis of a recommendation from pharmacists (n=382, 62.5%). Nearly 31% of their selection was based on antibiotic type. The majority of participants (n=413, 52%) obtained from pharmacists; 16.6% (n=132) of responses stated that they used previously purchased antibiotics for self-medication and 5.2% (n=41) responses stated that they obtained antibiotics from friends. The dose determination had been done mainly by consulting a doctor (40.38%) followed by pharmacists (28.9%), previous experience (15%), internet (9.6%), family members media, and guessing had also been practiced by few respondents (<5%).

The attitudes of the respondents on the use of antibiotics, the median (IQR) attitude score was 3 (2.0)out of a maximum score of 6, which showed a moderate level. Nearly one-third of respondents were uncertain whether to use antibiotics for treatment of sore throat or not. It showed a high rate of negative attitudes to the use of antibiotics for the treatment of cough. The multivariate logistic analysis identified that the age category 40-49 years, education level, education level category graduate/ bachelors, monthly income, and work in the medical field as the factors which were significantly associated with the attitude score.

The median (IQR) knowledge score of respondents was 4 (2.0) out of a maximum score of 8 which showed moderate knowledge; 6.5% did not indicate any correct response, whereas 35.6% listed 1-3 correct responses show a low level of knowledge. The majority of respondents correctly agreed only on the statements: “if you get side effects during a course of antibiotics treatment, you should stop taking them as soon as possible” and “different antibiotics are needed to cure different diseases”. They showed low knowledge about whether antibiotics were effectiveagainst cough, cold, viruses, fungal, and bacterial infections. The majority were uncertain about the usage and safety of antibiotic usage. The study results were comparable to the results reported in Kuwait (Awad et al., 2015).

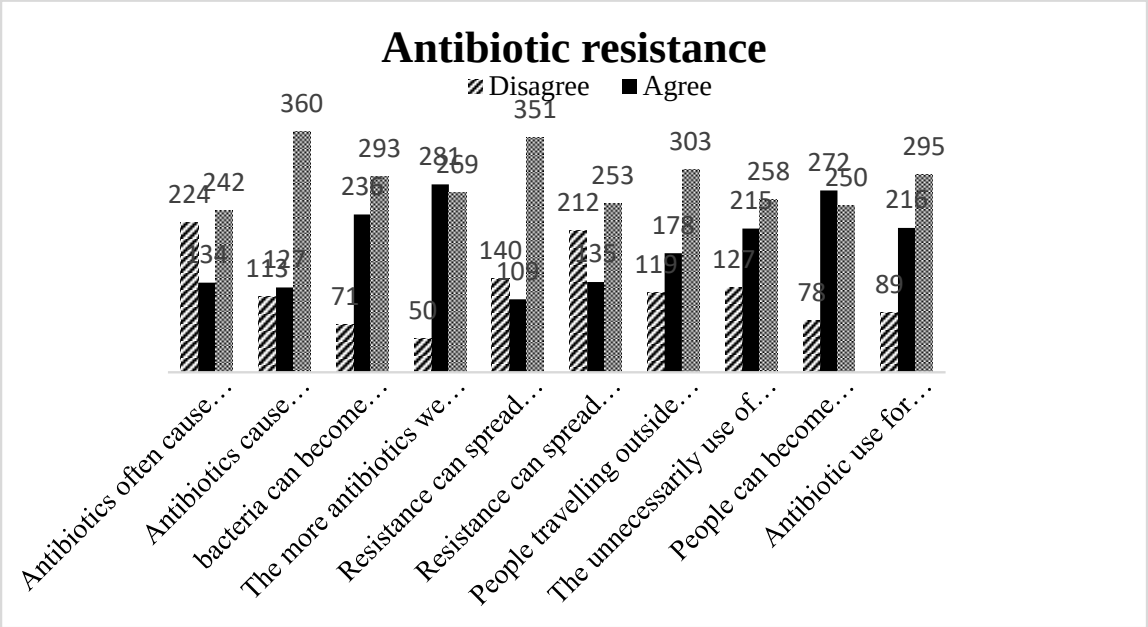

Figure 01. Knowledge on antibiotic resistance

Further, the study population was less knowledgeable and uncertain about antibiotic resistance. The median (IQR) knowledge on antibiotic resistance score was 2 (2.75) out of a maximum score of 10 which shows low knowledge. Nearly half of the respondents incorrectly agreed that “people can be resistant to antibiotics”. The majority was uncertain on eight statements

out of tenas illustrated in the figure, which signals the gap between the proper knowledge on the burden of antibiotic issue.

The findings illustrate that there is a clear confusion and misconception among the focused population regarding antibiotics and their uses which leads to irrational use of antibiotics, arising animportant issue that results in serious medical, social, and economic consequences. It was figured out that community pharmacists were the most accessible health care providers that can be contributed to public knowledge about correct antibiotic usage.

4. Conclusions

The study reveals that there was a significant association between age, education level, and occupation with the knowledge level. Low knowledge on antibiotic resistance provides further insight into designing future interventions to promote specific messages to reduce the knowledgeand attitude gaps as an effort towards preventing the development of antibiotic resistance. The malpractices needed to be studied in depth to understand why people practice them and what can be predicted. Proper awareness programmes, extension services are needed to be brought together with changes in the health care sector to eliminate the AMR burden successfully.

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An investigation on consumption of meat by undergraduates in Sri Lankan universities

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1. Introduction

Meat is the typical balanced diet with a tremendous source of proteins and micronutrients such as vitamins, and minerals (Jung, 2015). Global meat consumption continues to expand at one of the fastest rates of any agricultural commodity, account of rising incomes, shifting consumer preferences in many emerging economies, and reducing the costs of production and meat prices. (Devine, 2003). According to the FAO's meat market review, world total meat production is estimated at 337.2 million tons in 2020. The European Prospective Investigation into Cancer and Nutrition (EPIC) has used a computerized 24-h dietary recall interview approach to record the meat consumption of people in 10 different European countries and found that meat consumption patterns were shown to differ markedly between countries.

The total meat production in Sri Lanka has increased from 205,160 MT in 2015 to 264,680 MT in 2019.The per capita meat and meat product availability in Sri Lanka was 10.12 kg/year of chicken followed by beef (1.37 kg/year), pork (0.42 kg/year), and mutton (0.12 kg/year) in 2019 (DAPH, 2019). Since the protein malnutrition has become a huge concern in Sri Lankan society, addition of animal protein into the diet is crucial. It is utmost important to have an idea on the meat consumption pattern in the society in order to implement measures to improve the consumption. The consumption patterns of meat are influenced by a variety of factors. As Sri Lanka is a multi-ethnic and multi-religious society with long history and diverse cultural traditions, the awareness on those influencing factors is crucial. Therefore, studies performed in other countries could not be directly related to Sri Lankan context due to the specific nature of social, economic and cultural background of the country. University student population can be considered to represent all the above categories. Due to the fact that the previous studies included only a few figures on consumers' meat consumption habits, an attempt was made to find out the meat consumption pattern including the type and quantity of meat consumed and the degree of awareness on basic factors related to meat consumption among university undergraduates in Sri Lanka under the present study.

2. Materials and Methods

Sample of 250 undergraduates were selected by simple random sampling method and the data were collected via a pretested online questionnaire on favorite meat types, amount of consumption of meat, ways of obtaining meat, awareness on nutritive value and health hazards of meat. The sample represented 13 state universities; Sabaragamuwa University of Sri Lanka (115), University of Sri Jayewardenepura (47), University of Peradeniya (38), University of Moratuwa (11), Open University of Sri Lanka (8), University of Ruhuna (6), Wayamba University of Si Lanka (6), University of Colombo (5), Uva Wellassa University of Sri Lanka (3), University of Kelaniya (2), Rajarata University of Sri Lanka (2), University of Jaffna (2), Eastern University Sri Lanka (2), in the country and comprised of 14 faculties in different academic disciplines including Agriculture (79), Science (73), Social Sciences (21), Management (20), Engineering (14), Medicine (13), Geomatics (12), Technology (6), Allied Health Sciences (3), Computing (2), Veterinary Medicine and Animal Science (1) and Law (1).

The sample comprised of individuals from all the districts in the country, when their residential areas are concerned. Collected data were analyzed and discussed accordingly.

3. Results and Discussion

The most favorite meat types and amount of consumption, factors that considered in purchasing of meat, scientific awareness on nutritive value and health hazards of meat were revealed using the gathered data in the study.

All the respondents consumed at least one type of meat. The consumption pattern of fresh meat types was given in Figure 1.

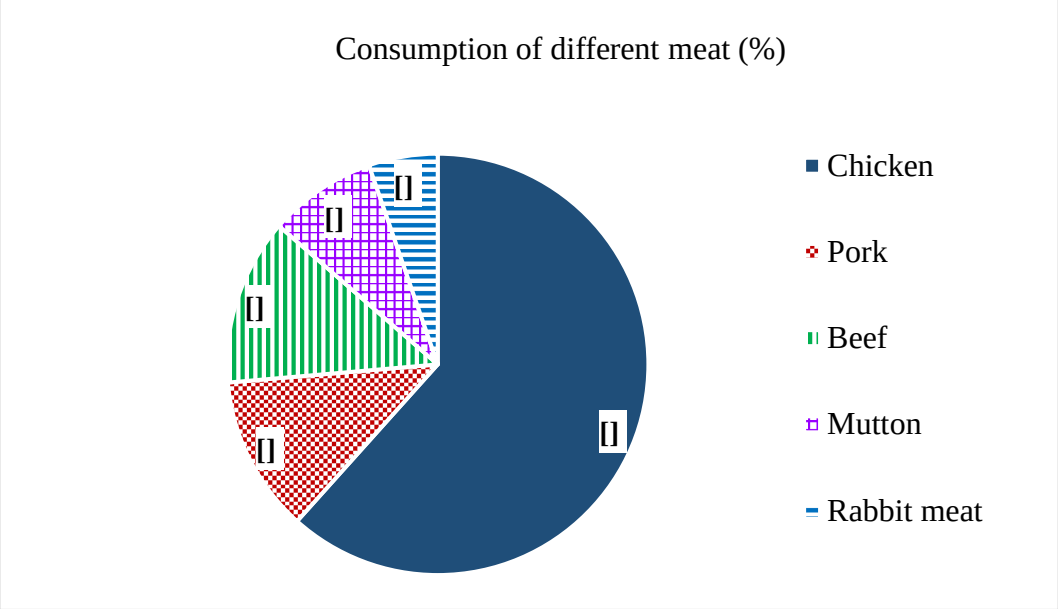

Figure 1. Consumption pattern of different meat types by university undergraduates

The study revealed that the most popular meat type among university undergraduates was broiler chicken meat (61.7%) followed by beef (12.8%), pork (12%), mutton (8.3%) and rabbit meat (5.3%). As the sample population of this study represented all the state universities, a large number of faculties, academic years and residential districts, the consumption patterns shown by them could be taken as a cross section of the Sri Lankan society. Generally, broiler chicken meat holds the highest per capita availability over other meat types in the country for many years and it may have led the higher consumption of broiler chicken meat among university undergraduates as well, because cultural and social taboos are minimum for broiler chicken meat.

Among the processed meat consumers, the most preferable (64%) meat product was sausage. Eighty six percent of meat consumers have shown the desire to taste different meat types other than what they consume at present, but various factors including health hazard (46%), less availability (33%) and high cost (21%) limit their accessibility to different types of meat. Consumption and purchasing pattern could be explained by the availability and price of meat, or regional/cultural differences (Alahakoon, 2016). Putnam, 1997 has also stated that price, income, taste, and preference as the key variables affecting the meat purchasing and consumption patterns. The majority of respondents are scientifically aware about the importance of meat including nutritional value, storage conditions and health hazards. It was shown that 68 % of respondents have some scientific awareness of meat, in which 31% was educated about nutritional value of meat through books/lectures and 23 % through social

media. Nutritional composition is not a key determinant of meat consumption pattern among undergraduates whereas, health hazards concern as the most. The most common (80%) way of obtaining meat was from meat stalls and a greater amount of respondents (77%) concerned about the carcass quality when purchasing meat. This may be due to their higher education level. It was found that the average meat consumption per month was less than 0.5 kilogram (kg) in the majority of the respondent's (60%) while only 22% of respondents had the average monthly meat consumption of above 1 kg. Fifty two percent of the respondents believed that beef was the most nutritious meat type whereas, 19%, 15%, 7%, 4% and 3% of the respondents believed it as mutton, chicken, pork, veal and rabbit meat respectively. Vast majority (52%) of undergraduates considered the liver as the most nutritious organ meat. This is a great misbelief in the view of meat science and it stresses the necessity of further awareness programs even for educated groups in the society. This study revealed that lectures /books and social media can be used as timely approachable sources of media to improve the awareness.

4. Conclusions

The religious beliefs have a strong influence on meat consumption pattern of Sri Lanka where it causes a suppression of the consumption of beef and pork. However, consumption of chicken is not considerably affected by ethno-religious beliefs compared to that of pork and beef among university undergraduates in Sri Lanka. It was also concluded that university undergraduates are aware about the importance of the carcass quality and highly concerned about the possible health hazards due to consumption of meat. Some myths related to meat consumption still exist even among educated population, so awareness mechanism has to be further strengthened.

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A preliminary study on performance of Artificial Insemination (AI) and perception of dairy farmers on present AI service in Kegalle district

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1. Introduction

Livestock makes a significant contribution to the economic livelihood of Sri Lanka. Dairying is the major component of the livestock industry and is acceptable to all communities and has no significant religious or social constraints. Dairy provides regular cash income throughout the year to the small scale farmers and hence it has a significant impact on the pattern of the livelihood of rural farmers, resulting in improved nutrition in both availability of milk and enhancement of dairy income (Banerjee, 2018). Thus, livestock development should focus primarily on dairy development and improvement of the productivity of dairy cattle since it is one of the key parameters in that process. The majority of dairy cattle in the country have a poor productivity leading to a stagnant milk production in the last few years. Artificial Insemination (AI) is a scientifically advanced technique in which semen is collected from a superior sire, processed, stored, and artificially inserted into the female reproductive tract. The development of the smallholder dairy sector in the rural areas will depend on the improvement of the productivity of the local cows by upgrading them by cross breeding with superior sires using AI. The total national production of cow milk in 2019 was 374,015,943 Liters (DAPH, 2020) and the main objective of all the dairy development programs is to increase the national milk production towards self-sufficiency. Genetic upgrading of local cattle can be used to achieve this. Therefore, measures should be taken in this regard to genetically upgrade the existing dairy herds in the country to obtain higher milk yield improving the AI service to dairy farms throughout the country. In order to take measures for improvement of the AI service, it is vital to analyze the existing situation of the service. The total cattle population in Kegalle district has been recorded as 17724 with 30% Indian and crosses, 55% European and Crosses, 15% local breeds in 2019. Having the average temperature around 25.7 ^{0}C, annual rainfall of 2306 mm, and relative humidity around 85% and land area of 1,693 km^{2}, Kegalle district, located in low country wet zone is identified as one of the potential areas to improve dairy farming. Therefore, a survey was conducted to study and evaluate the present situation and performance of the existing AI service in the district and perception of dairy farmers on present AI service in Kegalle district.

2. Materials and Methods

The study was carried out to appraise the performance of AI and farmer perception regarding AI in the Kegalle District using secondary data and farmer interview from twelve government veterinary ranges in the Kegalle District in 2019. The number of artificial inseminations in each government veterinary range, the number of pregnancy diagnosis and the number of calves born are the criteria used in data collection. Comments and suggestions were taken on the present AI service, potentials and constraints faced by farmers from twenty dairy farmers selected through Government veterinary offices. Collected data were analyzed using an Excel worksheet.

3. Results and Discussion

Indigenous breeds, crosses of European and Indian breeds and European breeds are the common cattle breeds available in Kegalle District. It was found that 98% of the dairy farmers in the district were well aware about the advantages of using AI technique for breeding animals. The total number of AIs performed in the district in 2019 was 3566, covering 82.5% of the annual target (4325). The breeding targets and actual performances in Kegalle district are given in Figure 1.

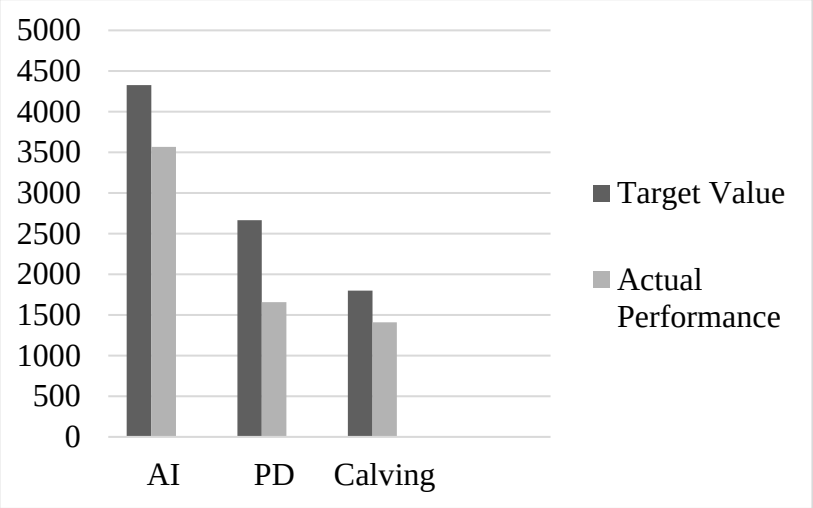

Figure 6. Annual Breeding Target and Performance in Kegalle in 2019 (AI- Artificial Insemination, PD- Pregnancy Diagnosis)

Eighty-five percent of the AIs have been done by governmental AI technicians and the rest by private technicians. Government AI service was higher in Galigamuwa and lower in Daraniyagala veterinary ranges during 2019. Out of the AI s performed, 1909 (53%) had to be repeated for the second time and 247 (15%) for the third time. A total number of 1657 pregnancy diagnosis examinations (PD) was done from inseminated cows during the year, covering 62.1% of the annual target (2667). The number of AI calves born in 2019 was 1410, out of the target of 1800, covering 78.3% of the annual target. Out of the twelve veterinary ranges in Kegalle district Warakapola VS range had the highest AI coverage while Rambukkana VS range had the lowest AI coverage in 2019. The pregnancy diagnosis (PD) performance was the highest in Warakapola VS range whereas Galigamuwa VS range had the lowest PD performance. The calving performance was also the highest in Warakapola VS range and it was the lowest in Rambukkana VS range. The AI, PD and calving performances in each VS range in Kegalle district are given in Table 1.

Table 01. AI, PD and calving performances in each VS range in Kegalle district

No	Name of the Veterinary Office	AI		PD		Calving	
		Target	performance	Target	Performance	Target	Performance
1	Aranayaka	259	239	173	101	142	92
2	Bulathkohupitiya	268	146	156	96	109	65
3	Daraniyagala	60	51	36	30	24	19

4	Dehiowita	150	128	90	91	51	33
5	Galigamuwa	852	844	492	162	384	390
6	Kegalle	360	341	257	173	141	121
7	Mawanella	550	555	330	238	249	196
8	Rambukkana	800	342	473	212	306	125
9	Ruwanwella	300	172	180	94	88	53
10	Warakapola	416	465	239	266	192	213
11	Yatiyanthota	160	127	139	84	64	49
12	Undugoda	150	156	102	110	50	54

Out of the interviewed farmers, thirty-five percent were not satisfied with the AI service provided by the government veterinary office. The main complaint was the unavailability of AI technicians at the proper time to perform AI. Difficulty in communication was also mentioned as a common problem. Twenty percent of the farmers complained about the higher price charged per AI by the technician. Thirty percent of the farmers were unhappy about the higher repeat breeding incidents subsequently to AI; thus, they have returned to obtain stud bull service.

4. Conclusions

Acceptable AI performance was seen in a few VS ranges in Kegalle district but it can be concluded that the AI service in the district requires a meticulous review and monitoring process in order to improve it to a satisfactory level. Semen quality, evaluation of semen used in AIs in the district and continues professional development activities for AI technicians are recommended to minimize the high return rate of cows after AI. Management systems adopted for pregnant animals also should be thoroughly investigated in order to improve the poor calving performances. Necessary steps have to be taken immediately to provide an effective and more suitable AI service for medium and small scale dairy farmers. Availability of AI technicians as well as ease of access to them should be increased. A proper and expedient charging system for AI has to be implemented.

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A study on performance of artificial insemination and occurrence of diseases in livestock species in Kalutara district

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1. Introduction

Since independence, much investment has been rolled in the Livestock sector to improve productivity of the Livestock sector as it plays an important role in the agrarian economy of Sri Lanka. It produces animal products to meet a part of the domestic consumption demand and provides income for well over half a million rural smallholder farmers. However, still the animal food production has not reached a satisfactory level in the country due to various reasons, including poor genetic upgrading, poor nutrition and high disease outbreaks. The poor performance of the genetic upgrading process of livestock species has led the poor productivity in the majority of livestock species, and it has resulted in the stagnant milk loss production in the past few years in the country. Improvement of the productivity of the livestock species can be achieved by upgrading them by cross breeding with superior sire using Artificial Insemination (AI). Disease outbreaks in livestock species cause severe losses to the farmer due to high mortality rates, poor growth of animals and low productivity. Some diseases are zoonotic, and thus, there is a menace to the public health causing additional expense in the health sector in Sri Lanka. Therefore, it is timely worth to study the present status of the AI and prevalence of common diseases in different livestock species in the country.

Kalutara district belongs to the wet zone in Sri Lanka and the land extent is about 159,800 ha. The farm animal population of Kalutara district is approximately 13,890, 7440, 5320, 9420 and 2,339,985 cattle, swine, goat, buffalo and poultry respectively (Annual report, DAPH, 2020). The total milk production in the district was reported as 13,749 litres in 2019. It is required to take possible measures to improve these livestock production capacities further in order to achieve the targets of being self-sufficient in livestock products. In order to increase the livestock production in an area, the productivity of animals has to be enhanced. Diseases in livestock species are considered one of the major constraints on the low productivity of animals. Therefore, accurate awareness on the disease surveillance among livestock species is an area of utmost importance in planning and implementing livestock development programs in the area. A range of Livestock disease outbreaks has been reported from Kalutara district in the western province during the past few years. Data on these outbreaks have been collected by individual government veterinary offices in the district, but there was no proper scientific evaluation and publications on these data. Hence, this study was conducted to appraise the present status and performance in AI and disease occurrences in cattle, goat, swine, buffalo and poultry in Kalutara district.

2. Materials and Methods

The survey was conducted using secondary data available in Government veterinary offices in Mathugama, Baduraliya, Bandaragama, Panadura, Bulathsinhala, Horana, and Kalutara in Kalutara district between July to September in 2021. Data were collected on the number of AIs performed in different livestock species, the success rate of AIs, major constraints faced by livestock farmers, common diseases in cattle, swine, goat, buffalo and poultry, frequency of

occurrence of disease outbreaks, common predisposing factors and control measures taken by authorities and assessed. Collected data were analyzed using Excel work sheets.

3. Results and Discussion

The study revealed that the artificial insemination is practiced throughout the district in different capacities with variable success rates. The total number of AIs done in cattle within the 7 studied veterinary ranges (VS ranges) out of 11 in the district was 2510 and the total number of AIs done in buffaloes was 233. The number of AIs done in goat and swine in the studied ranges was 99 and 3 respectively. The success rate of AI s in cattle was 60%, whereas it was reported as 56.7%, 62.5% and 68% in buffalo, goat and swine respectively. The major constraints related to AIs in the district were recorded as management problems and the incorrect detection of heat. Among the studied VS ranges in the district, Horana VS range recorded the highest AI performance while it was the lowest in Mathugama VS range. Table 1 shows the number of AIs performed in each of the veterinary range.

Table 01. The number of AIs performed in each of the veterinary range in Kalutara district

Veterinary Range	No. of AIs performed			
	Cattle	Buffalo	Goat	Swine
Mathugama	141	9	9	-
Baduraliya	211	14	12	-
Bandaragama	436	40	25	-
Panadura	229	6	21	-
Horana	1050	117	10	-
Kaluthara	335	25	6	-
Bulathsinhala	441	21	16	3
Total	2843	232	99	3

The study revealed that the predominant cattle breeds available in the district were Girilandio and Jersey × Sahiwal crosses. It was found that many contagious diseases are commonly found among livestock species in Kaluthara district. The most common diseases of cattle were Mastitis, Milk fever, Babesiosis, Ephemeral fever, Coccidiosis, Internal and External parasites and Lumpy skin disease. It was found that calves had been affected by calf diarrhea, Naval ill and Pneumonia. Prominent swine diseases in the district were Pneumonia, Internal parasites, Enteritis, Mastitis and Foot and Mouth disease. Piglet anaemia was the most prevalent condition among piglets. It was noticed that coccidiosis was the most common infectious disease among poultry, including both broilers and layers. Other common disease conditions were Fowl pox, Ranikhet, Infectious bursal disease and Internal parasites. The major disease conditions in goat in the district were Cerebrospinal Nematodiasis and Contagious Pustular Dermatitis, whereas mastitis and Lumpy skin disease are also found among the buffaloes. It was found from the study that poor management practices such as improper hygienic measures, under nutrition of animals and overcrowded housing and incomplete vaccinations are the common predisposing factors for disease outbreaks. The other predominant problems faced by livestock farmers in the district were lack of quality feeds and extension services. The disease outbreaks have been successfully controlled by following proper guidelines to improve hygiene, biosecurity and management aspects in all farms.

4. Conclusions

Artificial insemination process is conducted in Kaluthara district with a satisfactory success rate, but there are practical issues to be addressed immediately in order to improve the AI success. Occurrence of infectious diseases are common among livestock species in Kaluthara district and the major causes for disease outbreaks in cattle, swine, goat, poultry and buffalo in the district were related to poor management practices. The performance of the livestock sector in the district has been characterized by numerous practical obstacles faced by livestock farmers and immediate attention should be paid to mitigate those issues. The present situation could be improved to a much satisfactory level by increasing the farmer awareness and improve health management aspects. Therefore, an extensive farmer awareness programme based on proper housing management, farm hygiene and disease control measures including biosecurity is highly recommended.

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An investigation of the influence of country of origin on customer perception towards chocolate brands

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1. Introduction

According to the Nordquist (2016) chocolate is made from tropical cocoa tree seeds and its earliest use dates back to the civilization in Mesoamerica. There is different chocolate brand around the world and those brands also play a significant role in fast consumer goods market as well as the luxury food it-moving market. Those are Ferro Rocher, Galaxy, Cadbury, Toblerone, Toren, etc. The perception toward the country of origin also affecting to the consumer buying decision. Therefore, the modern market attitude toward the country of origin is having important to interact with the consumer goods market. According to Cateora & Graham (1999), Country of origin can be defined as any influence that the country of the manufacturer has on a consumer's positive or negative perception of a product. In detail Anwar, Yasin, Iqbal, and Sajid (2013) stated that COO is being viewed like different brands belonging to different countries. Those owning countries are called the country of origin. (Yunus & Rashid, 2015,). The study was mainly focused to examine the influence of country of origin on customer perception towards chocolate brands and the secondary objective was to study the influence of country of origin on perception for chocolate brand buying decisions in Sri Lankan consumers and to investigate how the country of origin on consumer perception influence by other important factors such as demographics factors (Age, Gender, Income).

2. Materials and Methods

The framework shows the relationship between the country of origin and the customer's perception of the mark. Other factors that may influence this process are also illustrated in frames as demographics like age, gender, and income. This study will primarily test factors and consumers' perception of the brand in the context of normal use and situation rather than in a particular context of use. According to the findings, there are two main variables as dependent variables (Perception toward brands) and independent variables (Country image, perceived quality, Brand Familiarity, and demographic factors). And the entire consumers respondent collected by using a questionnaire. And sampling size is 200 which are collected by randomly using nine provinces of Sri Lanka. And also, the choice experiment method was used for the analysis of customer respondents.

And the questionnaire was made up of both qualitative and quantitative data. For the gathering customer preferences for chocolate brands were mention nine choice cards were in the questionnaire form. There are attributes and levels in choice cards such as Attributes that represent Brand, Image, and Quality. According to each attributes they have some levels for Brand (Revello, Cadbury, and Toblerone), Image (High image, Low Image), Quality (High Quality, Moderate Quality, Low Quality).

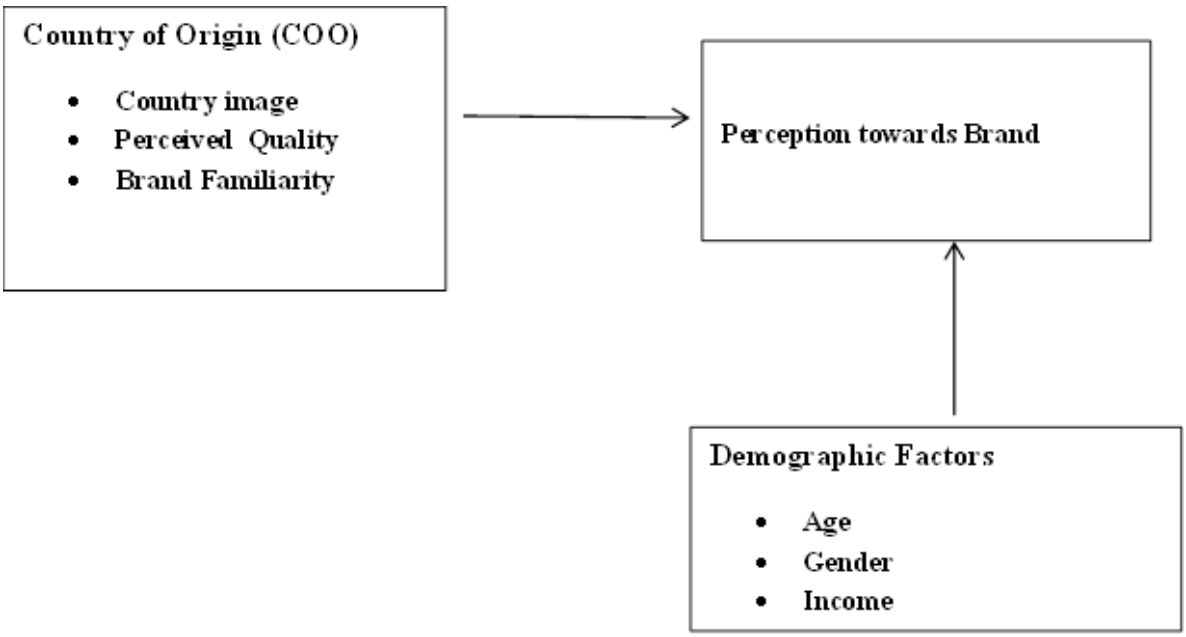

Figure 1. Conceptual framework

3. Results and Discussion

Table 01. Parameter estimation of maximum likelihood of a respondent

Parameters	Estimate	SE	X^2	$Pr>x^2$
Brand				
• Revello	-.257	.164	2.472	.116
• Cadbury	-.639	.187	11.648	.001
• Status quo	0[a]			
Quality				
• High	-.067	.206	.108	.743
• Moderate	.816	.175	21.794	.000
• Status quo	0 [a]			
Image				
• High	-.290	.156	3.426	0.643
• Status quo	0[a]			

a. Degree of freedom reduced because of constant or linearly dependent covariates
b. Constant or Linearly Dependent Covariates Toblerone = 1 - Revello - Cadbury; low = 1 - high - moderate ; plow = 1 - high

Estimated parameters of the model and relevant statistics are presented in table (2). The estimated parameter's value indicates that some of the relationships are not significant even at $\alpha = 0.10$ level. Descriptive labels for all variables are presented along with the zero coefficients for the reference levels. Within the attribute of "Brands" the part-worth utility (i.e., the estimated coefficient) for "Revello" is -.257, for "Cadbury" -.637, while part-worth utility for

the variable status quo is a structural zero. Hence Brand of Revello is preferred below the status quo (Toblerone) and the brand of Cadbury is preferred below both the status quo and the brand of Revello. The magnitude of the estimated coefficient indicates which objectives are more preferred by the sample respondents. The customer perception of the chocolate brand generally depends upon the Brand of chocolates. Under this first attribute, Cadbury proved very highly significant as indicated by the $Pr>x^2$ value even at $\alpha = 0.001$ level. Moving to the type "Quality" used in customer perceptions high Quality, moderate quality, and status quo (Low quality) situation. When compared to the status quo, high quality and moderate-quality were preferred, with the magnitude of the estimated parameter indicating high quality (-.067) was preferred below moderate quality (0.816). However, only the moderate quality proved significant at $\alpha = 0.01$ level. The third attribute tested in the model was "image". The status quo is preferred over the high image. However, all the parameters proved insignificant even at $\alpha = 0.10$ level indicating that the attribute of the image was not a significant determinant of preference in this issue.

4. Conclusions

According to the result, some attributes and levels have significant relationships. With this result can elaborate there is a relationship between choice and attributes. The utility of each attribute, customers are more preferred to purchase foreign chocolate than local chocolates. When customers are doing their purchases, they are highly concerned about the quality of the brands. When considering factors affecting perception towards the chocolate brand, concern about Country of origin and demographic factors are highly significant in the findings. Therefore, the results suggest that there is an impact on the perception of the brand based on the country of manufacture.

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An investigation on consumers' awareness and willingness to pay for organic vegetables : A case of Akuressa area

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1. Introduction

Nowadays patterns of food consumption are rapidly changing towards organic food due to various reasons. Agricultural products are grown without the support of any chemicals, synthetic pesticides, bioengineered genes, or any artificial fertilizers are called organic products. Due to the undesirable health effects of conventional agricultural products, consumers are encouraged to prefer organic vegetables. According to many studies, organic food provides a variety of advantages and nutritional value for human health such as being safer than conventional foods, immune system preserving, antibiotic resistance, greater antioxidant value, containing fewer pesticides, etc. (Gopalakrishna, 2019). When consumers move to organic vegetables, various reasons influence their buying preference and willingness to pay such as education and year of education (Piyasiri,2002). The purpose of this study is to investigate consumer awareness and factors effect for the willingness to pay for organic vegetables in the Akuressa area. Further, specific objectives identify buying preferences of organic products and to identify reasons for less consuming organic vegetables or not consuming organic vegetables. Data were collected from consumers (205) in the Akuressa area using interviews and questionnaires. The multiple regression analysis was used to determine which factors influence the WTP for organic vegetables. Organic products are considered as the best quality compared to conventionally produced products therefore the demand for organic products is increasing all over the world, as well as in Sri Lanka.

2. Materials and methods

The study area was Akuressa which is located in the Matara district of the southern province. The data collection method was interviews and questionnaires. Secondary data were collected by using various published researches, journals. The study is based on multiple regression analysis. The people who are living in the Akuressa area above 21 years old are sampling frame

Through the questionnaire, three sections have to collect information related to the survey. The first section of the questionnaire was designed to get information about the socio background of respondents like gender, age, education level, size of household, monthly income. The second section includes questions about awareness of organic vegetables and the third section is the most important section in this questionnaire which is the willingness to pay questions. It Includes open-ended questions and Categorical questions.

Face-to-face interviews with respondents were conducted using questionnaires. A sample of 205 consumers was interviewed in the Akuressa area. All these respondents were interviewed during February, March 2021, and the statistical package SPSS was used to analyze the data of this study.

The Model

$$Y = b0 + b1\ X1 + b2\ X2 + b3\ X3 + b4\ X4 + e$$

3. Results and Discussion

3.1. Socioeconomic factors

Among 205 respondents, 29.8% were male whereas 70.2% were female. Some female respondents, who were approached for an interview, refused to give an interview. The eldest consumer was of 70 years whereas the youngest was of 21 years. The average age of respondents was 40 years. 22.9% of respondents have primary education 48.3% of respondents have secondary education and the other 28.8% are university students. 63.9% of respondents were married whereas 36.1% were unmarried.

Through these socio-economic factors, three variables are highly significant with the willingness to pay variables. Those are income, size of household, education level, and monthly household income.

3.2. Consumer awareness about organic vegetables

Among the respondents, 15.1% had better knowledge about organic products, 75.1% respondents had some knowledge about organic vegetables while 9.3% did not have awareness. (Figure 01) According to the survey, the reasons for less consuming organic vegetables are insufficient to supply for market 44.4% (n=205), 22.9% respondents were mentioned as a result of the high price they have less consume of organic vegetables. According to responders insufficient supply for the market mean there are few supermarkets and the majority of grocery shop haven't organic vegetables in the Akuressa area so the organic vegetable sellers are not sufficient for this area.

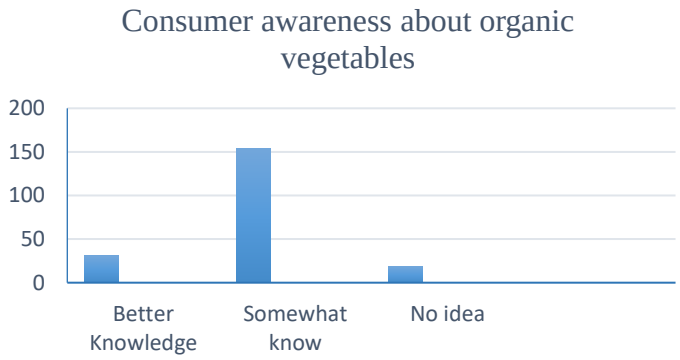

Figure 1. Consumer awareness about organic vegetables

3.3. Willingness to pay (WTP)

A multiple linear regression model was applied to estimate factors affecting for respondent's WTP. Maximum willingness to pay amount is considered as a dependent variable. Regression analysis results showed that of the four variables considered, income, size of household, education was significant at a probability level of 0.05, and monthly spend for normally vegetables was significant at a probability level of 0.01.

When adjusted R2 is closer to 1 it says there is a good model fit of dependent variables and independent variables because this model summary has a 0.885 (89%) value. According to the coefficient table, education and size of household have negative B value and income, monthly spend for normally vegetable have positive B value. It meant when income and monthly spend for normally vegetables goes 1% then willing to pay amount goes up by 0.022%,

1.455% because those two independent variables are positive. Education and size of the household go 1% then dependent variable goes down by 1111.234%, 532.102% because those are negative values. (Table 01)

Some respondents didn't contribute to the survey because some of them were on a limited budget so they didn't pay additional money for organic vegetables including 6.8% of people. 1.5% of respondents say they don't like to buy organic vegetables and 0.9% of people say this program is not important to them.

Table 01. Coefficient

Model	Unstandardized Coefficient		standardized Coefficient	t	Significant
	B	Std. Error	Beta		
(Constant)	4338.043	3407.892		1.273	0.205
Monthly income	0.022	0.011	0.070	2.089	0.038**
Size of household	-532.102	210.771	-0.069	-2.525	0.013**
Education level	-1111.234	494.551	-0.092	-2.247	0.026**
Monthly spend for vege;(Rs)	1.455	0.052	0.904	28.015	0.000***

**Significant at 5% level ***Significant at 1% level

Willingness to pay equation = Constant + income + Education + Size of household + monthly Spend on normal vegetables.

Willingness to pay = 4338.04 + 0.022**X1 + (1111.234**)X2 + (532.102**)X3 + 1.455***X4

4. Conclusions

This study indicates that consumer education effectively influences for demand organic vegetables. The willingness to pay for organic vegetables is shown to be significantly influenced only by the income, education, size of household, and amount of monthly spend for normal vegetables. Also, highly educated people are more concerned about organic products and they tend to purchase organic vegetables. Hence it could be concluded that, in general, educational programs would promote organic product consumption. Further, the majority of consumers are willing to pay a higher price for organic vegetables if those products are available in the market.

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Canned fish consumption: Impact of socio-economic and product characteristics in Bentota area, Sri Lanka

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1. Introduction

Canned fish is a value-added fish product. Fish and canned fish are sources of protein including essential amino acids, micro and macro elements (calcium, phosphorus, fluorine, iodine), types of fats that are valuable sources of energy, fat-soluble vitamins, and unsaturated fatty acids (Ismail, 2005). Due to unique nutritional values and long shelf life, consumption of canned fish products is beneficial for consumers. The national consumption of canned fish is at 250,000 cans per day (Perera, 2020). To meet such demand, the public and private sectors together commenced the local canned fish production where the factory was established in Galle in 2012. The production capacity was 10,000 cans per day. Then the second factory was established in Paliyagoda by the TESS group with a daily production capacity of 24,000 cans (Jayapala and Jayasiri 2018). Compared to the resource availability and the demand for canned fish products, the local production of canned fish is still at its infant stage. The strategic alignment of product characteristics with consumer preference will be insightful for local producers to grab the local market effectively. Therefore, the current study investigated to identify whether the socio-economic factors (family size, age, occupation, average monthly income) of consumers affect canned fish consumption and to determine the impact of product characteristics (price, quality and discounts) of canned fish products available at the local market. Knowing the factors affecting consumer consumption of a product have a competitive advantage to formulate the most appropriate marketing strategy and increase customer satisfaction for the products.

2. Materials and Methods

Bentota area was primarily selected as the study area where a total of 100 respondents were selected through the convenience sampling technique during the primary data collection. Convenience Sampling is a type of non-probability sampling technique that allows a researcher to select a sample of units from a population (Etikan 2016). The sample size is calculated using the formula n=N/1+N(e)^2 provided by Yamane (1967:886) (n= sample size, N= Population, e= level of precision (±10%) (Israel 1992). A structured questionnaire was designed using a google form to collect the primary data for the study. The questionnaire was spread widely in social media such as Facebook, Twitter, online messenger services and WhatsApp.

The questionnaire included socio-economic factors such as age, gender, education, income, occupation, family size and the purchasing information of canned fish; purchase frequency and monthly consumption. By utilizing a 5-point Likert scale where; 1= strongly disagree to 5 = strongly agree, consumers were asked to score the effect of price, quality, and discounts to know whether the product characteristics influence the consumption of canned fish products. The reliability test was used to determine the quality and usefulness of the test, while descriptive statistics, frequency analysis, and percentage analysis were used to understand the purchase and consumption behavior (Ibrahim, Abdul Fatah, and Saili 2020). Multiple

regression analysis was used to identify the significant factors that affected consumer consumption of canned fish products. Multiple regression was vastly used to determine the relationship between a dependent variable and an independent variable (Kraemer et al. 2003).

3. Results and Discussion

The descriptive test results explained that the respondent cohort was composed with 65 percent of female respondents and 35 percent were males. Among them, 57 percent were married and 43 percent were single. The 74 percent of respondents were mostly degree/ diploma holders. They belong to the government sector, private sector employees, students, unemployed and self-employed with 14, 18, 14, 7, and 47 percent respectively. Out of them, 40 percent of respondents frequently, 28 percent for special occasions, 24 percent rarely, and 8 percent very rarely have purchased canned mackerel fish products.

Table 01. Coefficient results of regression analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-246.130	76.685		-3.210	0.002
	Age	-000.460	00.781	-0.016	-0.589	0.557
	Occupation	001.553	06.222	0.007	0.250	0.803
	Family size	067.028	15.789	0.280	4.245	0.000
	Average Monthly Income	000.004	.001	0.238	4.461	0.000
	Price	-025.750	11.229	-0.063	-2.293	0.024
	Quality	067.605	26.399	0.164	2.561	0.012
	Discount	105.188	18.960	0.337	5.548	0.000

a. Dependent Variable: Monthly Consumption

According to the multiple linear regression results, the R square was reported at a value of 0.936 and can be accepted for the regression analysis with a statistical significance of $p<0.05$. This indicated that independent variables (age, family size, average monthly income, occupation, discount, price, and quality) possessed an association with the dependent variable (monthly consumption). This link showed that each independent variable elaborated 93.6 percent of the variation, which occurred in monthly consumption. The Durbin-Watson statistical was 1.907 which means that the residuals are uncorrelated and the independence error assumption is satisfied.

Based on table 1, Age (β=-0.460, $p> 0.10$) and occupation (β=1.553, $p>0.10$) have not significantly influenced the consumer consumption of canned fish products. Family size (β=67.028, $p<0.01$), average monthly income (β=0.004, $p<0.01$) and the product characteristics such as price (β=-25.750, $p<0.05$), quality (β=67.605, $p<0.05$) and discounts (β=105.188, $p<0.01$) have a significant influence on the canned fish consumption. These results tell that a one-point increase in family size (X1), average monthly income (X2), quality (X4) and discounts (X5) are expected to increase in monthly consumption of 67.028, 0.004, 67.605, and 105.188 respectively. Price (X3) has a significantly negative impact as expected. Hence each unit increase in price is expected to decrease by 25.750 units in monthly consumption.

$$\hat{Y} = -246.130 + (67.028)\, X_1 + (.004)\, X_2 + (-25.750)\, X_3 + (67.605)\, X_4 + (105.188)\, X_5 + \varepsilon$$

$\hat{Y}$= Monthly Consumption (Dependent variable)

X_1= Family size
X_2= Average monthly income
X_3= Price
X_4= Quality
X_5= Discounts
ε = Error term

Results associated with socio-economic factors indicated that the characteristics of the family and monthly income strongly influence the monthly household canned fish consumption. The statistical results of product characteristics showed that consumers place high concerns on price, quality and discounts of canned fish products. This result indicated that product quality is an essential factor in canned fish consumption. Consumers are likely to choose high-quality products as they are rich in terms of taste and nutritional aspects (Goyal and Singh 2007). Besides that, the price also significantly influences the monthly canned fish consumption plus the available discounts. Consumers were normally attracted to canned fish with a worth value. Discount is a significant factor that attracts more consumers. Increased consumption is boosted by higher discounts with lower prices and high-quality canned fish products.

4. Conclusions

It is important to get an idea about socio-economic factors and product characters that affect consumer consumption of canned fish. The producers' hands-on information about socio-economic factors that support market segmentation is important for any business. According to the findings consistent good quality, affordable price, and promotional activities such as discounts of products are major factors to get a competitive advantage from canned fish production. The findings of the current study provide the insights to increase sales and increase the market share hold by local canned fish production, which is a crucial factor in reducing the import of canned fish products to some extent.

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Factors affecting youths' interest towards agricultural entrepreneurship: A study in Mattegoda area in Sri Lanka

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1. Introduction

Agriculture is the backbone of the economy in many developing countries like Sri Lanka (Pelzom et al., 2017). It provides livelihood for half the total population. Agricultural entrepreneurship plays a vital role in the making of society and the developing economy of a country. It is a weapon that helps battle unemployment, makes productivity, and helps accomplish competitive dominance (Sahni et al., 2020). Young people are crucial in generating economic sustainability in agriculture because they are the productive group in the overall population (Abdullah et al., 2013). But the youths' participation in agricultural businesses has been decreasing over the years because most of them tend to find non-agricultural jobs thinking that agribusinesses are not profitable and not prestigious. The economic crisis of the country has also made pitfalls to youths to find appropriate and fruitful jobs. As a result of that, the rising of unemployment particularly among youths has become higher (Davies, 2008). In this study, the objectives are to identify factors that affect youths to become agricultural entrepreneurs and to analyze the relationship of the factors with the youths' interest involved in the agricultural sector as agricultural entrepreneurs. The research was conducted in the Mattegoda area where youths are diversified in their age, gender, ethnicity, marital status, educational level, income, and employment to achieve the above objectives.

2. Materials and Methods

This study used a random sampling method. Data were randomly collected from 200 youths who are between the ages of 18 and 35 years in the Mattegoda area in Sri Lanka as the respondents. Data was collected by selecting houses two by two using a self-administrated questionnaire. The questionnaire is separated into four categories. Category A describes the socio-demographic characteristics of the respondents.

Category B explores the factors that affect youths to become agricultural entrepreneurs. The factors are identified from the previous literature reviews are; attitudes, knowledge, and personality of the respondents to become an agricultural entrepreneurs. These factors were analyzed by using five-point Likert scales ranging from 1= Strongly Disagree to 5= Strongly Agree. Based on that, the mean values of these three factors were analyzed using SPSS.

Category C explores the relationship of factors with the youth's interest to become agricultural entrepreneurs. The dimensions of three factors; "attitude", "knowledge" and "personality" are considered as independent variables. The dimension of the factor "interest" is considered as the dependent variable.

The statements of the five-point Likert scales are developed based on the literature and the knowledge of the author. Altogether there are 29 statements of both dependent and independent variables to be analyzed. A reliability test was done for all 29 statements by using SPSS. The relationship between factors and youths' interest to become agricultural entrepreneurs are

determined by the multiple regression method using SPSS. Section D is an open-ended question to investigate the other factors that influence youths to become agricultural entrepreneurs.

3. Results and Discussion

The socio-demographic characteristics such as age, gender, race, religion, marital status, income, educational level, and employment of each respondent are recorded as descriptive statistics. To answer the first objective of the study which identifies the factors that affect the youths to become agricultural entrepreneurs, the mean values of each independent variable are measured. The mean value of variable attitude is 4.2436, the mean value of variable personality is 4.2050 and the mean value of variable knowledge is 4.1350. All these mean values are measured from the result of the five-point Likert scales. According to these results, it can be determined that all respondents have agreed that these variables are the factors that influence the youths' interest in agricultural entrepreneurship.

To answer the second objective of the study which analyses the relationship between factors and youths' interest to become agricultural entrepreneurs, multiple regression results are investigated. There are three factors of independent variables are identified such as attitude (X_1), knowledge (X_2), and personality (X_3) while the dependent variable is identified as the youths' interest to become agricultural entrepreneurs (Y). According to the result, the model is significant ($F_{3, 196}=4.812$ $p<0.05$) because the model p-value is 0.003 which is less than the alpha value of 0.05. The adjusted R square is 0.54 which depicts that it contains a moderate model fitness.

According to the results in table 1, the attitude factor and personality factor are significant as the p values (0.006 and 0.008) are less than the alpha value of 0.05. It shows that these two factors have a strong and significant relationship with the youths' interest in agricultural entrepreneurship. The significant relationship between the variable attitude and youths' interest to become agricultural entrepreneurs is similarly mentioned in the previous literature (Abdullah et al., 2013). But the knowledge factor is not significant because the p-value (0.229) is higher than the alpha value, so that, the knowledge factor has no significant relationship with the youths' interest in agricultural entrepreneurship. This insignificant relationship between the level of knowledge and interest of youths is similarly mentioned in the previous literature (Abdullah et al., 2013). Regression coefficients for the equation can be found in column "B" in table 1 and it shows the unstandardized regression coefficient. The regression coefficient equation is;

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 ..... + \beta_nX_n + \varepsilon$ ($\varepsilon=0$),

Interest = 3.407 + 0.231(Attitude) + 0.102(Knowledge) – 0.247(Personality).

As the other factors that can impact youths to become agricultural entrepreneurs, 47.5% of respondents have recorded as family support, 31% of respondents as technology, 14.5% of respondents as experience, 11.5% of respondents as government support, and 11% of respondents as promotional programs. According to the results of the reliability test, the Cronbach's Alpha value is 0.729 which indicates that the overall scale is having good reliability.

Table 01. Coefficients of the independent variables

Model	Unstandardized Coefficient		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	3.407	0.393		8.679	0.000
Attitude	0.231	0.083	0.245	2.772	0.006
Knowledge	0.102	0.084	0.095	1.206	0.229
Personality	-0.247	0.092	-0.219	-2.672	0.008

4. Conclusions

The attitude of the respondents and personality to become an agricultural entrepreneur including risk-taking ability, innovative thinking, persistence, enthusiasm, and optimism have a significant relationship with the youths' interest to become an agricultural entrepreneur while the knowledge level is relatively insignificant to become an agricultural entrepreneur. Like the other factors, promotional programs such as exhibitions and competitions, family support, government support such as providing infrastructure, subsidies and raw materials, technology, and experiences are also equally important to promote agricultural entrepreneurship among youths. These results show that youths have an interest in agricultural entrepreneurship but the other factors also should be equally considered.

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Assessment on factors affecting towards consumer preference of powdered milk vs fresh milk in Sri Lanka: A case of Rathnapura divisional secretariat division

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1. Introduction

Having a cup of milk tea is very common habit of Sri Lankan lifestyle. Milk is a balanced food which is rich in nutrients such as protein, calcium, phosphorous and vitamins. The dairy sector in Sri Lanka is a sub sector of livestock sector and it had growing well from the past to present due to open economic system (Perera, 2018). With the development of technology milk came out in different forms. Powdered milk is one form of milk. Due to the busy lifestyle, most of the people start to go for powdered milk instead of fresh milk. In 1970's 80% of demand for milk is fulfilled by local market. But at present, only 33% is covered by local market and the remaining is met by imported milk by spending a significant portion from GDP. It was due to the brand positioning strategies of well reputed multi-national companies. However imports of dairy sector had turned down after the detection of DCD (Dicyandiamide) in imported milk powder which caused to change the consumer preference toward local brands. (Vidanapathirana, 2017). This had created great opportunity to local milk producers to grab the market. The study is investigating with the aim of identifying factors which influence to consumer preference on powdered milk vs. fresh milk. Having information on consumer preference on milk is the key determinant to uplift the efficiency of the local dairy sector. And also analysis of information on consumer preference is help projection of the future development of the dairy sector in Sri Lanka.

2. Materials and Methods

The approach is to identify the factors which had affected on consumer preference towards powdered milk vs. fresh milk by using the conceptual model. The selected study location is Rathnapura Divisional Secretariat Division, which is located at Sabaragamuwa province in Sri Lanka. The sampling frame of this study is individual from a household. The sample size is about 300. The sampling technique which had used to collect data is simple random sampling method. Primary data collect through structured questionnaire using in depth interviews. Published articles, research papers, and documents will use as the secondary data. This approach belongs to the quantitative data analysis. Descriptive statistics and binary logistic regression were used to examine the results. The relationship between the dependent variables and the independent variable had examined by using binary logistic regression. The dependent variables of this survey are consumer preference of powdered milk and consumer preference of fresh milk. Independent variables are personal factors, economical factors, psychological factors, social factors. Furthermore, the conceptual model was developed based on the literature review. The developed conceptual model is showing in the below figure.

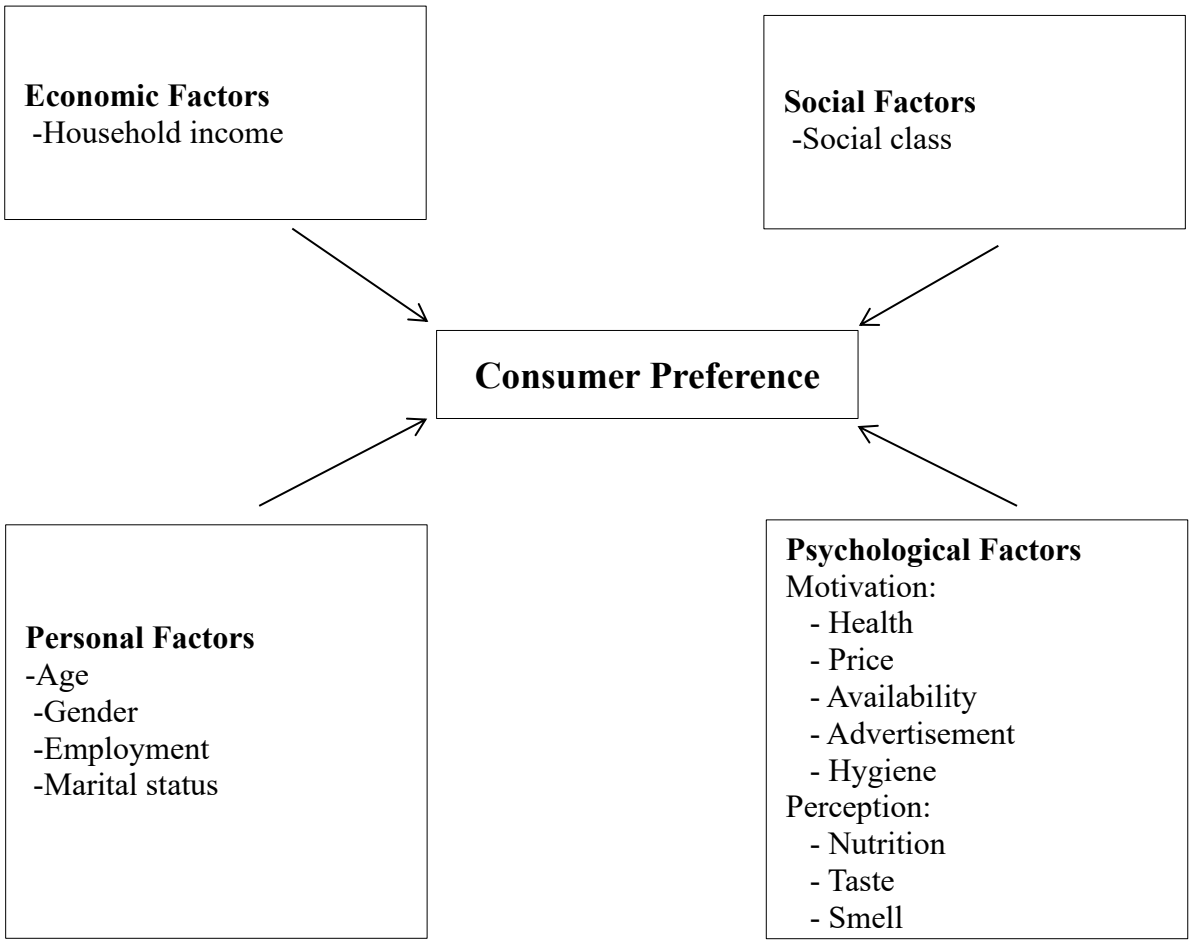

Figure 1. Conceptual model

3. Results and Discussion

Descriptive statistics

According to the results the socio-demographic profile of participants revealed that, most of the participants were male (52%). The majority level of education is up to higher level (40%). The 38% of participants were full time employed. When considering marital status of participants the majority were married (59%). In terms of monthly household income, the 63% of participants received mean household income in between LKR 40 001 - 80 000. Among 300 participants most of the individuals about 62% is prefer to drink powdered milk and only 37% is prefer to drink fresh milk. So it is suggest that the most preferred milk of consumers is powdered milk.

Binary logistics regression

Binary logistic regression was used to identify the factors which had affected on dependent variables. The dependent variables of this survey are consumer preference of powdered milk and consumer preference of fresh milk. The independent variables are age, gender, employment, marital status ,income, social class, health, price, availability, advertisement, hygiene, nutrition, taste and smell. According to the Classification table results, overall percentage predicts that, this approach to prediction was correct 69.2% of the time. Omnibus tests of model coefficients results revealed that, Chi-square value (47.90) was very significant at 0.01 level ($p = 0.001 < 0.01$). Therefore it suggests that estimated model is significant.

According to the Model summary test results, Nagelkerke R square suggests that the model explains 20% of the variation in the outcome.

According to the Variables in the equation results, variable full time employment status and variable marital status of married were indicated positive significant (at 0.05 levels) relationship with consumer preferred milk. Variables including income, health, and perception were significant at 0.05 level and they were positively associates with dependent variables as beta values indicated positive values. It means if income of consumer, health and perception properties are increased then the preference toward powdered milk or fresh milk is increasing. Also variables including availability and sensory were very significant at 0.01 level and indicated positive relationship with dependent variables. It suggests that if the preferred milk is highly available and sensory properties are increased then the preference toward fresh milk or powdered milk goes up. Further, variable advertising was highly significant at 0.001 levels and indicated positive beta value. It suggests that advertising is highly affected on consumer preference toward milk and if the advertising strategies were increased the preference of consumer toward fresh milk or powdered milk goes up. Even though variable price is significant at 0.05 level it is having negative relationship with preferred milk means increase of price lead to reduce the consumer preference on milk. However the other factors including at the conceptual model (independent variables) such as, personal factors including age, gender and social factor including social class were not add significantly to the model which means those variables were not associate to preferred milk of consumers.

Model can written as,

$$\ln[p/(1-p)] = 0.327 + 0.85X1^{*} + 0.83X2^{*} + 2.01X3^{*} + 2.25X4^{*} - 2.34X5^{*} + 3.11X6^{**} + 0.34X7^{***} + 1.15X8^{*} + 2.42X9^{**} + 1.0X10 - 1.01X11 + 0.88X12$$

$^{*} = 0.01<P<0.05$ $^{**} = 0.001<P<0.01$ $^{***} = P<0.001$

Table 01. Variables in the equation results

Variable	Description	Sig.	B
Personal Factors:			
Employment	Employment status		
	Full time	0.036	0.843
Marital	Marital status		
	Married	0.048	0.826
Economic Factors:			
HouseholdIn	Monthly household income	0.044	2.012
Psychological Factors (Motivational):			
Health	It is a great source of bone development and strengthen the tooth persuade me to buy it	0.043	2.250
Price	It has fair price persuades me to buy it	0.046	-2.341
Availability	It is easy to find at any area	0.007	3.117

Advertising	The message on advertisement attempts to persuade me to buy it	0.000	0.364
Psychological Factors (Perception):			
Nutrition	It is nutrition as it contain protein, calcium, vitamins and minerals	0.022	1.159
Sensory1	It has nice smell and good taste	0.009	2.425
Constant		0.329	0.327

4. Conclusions

According to the results estimated model was statistically significant with Chi-square value of 47.90 and $p < 0.001$. According to the descriptive statistics results suggests that preference for powdered milk is higher than the preference for fresh milk. The aim of this study is to identify the factors which had affect for the consumer preference on powdered milk vs. fresh milk. Factors included in the conceptual model such as full time employed, married, monthly household income, health, price, availability, advertising, nutrition, and sensory had significantly affected to the preference toward powdered milk vs. fresh milk. But other factors including age, gender and social class were not affected for this. The findings of this study will help for future projections to uplift the dairy industry in Sri Lanka.

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Assessing farmer's preference for sustainable agricultural practices in Kurunegala area by using choice experiments

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1. Introduction

Sustainable agriculture is a combination of practices which mitigate damage to the environment. (Flora, 2008). According to FAO 2011, Sustainable Agricultural Practices (SAP) are the practices that can sustain the health of the agricultural lands, soil, water and biodiversity. Those practices include approaches like farming system management, soil conservation, pest, and environmental conservation (INRA, 2016). Adopting SAP is a win-win strategy for developing countries because of their potential to enhance food security and mitigate environmental issues (Zeweld et al., 2017). The emergence of green agricultural innovations includes many SAP practices like precision farming, enhanced nutrient management and irrigation systems (Adnan, et al., 2017). Due to enhanced yields, easy application, and the government subsidy, the usage of synthetic fertilizer introduced with the green technology has been increased dramatically and created negative effects on the environment and human health. With a proper training and support, farmers are considered as the agents to introduce SAP. Hence, assessing their preference towards SAP is an indispensable preliminary step to promote sustainability (Füsun Tatlıdil et al., 2009). Most of the empirical studies followed the traditional ranking methods to investigate farmer perception on SAP but dearth of studies following the random utility theory in Sri Lankan context. Given this gap, major objectives of this study are (a). to explore the farmer's level of importance for selected SAP practices and, (b). how socio-economic factors affect their attitudes towards SAP using random utility theory (choice experiments). The results of this study are judicious and help policymakers to formulate policies to promote SAP and initiate necessary extension programs.

2. Materials and Methods

This study uses Choice Experiments (CE) to explore farmer preference for selected sustainable practices. CE are a derivative of conjoint analysis which is used to estimate the structure of an individual's preferences by developing the relative importance of attributes (Wattage et al., 2005). In here, selected sustainable practices are considered as key attributes and their attached levels. These attributes and levels produce a total of 56 different combinations using the main effects design. By employing an orthogonal design 56 combinations were reduced to 9 choice cards. Respondents are allowed to select their most preferred profile. The choice cards were displayed in the second section of the questionnaire and used a Conditional Logit Model (CLM) to estimate the parameters explained under each attribute. According to Wattage, et al., (2011) CLM gives the probability that individual i selects alternative j as a function of the attributes that differ for the alternatives and unknown parameters. Xij is used as a vector of attributes site j and individual i, with the probability that individual i selects alternative j considered as:

$$\mathrm{P}\, r_i\,(j) = \frac{e^{Xij\beta}}{\sum_{K=1}^{J} e^{Xik\beta}}$$

The questionnaire includes several socio-economic and farming-related questions important for the analysis and validation of the choice results. Descriptive statistics were used to interpret the results.

Primary data was gathered by using a questionnaire completed by 100 farmers who engage in paddy farming in four Grama Niladari divisions of Polgahawela DS division in Kurunegala district based on location, population density, and paddy farming potential. Simple random sampling was adapted as the sampling technique.

Table 01. Attributes and accompanied objective levels

Attributes	Level 1	Level 2	Level 3
Usage of fertilizer	Chemical	Organic fertilizer	Biofertilizer
Method of pest control	Chemical	Integrated pest management (IPM)	Traditional
Type of farming	Smart farming (Using machinery with ICT technology)	Conventional (Without ICT technology)	-
Willingness to pay (WTP) (The amount people would like to pay for the benefits they are receiving through sustainability)	40000	30000	20000

3. Results and Discussion

3.1 Choice Model on assessing the preference for SAP.

The model has chi-square values for all the tests 45.633, 50.366 and 50.366 respectively. They are significant at 1%, showing a strong relationship between attributes and the levels.

"Fertilizer": The organic and chemical fertilizer are preferred over biofertilizer which is the status quo. Organic fertilizer (1.299) is preferred at 1% over chemical fertilizer (0.601) at $\alpha = 0.1$ level. Therefore, organic fertilizer is mostly preferred by the farmers. The negative impacts which create to the environment and for human health due to higher usage of chemical fertilizer is the major reason for this. (Widyanti et al., 2014).

"Pest control": Chemical pesticides and IPM methods were tested against traditional methods of controlling pests which is the status quo. Chemical pesticide (1.255) was preferred over the IPM method (1.027). Both parameters tested under this proved highly significant at $\alpha = 0.01$ level.

"Farming method": The Smart farming parameter is not significant even at the $\alpha = 0.1$ level. Therefore, it makes no sense for the model. The reasons could be inappropriateness of the sampling method, respondent's mindset at the time of data collection, and lack of

understanding (Wattage et al., 2011). Therefore, the farming method was not a significant determinant of farmer preference. Further research should be conducted to explore exact reasons for the insignificance.

"Willingness to pay (WTP)": The parameter 40,000.00 LKR (0.649) was significant at the α = 0.05 level. However, 30,000.00 LKR is not having any effect on the model because it's insignificant. Therefore, the results can be concluded as farmers would like to pay more for the benefits that they are getting through moving towards innovative SAP.

Table 02. Results of conditional logit regression analysis

Parameter variable	Estimate	SE	Wald	df	Sig	Exp(B)
1.Fertilizer application						
Chemical fertilizer	0.601	0.322	3.489	1	0.062	1.824
Organic fertilizer	1.299	0.316	16.930	1	0.000	3.667
Bio fertilizer				0		
2.Pest control						
Chemical pesticides	1.255	0.369	11.568	1	0.001	3.509
IPM	1.027	0.372	7.601	1	0.006	2.792
Traditional methods				0		
3. Farming method						
Smart farming	0.334	0.294	1.284	1	0.257	1.396
Conventional farming				0		
4. Willingness To Pay (WTP)						
40000LKR	0.649	0.286	5.153	1	0.023	1.914
30000LKR	-0.373	0.309	1.452	1	0.228	0.689
20000LKR				0		

3.2. Relationship between preference towards SAP and socio-economic characters of Sri Lankan Paddy farmers.

Land ownership, preference for SAP, and ability to practice SAP were identified as the most significant socio-economic characters. Majority are male farmers accounting 76 percent. among the respondents, 45 percent had primary education and (42%) had secondary education. Only (6%) is having a university education. Therefore, majority of the respondents don't have a sound formal education. And 82 percent were their own land holders and a similar percent prefer SAP. This reveals that every farmer who owns their land has a higher perception of practicing SAP than those who do not possess a own land. This is also supported by a study done by (Füsun et al., 2009). Most of the respondents in this area engaged in paddy farming mainly for their own household consumption as they own additional income sources with mean worth of 25,830.00 LKR. Therefore, respondents mostly think about health and land sustainability, and choose to apply organic fertilizer as their first preference and they prefer IPM as the second preference to eradicate pests. However, some farmers prefer chemical fertilizer and pesticides as they possess poor educational background (45%), and lack of awareness (25%), and comparative difficulty in engaging in SAP (37%) and leading to ignore in adapting sustainable farming practices (18%). This could be a reason to select synthetic pesticides over IPM.

4. Conclusions

This study was done to assess farmer perception towards adopting SAP and the relationship between socio-economic factors. According to the results, application of organic fertilizer, chemical pesticides, and prefer to pay Rs. 40000 to value the benefits they are receiving through adopting SAP, are the most preferred combination of alternatives in CE. Majority, of the

farmers are willing to practice SAP. Because majority are engaged in paddy farming for household consumption and SAP is beneficial for both human and production. Overall, promoting new trends and techniques for SAP and initiating extension programs to promote organic fertilizer and IPM methods to reduce chemical pesticide usage are recommended.

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An investigation of consumers' awareness and consideration on the nutrition facts table of dairy products when making the buying decision in the Balangoda area

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1. Introduction

Dairy products are an essential part of the diet in many regions of the world. Dairy products often give the foundation for the first foods introduced to infants as they provide a good balance of nutrients and a variety of essential vitamins and minerals. In recent years nutritional issues in Sri Lanka have been increased due to wrong food consumption patterns. There are many significant diet-related public health problems and diseases occurred in recent years. The World Health Organization reported that dietary factors accounted for approximately 30% of cancers in industrialized countries. People can decrease diet-related public health problems and diseases from concerns of food nutrition. Therefore, the nutrition facts table on the label of food products can minimize these health issues. It gives information on serving size, calories, and percentage of daily intake value of food products. The nutrition facts table can affect the consumers' purchasing behaviour because some evidences reveal that nutrition information may allow consumers to switch consumption away from unhealthy products toward healthy products more easily (Gary & Zarkin, 1992).

Considering the significant role of consumers' awareness about food labels in making healthy food choices, this survey tries to get comprehension about consumers' awareness and consideration on nutrition facts table of dairy products when making the buying decision in Balangoda area. The study also identifies factors that consumers consider other than nutrition facts, level of nutrition knowledge, and use of their nutrition knowledge and understanding of nutrition information on food labels.

2. Materials and Methods

This study used primary data, and data were collected through structural questionnaires. It was distributed as a Google form questionnaire with randomly selected people in Balangoda area. The study location is Balangoda, and the target people of this study are the people who use dairy products in the Balangoda area. The simple random sampling technique is used as a sampling technique, and the sample size of this study was 200 respondents. The first part of the questionnaire sought socio-demographic profiles such as gender, age, marital status, education, and family's monthly income. The second part of the questionnaire had questions about consumers' awareness and consideration of the nutrition facts table of dairy products using open-ended, close-ended questions. It also included questions seeking consumers' consideration of other factors when they purchase except for the nutrition facts table of dairy products. Although consumers' perception of dairy products, nutrition information, how these affects their buying behaviour. Consumer knowledge about the nutrition of dairy products was captured by using close-ended questions. All these questions were created to fulfil the broad objective and other specific objectives. Data analysed by Binary Logistic Regression and Descriptive Statistics using SPSS (Statistical Package for Social Sciences) version 25.

3. Results and Discussion

Table 01. Variables in the equation

	B		S.E.		Wald		df		Sig.		Exp(B)	
	A	C	A	C	A	C	A	C	A	C	A	C
Gender	0.072	0.200	0.537	0.410	0.018	0.239	1	1	0.893	0.625	1.075	1.222
Age	-0.083	-0.057	0.029	0.026	8.242	4.878	1	1	0.004*	0.027*	0.920	0.945
Marital status	1.754	0.840	0.710	0.543	6.102	2.398	1	1	0.014*	0.122	5.775	2.317
Level of education	1.816	0.980	0.646	0.330	7.890	8.818	1	1	0.005*	0.003*	6.146	2.665
Level of monthly income	0.000	0.000	0.000	0.000	1.620	0.056	1	1	0.203	0.183	1.000	1.000
Use of dairy products	0.585	-0.071	1.429	1.339	0.168	0.003	1	1	0.682	0.958	1.795	0.932
Constant	-1.723	-1.586	2.448	1.756	0.495	0.816	1	1	0.482	0.366	0.179	0.205

B: coefficient, S.E.: standard error, Wald: wald chi-square value, df: degrees of freedom, Sig.: significance level, Exp(B): odds ratios, A: Awareness on the Nutrition Facts Table of Dairy Products, C: Consideration on the Nutrition Facts Table of Dairy Products

Note: * statistically significant *p* at the 0.05 level

Demographic characteristics by awareness on the nutrition facts table of dairy products

Binary logistic regression was used to determine the influence of the predictor variables (gender, age, marital status, level of education, level of monthly income, use of dairy products for fulfill needs) on outcome variable (consumer awareness on the nutrition facts table of dairy products).

The full model containing all predictors was statistically significant, $x^2(6, N=200) = 62.535$, with a *p*-value of 0.000 ($p<0.000$), indicating that the model was able to distinguish between predictor variables. The results demonstrated a good fit of data to the model. The log-likelihood ratio, which measures the goodness of fit is 96.470. This ratio is relatively low, implying that the model fit is perfect. The model as a whole explained between 52.4% (Nagelkerke R squared) of the variance in predictor variables. Therefore, the Classification Table is correctly classifying the outcome for 88.4% of the cases. This indicated the existence of a moderately strong relationship between prediction and grouping for this model.

In assessing the influence of demographic indicators of the respondents, the estimated coefficients for age (0.004), marital status (0.014), and level of education (0.005) were found statistically significant; indicating that these factors are likely to influence the consumer awareness on nutrition facts table of dairy products. Exp(B) value (odds ratio) for age is 0.920, means that for each one unit increase in age, there is lesser likelihood in awareness of nutrition facts table of dairy products of 0.920 units (Odds ratio>1). According to the odds ratio, highest impact shows in level of education (6.146) (Table 01).

Demographic characteristics by consideration on nutrition facts table of dairy products

Binary logistic regression was used to determine the influence of the predictor variables (gender, age, marital status, level of education, level of monthly income, use of dairy products for fulfill needs) on outcome variable (consumer consideration on the nutrition facts table of dairy products).

The full model containing all predictors was statistically significant, $x^2(6,N=200) =30.667$, with a *p* value of 0.000 ($p<0.000$), indicating that the model was able to distinguish between predictor variable and demonstrating adequate fit of data to the model. The Model Summary provides the 156.468 log-likelihood ratio which measures the goodness of fit. This ratio is

relatively low, implying that the model fit is perfect. The model as a whole explained between 26.2% (Nagelkerke R squared) of the variance in predictor variables. Classification Table is correctly classifying the outcome for 70.7% of the cases.

In assessing the influence of demographic indicators of the respondents, the estimated coefficients for age (0.027) and level of education (0.003) were found statistically significant, indicating that these factors are likely to influence the consumer consideration on the nutrition facts table of dairy products. Exp(B) value (odds ratio) for age is 0.945, means that for each one unit increase in age, there is lesser likelihood in consideration of nutrition facts table of dairy products of 0.945 units (Odds ratio>1). According to the odds ratio, highest impact shows in level of education (2.665) (Table 01).

Table 01 shows effect of demographic characteristics to consumers' awareness and consumers' consideration on nutrition facts table of dairy products. Higginson et al. (2002) cite studies which indicate that in the UK 62 % of consumers are aware of nutrition labels only 22%-59% of adults look for information on nutrition when shopping.

Factors consider other than the nutrition facts table

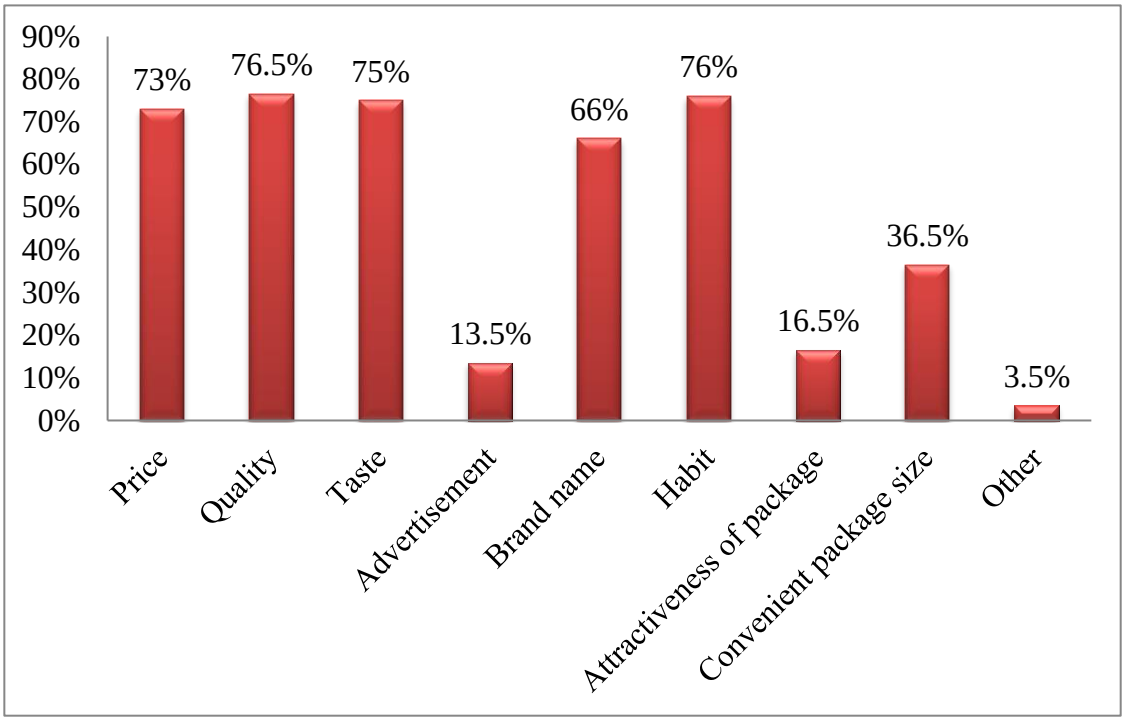

Figure 1. Factors consider than the nutrition facts table

Product quality is shown to be a significant factor with 76.5% of the impact on consumers when purchasing dairy products.

Consumers' knowledge regarding nutrition facts of dairy products

For the purpose of investigating consumers' knowledge of the nutrient components of dairy products, they were asked to give their opinions for four statements as their knowledge. For the first statement 74.5%, the second statement 86%, the third statement 53.5%, and the fourth statement 80.5% were correctly answered. As an average 73.6% consumers' have knowledge about nutrition of dairy products.

4. Conclusions

The level of awareness on the nutrition facts table of dairy products among consumers in Balangoda area is relatively high (77%). However, most consumers do not consider such information to make their purchases. Awareness and consideration of nutrition facts table in Balangoda area does vary according to demographic characteristics of consumers. Among predictor variables age, marital status, and level of education were statistically significant in terms of awareness on nutrition facts table of dairy products and age, level of education were statistically significant in terms of consideration on nutrition facts table of dairy products. Results indicate that product quality is the main factor except for the nutrition facts table, which consumers considered. The study highlights as an average 73.6% have knowledge about nutrition of dairy products.

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Liquid and powder milk consumption patterns and preference among undergraduates

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1. Introduction

Milk plays a crucial role in minimizing food insecurity. Although fresh milk is the most heavily consumed beverage in the world, the level of consumption in Sri Lanka is considerably low with a per capita consumption of about 4.14 kg per year. Only about one percent of the population on the island consumes fresh milk regularly as compared to 63 percent of other consumer varieties of full cream milk powder (Susudu et al., 2006). Studies on milk and milk products in Sri Lanka are concentrated only on a few regions and communities (Abeywickrama et al., 1965; Susudu et al., 2006). Milk consumption among Sri Lankan undergraduates is not well understood so far. So the empirical gap has been set on the preference and consumption pattern of milk among university students. Since they are considered as the cream of the young generation, their wellbeing is a consideration to the future economy of the country. To see whether becoming an undergraduate has affected their consumption pattern and preference of liquid and powder milk within five-year period was focused on this study. Understanding the consumption will identify the bottlenecks that hinder the growth of the liquid and powder milk production and target specific measures for developing market opportunities to meet the demand of young consumers (Njarui et al., 2011). Consumer buyer behavior is influenced mainly by social, cultural, personal, and psychological factors. These factors affect consumer preferences about developing products and brands (Rani, 2014). This paper investigated the buyer behavior, effect of demographical factors, and availability on consumer trends among undergraduates.

2. Materials and Methods

The study was carried out with 334 undergraduates residing in different provinces in Sri Lanka representing 44% Western, 10%, Central, 17% Southern, 2% North Central, 3% Northern, 2% Eastern, 6% North-Western, 3% Uva, and 13% in Sabaragamuwa provinces. An online questionnaire form was created to gather data; hence, the survey did not include direct questioning and informal discussion. All the respondents were randomly selected representing state universities in Sri Lanka. The study was carried out from April to September 2020. Information collected included household demographic characteristics, milk and milk products consumption pattern, consumption frequency and preferences. The living area at the time of data collection was taken as the residential area of the students. The frequencies of consumption were sourced on a daily, weekly and monthly bases.

Data were converted into a spreadsheet and checked for errors before analysis. Data Analysis was performed with descriptive statistics and Chi-square test using the Statistical Procedures for Social Sciences (SPSS) version 26 for Windows (SPSS 10). The results are presented using descriptive statistics, tables, and graphical illustrations. Chi-square formula was performed as:

$\chi^2_{test} = \sum \; [((Qi - Ei))/Ei] \; ^2$ where; X^2: Chi-square value, Q*i*: observed frequency, E*i*: expected frequency.

3. Results and Discussion

Based on the demographic characteristics, the survey involved 334 students, representing 227 females and 106 males. 214 of them were studying in Science faculties, 65 in Management and 52 in Arts faculties. The age levels of the students with their percentages were; 18-22 years old (17%), 23-26 (77%), and 27- 30 (6%) respectively. Household sizes of the respondents were as 1-4 family members (4.2%), 5- 8 (56.8%), and 9-12 (38.7%). Living areas of students were categorized into three groups such as urban (73%) semi-urban (22%) and rural (5%). According to the survey results, 92% of students preferred to consume any form of milk, whereas 8% of students did not prefer to consume milk. Under the hypothesis that there was no significant association between demographic characteristics to the preference towards milk, only 'gender' had a significant association with a 90% confidence interval (X^2 =0.285; P=0.10) which implies more females prefer to consume milk than males.

From students who consume milk, 59% of students preferred to consume powder milk, 10% liquid milk, and 31% preferred both forms. The consumers' choices were examined further on the product's origin, and 73% of respondents preferred local powder milk whereas 27% of respondents preferred imported products. By the Chi-square test, it was found that there is a significant association between preference on product origin and form of milk they consume (X^2=10.42; P=0.005), which can be interpreted as consumers' tendency to be more towards local powder milk brands. In addition, residential areas also showed a significant association with the form of milk preferred (X^2 =7.39; P=0.10), which can be interpreted as urban consumers' tendency to be more towards powder milk.

Table 01. Factors affecting preferences of milk consumption

		Liquid		Powder		Both				
		n	*%*	*n*	*%*	*n*	*%*	DF	(X^2)	P
Choice of milk	*Imported*	6	2.1	68	23.5	18	6.2	2	10.421	0.005
	Local	17	5.9	107	37.0	73	25.3			
	Total	23	8.0	175	60.6	91	31.5			
Residential area	*Urban*	18	5.9	133	43.3	77	25.1	4	7.399	0.100
	Semi urban	11	3.6	38	12.4	13	4.2			
	Rural	2	0.7	10	3.3	5	1.6			
	Total		10.1	181	59.0	95	30.9			

Respondents were questioned on their preferences on the form of milk at present and at five years ago. The results were at present; 76% powder, 6% liquid, and 17.4% both in which, at five years ago; 59% powder, 10% liquid, and 31% preferred both liquid and powder form. Results revealed that within five years, consumption pattern has changed from liquid and both towards powder-milk.

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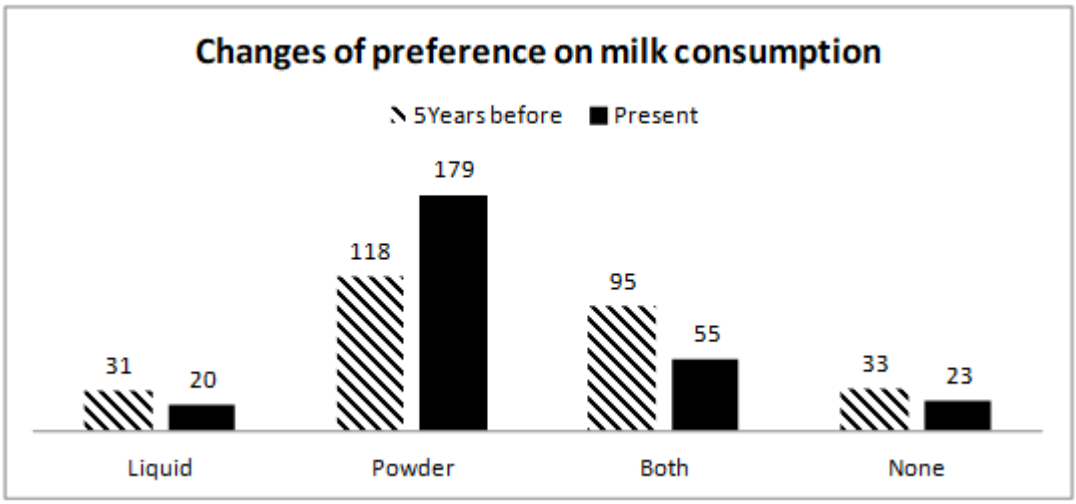

Figure 1. Change of preference on the form of milk within five years

According to the survey; it was found out that 62.2% were not in the habit of drinking liquid milk. From them, 50% rely on powder milk due to the minimum availability of liquid milk. 20% of students thought powder milk is easier to use and store than liquid milk. 13.45% of them disliked the taste and smell of liquid milk, 6.72% believed powder milk is more nutritious than liquid milk, and 10.31% had other causes.

4. Conclusions

According to the results, it was found that 92% of the students questioned in this study were consuming milk as a habit. This is a significant proportion. The major reasons for the behavior were the nutritional value, taste and availability of milk. The consumption pattern has been directed towards the usage of liquid milk and local brands. Further, a significant association was found between gender and milk consumption and between product origin, residential area, and form of milk. When all the results were concluded, activities should be continued to promote the consumption of this essential food in a healthy and balanced diet.

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Factors influencing fresh milk consumption and consumer's buying decision

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1. Introduction

Milk is considered a balanced food source containing various nutrients such as calcium, protein, phosphorus, and vitamins. Therefore, consuming milk and milk products is a good habit for humans at every stage of their life (Unal & Besler, 2006). The Sri Lankan dairy sector experienced an unstable period in 2013, after detecting DCD in imported milk powder. Consumer purchasing behavior, attitudes, requirements, wants, and demand for milk products had all been affected significantly. (Vidanapathirana, Rambukwella, & Priyankara, 2017). To cater to the changing needs, it is important to be aware of what factors affect consumer buying decisions. Several studies have interpreted that various factors such as socio-economic factors including consumer's age, gender education, occupational status, and ethnicity affect the food selection behavior of the consumers (Wham & Worsley, 2003). The study of (Kumar & Babu, 2014) in Pondicherry state reveals product quality, availability, pricing, and advertisement were the top factors given by the consumers of fresh milk. In the Sri Lankan context, (De Alwis, Edirisinghe, & Athauda, 2011) revealed; taste, nutrition, age, ethnic group, availability, health, price, household income, and size were factors that affected consumers' purchasing decisions. Lack of availability, accessibility, and quality of local fresh milk and milk-based products are the main reasons for consumers to buy more imported powdered milk and other dairy products, among Sri Lankan consumers (Vidanapathirana, Rambukwella, & Priyankara, 2017). Therefore, this research concentrates on studying how consumers' demographic, social and psychological factors affect consumers' purchasing decisions of fresh milk as the main objectives.

2. Materials and Methods

The research targets the individuals who would be in charge of purchasing food products for households in the Mawanella area, who might or might not purchase fresh milk. The research area is a suburb of Kegalle in the Kegalle district. The sample size was limited to 100 since the study is not a general consumer study. Respondents were randomly selected relevant to the sample frame. Data collection was done through a questionnaire. Questionnaires were distributed to the selected sample of 100 respondents as self-administrated questionnaires through preparing google forms. No field surveys were carried out due to the covid-19 pandemic situation. Questionnaires were created using open-ended and closed-ended questions related to the set objectives. The complete questionnaire included a total of 3 sections. Section 01, data were collected regarding the respondents' demographic characteristics about their buying- decision towards fresh milk. In section 02, information about consumers' social and consumers'' psychological characteristics was included in section 03. Collected data analyzed through SPSS software. To attain major objectives many statistical approaches were used. Frequency tables and percentages of descriptive data were used as one of the statistical analysis methods to analyze the collected sample data. The binary logistic regression analysis method was used to find out the respective relationships between the decision to purchase fresh milk

(dependent variable) and the independent variables which included the respondent's characteristics that affect for purchase decision of fresh milk.

3. Results and Discussion

The results of the study for psychological factors show a positive significant (at the 0.05 level) relationship between consumers' purchase decisions, perception towards health factors, and the nice smell of fresh milk when purchasing fresh milk. Results indicate that increased perception about health benefits can increase the consumption of fresh milk. Furthermore, it shows that consumers have high motivation to purchase fresh milk if the fresh milk smell is nice.

Table 01. Results of the binary logistic regression of the factors affecting consumers' buying decision

Variable	Significance Coefficients	
		Psychological factors
Health benefits	0.069	2.222
Price reduction	0.067	1.124
Health condition	0.023	1.465
Taste	0.298	-.691
Nice smell	0.006	1.567
Availability near home	0.682	.216
Advertising	0.789	-.165

Research findings indicate that consumers' motivational factors such as the health condition of the consumers when purchasing fresh milk and reduction of the price of fresh milk are positively and significantly affect (at the 0.05 level) the buying decision towards fresh milk consumption. The findings demonstrate that lowering the price of fresh milk can encourage people to buy more of it, implying that the likelihood of fresh milk consumption is increasing. Furthermore, consumers' overall health is linked to a higher likelihood of drinking fresh milk. Findings revealed that greater availability or convenience is a significant element that influences consumer purchasing decisions for fresh milk. We can interpret that the health benefits of fresh milk, a price reduction for fresh milk, the nice smell of fresh milk, and the consumers' health status have a positive significant impact on the fresh milk purchasing choice.

Results identified that Taste of Fresh Milk and availability near home is correspondingly has a positive impact on a fresh milk purchasing decision. Even though these factors are not significant. Similarly, there is a not significant but negative relationship between advertising and fresh milk consumption. Thus, advertising does not play a positive role in changing purchasing habits of the respondents.

The descriptive analysis shows, most consumers among respondents were female, indicating 60.6%. The respondent's ages range between 18 years and 67 years old people. The majority of them have completed secondary (89.9%) and graduate level (9.1%) education. Most of the consumers were employed, indicating 93.9% of the total respondents. A high proportion of the respondents were married, which indicates 64.6% of the total responses. Thus, the results interpret that implementing strategies to improve fresh milk consumption in the local market will be more successful if they focus on female consumers who are between 18 and 67 years old, employed, married, and completed at least their secondary education.

Research interprets that, majority of consumers' household composition ranged from 2 to 8, from that most of them were consisted of 4 to 5 family members. Indicates 31.3% and 28.3% respectively. In these families, there were children aged below 6 years in some families. 16.2%

of families had one child and 13.1% of families had 2 children below 6 years of age. 45.4% of the families had elders above 65 years. From that, 21.2% of families had only one elderly person and 22.2% of families had 2 elderly persons. Finally, the results indicate that families with 4 to 5 members and have children and elderly persons in their households are more tend to consume fresh milk with a high percentage.

4. Conclusions

Findings of this research conclude milk producers and processors should focus on female consumers aged between 18 and 67 years, employed, married, educated (secondary education), families with 4 to 5 members with children and elderly persons, health conditions of the consumers, a price reduction, health benefits gained from fresh milk, Availability, nice smell, and taste. When implementing strategies to improve fresh milk consumption. As a policy implementation, the government can introduce educational programs to improve the awareness of the health benefits of fresh milk. Furthermore, the government can implement convenient locations of milk parlors and make good availability of fresh milk for fresh milk consumers.

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Consumer perception on food safety during COVID-19 pandemic -A choice-based study in Polgahawela area

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1. Introduction

Thousands of infections and deaths are reported daily owing to the COVID-19 pandemic. Global food safety issues have also risen since the world's population is on lockdown. Food is a basic need for human survival and its demand is on the rise with the pandemic. With the COVID-19 pandemic, people have started to panic about buying food and other daily necessities. People were highly concerned about the availability of food in the first stage of the COVID-19 pandemic. Also, a greater emphasis was made on food safety and cleanliness. Food safety is a condition that ensures that the food is free from hazards and that it does not cause any harm to the consumer when prepared and consumed according to the intended use (Dawson, 1995). The unsafe nature of local food markets is a guide to global impact. Availability and access to food were restricted due to the issues of transportation, distribution, and delivery of fresh produce and processed food items (Galanakis, 2020; Vallianatos et al., 2010). The safety of food supply was neglected in food systems long before the onset of the COVID-19 pandemic (Nagyova et al., 2019). Therefore, the study's broad objective is to examine consumer perception of food safety during the pandemic situation in the Polgahawela area. The specific objective is to identify internal and external factors affecting consumer perception of food safety during the pandemic situation in the Polgahawela area.

2. Materials and Methods

Polgahawela division was selected as the research area. It was a suburb of the Kurunegala district. The sampling technique was simple random sampling and the sample size was 150. The response rate was 75%. The questionnaire consisted of three parts. The first part included a demographical profile of the consumer. To prove the choice experiment result second section elicited risk perception statements including the sources of information that generated perception about food safety. That statements were measured by 5 points Likert scale. The third section piloted the main analysis: the choice experiment. Its main target is to estimate the structure of an individual's preferences by establishing the relative importance of attributes. The total utility is based on that alternative and thereby is determined by the utility to the individual of each of the attributes. Limited scope for food safety practices during this pandemic and the existence of revealed that preference choice experiments fit well in this context. The respondents were required to complete the questionnaire by choosing choice cards. The choice card consisted of three attribute groups and three levels. Attributes provided a yardstick to gauge the public support for the survey and measure the perception correctly. The levels attached to the attributes chosen in the survey are depicted in table 1. It produced a total of 27 different combinations used for choice cards. The orthogonal design was used to limit the too many choices, and it minimized the number of cards to 9. Descriptive statistical analysis and choice modeling techniques were used. Data were analyzed using SPSS software and MS excel.

Table 01. Level and attributes of the choice experiment

Attributes	Level I	Level II	Level III
1. Price	2000/=	Between 2000-500 /=	Above5000/=
2. Exposed place & checking traceability	Retailing+Buying Tested	Processing+Buying Not tested	None+Not tested
3. Way of fears came	Among people	Social media + People	Different ways

3. Results and Discussion

According to the choice experiment result, attribute "Stage of contamination and traceability", a part-worth utility for "both not tested" is +0.6895 and for "processing, buying" was +0.651. Both levels were significant. The variable status quo (Retailing and buying) was a structural zero. The magnitude of the estimated coefficient indicated which objectives were more preferred by the sample respondents. Here "Processing and buying" and "both not tested" were preferred over the "status quo". From both, the selection was "None of stages and traceability not tested".

Attribute "Fears" came on food operations, and the levels were 'Social media, people' and 'different ways'. It was tested against the status quo situation in which 'between people'. β value of the status quo variable was structurally zero. 'Between social media and people' base value was +0.468 and it was significant. The different ways value was -0.2 and it makes no sense for the model because it was not significant. Fears about food operations generated from social media and people were preferred than status quo and different methods.

The third price level was the status quo, the variable was structurally zero. The first Price level (above 5000) is 0.531 not significant. The second price level (2000-5000) was 0.682; significant according to the model. (at the α=0.10). LKR 2000-5000 preferred rather than the first choice of price. To achieve more accurate results, a Likert scale analysis was also conducted and the result was compared. The researcher has identified the sources that disseminated knowledge on food safety. Accordingly, 90% strongly agreed that social media was the most common source of information variable.

4. Conclusions

The most neglected attribute was food perception fears among the different ways as it reported a negative value of the result table. The research revealed that information flowing from social media was a strong factor that affected consumer perception of food safety. Perception on the stage of contamination & availability of checking the traceability proved to be affecting the consumer choice. According to the study, the consumer spends a medium concern over these prices of the food product during the pandemic. The respondents expressed low awareness about food safety and they had fears regarding fresh food leading to contamination.

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The impact of SARS-CoV-2 pandemic on purchasing behaviour and the consumption pattern of poultry derived foodstuffs by the communities in selected districts of Sri Lanka

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1. Introduction

Livestock sector is currently considered as one of the major pioneers contributing to food security in Sri Lanka. Of the different livestock entities, poultry is the second major subsector next to cattle, producing chicken meat (225,000 MT) and eggs (2 billion) to the nation (Department of Animal Production and Health, 2019).

In 2019, Sri Lanka ranked 66/113 on the Global Food Security Index (Ministry of Environment, 2021). According to the Food and Agriculture Organization (FAO), more than 25% of the total population in Sri Lanka do not receive nourished food, making child malnutrition to be an emerging threat (Ministry of Environment, 2021). Current per capita consumption of chicken meat and eggs in Sri Lanka are 10.1 kg and 120.23 eggs, respectively (Department of Animal Production and Health, 2019). As eggs and chicken meat are considered the most affordable animal protein sources, an urgent attention must be paid to increase their per capita availability among the Sri Lankan community.

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is an RNA virus which was first isolated in late December, 2019 from Wuhan city in Hubei province, China (Martin, 2020; Hafez et al., 2021). SARS-CoV-2 infection is currently considered an unprecedented global emergency (Martin, 2020). Though the SARS-CoV-2 pandemic has been interpreted primarily as a public health crisis, it has created a significant impact on global economies, leading to socio-economic crisis and disruption of the food supply chain. Sri Lanka as one of the middle-income countries suffers adversely during the pandemic. Several containment efforts such as intermittent lockdowns, quarantine and opening of checkpoints and roadblocks to prevent virus spread has shown the economic activities to be stagnant and made the consumers disconnect from the local market (Martin, 2020). Since we assumed this dysconnectivity could negatively affect the routine chicken egg purchasing and consumption among Sri Lankans and possible malnutrition as a future consequence, the present study was conducted to assess the impact of SARS-CoV-2 pandemic on (i) purchasing behaviour (or decision processes and acts of customers involve in buying) and (ii) the consumption pattern (or frequency or ways with which the consumers are habitually consume) of poultry derived foodstuffs by the communities in selected districts of Sri Lanka.

2. Materials and Methods

The present study was carried out in Gampaha, Kandy and Galle districts by considering the highest number of population and the locality. The research approach was deductive and the study obtained both primary and secondary data. The sample consisted with 629 respondents selected from each district using simple random sampling technique. A pre-tested interviewer administrated questionnaire was used as the key data collecting tool. The questionnaire was designed to investigate the purchasing behaviour and the consumption pattern of poultry derived foodstuffs by the communities in the aforementioned three districts. Questionnaire surveyed the various health and socio-economic aspects affecting on buying and consumption

frequencies of poultry derived foodstuff such as chicken meat, meat products and eggs before and during SARS-CoV-2 pandemic. Data was analyzed using SPSS (Statistical Package for Social Sciences) version 22 software and Microsoft Excel 2016 software. To analyze the collected data, descriptive statistics such as frequencies and percentages analysis were used.

3. Results and Discussion

The SARS-CoV-2 pandemic is an unforeseen situation, which created tremendous effects on the lifestyles of people. Due to the imposition of the curfew, travel restrictions, and Island-wide curfews, the supply chain flows were disrupted. Though agriculture is concerned as the least affected sector by the SARS-CoV-2, it has created remarkable changes in the consumer purchasing behaviour and in food consumption patterns.

The results revealed that the majority of the respondents are Sinhalese and Buddhists. Of the total respondents, 64.39% of the sample belongs to 18-30-year age category and the majority are female (61.84%). The majority of the respondents represent higher education level (50.40%).

Of the total respondents, 41.18% consume eggs as their main protein source and 27.98% and 22% do consume fish and meat/processed meat products, respectively as their main protein source. From the sample, 75.04% consume chicken meat and 87% of the respondents who used to eat meat, consume processed foods such as processed meatballs and sausages. Of the total respondents, 60.26% stated that SARS-CoV-2 pandemic made an impact on their chicken or processed chicken product consumption frequencies whilst 26.23% of the respondents admitted the fact that they did not change their consumption frequencies amidst the effect of SARS-CoV-2 pandemic. Majority of the respondents (34.66%) were admitted a declined weekly purchasing amount of chicken or processed chicken products because of the pandemic. It implies that the SARS-CoV-2 pandemic created a significant impact on consumers to reduce the frequencies as well as the weekly purchasing amount of chicken or processed chicken products. As described by Hafez et al. (2021), several rumors have been spreaded since February 2020 highlighting the potential involvement of chicken meat and eggs in the spread of SARS-CoV-2, which resulted a significant drop in demand for poultry derived foodstuffs. When considering the changes to buying pattern of chicken meat due to the pandemic, majority of the buyers tend to purchase chicken or processed chicken products from the retail shops (53%). Majority (53.42 %) of the respondents did not change their buying method of chicken or processed chicken products. However, 31.32% of the respondents showed changes in their method of buying chicken or processed chicken products because of the pandemic.

Results of the present study revealed that 85% of the respondents used to consume chicken eggs whereas less than 1% of the respondents consume duck, turkey, and geese eggs. Before SARS-CoV-2 pandemic hits Sri Lanka, 45.47% of the respondents consumed eggs one to two days per week while 28.93%, 5.72% and 5.25%, of the total respondents consumed eggs at a frequency of three to four days per week, and four to five days per week and daily, respectively. During the pandemic, it is found that 40.22% of respondents consume eggs one to two days per week while 31.96%, 7.15%, and 5.88% of respondents take eggs into their meals three to four days per week, daily and four to five days per week, respectively. Of the total respondents, 42.61% were admitted that their consumption behavior did not changed as a result of the pandemic whereas 23.05% and 19.87% of the respondents agreed with the fact their consumption frequencies of egg increased and decreased, respectively as a consequence to the pandemic.

The study suggested that many respondents increased their egg consumption and 85 out of 145 have been influenced by the concerns on better health and the immunity during the pandemic. Of the respondents of the sample, 125 believed that the egg consumption frequency decreased

due to the pandemic. The reasons for their increased egg consumption frequency are illustrated in the Figure 1. According to the results, it is clear that apart from concerns on better health and the immunity, the lockdown and travel restrictions is the main reason for increasing consumption frequency for eggs. In general, 88% of the respondents stated that the imposition of quarantine did not affect the resulted increment in the consumption frequency of eggs (Figure 1).

Despite that, 58.03% of those who were interviewed said that the pandemic did not make any impact or changes in their buying behavior for eggs. However, 173 respondents (27.50%) agreed with the fact that they had to change their buying behavior consequently to the pandemic. Moreover, the study indicated that the major reason behind the change in buying method is lockdown and travel restrictions followed by convenience, low income during the pandemic, limited availability of eggs usually consumed, and the quarantine period.

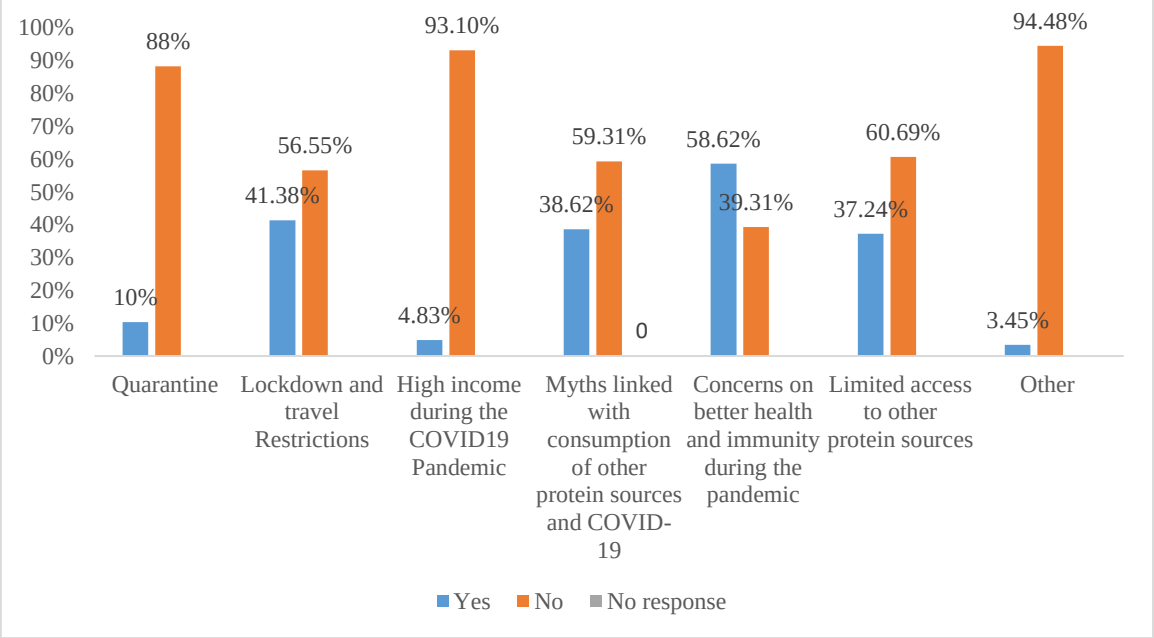

Figure 1. Reasons for increasing egg consumption frequencies as a consequence to SARS-CoV-2 pandemic in selected districts of Sri Lanka

Moreover, the majority (55.33%) of the respondents do stock poultry products in their homes during the pandemic period. The main reason outlined by the consumers for stocking was 'to avoid multiple time contact with the community'. According to the World Health Organization (WHO, 2020), the SARS-CoV-2 virus is thermolabile and can be destroyed by cooking chicken eggs, chicken meat, and meat-based products to a temperature above 70 ºC. The results revealed that 33.55% of the respondents are aware of this fact and from them, only 17.81% of the respondents have changed their cooking methods for chicken, processed chicken products or eggs than they did in the past.

4. Conclusions

The present study concluded that though the purchasing frequencies and the amount of chicken or processed chicken products have been changed consequently to SARS-CoV-2 pandemic, neither the purchasing method nor purchasing brand has been changed. The pandemic has no influence on buying behaviour for eggs. Concerns on better health and the immunity during the pandemic and the lockdown and travel restrictions imposed during SARS-CoV-2 pandemic have contributed to increase egg consumption frequency among the public.

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The impact of coconut price increment on household consumption in 2020- A study in Panadura area

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1. Introduction

Coconut, *Cocos nucifera* is one of the most consumed domestic plantation crops in Sri Lanka. Further, rainfall and temperature are the major two climatic factors influencing the coconut yield (Peiris, et al., 1995). Non-economic factors including; dietary concerns, changes in tastes and preferences also impact coconut demand (Samarajeewa, 2002). As a plantation crop, coconut holds a significant place in the Sri Lankan economy for being one of the top three and as a major export crop. Statistical Information on Plantation Crops 2018 shows from the annual nut production, domestic nut consumption is 68.39% and the rest of the 31.61% is used for various other productions and purposes e.g.: desiccated coconut, copra, coconut oil. Population growth has accelerated the demand for coconut but the supply continuously fails to address the prevailing demand (Kumari, 2021). As a result price fluctuation is prominent in the coconut industry. Compared to the past records, the year 2020 recorded the highest coconut retail price in Sri Lankan retail market causing people to go through some hardships during the purchase of fresh coconut and coconut oil. This year government imposed new policies (Circumference below 12 inches LKR 60.00 and Circumference between 12-13 inches 65.00 Circumference over 13 inches LKR70.00) to calculate the coconut price and from that, both consumers and retail shop owners also faced many hardships. Therefore, this research aimed to observe how the coconut price increment impacts on household consumption and to identify the changes made by the consumers. As well as to determine how the socio-economics of consumers affect the consumption pattern during a price hike situation of coconut.

2. Materials and Methods

The study was carried out in Panadura municipal council area with 100 participants. Simple random sampling method was adopted in the selection of the study sample. Due to the pandemic situation, respondents were approached by circulating an online google form via emails and social media platforms. The main objective was to identify how the coconut price increment impacts on household consumption in 2020. One of the specific objectives was to identify whether the price hike caused a shift in consumption patterns from fresh coconut to coconut milk powder or liquid coconut milk. Based on the research questions formulated in this study descriptive analysis was conducted to achieve this objective. Another objective was to determine the relationship between socio-economic factors income and number of family members with the change of coconut consumption pattern. Monthly coconut consumption was identified as the dependent variable whereas monthly income, the number of family members and the average price of coconut were considered as the independent variables. Multiple regression analysis was carried out to measure the relationship between each variable.

3. Results and Discussion

In the descriptive test results, 52 percent of consumers indicated that they had limited the household consumption with the price hike and 42 percent continued the same consumption

level despite the price hike. Further, 23 percent of the consumers expressed that they substituted the consumption of fresh coconut with coconut milk powder due to both price increment and limited availability of fresh coconut. However, 77 percent of consumers remained to consume fresh coconut as they were able to afford the increased market price and they prefer fresh coconut taste to coconut milk powder/coconut liquid milk. 47 percent of respondents were self-sufficient with their own palm production.

Under the second objective, the relationship between socio-economic factors with the price increment of coconut was determined through the multiple regression analysis.

Table 01. Coefficient of the regression analysis

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1914.414	451.662		4.239	0.000		
	Number of family members	0339.351	046.755	0.476	7.258	0.000	.614	1.628
	Monthly income	0000.011	000.003	0.222	3.732	0.000	.749	1.335
	Average price of a coconut	-0018.923	003.594	-0.343	-5.265	0.000	.623	1.604

a. Dependent Variable: The monthly expenditure for the consumption of coconuts

R square value of the model was determined as 0.746 and the P< 0.05. Table 01 shows the results of multiple linear regression. The dependent variable is monthly expenditure for the consumption of coconut and the independent variables are the number of family members, monthly income, and average price of a coconut. According to the above results, all the independent variables have significant impact on the monthly expenditure for consumption of coconut since p values are less than 0.05 significant level. The number of family members and the monthly income has a positive relationship with monthly expenditure for coconut consumption whereas the average price of a coconut has a negative relationship with monthly expenditure for coconut consumption. After considering all the above data and the results, the final equation for the model can be interpreted as;

"Coconut consumption = 1914.414 +339.351 (Family members) + 0.011 (Monthly Income) - 18.923 (Price of a coconut)".

4. Conclusions

The results of the study conclude that the consumers have not completely shifted for coconut milk powder or liquid coconut milk but only 23 percent due to the coconut price increment and the other 77% percent remained to consume fresh coconut as they were able to afford the increased market price and they prefer fresh coconut taste to coconut milk powder/coconut liquid milk. It indicates that consumers still choose to consume fresh coconut even though the price fluctuates from time to time. Monthly household coconut consumption depends on monthly household income, the number of family members, and the average price of a coconut. When the average price of coconut increases the monthly coconut consumption has decreased whereas the monthly income is high, monthly coconut consumption is high. When the number of family members increases the monthly coconut consumption increases simultaneously.

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A study of school children's body mass index and eating habits in Galle district

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1. Introduction

Healthy eating habits are very important for school aged children in order to improve their performance and to prevent many non-communicable diseases that can cause at a very early stage in their life. Sri Lanka has undergone rapid development during the past few decades, resulting in broad socioeconomic changes including rapid urbanization and industrialization (Hettiarachchi et al. 2018). Due to those reasons; the lifestyles of adults as well as children also change and most of them prefer to consume instant food other than the balanced diet. The eating habits are influenced by lack of time to prepare meals at home, and the availability of fast-food outlets and food vending machines (Wickramasinghe et al. 2010). These causes may lead to a nutrition transition with an increase in the prevalence of overweight and obesity. The Body Mass Index (BMI) is widely accepted as providing a convenient measure of a person's fatness (Jayasinghe and De Silva 2014). It is defined as a person's weight in kilograms divided by the square of the person's height in meters (kg/m^2) (WHO, 2021).It's simply numeric measure of a person's body 'thinness' or 'thickness'. This study was carried out to get an idea about whether a child has the healthy BMI which represents an index of an individual's fatness. Also, to compare the body mass index with eating habits, lifestyle and physical activities of the school children in Galle district.

2. Materials and Methods

Study description

The sample of the study was 151 school children between 10 to 19 years of age in Galle district (75 females, 76 males) and it was conducted as a multistage study. Respondents were selected by random sampling technique. This study sample of children was obtained from 30 schools.

Questionnaire

Data were collected primarily using a self-administered online questionnaire thorough Google form. The questionnaire was divided into four main parts. First part of the questionnaire was focused on the personal information of the respondent: age, place of the residency, gender, height, weight, income of the family and occupation of the parents/guardian. The second part of the questionnaire consisted of details about food habits of the respondents.

The third part of the questionnaire inquired about the respondent lifestyle pattern. Finally information was gathered on the respondent's idea about physical activity impact for the body maintenance.

BMI

Reported height and weight were used to calculate BMI as weight/ $height^2$ (kg/m^2).

Statistical analysis

Surveyed data were descriptively analysed by using IBM SPSS and Microsoft Excel. Regression and correlation analysis were conducted to find out relationships in BMI with gender, daily fluid intake, hours engaged in physical activities, consumption of high sugar-containing beverages, mobile phone usage, consumption of additional meal/s and usage of caffeine-containing drinks after the main meal. Chi square analysis was conducted to find out which gender category most aware about the instant food and find out which gender category has low BMI. Frequency analysis was conducted to find out frequencies in some variables.

3. Results and Discussion

According to the demographic variables of the respondents in the sample majority of school children are from rural context (43.7%) wherein others are from semi urban (37.7%) and urban (18.5%). It has revealed the 33.8% of them are from low- income families (less than Rs. 15000 per month).

Considering the food habits of respondents in the survey, 31.8% students neglect any meal per day. Majority of children miss their breakfast and as a percentage it is 70.8%. The reported reasons for not having meals properly are the tight daily schedule (25.5%), economic reasons (2.1%) and due to other reasons (72.3%) like; lack of appetite, fasting/religion, lack of parental emphasis on the breakfast and not being hungry. For breakfast, most of the respondents (61.6%) prefer to eat rice and curry while for dinner it is 47.7%. The least number of children consume instant food for their main meals and as a percentage it is 4% in the breakfast. It was revealed that 73.5% of respondents consume additional meals in between their main meals. According to the results 8.6% students have been reported as vegetarian.

Considering the knowledge and habits regarding instant food of the respondents, the majority (92.1%) of them have an idea about what is an instant food. According to the chi- square test, male (51.8%) students have an idea about what is an instant food than female students. Around 54% of respondents are consuming instant food rarely. Water consumption of the respondents is not at a satisfactory level and only 55.3% use 2-3 liters of water as daily intake. Considering the non-communicable diseases among the respondents 12.7% get medicines for eye diseases (7.9%) and for nerve diseases (3.3%). There are no other diseases reported within the sample.

Considering the lifestyle of the respondents' majority (89.4%) are having a good sleep after dinner. Nearly 37% of respondents are interested in having a drink containing caffeine after their main meals. Also, 43% of the respondents preferred high sugar containing drinks and majority of them are knowledgeable about the color coding of sugar containing beverages.

A satisfying number of respondents (90.7%) have an awareness of the importance of physical activities for maintaining good health and it was revealed that 70.2% are concerned about their body shape.

According to nutrition division of Ministry of Health in Sri Lanka, BMI is categories into five groups; underweight (<18.5), normal (18.5- 22.9), risk to overweight (23-24.9) overweight (25-29.9) and obese (>30). Considering the calculated BMI values of the sample, 43% are in the healthy range of BMI, which is the value range between 18.5-22.9. Nearly 44% are in below the healthy range (<18.5) of BMI while nearly 6.6% are in the range of risk to overweight and 6.6% are above the healthy range (include in overweight and obese categories) of BMI. Therefore, a considerable number of respondents haven't reached the healthy range of BMI yet. It has revealed that 36 males and 39 females are present in the sample having less than its median BMI value which is 19.06.

The relationship of BMI with the variables of income of the family, sleeping hours, taking extra meal/s, daily water consumption, consuming sugar-containing beverages, sporting hours and mobile phone usage were analysed by using Pearson's correlation statistical tool. According to

the results it has revealed that only two variables have the relationship with BMI at 0.05 significant level. They are extra meal/s consumption and the family income.

4. Conclusions

Among the respondents 43.7% were found as the BMI exists in below 18.5(kg/m^2) and thus they are suffering from underweight. Only a few percent (5.9%) have been recorded as overweight within the sample. Underweight among the adolescents in the Galle district might be a significant public health problem. The main reason for this problem might be most of the underweight respondents are from the rural context and it was reported as 48.5%. Within the rural context most of them are from low income families (37.9%) and therefore they are unable to concern about their meal properly.

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Factors affecting consumers' purchasing intention on safe vegetables in Rambukkana area

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1. Introduction

With the upgrading of consumer lifestyle, the concern towards the safety and quality of fresh produce has also risen. According to Thuy and Tran, 2016 highly perishable fresh produce i.e. vegetables/fruits are prone to pathogenic and chemical contamination easily. Vegetables being a compulsory addition to the diet, safety and quality concern over the produce can significantly affect the purchasing intention of consumers. Consumers are an integral part of the vegetable supply chain and act as the end-users. The current study was undertaken with an attempt to investigate the consumers' purchasing intention. Purchasing intention is affected by the quality and health awareness, subjective norms, barriers, and habit experiences (Dickieson et al., 2009). In purchasing safe vegetables for daily consumption, consumers consider a variety of criteria. Freshness, nutrient content, price, outer-appearance, availability, family encouragement, awareness about safe vegetable consumption, and the way vegetables are displayed for sale are the factors examined (Dickieson et al., 2009). Hence, the aforementioned factors can have a major impact on customers' purchasing intention. The objectives of the study were to find out the level of quality awareness, subjective norms, barriers, and habit experience factors on consumers' purchase intention on safe vegetables and to identify the relationship between aforementioned factors and the consumers' purchasing intention on safe vegetables.

2. Materials and Methods

Two hundred (200) customers, purchasing vegetables from public market and supermarkets in Rambukkana area, were selected as the sample of the study. The study was conducted using deductive approach. Data were gathered via survey strategy through convenience sampling technique. Primary data were collected through online administered structured questionnaire. The questionnaire consisted of 34 five-point Likert scale questions. Online journal databases were used as secondary data sources to gather more information about purchasing intention on safe vegetables. Collected data were analysed using Microsoft Excel and through univariate and bivariate analysis in SPSS software version 21. Descriptive tools such as frequencies, tables and percentages were used to describe the socio-economic characteristics of the respondents and to identify the level of impact of the factors. Multiple regression analysis was used to identify the impact of factors for the purchasing intention on safe vegetables. Univariate analysis was used to identify the level of each factors on consumers purchase intention on safe vegetables. Correlation analysis was used to investigate the relationship between each factor and purchasing intention. Figure 01 depicts the conceptual framework for the study.

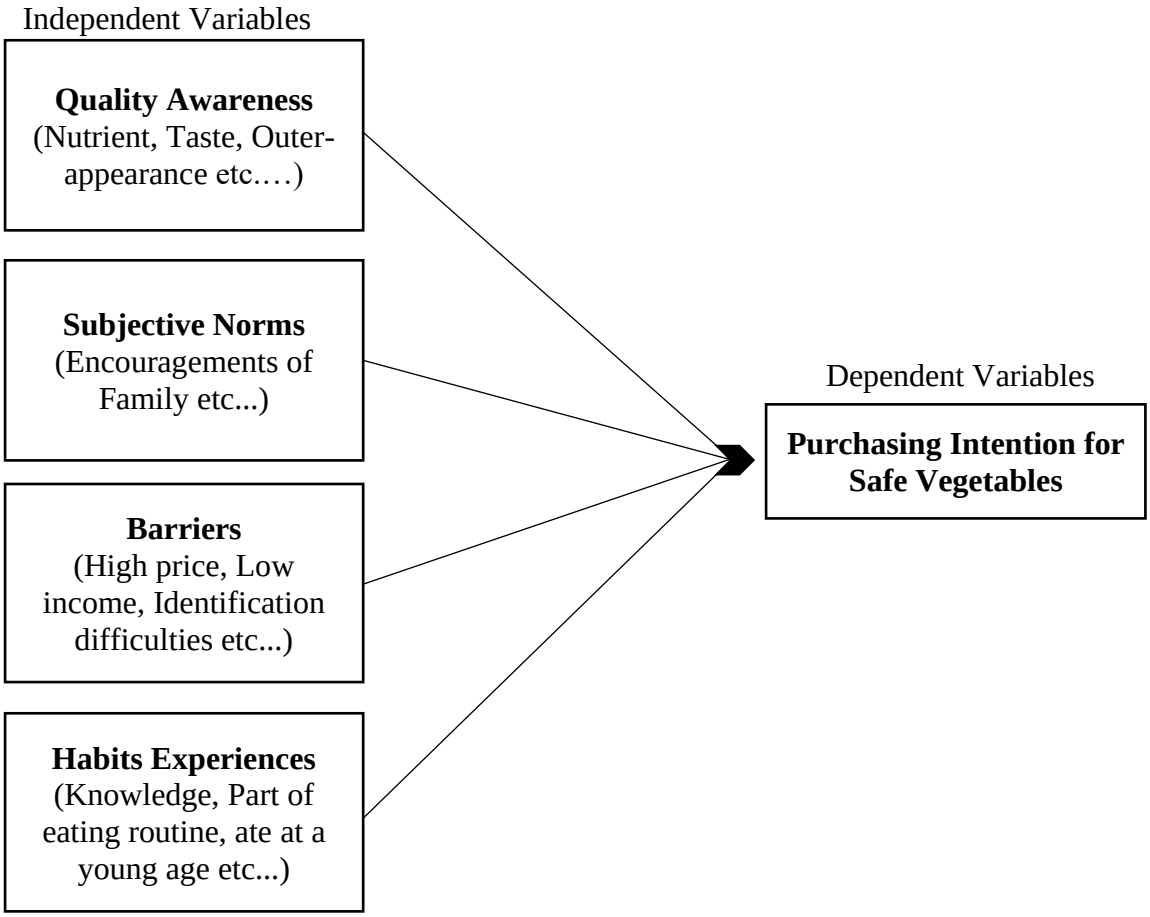

Figure 1. Conceptual Framework

3. Results and Discussion

The female representation of the entire sample was 66.5%. The age group, 41 years, represented 9% while the majority of the participants had received secondary education, which was 47%. When the monthly income of the participants was considered, the majority had received an income of 30 000 LKR.

Out of the entire sample, each individual considered safety issues before purchasing the vegetables, and among them, 71% respondents were willing to pay more for buying safe vegetables. Variables of quality awareness, subjective norms, barriers and habits experiences (independent variables) was tested against the dependent variable; and purchasing intention for safe vegetables (dependent variable) in order to analyse factors affecting consumers' purchasing intention on safe vegetables in Rambukkana area. Multiple regression analysis was used to identify the impact of these four independent variables on purchase intention for safe vegetables.

The fitted model for the analysis is given below:

$PISVi = \beta 0 + \beta 1\ QA + \beta 2\ SN + \beta 3\ B + \beta 4\ HE + ui$

PISVi = Purchasing Intention on Safe Vegetables
QA = Quality awareness
SN = Subjective norms

B = Barriers
HE = Habits and experiences
β0 = intercept (constant) value
β1 = coefficient
ui = error term

According to R value, there is a relationship between dependent and independent variables. It is 94.4%. According to R Square value, 89.1% is represented by these four independent variables to purchasing intension and remaining 1.09% is represented by other factors.

According to the coefficient table 01, a significant value of quality awareness, subjective norms, barriers and habit & experiences, are lesser than to alpha value 0.05. Therefore, these four variables significantly impact on the purchasing intention.

Table 01. Coefficient table for purchasing intention on safe vegetables

Variable	Unstandardized Coefficients		Standardized Coefficient	T	Sig.
	B	Std. Error	Beta		
Constant	-0.386	0.123		-3.140	0.002
Quality awareness	0.190	0.048	0.200	3.987	0.000
Subjective norms	0.224	0.058	0.216	3.870	0.000
Barriers	0.401	0.061	0.337	6.546	0.000
Habits and experiences	0.261	0.077	0.254	3.373	0.001

(Source: Survey Data)

According to the coefficient result, the regression model can be expressed as follows:

$Y= \beta0 + \beta1\ QA + \beta2\ SN + \beta3\ B + \beta4\ HE + ui$

$Y= -0.386+ 0.190(QA) + 0.224(SN) + 0.401(B) + 0.261(HE)$

According to Table 01, the constant value is -0.386. It shows that model would predict if all the independent variables values were zero. According to the univariate analysis, all mean values of each independent variables are above 3.5(3.5-5). Therefore, these four variables have a high level of contribution to the purchasing intention on safe vegetables. According to the correlation (bivariate) analysis, all R-values between purchasing intention and independent variables are more than 0.7. Therefore, there is a high positive relationship between purchasing intention and independent variables. Alamsyah et al., 2017 identified a relationship between safe vegetables products and purchase intention. Bagozzi (1992) identified that subjective norm has a relationship with purchase intention. Angulo, Gil and Tamburo (2005) has also identified that barriers have a positive relationship with purchase intention.

4. Conclusions

According to the study, factors such as quality awareness, subjective norms, barriers and habit experiences have a significant impact on the purchasing intention and on safe vegetables in Rambukkana area. Quality awareness, subjective norms, barriers and habit experiences have a high level of contribution to the purchasing intention on safe vegetables. The result indicates that there is a statistically and high positive relationship among quality awareness, subjective norms, barriers, habit experience and the purchase intention for safe vegetables.

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Pepper supply chain and price behaviour in Sri Lanka

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1. Introduction

Pepper is the most widely used spice in the world which is known as the 'king of the spices' originated from the Piperaceae family. Pepper is mainly cultivated over an area of 40244 hectares and majorly in the districts of the Matale, the Kandy, the Kegalle, and the Kurunegala (Government Information Centre, 2020). Whether Sri Lanka earns a high unit price for pepper at the export market, producers are not reaping benefits adequately by dint of several critical issues in the supply chain. The smallholders are lacking the capacity to invest in infrastructure for GMP, HACCP, ISO-certified production, and manufacturing. Moreover, production flows and the workplaces at the smallholder level are not convenient for them. Because of this, there is a significant shortage of quality supplies to the market. In addition to those implications, the suppliers are willing to sell their goods when the pepper price is high. But all harvests come together and there will be an excess of pepper goods in the market which tends to reduce the pepper price. Hence the pepper producers are discouraged to cultivate pepper in the long run, owing to inadequate income from their harvest. Hence, this study mainly focused on identifying the factors related to the black pepper supply chain in Sri Lanka. Further, specifically concerned to identify how the pepper price behaves during the season which was not covered by the previous studies.

2. Materials and Methods

This study is based on the pepper supply chain in the Deniyaya, the Kotapola, and the Kamburupitiya divisions by way of collecting qualitative and quantitative data and exploring the complex obstacles. The research method was used, is a case study to use some techniques of in-depth interview, literature studies, and document analysis to gain an in-depth understanding of the development of pepper supply chain management (TOMY PERDANA, 2018). Simple Random Sampling was used to select 200 small-scale pepper farmers. Small scale holders were purposively selected due to their significant contribution towards total black pepper production in Sri Lanka. Primary data for the study were collected through a structured questionnaire and the secondary data were obtained from the websites of the International Pepper Community and the Department of Export Agriculture (Government Information Centre, 2020). Data consists of production information, socio-economic characteristics, and constraints are being faced by the production level. The analysis of data was used is a Multiple Regression Analysis to identify the relationship between the pepper harvest per season and other predictor variables like age, gender, education level, land allocated for cultivation, working experience, perception on seasonal price, number of plants per acre, price per kilogram.

3. Results and Discussion

3.1 Descriptive Statistics Results for continuous variables

The mean age of household heads is 40-50 years meaning the majority of them were in productive age. The average educational status of respondents was primary level. The average working experience of a household head is 13.76 years. The land allocated by sampled farmers

was the average 0.83 hectares. The average number of plants per acre was 33. The average price per kilogram was Rs.482. Moreover, the statistics reveal that the perception of seasonal prices of most farmers is in the negative category, and the price per kilogram is the average Rs.480.

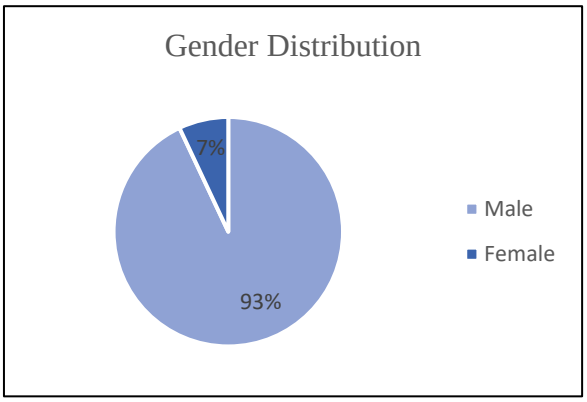

Figure 1. Gender distribution

3.2 Multiple Linear Regression Model

3.2.1. Inter-Correlation Matrix

The Pearson Coefficient for all the independent variables is less than 0.9. Hence, it reveals that the risk for multicollinearity would be very less.

3.2.2. Tolerance Values and Variance Inflation Factor (VIF).

The tolerance values are higher than 0.2 and VIF values are less than 0.5 which are within the expected range that prevents multicollinearity ($VIF \geq 5$) According to that, the Multiple Regression Analysis can proceed.

3.2.3. Model Summary

The R square statistics is 0.981. This suggests that 98% of the variants in the Harvest per Season were predicted from the predictors. The Durbin-Watson statistic was 1.918 and between +1 and +3. It means that the independence of the observations has been met.

3.2.4. The F-Ratio in the ANOVA Table

The F-ratio in the ANOVA table is 0.000. The table indicates that the predictor variables statistically significantly predict the outcome variable. That is the regression model is a good fit for the data.

3.2.5. Coefficients

The experience and land allocated variables were significant at 0.05% level and all of the others were significant at 99% significant level. Age of the household head, Education of household held, Gender of household head, Working Experience, Land allocated for cultivation, Number of plants per hectare indicate a positive effect with the Harvest Per Season variable. Where Price per Kilogram and Perception of seasonal price indicates negative effects with the dependant variable.

Table 01. Coefficient

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-40.019	32.991		-1.213	.001***
	AGE	2.298	4.351	.007	.528	.000***
	EHH	4.342	7.444	.011	.583	.014**
	GENDER	6.249	12.766	.008	.490	.000***
	WE	.037	.361	.001	.102	.000***
	LEFC	9.324	8.849	.013	1.054	.011**
	NPA	3.824	.042	.986	91.975	.000***
	PPK	-.004	.016	-.004	-.269	.000***
	PSP	-2.733	4.711	-.011	-.580	.000***

a. Dependent Variable: HPS

3.2.6. Regression Equation

The following regression equation can be derived from the available data for predicting the Harvest/Supply per Season from those predictor variables.

$$\bar{y} = -40.019 + (2.298)x_1 + (4.342)x_2 + (6.249)x_3 + (0.037)x_4 + (9.324)x_5 + (3.824)x_6 + (-0.004)x_7 - (2.733)x_8$$

3.3. SWOT Analysis in The Black Pepper Supply Chain at Producer Level

The constraints identified from this study are listed below.

- Price fluctuation especially in the season
- The high-profit margin of the intermediaries
- Post-harvest damage
- Engage in value addition

The opportunities identified from this study are listed below.

- High farm gate prices due to the international demand
- Low application of Agro-chemicals
- Ability to cultivate as mixed-crops

4. Conclusions

In keeping with the results of this study reveal that the black pepper harvest in the season is significantly influenced by the socio-economic factors and other factors which were used in this study. Specifically, we can observe that the price tends to be more negative during the season while discouraging the farmers to cultivate pepper in the long run. Despite the prominent role in the economy of Sri Lanka, the black pepper supply chain actors confront several constraints related to the traditional marketing system. Hence, building up a proper system is necessary to protect this industry in the long run.

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Customer perception towards food delivery services during COVID-19 pandemic: with special reference to Colombo district

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1. Introduction

Before Covid-19 Pandemic, dining out was much popular among the Sri Lankans than the use of food delivery services. They enjoyed visiting the food-providing entities and to have their meals at the same place. Lack of trust in delivering a commodity like food was the key reason for them to adopt dine out as a self-protective and to prevent the damages occurring during the delivery. As per the travel restrictions imposed by the government to prevent the spread of the Covid-19 virus, people had to face the challenge of fulfilling their food requirements. As a result, both the food industry and the consumers adopted the online Food Delivering Service (OFD). This causes a positive effect on the OFD (Global Online Food Delivery Services Market Report 2021: COVID-19 Growth, 2021). And on the other side, this made a huge competition within the Online Food Delivery Services as new players entered into this industry as well as they need to adhere to the health and safety guidelines. (Hirishegan et al., 2020) While fulfilling the consumers' requirements. Under that focus, the main objective of the current study was to investigate the customers' perception towards OFD and to find out the key factors that influence the customers to build trust and loyalty towards the food delivering services with special reference to Colombo District.

2. Materials and Methods

Colombo district was selected as the study area as the outdoor dining and the OFD was much popular comparatively. A total of 250 respondents were chosen as the study sample through the convenience sampling technique. The questionnaire was distributed via online and physical modes due to the Covid-19 pandemic situation. Primarily the questionnaire included Liker questions and choice cards were adopted in primary data collection to gather the information regarding the consumer perception of OFD during the Covid-19 Pandemic. The study adopted the Consumer Based Conjoint Analysis (CBCA) approach in data analysis. The combination of the attributes and their levels (Table 01) was used and it finally resulted in 9 different choice cards. A Cox Regression was conducted by the SPSS to gain the results of research objectives.

In this study, three attributes were chosen concerning the research objectives as, factors that are being considered by the consumers when selecting an online delivery service (factors) with three levels of accessibility, officers, and the price of the delivery service. As the second attribute, it is considered the newest trends use by the online delivery services to affect the consumers' perception. Here this attribute has been measured concerning the levels like After-Sale Services, Easy Payment options and Customer loyalty benefits given by the Online Delivery Services. And the third attribute is how the Covid-19 Effect affect the food delivery services which has been evaluated about the levels of low, moderate and high effect of Covid 19.

In each attribute Level 01 and Level 02 were comparatively analysed with Level 03 which is also known as Status Quo.

Table 01. Attributes and levels adopted designing the choice experiment of consumer perception towards the OFD services during the Covid-19 situation

Attributes	Level 01	Level 02	Level 03 (Status Quo)
Factors	Accessibility (ASS)	Offers (OFF)	Price (P)
Trends	After-Sale Services (AS)	Easy Payments (EP)	Loyalty Methods (LM)
Covid-19 Effect	Low	Moderate	High

3. Results and Discussion

The importance of each attribute was analyzed using the choice modeling where a sample of people was asked to select their preferred option from all the possible alternatives which include the status quo. The Levels like P, LM, and Covid-19 Effect –High (Table 2) were dummy variables. So these variables were considered as the status quo.

Variable Price was considered as the status quo when considering the attribute, "factors" that consumers consider basically when selecting an Online Food Delivery Service. So when comparing both variables ASS (.005) and OFF (.000) with the status quo they are significant. It indicates that customers will consider more about the offers than the accessibility of the Online Food Delivery Service when selecting it (.005<.000).

The variable Loyalty Methods (LM) out of the Online Food Delivery trends, considered as the status quo. The AS variable was significant (p=.003) when compared the difference between the status quo. At the same time when comparing the status quo with, the variable EP it was also significant (p=.000). But this indicated that the customers were preferring the Easy Payment trend currently more than the trend of providing the After-Sale Services when considering the trends relating to the Onile Food Deliveries (.000 > .003). Therefore, the OFD providers needed to be more concerned about making arrangements for convenient payments methods while introducing special methods to create a more loyal customer group. In addition to that, the variable High was the status quo when considering the Covid-19 effect on the OFD. So here when comparing the status quo with the variable Low was not significant (p=.454). At the same time, the variable Medium too was significant when compared with the difference (p=.002). Therefore, it indicated that the Covid-19 effect was highly affected to change the consumers' perception towards the OFDs' in a positive way.

According to the findings of current research, the majority of the respondents were quite unfamiliar with Online Food Delivery as they enjoyed visiting the places to have food with their families and friends, and at the same time, they enjoy the shopping experience in past. In addition to that, except for the other consumer goods, individuals believe that the food items might get damaged and will not be delivered at best quality during the delivery. Therefore, the respondents were expecting the factors including Price, Service Quality, and Accessibility except to the delivery service. Furthermore, the Covid-19 pandemic situation had created a great influence on the OFDs operations. Compared to the earlier situation in the food industry with this new normal situation, some additional factors were considered by the customers when selecting an ODF service provider mainly the safety and hygiene practices adopted by the individual service providers.

Table 02. Test results of equation's variables

	B	SE	Wald	df	Sig	Exp(B)
ASS	-.506	.178	8.067	1	.005	.603
OFF	-.671	.178	14.173	1	.000	.511
P				0		

AS	-.680	.227	8.962	1	.003	.506
EY	.998	.159	39.413	1	.000	2.713
LM				0		
Low	-.130	.173	.562	1	.454	.878
Moderate	-.588	.192	9.407	1	.002	.555
High				0		

a. Degree of freedom reduced because of constant or linearly dependent covariates
b. Constant or Linearly Dependent Covariates price = 1 - ass - off ; lm = 1 - as - ep ; high = 1 - low - mod ;

4. Conclusions

The findings of the current study concluded that the world pandemic situation and travel restrictions motivated the Sri Lankan consumers' to adopt the OFD mechanism more frequently and this adoption rate changed in a positive direction. This current trend of OFD was positively influenced by transportation restrictions imposed by the government. Further, the study results indicated that the perception towards OFD was mainly affected by the Offers given by the OFD rather than considering the accessibility, which means consumers' tendency is more towards the benefits they will gain. Furthermore, customers are always concerned about the convenient Easy Payment options provided by the delivery channels and this facility made them loyal towards a particular OFD service. Therefore, the Online Food Delivery service provider is required to adopt and try to fulfill the customers' expectations while adhering to the health guidelines imposed by the relevant authorities to be successful and stand against the rivals.

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An institutional environment and its involvement in coconut oil value chain

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1. Introduction

Coconut oil is the most widely used domestic cooking oil in Sri Lanka (WHO, 2020) which has steady demand exist throughout the year. Sri Lankans footmark on global coconut production is still momentous has been the fourth largest coconut producer (EDB, 2020). However, coconut oil manufacturing showed a notable declined in 2020 due to drought and supply chain disturbances, which increased importation significantly (Cenral Bank of Sri Lanka, 2020). These market analyses suggest the need of formulating new strategies and policies to capture the optimal market share and uplift both local and global competitiveness.

Institutions are established based on formal and informal laws, which are the mechanisms monitoring and enforcing (Campbell, 2004) the industry. According to (Dollar & Kidder, 2016) economies with better institutional framework have a strong participation in both local and global value chains while economies with weak institutions have only a small role. As a coconut oil supplier in a developing country Sri Lanka should have to adopt upgrading strategies in order to improve their position in the value chain by capturing more market share compared to rivals. Literature highlights that upgrading potentials influence by local institutions and strategies that generate both positive and negative impacts for chain participants (Mitchell & Coles, 2011; Rossi, 2013). Therefore, this study aimed to perform institutional analysis and identify the institutional environment and its participation in coconut oil value chain. Further, study focused into identify the institutional networks and strategies in empowering coconut oil value chain and new opportunities for upgrading potentials.

2. Materials and Methods

This study was exploratory in nature. In-depth interviews with selected institutional representatives feed the primary data requirements of the study while secondary data collection tools were mainly internet-based data collection techniques such as institutional websites, social media, annual reports, webinars, etc. Industry public information, companies' periodical statements, and journal databases and reports published by both public and private sector were used to obtain the data. Local authorities responsible were identified and further information was collected through their authoritative data sources such as official websites and blogs. Export Development Board (EDB), Sri Lankan Custom, Central Bank of Sri Lanka, Coconut Development Authority (CDA), Department of Census and Statistics, Coconut Research Institute (CRI) were such identified authoritative entities. It also provided an opportunity to identify key people (industry experts) who involved with coconut oil industry and their contact details. The qualitative data gathered was primarily grouped based on their influence on micro and macro level of the coconut value chain and prepare an institutional network diagram. Relationships and functions of institutions and institutional networks were analysed to identify the insights on institutions on coconut oil value chain.

3. Results and Discussion

According to figure 1, Coconut oil institutional framework mainly divided into micro and macro level for the study purpose. Micro level institutions were grouped as; government institutions for capacity building, regulation bodies and private institutions. Macro level institutions grouped as; government institutions for capacity building, national level regulatory bodies, intergovernmental organizations (capacity building and regulatory bodies) and non-governmental organizations both in local and global level.

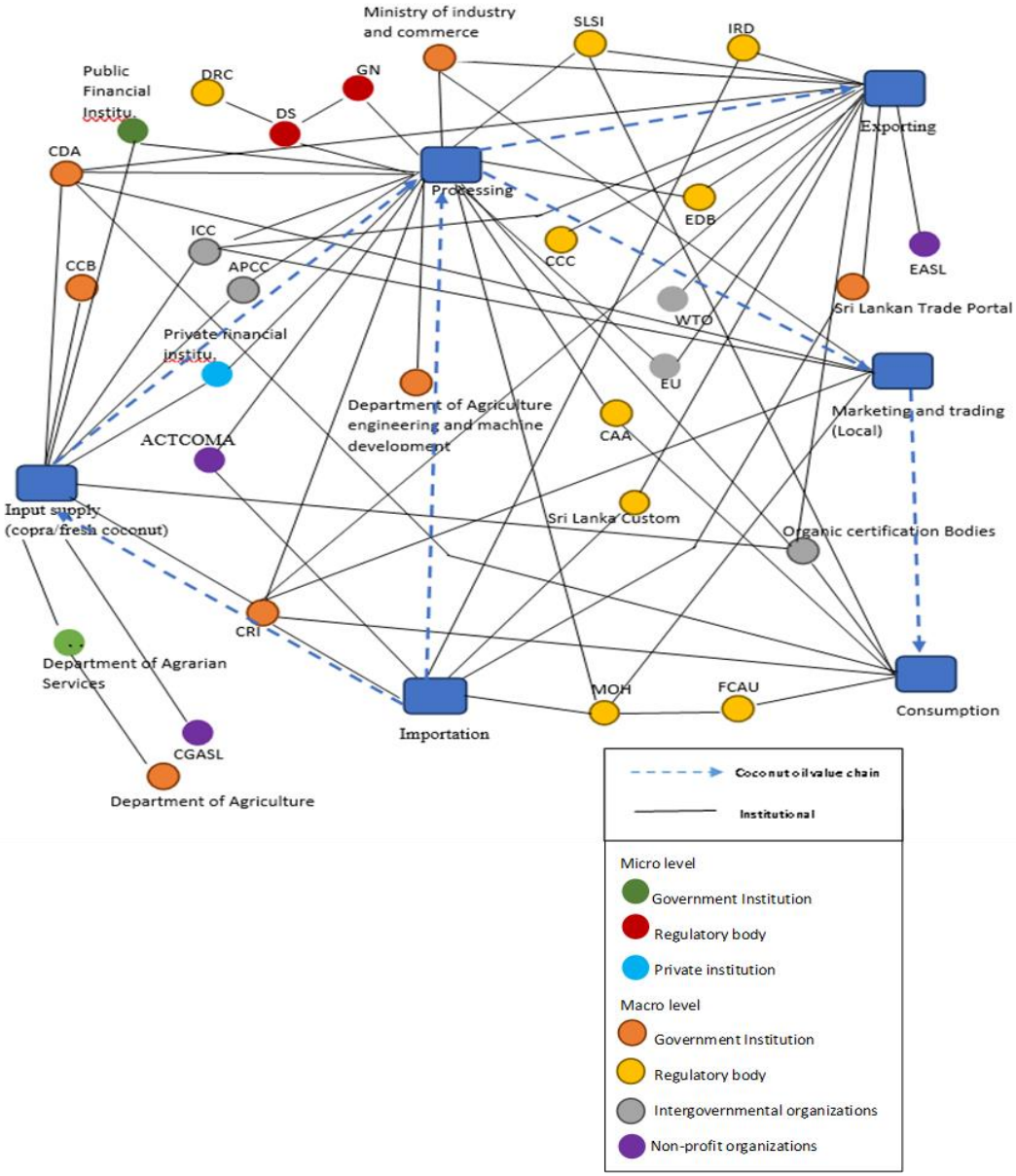

Figure 1. Institutional framework for coconut oil value chain

Upstream of the value chain both micro and macro level governmental institutions implemented several programs in recent past to uplift the living standards and the productivity of the industry such as providing fertilizer subsidy, high quality coconut plants, training and awareness programs, loan programs collaborate with state and private banks etc. In field level regional offices, field officers take these programs towards coconut growers and supervise them. Downstream of the value chain micro and macro level institutions involved in regulating and implementing services such as finance and insurance, logistic, verification and testing,

supportive services (machinery) facilitate to deal with both local and between nations. Non-profit and intergovernmental organizations help to develop, promote and better trading facilities within and outside the nation.

However, regulatory and institutional weaknesses and disturbances stem from institutional environment has hinder contribution toward the upliftment. Present study addresses some key problem areas which provide potential to upgrade. Such as complex institutional structures require heavy paper work and time, overlapped regulatory activities, conflicts between institutional objectives and facilitate of trade, lack of overall coordination between government level due to the fragmentation of ministerial portfolio which scattered institutions among diverse ministries, lack of national food control system which cover whole coconut oil value chain from farm to plate etc. However, finds that lead firms in each value chain node tight coordination institution framework on knowledge transmission, finance, information etc. compare to small scale value chain participants.

It is important to transform fragile coordination into strong market opportunities under present globalization. Some of the policies recommended are public-private partnerships in order to achieve a better position in global value chain, each institution should implement clear strategies with their target audience, and implement bench marks to analyse the performance, setting up a conducive legal framework, promoting linkage with national international collective agencies which are important sources of transforming information, triggering knowledge, access toward larger client base, and possibilities of attracting foreign direct investment. R&D constitutes a major gap in institutional setting highlight the important of participation of public and private universities with institutional framework and joint research between private and public which is also very rare. Rapid concern on safety and quality factors in international value chain influence on develop national level standard based on international standards particularly important for producers and exporters who want to access international markets. Interviewers also criticised the lack of promoting Sri Lanka's products internationally. This again highlight the proper institutional mechanism to bring more attention to Ceylon coconut oil such as co-financing of visits to trade fairs, implement policies with faster and less bureaucratic procedures etc.

4. Conclusions

This paper reviews the institutional analysis to identify its insights on coconut oil value chain and their involvement or role on each value chain stage. Proper coordination mechanism among institutions, clear separate institutional mandates, smooth flow of information, and macro level government and regulatory bodies, intergovernmental organization and non-profit organizations will improve the efficiency and international competitiveness in the coconut oil industry in Sri Lanka. Properly organized industrial framework will smooth the flow of value chain in more systematic manner. This also highlights the important of participation of stakeholders with institutional and legal framework throughout the coconut oil value chain.

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Extended Abstracts

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