ICST 2021

PROCEEDINGS OF PAPERS

1st INTERNATIONAL CONFERENCE ON SCIENCE AND TECHNOLOGY | 2021 27 - July

" Technology-based Research and Innovation for Empowerment and Sustainability "

Faculty of Technology
South Eastern University of Sri Lanka
Sri Lanka

ICST 2021

Proceedings of Papers

1st International Conference on Science and Technology 2021

July 27th, 2021

" TECHNOLOGY-BASED RESEARCH AND INNOVATION FOR EMPOWERMENT AND SUSTAINABILITY "

Faculty of Technology
South Eastern University of Sri Lanka
Sri Lanka

ICST 2021

1ST INTERNATIONAL CONFERENCE ON SCIENCE AND TECHNOLOGY

SOUTH EASTERN UNIVERSITY OF SRI LANKA - JULY 27, 2021

Title : *Proceedings of Papers, ICST 2021*

Published by : *Faculty of Technology*
South Eastern University of Sri Lanka
Sri Lanka

Pages : *(XIV+263) Pages*

Layout : *Mr. M.J. Ahamed Sabani*
Mr. M.M.M. Uyaam

Cover Design : *Mr. S. Safdhan*

ISBN : *978-624-5736-17-1*

Conference Secretariat
1st International Conference on Science and Technology
South Eastern University of Sri Lanka
University Park
Oluvil. #32360
Email: icst_ft@seu.ac.lk

CONFERENCE EDITORIAL TEAM

CHIEF EDITOR

Dr. A.D.N.T. Kumara

CO-EDITOR

Mr. M.J. Ahamed Sabani

EDITORIAL TEAM MEMBERS

Dr. Muneeb M. Musthafa
Mr. S.L. Abdul Haleem
Mr. K. Muhammad Rifthy
Mr. P. Pirapuraj
Ms. S.L. Rasmiya Begum

EDITORIAL ASSISTANTS

Mr. M.M.M. Uyaam
Mr. S. Safdhan
Ms. M.F. Nihla

ICST 2021

CHAIRPERSON

Dr. U.L. Abdul Majeed
Dean, Faculty of Technology
SEUSL

CHIEF GUEST

Prof. M.M.M. Najim
The Vice Chancellor
SEUSL

KEYNOTE SPEAKER

Prof. Ajith De Alwis
Senior Professor in Chemical and Process Engineering
Dean, Faculty of Graduate Studies
University of Moratuwa

COORDINATOR

Dr. M.G. Mohamed Thariq
Senior Lecturer
SEUSL

SECRETARY

Ms. M.S. Shafana
Lecturer
SEUSL

CONFERENCE STEERING COMMITTEE

Dr. U.L. Abdul Majeed - **CHAIRMAN**
Dr. M.G. Mohamed Thariq - **COORDINATOR**
Ms. M.S. Shafana - **SECRETARY**
Dr. I.M. Kalith - **TREASURER**

TRACK COORDINATORS

Dr. Muneeb M. Musthafa - Animal and Aquatic Science and Technology
Mrs. N. Sujirtha - Agriculture Economics and Entrepreneurship
Mr. A. Narmilan - Biosystems Engineering
Dr. A.N.M. Mubarak - Crop Science and Technology
Mrs. M.B.F Jemziya - Food Science and Technology
Mr. S.L. Abdul Haleem - Network and Security Technologies
Mrs. A.R.F. Shafana - Computing and Information System
Mr. R.K.A.R. Kariapper - Software Technologies
Mr. P. Pirapuraj - Ubiquitous Computing Technologies
Mrs. A.F. Musfira - Multimedia and Gaming Technologies

COMMITTEE MEMBERS

Dr. A.D.N.T. Kumara
Mr. K. Muhammad Rifthy
Mr. M.J. Ahamed Sabani
Ms. S.L. Rasmiya Begum

INTERNATIONAL ADVISORY BOARD

Prof. Rizana Maharoof - *Professor*
Department of Biological and Physical Sciences
South Carolina State University, USA

Dr. Faiz Marikar - *Director, Staff Development*
Sir John Kotelawela Defence University
Sri Lanka

Dr. Shahjahan Anwer - *Research Associate*
University College London
United Kingdom

Dr. Bulent Tugrul - *Assistant Professor*
Department of Computer Engineering
Ankara University, Turkey

LIST OF REVIEWERS

Prof. A.M. Muzathik, *Dept. of Mechanical Engineering, SEUSL*

Prof. A.M. Razmy, *Dept. of Mathematical Sciences, SEUSL*

Prof. (Mrs.) Champa M. Nawaratne, *Dept. of Agricultural Engineering, UOR*

Prof. (Miss.) J. Sinniah, *Dept. of Aniaml Science, UOJ*

Prof. M.I.M. Mowjood, *Dept. of Agricultural Engineering, UOP*

Prof. M.M.M. Najim, *SEUSL*

Prof. Nazrim Marikkar, *National Institute of Fundamental Studies*

Prof. P.K. Dissanayake, *Dept. of Export Agriculture, SUSL*

Prof. R.G.N. Meegama, *Dept. of Computer Science, USJ*

Prof. S. Sabraz Nawaz, *Dept. of Management and Information Technology, SEUSL*

Prof. (Mrs.) Thevaki Mahendran, *Dept. of Agricultural Chemistry, EUSL*

Dr. A.D.N.T. Kumara, *Dept. of Biosystems Technology, SEUSL*

Dr. A.N.M. Mubarak, *Dept. of Biosystems Technology, SEUSL*

Dr. (Mrs.) Amani Mannakkara, *Dept. of Agricultural Biology, UOR*

Dr. (Mrs.) B.G.N. Sewwandi, *Dept. of Zoology and Environmental Management, UOK*

Dr. Chandima Gajaweera, *Dept. of Animal Science, UOR*

Dr. Eranga M. Wimalasiri, *Dept. of Export Agriculture, SUSL*

Dr. Faiz Marikar, *General Sir John Kotelawal Defence University*

Dr. H.T.R. Wijesekara, *Crop Protection Division, CRI*

Dr. I.M. Kalith, *Dept. of Information and Communication Technology, SEUSL*

Dr. K. Premakumar, *Dept. of Agricultural Chemistry, EUSL*

Dr. Lakmal Rupasinghe, *Faculty of Computing, SLIIT*

Dr. M.A.C. Akmal Jahan, *Dept. of Computer Science, SEUSL*

Dr. M.N. Ajmal Hinas, *Dept. of Computer Science and Engineering, SEUSL*

Dr. Muneeb M. Musthafa, *Dept. of Biosystems Technology, SEUSL*

Dr. (Mrs.) Nayanie S. Aratchige, *Crop Protection Division, CRI*

Dr. (Mrs.) Niranjana Rodney Fernando, *Dept. of Agricultural Biology,EUSL*

Dr. Prabath Jayasinghe, *NARA*

Dr. R.H.G. Ranil, *Dept. of Crop Science, UOP*

Dr. R.M.N.A. Wijewardane, *Research and Development Center, NIPHM*

Dr. Ruwani Nugara, *Dept. of Biosystems Technology, USJ*

Dr. S. Pathmarajah, *Dept. of Agricultural Engineering, UOP*

Dr. S.M.C. Himali, *Dept. of Animal Science, UOP*

Dr. Shajahan Anver, *Dept. of Genetics, Evolution and Environment, Uni. Col. London, UK*

Dr. Sivaramalingam Kirushanth, *Dept. of Physical Science, Vavuniya Campus, UOJ*

Dr. T. Geretharan, *Dept. of Crop Science, EUSL*

Dr. Thivahary Geretharan, *Dept. of Agricultural Economics, EUSL*

Dr. U. Farook, *Dept. of Mechanical Engineering, SEUSL*

Dr. U.L. Abdul Majeed, *Dept. of Biosystems Technology, SEUSL*

Dr. W.M. Wishwajith W. Kandegama, *Dept. of Hortic. and Landscape Gardening, WUSL*

Mrs. A. Fathima Musfira, *Dept. of Information and Communication Technology, SEUSL*

Mr. A. Narmilan, *Dept. of Biosystems Technology, SEUSL*

Mr. A.L. Hanees, *Dept. of Computer Science, SEUSL*

Mr. A.L.M. Rifky, *Dept. of Biosystems Technology, EUSL*

Mrs. A.M. Samaraweera, *Dept. of Animal Science, UWU*

Mrs. A.R. Fathima Shafana, *Dept. of Information and Communication Technology, SEUSL*

Mr. Abhaya Seneviratne, *Sri Lanka Instituite of Packaging*

Ms. Amuthenie S., *Dept. of Agricultural Chemistry, EUSL*

Mrs. Brintha Karunarathna, *Dept. of Crop Science, EUSL*

Ms. J.K.W.N. Subashini, *Dept. of Hortic. and Landscape Gardening, WUSL*

Mr. K. Muhammad Rifthy, *Dept. of Information and Communication Technology, SEUSL*

Ms. Lishani Wijewardene, *Dept. of Limnology and Water Technology, UOR*

Mr. M. Rajendran, *Dept. of Agricultural Engineering, EUSL*

Mr. M. Sugirtharan, *Dept. of Agricultural Engineering, EUSL*

Mrs. M.A.A.P. Kumari, *Dept. of Animal and Food Sciences, RUSL*

Ms. M.B. Fathima Jemziya, *Dept. of Biosystems Technology, SEUSL*

Mr. M.J. Ahamed Sabani, *Dept. of Information and Communication Technology, SEUSL*

Mrs. M.M. Fathima Naja, *Dept. of Information and Communication Technology, SEUSL*

Mr. M.M. Mohamed Mufassirin, *Dept. of Computer Science, SEUSL*

Ms. M.R. Roshana, *Dept. of Biosystems Technology, SEUSL*

Ms. M.S. Shafana, *Dept. of Information and Communication Technology, SEUSL*

Mr. M.S.S. Razeeth, *Dept. of Computer Science and Informatics, UWU*

Mr. N. Nusrathali, *Dept. of Biosystems Technology, SEUSL*

Mr. Nihmathulla Asoomath, *Sri Lanka Standards Institution*

Ms. Nishanthi Sivasubramaniam, *Dept. of Agricultural Biology, EUSL*

Mr. P. Pirapuraj, *Dept. of Information and Communication Technology, SEUSL*

Mr Pilana Vithana Sajith Harshana, *Dept. of Agricultural Economics, UOR*

Ms. R. Dinusha Debarawatta, *Dept. of Hortic. and Landscape Gardening, WUSL*

Mr. R.K.A. Rifai Kariapper, *Dept. of Information and Communication Technology, SEUSL*

Ms. S.L. Rasmiya Begum, *Dept. of Biosystems Technology, SEUSL*

Ms. Sujirtha Nadarajah Vishnukumar, *Dept. of Biosystems Technology, SEUSL*

Mr. Suneth Gunathilaka, *Pelwatte Dairy Industry, Sri Lanka*

Mr. T.A.B.D. Sanjeewa, *Dept. of Plant Sciences, RUSL*

Mr. V. Senthooran, *Dept. of Information and Communication Tech., Vavuniya Campus, UOJ*

MESSAGE FROM THE VICE CHANCELLOR

Faculty of Technology of the South Eastern University of Sri Lanka (SEUSL) is the youngest Faculty in South Eastern University of Sri Lanka but has proven to possess excellent traits including novel areas of teaching, research and innovations, and also caters to the needs of the Country by producing abled undergraduates. Further, the Faculty of Technology is the pioneer Faculty in South Eastern University of Sri Lanka to start a Ph.D. research degree programme.

The Faculty of Technology for the first time has organized its annual International Conference on Science and Technology, ICST 2021 entitled "Technology–based Research and Innovation for Empowerment and Sustainability" in July, 2021. The faculty has taken steps to disseminate the valuable research outputs generated in Technology by its students, staff, stakeholders from other faculties of the University, other Universities and research organizations from Sri Lanka and overseas. This conference provides the opportunity for all researchers to present their findings with the presence of an audience of experienced researchers and with their, endorsements, such research will be disseminated through the proceedings published today. Further, selected research outputs presented will be given the option of publishing in the Sri Lanka Journal of Technology (SLJoT) of the faculty. Hence, this annual research conference of the Faculty of Technology will contribute in the achievement of the vision of the SEUSL of becoming a world class academic and research institution.

The commitment and enthusiasm shown by organizing committee of this conference is commendable. The leadership given by the Dean of the Faculty, Dr. UL. Abdul Majeed as the Conference Chair and Dr. MG. Mohamed Thariq as the Coordinator of the Conference together with the team of energetic staff made this a very successful event. I hope that this conference will be remembered as one of the annual events that is in the forefront in disseminating technology related research in the Country.

I am greatly honoured and pleased to welcome all the paper presenters and the participants to this conference. I extend my gratitude to all who are party to this conference and wish all the researchers who present their findings all the success. I am sure that with all your contributions, the South Eastern University of Sri Lanka could retain its role as a leading University in the country.

Professor M.M.M. Najim
Vice Chancellor
South Eastern University of Sri Lanka
Oluvil.

MESSAGE FROM THE CHAIRMAN

As the Dean of the Faculty of Technology, I am honoured to write this felicitation message to the first International Conference on Science and Technology-ICST 2021, organised by the Faculty of Technology of South Eastern University of Sri Lanka. The theme of the conference is "Technology-based Research and Innovation for Empowerment and Sustainability". The conference theme is founded on five main pillars such as Technology, Research, Innovation, Empowerment and Sustainability which are the terminologies of the present world and are indispensable to the contemporary world. Here, the technology, research and innovation are interrelated specially in the context of empowerment and sustainability. For a stable growth and development of a country, empowerment of economy, education, health, security, research and innovation, etc. is again indispensable. Not only the empowerment of the sectors mentioned above is adequate, but it should be achieved through sustainability.

Many scholars in the world have given with many different definitions for the term "Sustainability". The definition admired me is "Sustainability is "a process that helps create a vibrant economy and a high quality of life, while respecting the need to sustain natural resources and protect the environment. It expresses the principle that future generations should live in a world that the present generation has enjoyed but not diminished. Again, the sustainable development has three components: environment, society, and economy. If you consider the three to be overlapping circles of the same size, the area of overlap in the centre is human well-being. As the environment, society, and economy become more aligned, the area of overlap increase, and so does human well-being.

Based on the illustrations, the theme of the first international conference of the Faculty of Technology is significant and timely. I am pleased to state that more than fifty research papers have been received from local and internal researchers from different disciplines. It is a great achievement and endorsement for the commitment extended by the Faculty of Technology in maintaining its standards to the contribution of academic, research and the society.

I would like to congratulate all the scholars, researchers and presenters for their participation in the international conference that will be held virtually from the distance mode due to the prevailing Covid-19 situation in the country.

Finally, I would like to express my sincere thanks and gratitude to the Chief Guest, Professor M.M.M. Najim, Vice Chancellor of SEUSL, the Key-note Speaker Professor Ajith De Alwis, Senior Professor in Chemical & Processing Engineering, University of Moratuwa and the Project Director - Coordinating Secretariat for Science, Technology and Innovation (COSTI), Ministry of Science, Technology & Research, moderators, distinguished quests, scholars, presenters, the organising committee, Faculty staff & students and the university administrative staff for their fullest and enormous support and co-operation to make this historic event a success. I also wish to extend my thanks to all who supported directly and indirectly during the different stages to make this international conference a successful event.
Thanks.

Dr. U. L. Abdul Majeed
Dean
Faculty of Technology
South Eastern University of Sri Lanka.

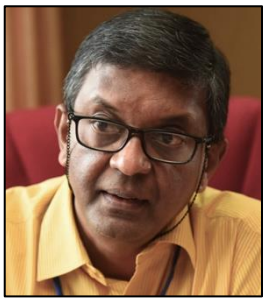
MESSAGE FROM THE COORDINATOR

This is a privilege to me for being the coordinator and giving this message to the proceedings of the first International Conference on Science and Technology 2021 (ICST 2021) under the theme of "Technology-based Research and Innovation for Empowerment and Sustainability" organized by the Faculty of Technology of the South Eastern University of Sri Lanka. I feel it is important to note here that the Faculty of Technology of the South Eastern University of Sri Lanka was established having realized the need for technology education and research and its contribution to the development of the country. The main objective of the technology faculty is to produce graduates who are competent and are able to meet the demands in the world of work for technological professionals. Under this context, this conference is an important event, which created a platform for research students, academics, practitioners, and industrialists to present and discuss their innovations and findings. The conference will have an added value with a keynote speech to be delivered by Prof. Ajith De Alwis, an eminent personality in Sri Lanka and currently the Project Director for the Coordinating Secretariat for Science, Technology, and innovation. In this conference, we have 50 full papers accepted after double-blind peer-review process for oral presentations under 10 different tracks.

At this occasion, I would like to extend my heartfelt gratitude to Prof. M.M.M. Najim, Vice Chancellor, South Eastern University of Sri Lanka for the support and guidance given to make this event a successful one. My heartfelt gratitude also goes to Dr. U.L. Abdul Majeed, Chairman of the conference, and the Dean of the Faculty of Technology for the support given and for engaging in all the conference activities actively. My special thanks go to Ms. M.S. Shafana, secretary of this conference, for playing the main role throughout with great efforts and dedication to make this event a reality. My sincere thanks also go to track coordinators and members of the conference committee for their valuable contributions and for carrying additional tasks under the prevailing pandemic situations. Further, I extend my gratitude to Dr. A.D.N.T. Kumara, chief editor, and Mr. M.J. Ahamed Sabani, co-editor, and the members of the editorial board for their contributions to bring out this proceeding, the book of abstract, into this current professional format and look. I would also like to extend my sincere gratitude to Mr. R.K.A. Rifai Kariapper and the members of the technical committee for their contributions for arranging this event in a virtual mode. My sincere thanks also go to Dr. I.M. Kalith, treasurer of the conference for smoothly handling conference financial activities. I would like to convey my gratitude to all the authors and paper presenters who are the main contributors to this event. Further, my sincere thanks go to reviewers and panel members for valuable comments and inputs on different research topics. In addition, I would also like to register my gratitude to the university and the other organizations for their financial support to make this conference a success. My gratitude also goes to all the University staff members who directly or indirectly contributed to this event. Further, my sincere thanks go to guests, all the participants, and media personals. Finally, I wish a successful conference.

Dr. M.G. Mohamed Thariq PhD
Coordinator
International Conference on Science and Technology (ICST 2021)
Faculty of Technology
South Eastern University of Sri Lanka
Sri Lanka.

MESSAGE FROM THE KEYNOTE SPEAKER



It is interesting and important to note the South Eastern University Faculty of Technologies theme for 2021. Technology based Research and Innovation for Empowerment and Sustainability. 2021 too is proving to be quite a challenging year as the impacts of 2020 are not yet resolved – the virus is still wreaking havoc among us. We are still to a better part of our times, literally in hiding! Coming out of this Covid-19 instituted lockdowns and travel restrictions indeed depend on research and innovations. Universities have a greater responsibility in this regard. One hears the Astra Zeneca Oxford vaccine for Covid-19 and the role of a university is clearly present.

Research and innovation has paved the way for the world to have vaccines in record time in 8 months instead of 4 years! It is important we understand the value of research and innovation in powering societies and when universities take a lead in this regard we simply produce a community of practitioners with such a mindset. The university thus become an important institution for the society only through that manner. I wish South Eastern University and the Faculty of Technology in particular for the efforts taken in ensuring this important event a reality. What is finally of importance is seeing that what is discussed is delivered via the performance of the student body. All the best!

Prof. Ajith De Alwis
Senior Professor in Chemical and Process Engineering
Dean, Faculty of Graduate Studies
University of Moratuwa.

ABSTRACT OF KEYNOTE SPEECH

R&D for the Society – Create and Eco-system of Innovators

If the world has changed in some way there is always an innovation. An innovation requires different type of inventors along the way. Someone may use science and technology to come out with an invention. Taking the invention to the market depends on many others supporting and may be perhaps creating difference situations of value. However critical the original idea is in the process of innovation, invention still is credited with only 10% of value of an innovation. 80-90% of the effort is needed in completing the process of innovation. Hence when fruits of R&D come out to the society so much has to happen and so many have to interact positively with the right mindset. Otherwise there going to be so many disappointed people.

Our universities need to be transforming themselves to research universities. It is on research and development that a university can transform itself. How do you ensure that transformation? Covid-19 has perhaps transformed our way of university education forever. We should not be planning to go back to the old normal but instead seek ways to make use of new ways to benefit ourselves and move forward. Can we embed more research at undergraduate level and do we have ways of enabling more undergraduate and postgraduate research interaction?! Definitely this is possible. Few solid research successes could literally transform the university environment overnight. Such examples are available from outside and in this more connected universe we must not just look at research and development not as a nice thing to do but as a must do activity. We are in for a decade with so much challenges and the presence of Covid-19 has not helped in anyway. Yet if lessons are to be taken one lesson is disasters have given rise to significant developments simply because of the way people respond to such situations. The presentation would prompt one to think along those lines to support empowerment and sustainability.

TABLE OF CONTENTS

TRACK - ANIMAL AND AQUATIC SCIENCE AND TECHNOLOGY

Consumer Perception of Organic Animal-based Foods in Colombo District, Sri Lanka

K.L.D.B.P. Liyanage[1*], S.A.C.H. Rodrigo[2], P.M. Korale Gedara[3], J.K. Vidanarachchi[4] & K. Samarasinghe[5]

[1]*Department of Plantation Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Sri Lanka*
[2]*Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Sri Lanka*
[3]*Department of Agricultural Economics and Business Management, Faculty of Agriculture, University of Peradeniya, Sri Lanka*
[4,5]*Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka*

[1*]b.p.liyanage93@gmail.com, [2]chathuri.rodrigoask@gmail.com, [3]pradeepa.malkanthi@gmail.com, [4]janakvid@pdn.ac.lk, [5]ksamaras12@gmail.com

Abstract- *Due to concerns about non-communicable diseases, animal welfare, and the organic animal product sector have become emerging trends in the world as well as in Sri Lanka. As very little is known about consumer perception about organic animal products, a survey was conducted in Colombo district, Sri Lanka together with 178 respondents. Five supermarkets and one organic selling place (Good market) were used for the survey. By using the chi-square method, the effect of each demographic character on awareness and purchasing behaviour about organic animal products was evaluated. Out of total respondents, 51% of respondents reported that they did not hear about organic animal products. Only 49% of respondents had heard about organic animal products. Among 49% of respondents, only 61% of respondents were buyers and 37% were non-buyers. The majority of the organic animal products buyers were in middle age (31-45 years old), well-educated, and had higher family income over 100,000 LKR. The higher price was reported as a barrier to purchase organic animal products. The majority of the respondents believed that organic animal products do not contain residues of pesticides, antibiotics, and medications, as well as majority of respondents, believed that there was no difference in taste between organically and conventionally produced animal products. At present in Sri Lanka, certified organic animal products are not available. Therefore, out of total buyers, 98% of respondents had been misled the term organic and they purchased free-range animal products.*

Keywords: Organic, Consumer perception, Animal products, Colombo district

I. INTRODUCTION

In recent years, conventional livestock farming has been increased due to the high performances of farm animals and less production cost. Meanwhile, intensification of production leads to issues of animal health, animal welfare, and environmentally friendly production. As a response to these issues, organic livestock farming was introduced a few decades back. The increase of interest in organic food throughout the world is a response to concerns about the intensive agricultural practices and their effects on consumers' health and the environment (Yiridoe *et al*., 2010). Therefore, demand for organically produced animal-based products is increasing in all over the world due to positive effect on human health as well as positive effect on the environment.

The livestock-based food production system has been directed towards conventional farming practices through extensive use of pesticides, herbicides, feed additives, different detergents, chemicals, and medications. According to the Sri Lankan context, there is an ongoing faster development in the organic sector in the country. At present out of the total agricultural lands, the organic agricultural lands are about 96,318 ha in Sri Lanka and Sri Lanka is in the top ten countries with the highest increase in organic agricultural lands (Willer *et al*., 2018)

Many studies have been conducted on consumer perception towards organic foods in Europe and Western countries, notably the USA, Australia, and New Zealand (Roitner-Schobesberger *et al.*, 2008). However, there are very few studies carried out in Asian countries about consumer perception towards organic foods. At present, organic

vegetables and fruits are available all over Sri Lanka. But there is very little attention on organic livestock-based food production systems in Sri Lanka. Furthermore, all most all the publications available in relation to organic farming in Sri Lanka are on organic field crops, plantation crops, export agricultural crops, and organic manure preparation. There is no any proper investigation carried out in relation to consumer perceptions on organic animal-based food products in Sri Lanka. Therefore, the problem statement which was investigated in the current study was consumer perception about organic-based animal products in Colombo district, Sri Lanka.

II. LITRETURE REVIEW

The organic animal production sector is a subsector of organic foods, which does not contain residues of antibiotics, disinfectants, and veterinary medications. Due to the prevalence of non-communicable diseases and concerns on animal health, the demand for organic animal products has been increased in the world (Gifford and Bernard, 2006).

A. Consumer perception towards the organic foods

At present rather than just consuming foods for the hunger, consumers think on food safety, the impact of foods on human health and the environment (Fillion and Arazi, 2002). As a response to these considerations, organic foods have become more popular in the world.

Some studies have shown that, normally organic food buyers are well educated, affluent as well as they belong to a higher social class (Padel and Foster, 2005; Stobbelaar *et al*., 2007; Shafie and Rennie, 2012). A similar study has also revealed that there is a positive correlation between consumption of organic foods and level of formal education (Lockie *et al*., 2002). Ureña *et al.* (2008) described that there are three types of organic food consumers based on the frequency of consumption as regular, occasional and non-consumers. In the above study among total consumers, 12% of them were represented by regular consumers, 42% were occasional consumers, and the remaining 46% were represented by non-consumers. However, among non- consumers, 25% had an intention to buy organic foods in future.

B. Consumers' willingness to pay for organic foods

Generally, consumers have to pay a premium price for organic foods. Organic food consumers are generally elder, come from tertiary educated households, and have higher income with compared to non-consumers of organic foods (Padel and Foster, 2005; Roitner-Schobesberger *et al*., 2008). Wandel and Bugge (1997) have found that there is no significant effect of income and occupation on consumer perception towards organic animal foods. Organic food consumers are motivated to increase their purchasing frequency, by improving the sensitivity and availability of organic foods (Woese *et al*., 1997).

C. Comparison of nutritional properties and sensory properties of organic animal products and conventional animal products

There are several researchers carried out to compare nutritional qualities and sensory qualities in between organic animal products and conventional animal products. Lund (1991) showed that there are no major differences between organically produced milk and conventionally produced milk. Inorganic pig production, the exclusion of synthetic amino acid supplementation from the diet has been caused to increase the intramuscular fat content in pigs (Sundrum *et al*., 2000).

III. METHODOLOGY

A. Questionnaire preparation

The questionnaire was designed to gather exploratory data about consumer perception of organic animal-based foods in Colombo district, Sri Lanka with the help of experts in organic farming.

B. Structure of the questionnaire

The questionnaire was composed with four main categories. In the first category, basic demographic information of respondents was collected. In the second category, respondents who indicated as "never heard about organic animal products" were categorized separately. The respondents who indicated "heard about organic animal products" were asked whether they agree or disagree with several statements regarding their knowledge about organic animal foods.

In the third category, the respondents who indicated "heard about organic animal products" were divided into two parts based on whether they

purchase organic animal-based foods or not. Respondents who indicated as "non- buyers" were categorized as "heard about organic animal-based foods and non- buyers". Furthermore, respondents who indicated as "buyers" were categorized as "heard about organic animal foods and buyers". In the fourth category, respondents were asked to indicate any suggestions to improve organic animal-based foods in Sri Lanka.

C. Sampling and data collection

The current study was carried out in Colombo district, Sri Lanka. For this study, five supermarkets and one organic food selling place (Good Market) were selected to approach different customer types. Five supermarkets were selected randomly from different cities of the Colombo district, Sri Lanka. It was done in order to include a different range of customer types into this study as well as to cover up the entire Colombo district, Sri Lanka. One organic food selling open market; Good Market was selected because it is the main organic food selling market in Colombo district, Sri Lanka. Twenty customers were interviewed from each supermarket. All together 100 customers were interviewed from 5 supermarkets and 100 customers were interviewed from the organic market. Finally, 200 customers were interviewed in this study. Customers were approached randomly. Out of the total questionnaires, usable questionnaires were 178 questionnaires representing an 89% of successful response rate.

D. Data analysis

Data were collected from November 2018 to January 2019. The collected data were summarized by using the Microsoft excel office package (2016) and SPSS software (Version 22). By using the chi-square method, the effect of each demographic character on awareness and purchasing behavior about organic animal-based foods was measured. The respondents except the respondents, who indicated as "never heard about organic animal products" were presented with different statements and those data were analyzed descriptively by using Microsoft excel package (2016).

IV. RESULTS AND DISCUSSION

The profile of the sample respondents is shown in Table 01. Out of total respondents, 49% of them claimed that, they had heard about organic animal products and the rest (51%) were not heard about organic animal products. Among the 49%, sixty-one (61%) of them were buyers of organic animal products and 37% were non-buyers of organic animal products. The majority of the respondents, who purchased organic animal products, were 31-45 years old, whereas, majority of the non-buyers of organic animal products were fallen in to the age between 15-30 years old. Respondents, those who purchase organic animal products have an income over 100,000 LKR while, majority of the non-buyers of organic animal products have a monthly income between 50,000-100,000 LKR. Majority of the respondents with lower income level (<20,000 LKR), lower education level and age between 15-30 years and more than 60 years, have not heard about organic animal products. Above findings were similar to already published researches of Padel and Foster (2005) and Roitner-Schobesberger *et al.* (2008) and they exhibited that, organic food consumers are generally older, come from tertiary educated household and have higher income with compared to non-consumers of organic foods. Out of the total respondents, un-employers and school students have very poor awareness about organic animal products. Regarding the gender, the category of who have "never heard about organic animal products" was mainly represented by male (56%) over female.

Out of total organic animal products buyers, 51% of respondents tend to be graduates or undergraduates. Meanwhile, 36% of respondents tend to be post-graduates. Therefore, it could be argued that, majority of the organic animal products buyers are well educated. Some studies also have shown that normally organic food buyers are well educated, affluent as well as they are from a higher social class (Padel and Foster, 2005; Stobbelaar *et al*., 2007). In addition, another study has emphasized that, there is a positive correlation between consumption of organic foods and level of formal education (Lockie et al., 2002). Regarding the occupation, the majority of the organic animal products buyers (34%) were in the government sector. Out of organic animal products buyers, 38% of respondents had four members in their family. There were two types of respondents based on awareness about organic animal-based foods. Those two groups were 'respondents, who had heard about organic animal-based foods' and 'respondents, who never heard about organic animal-based foods. The effect of each demographic character on awareness about organic animal products was measured to identify whether there was a significant effect of demographic characters on awareness on organic animal products (Table 02).

Except for age and gender, all other demographic characters have significant differences with the awareness about organic animal-based products. But Wandel and Bugge (1997) has provided evidences, which are incompatible with these findings, and found that there is no significant difference between income and occupation with the consumer perception towards organic animal foods. There were two types of respondents based on purchasing behaviour. One category was identified as 'respondents, who have heard about organic animal products but non- buyers. Another category was 'respondents, who have heard about organic animal products and buyers. The effect of each demographic character on the purchasing behaviour of organic animal products was measured to identify whether there was asignificant effect of demographic characters on the purchasing behaviour of organic animal products (Table 03). Except for the educational level, all other demographic characters do not show significant differences with the purchasing behaviour on organic animal-based products. The above finding was supported by some researches and they have revealed that organic food buyers are well educated (Padel and Foster, 2005; Stobbelaar *et al*., 2007).

Table 01: Demographic characters and awareness about organic animal-based foods

Demographic character	Number of interviewees	Never heard	Heard, non-buyers	Heard, buyers
Age				
15-30 years	72	59.7%	20.8%	16.6%
31-45 years	47	36.2%	17.0%	46.8%
46-60 years	38	47.4%	18.4%	34.2%
>60 years	21	57.1%	9.5%	28.6%
Gender				
Male	87	44.8%	20.7%	33.3%
Female	89	55.5%	15.6%	26.6%
Family size				
Two	1	-	100.0%	-
Three	26	26.9%	19.2%	53.8%
Four	84	53.6%	21.4%	23.8%
Five or more	67	56.7%	11.9%	28.3%
Occupation				
Government sector	31	22.6%	16.1%	58.1%
Private sector	49	51.0%	16.3%	32.6%
Own business	31	48.4%	22.6%	29.0%
Retired	19	47.4.%	10.5%	36.8%
Unemployed	8	87.5%	12.5%	-
Still schooling	22	77.3%	13.6%	4.5%
Other	18	55.6%	33.3%	11.1%
Education Level				
Up to G.C.E. 0/L	41	85.4%	2.4%	9.8%
Up to G.C.E. A/L	62	74.2%	21.0%	4.8%
Undergraduate/ graduate	51	15.7%	29.4%	53.0%
Postgraduate	24	4.2%	12.5%	79.2%
Monthly family income				
< 20,000 LKR	4	100.0%	-	-
20,000- 50,000 LKR	26	57.7%	23.1%	19.2%
50,000-100,000 LKR	84	60.7%	16.6%	21.4%
>100,000 LKR	63	31.7%	19.0%	47.6%

Note - The missing percentage did not give an answer

Table 02: Demographic characters and awareness about organic animal-based foods

Demographic character	Chi-square value	Awareness
Age	7.25	Ns
Gender	2.27	Ns
Family size	8.29	*
Occupation	22.15	*
Educational level	81.18	*
Monthly family income	16.82	*

Note: *Denotes significance at $p< 0.05$; NS denotes not significant

Table 03: Demographic characters and purchasing behaviour of organic animal-based foods

Demographic character	Chi-square value	Awareness
Age	7.25	Ns
Gender	2.27	Ns
Family size	8.29	*
Occupation	22.15	*
Educational level	81.18	*
Monthly family income	16.82	*

Note: *Denotes significance at $p< 0.05$; NS denotes not significant

The respondents, who had heard about 'organic animal-based foods' were asked to provide their general opinion and knowledge on organic animal products by indicating whether they agree or disagree (Table 04).Out of the total respondents, around 70% of respondents strongly agreed with the statement that 'organic farming is good for the environment'. A similar study was conducted in Bangkok, Thailand has also found that around 90% of respondents agree with the statement that 'organic farming is good for the environment' (Roitner-Schobesberger *et al.*, 2008). All most half of the interviews of the current study agreed with the statement that 'organic animal products are the same as natural/traditional animal products" with ensuring the majority of them in a misconception about organic animal products. Similarly, Roitner-Schobesberger *et al.* (2008) have also observed that around 65% of respondents were in a misconception that natural/traditional products are the same as organic products. Out of the total respondents, 90% of respondents agreed with the statement that organic animal products do not contain any residues of pesticides or herbicides. Roitner-Schobesberger *et al.* (2008) have also found that, majority of the respondents (72%) accepted that, organic products do not contain pesticide residues or any other residues of synthetic chemicals. Another study has also revealed that organic foods contain only one third of pesticide residues with respect to conventional foods (Baker *et al*., 2002). In the current study, the majority of the respondents accepted that organic animal products do not contain antibiotics, disinfectants, hormones, veterinary drugs, and GMOs (Magnusson *et al*., 2004; Arvola *et al*., 2008). There were positive attitudes on organic foods among consumers with compared to genetically modified foods. Many European studies have also emphasized that consumers have negative attitudes about genetically modified foods (Grunert *et al*., 2000; Gifford and Bernard, 2005). But, Woese et al. (1997) have shown that there is no difference in pesticide residues between organic and conventional animal products. More than half of the respondents (80%) were in the opinion that, organic animal products are more nutritious. But Lund (1991) has shown that, there are no major differences between organically produced milk and conventionally produced milk. According to many studies, which have been conducted about consumer perception towards organic foods, have found that the higher price is the main reason for not consuming organic foods (Padel & Foster, 2005). The respondents who had heard about organic animal products as well as already purchasing organic animal products were asked nutritional quality, sensory quality and some other related questions about organic animal products (Table 05). Out of total consumers, 68% of them indicated that organic animal products are better in quality than conventional animal products. In organic pig production the exclusion of synthetic amino acid supplementation from the diet has been caused to increase the intramuscular fat content in pigs (Sundrum *et al*., 2000). The enhancement of intramuscular fat content increases the eating quality characteristics of meat. None of the organic animal product buyers indicated that conventional animal products better in quality or tasty than organic animal products.

Table 04: Assessment of general knowledge and opinion towards the organic animal-based foods by the respondents who had 'heard about organic animal-based food' (n =87)

Statement	Strongly agree	Agree	Fair	Disagree	Strongly disagree
Organic farming is good for environment.	69%	29%	1%	-	-
Organic animal-based foods are same as traditional/natural animal foods.	14 %	39%	8%	32 %	6 %
Organic animal foods never contained genetically modified organisms. (GMO)	16%	56%	17%	1%	5%
Organic animal products do not contain any pesticide or herbicide residues.	29%	61%	8%	1%	-
Organic animal products are more nutritious over conventional animal products	29%	51%	16%	3%	-
Higher price of organic animal products is a barrier to buy them	52%	44%	-	3%	-

Note - The missing percentage did not give an answer

Table 05: Assessment about organic animal-based foods by the respondents who have heard of 'organic animal-based foods and buyers of organic animal-based foods' in percent (n =53)

Statement	Yes, I agree	Undecided	No, I disagree
I think there is a difference between organic animal products and conventional animal products.	91%	8%	-
I am happy about accessibility to organic animal products in Sri Lanka.	17%	26%	55%
I feel organic animal products are in better in quality than conventional animal products.	68%	30%	-
I feel organic animal products are better in taste than conventional animal products.	86%	11%	-

Note - The missing percentage did not give an answer

Moreover, Roitner-Schobesberger *et al*. (2008) have also shown that most of the buyers believe that, organic foods are better in taste. However, Fillion and Arazi (2002) have found that there is no difference in taste between organic milk and conventional milk. The respondents who have heard about organic animal products but non-buyers were asked why they do not purchase organic animal products (Table 06).

Table 06: Assessment of statements about organic animal-based foods by the respondents who have heard of organic animal-based foods and non- buyers of organic animal-based foods' (n =32)

Statement	Yes, I agree	Undecided	No, I disagree
Organic animal products are too expensive	94%	6%	-
Organic animal products can afford only in upper class consumers	81%	6%	13 %
Organic animal products are not available in everywhere	94%	6%	-
I don't feel organic animal products are better than conventional animal products.	9%	16%	75%
I am confused on certification regarding organic animal products in Sri Lanka	50%	38%	-

Note - The missing percentage did not give an answer

Majority of the respondents claimed that, organic animal-based foods are too expensive and not commonly available to purchase. Moreover, all most half of the respondents emphasized that, they were not satisfied about the certification procedures of Sri Lanka.

V. CONCLUSION

Majority of the respondents have very poor awareness on organic animal products. Furthermore, majority of the organic animal product buyers were in middle age (31-45 years), well-educated and having a monthly income over 100,000 LKR. However, real organic animal products are not available in Sri Lanka. Therefore, around 99% of organic animal products buyers have a misconception that, they purchase organic animal products and actually, they purchase free-range animal products. Government should involve improving the awareness about organic animal products, through conducting awareness programs. Subject on organic animal products need to include into school syllabus to improve the awareness on organic animal products for school children.

REFERENCES

Arvola, A., Vassallo, M., Dean, M., Lampila, P., Saba, A., Lähteenmäki, L. and Shepherd, R. 2008. Predicting intentions to purchase organic food: The role of affective and moral attitudes in the Theory of Planned Behaviour. *Appetite*. 50(3), 443-454.

Baker, B.P., Benbrook, C.M., Iii, E.G. and Benbrook, K.L. 2002. Pesticide residues in conventional, integrated pest management (IPM)-grown and organic foods: insights from three US data sets. *Food Additives & Contaminants*. 19(5), 427-446.

Fillion, L. and Arazi, S. (2002) 'Does organic food taste better? A claim substantiation approach', *Nutrition & Food Science*. 32(4), 153–157.

Gifford, K. and Bernard, J.C. 2006. Influencing consumer purchase likelihood of organic food. *International Journal of Consumer Studies*. 30(2), 155-163.

Grunert, K.G., Bech-Larsen, T. and Bredahl, L. 2000. Three issues in consumer quality perception and acceptance of dairy products. *International Dairy Journal*. 10(8), 575-584.

Lockie, S., Lyons, K., Lawrence, G. and Mummery, K. 2002. Eating 'green': motivations behind organic food consumption in Australia. *Sociologia ruralis*. 42(1), 23-40.

Lund, P. 1991. Characterization of alternatively produced milk. *Milchwissenschaft*. 46(3), 166-169.

Magnusson, M.K., Arvola, A., Hursti, U.K.K., Åberg, L. and Sjödén, P.O. 2003. Choice of organic foods is related to perceived consequences for human health and to environmentally friendly behaviour. *Appetite*. 40(2), 109-117.

Padel, S. and Foster, C. 2005. Exploring the gap between attitudes and behaviour: Understanding why consumers buy or do not buy organic food. *British food journal*. 107(8), 606–625.

Roitner-Schobesberger, B., Darnhofer, I., Somsook, S. and Vogl, C.R. 2008. Consumer perceptions of organic foods in Bangkok, Thailand. *Food policy*. 33(2), 112-121.

Shafie, F.A. and Rennie, D. 2012. Consumer perceptions towards organic food. *Procedia-Social and Behavioral Sciences*. 49(2), 360-367.

Stobbelaar, D.J., Casimir, G., Borghuis, J., Marks, I., Meijer, L. and Zebeda, S. 2007. Adolescents' attitudes towards organic food: a survey of 15- to 16-year-old school children. *International Journal of Consumer Studies*. 31(4), 349-356.

Sundrum, A., Bütfering, L., Henning, M. and Hoppenbrock, K.H. 2000. Effects of on-farm diets for organic pig production on performance and carcass quality. *Journal of animal science*. 78(5), 1199-1205.

Ureña, F., Bernabéu, R. and Olmeda, M. 2008. Women, men and organic food: differences in their attitudes and willingness to pay. A Spanish case study. *International Journal of consumer Studies*. 32(1), 18-26.

Wandel, M. and Bugge, A. 1997. Environmental concern in consumer evaluation of food quality. *Food quality and preference*. 8(1), 19-26.

Willer, H. and Lernoud, J. 2018. The World of Organic Agriculture Statistics and Emerging Trends 2018. Research Institute of Organic Agriculture (FiBL) Ackerstrasse113, 5070 Frick, Switzerland, 22-31.

Woese, K., Lange, D., Boess, C. and Bögl, K.W. 1997. A comparison of organically and conventionally grown foods—results of a review of the relevant literature. *Journal of the Science of Food and Agriculture*. 74(3), 281-293.

Yiridoe, E.K., Bonti-Ankomah, S. and Martin, R.C. 2005. Comparison of consumer perceptions and preference toward organic versus conventionally produced foods: A review and update of the literature. *Renewable agriculture and food systems*. 20(4), 193-205.

Evaluation of Physico-chemical Characteristics of Locally Available Broken Rice as Feed Ingredients for Poultry

M.G. Mohamed Thariq[1*] & R.M.P.P. Rathnayaka[2]

[1,2]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*]mgmthariq@seu.ac.lk, [2]pulara3434@gmail.com

Abstract- *The increased price for maize forced domestic farmers to search for a novel type of ingredient as an energy source and the utilization of locally available broken rice is observed as a replacement to maize. Most importantly, feed cost accounts for up to 70% of the total cost. Any mistake in the formulation can negatively affect poultry production and profit. The performance of compounded feed is a contribution from different raw materials. An understanding of the Physico-chemical properties of feed ingredients is important since these influence the performance of chicken. Hence, this study investigated bulk density, ash content, foreign matter content, grades of broken rice, crude protein and gross energy content of broken rice types sudu kekulu, red peacock and parboiled rice with laboratory analysis. The study found that bulk density, ash content, crude protein and gross energy content were not significantly different (P<0.05) between broken rice types indicating that three broken rice types are similar in these characteristics. Gross energy and crude protein content are the two most important parameters investigated when considering the replacement to maize grain. Mean crude protein and gross energy values of broken rice types were 9.36% and 15.91 MJ/Kg respectively. Based on the findings of the study, it is concluded that maize grain can be replaced with the domestically available broken rice types when considering their crude protein and gross content. However, it is suggested to conduct a feeding trial with a feed formulated with locally available broken rice types to investigate the production performance of poultry.*

Keywords: poultry production; energy; crude protein: broken rice grades

I. INTRODUCTION

Poultry farming is a promising income generation operation and a quick way for return on investment. In the commercial poultry operation, feeding of a balanced ration and correctly formulated feed increases animal productivity, quality of product, and animal welfare. On the other hand, according to Waller (2007), feed cost is the primary component of the variable cost, accounting for up to 70% of the total cost. Therefore, any mistake in the feed formulation can negatively affect farm profits as well as animal production. These together indicate the research needs in general on feeds and feeding with the prime goal of cutting down the costs expended on feeding the animals, without compromising the quality of feed.

A large number of raw materials are utilized for the production of livestock feed based on their chemical composition and current price structure. The quality of compounded animal feeds is based on the quality of its constituents used to formulate the ration. Hence, the assessment of the quality of incoming ingredients is crucial for predicting the quality of a finished feed. The physical properties of the feed are a very important factor in feed processing. The efficiency of handling, processing, and storage of feed in feed mills not only requires information about the chemical nature and nutritive value; but the physical properties of the feed should also be known (Jaelani and Firahmi, 2007). Further, the physical properties are much related to the processing or handling of feed material mechanically (Syarif and Irawati, 1988). Apart from these, according to De Lange (2000), there should be an understanding of the physico-chemical properties of feed ingredients because these properties may influence nutrient digestibility, the gut microflora, and associated microbial fermentation and gut health.

Rezaei et al. (2006) concluded that the use of broken rice up to 500 kg/T in the broiler diets has no adverse effect on performance. Chen et al. (2020) investigated the effect of replacing dietary corn with broken rice on goose growth performance, body size, and bare skin color. With regard to the performance of goose, they concluded that replacing corn with broken rice in diets has no adverse effect on the body weight of geese and further they recommended that 75% of

broken rice can be used instead of corn in goose diets. Apart from the studies on the poultry performance on the inclusion of broken rice in the diet, there are studies on Phsysico-chemical characteristics of broken rice in different parts of the world (Mukhopadhyay and Siebenmorgen, 2017; Bruce et al. 2020). However, Omede (2008) indicated that the influence of physical characteristics of feeds and feedstuffs on animal production in the tropics received limited attention because this is not considered a major factor of influence on livestock productivity. Hence, investigating the quality of feed raw materials not only in terms of their nutritional potential but also of their physical characteristics is important in the formulation of commercial feeds and the evaluation provides different types of information, as required by nutritionists and farmers.

A large quantity of broken rice 5% – 25% is produced as a byproduct of the rice milling process (IRRI, 2021). According to the Department of Census and Statistics (2020), the paddy harvest was 5.12 million metric tons in Sri Lanka in the year 2020. Hence, it is estimated that 0.25 – 1.28 million MT of broken rice might have been produced as a byproduct from the rice milling process as per the paddy production in the year 2020. Whereas, our preliminary observation indicated that local farmers in recent days move towards the broken rice as an energy source in poultry feed production by replacing maize because of the increased price of maize due to the short supply. However, to our knowledge, the data about the characteristics of the locally used broken rice as a feed ingredient in poultry feed so far is quite low. Therefore, it is necessary to evaluate the Physico-chemical properties of broken rice used in local poultry farms, which is crucial for predicting the quality of the finished feed. Hence, this study was an attempt to determine the Physico-chemical characteristics of the locally used broken rice as a feed ingredient. Further, this study compared crude protein and gross energy content of broken rice types with that of maize having the data available in the previous study. It is expected that the findings of this study will be helpful for farmers in formulating balanced poultry feeds at a domestic level.

II. RESEARCH METHODS

A. Preparation of Samples

Three broken rice types namely Sudu Kekulu, red peacock, and parboiled rice that are locally available and used in poultry feed production as an energy source were selected for the study. Primary samples were collected using a grain sampler directly from three bags separately for each broken rice type. For this purpose, 500g of broken rice from the top, bottom and sides of each bag was collected thus nine primary samples were obtained. The primary samples of each broken rice type were mixed and prepared a composite sample of 2 Kg. The composite sample was piled to create a cone shape heap. A minimum of 300g of sample was taken from the composite sample for each laboratory analysis.

B. Estimation of Bulk Density

Each broken rice type was filled in a measuring cylinder with a volume of 100cm^3. Then each type of broken rice was taken out from the measuring cylinder and the weight was taken. Having the volume and the weight bulk density for each rice type was obtained (Zainuddin *et al*, 2014).

C. Estimation of Foreign Matter

Broken rice sample of 100g was obtained for each rice type from the composite sample. Then the sample was sieved. The sieve was shaken horizontally 20 times and powder was removed. Then the sample that remained on the sieve was taken and were divided into five groups and spread on the white sheet. Then the foreign matter was separated manually using the forceps and the weight was taken.

D. Grading the Broken Rice Type

A 100g sample of broken rice from each type was taken and sieved. The sample remained on the sieve was removed and were divided into five groups. Each group was spread on the white sheet and the broken rice was manually separated into three grades as given below.

Grade 1: large broken kernel containing 50% - 75% of the whole kernel

Grade 2: medium broken kernel containing 50% - 25% of whole kernel

Grade 3: small broken kernel containing less than 25% of the whole kernel

(EAS, 2011)

E. Estimation of Crude Protein

The Kjeldahl method was performed according to AOAC International (Latimer, 2016). Approximately 1g of powdered broken rice samples from Sudu Kekulu, parboiled and red peacock were hydrolyzed with 20 ml concentrated sulfuric acid (H_2SO_4) containing two catalyst

tablets (potassium sulphate , copper sulphate) in a heating block for 40 min at 300℃ and 90 min at 420℃. After cooling distilled water was added to hydrolysates in sufficient quantity to double the final volume of the solution and manually stirred and the content was steam distilled in the Kjeldhal distillation apparatus. Then the nitrogen content was estimated by titration.

F. Estimation of Gross Energy

The IKA C 6000 global standards oxygen bomb calorimeter was used to estimate the gross energy of broken rice. For each broken rice type, 1g of powder was taken after grinding and placed in the bomb. The vessel was then filled with oxygen, the sample was combusted, and the heat produced was recorded. The gross energy was obtained in Joule/g then converted into MJ/kg.

III. RESULTS

A. Descriptive Statistics

The descriptive statistics for bulk density, true density, ash, foreign matter, grades (grade 01, grade 02, and grade 03) crude protein, and gross energy of three broken rice types i.e. Sudu Kekulu, red peacock, and parboiled rice were given in Table 01.

Results in Table 01 indicated that bulk density, true density, ash and foreign matter of the three broken rice types vary from 0.727 g/cm^3 to 0.838 g/cm^3, 0.8096 g/cm^3 to 0.8867 g/cm^3, 0.9650g to 3. 4920g and 0.2100g to 0.5000g with the mean of 0.806, 0.8509, 2.0319 and 0.3492. Similarly, the grades of the broken rice vary from 14.319g to 63.599g, 28.820g to 65.984g and 6.562g to 19.966g with the mean of 37.2144, 49.2111 and 12.6654 respectively. The value of crude protein and gross energy vary from 9.1065g to 9.6318g and 15.4949MJ/Kg to 16.4290MJ/Kg with the mean of 9.369 and 15.915 respectively.

B. Comparison of Different Broken Rice Types

Table 02 provides outcomes of the analysis of variance of the Physico-chamical parameters of the broken rice types of Sudu Kekulu, red peacock and parboiled rice.

Table 02: ANOVA for comparisons of Physico – chemical parameters of three different types of broken rice analyzed.

Physico-chemical parameters	**df**	**F- value**	**P- value**
Bulk density (g/cm3)	2	1.116	0.369
Ash (g)	2	3.974	0.058
Foreign matter (g)	2	8.678	0.008
Grade 01 (g)	2	27.353	0.000
Grade 02 (g)	2	16.389	0.001
Grade 03 (g)	2	44.630	0.000
Crude protein (g)	2	4.000	0.142
Gross energy (MJ/Kg)	2	1.762	0.226

P<0.05 is statistically significant at 95% confidence interval.

According to the results in Table 02, foreign matter content and grades of the broken rice types were significantly different (P <0.05). Whereas the difference in the bulk density, crude protein and gross energy between three broken rice types was not significant at P<0.05.

Table 01: Descriptive statistics for Physico-chemical parameters of broken rice types (common minimum, maximum, mean, and standard deviation values for all three broken rice types).

Parameters	**Number of samples**	**Minimum**	**Maximum**	**Mean**	**Std. deviation**
Bulk density (g/cm^3)	12	0.7270	0.8380	0.8060	0.036
True density (g/cm^3)	12	0.8096	0.8867	0.8509	0.025
Ash (g)	12	0.9650	3.4920	2.0319	0.897
Foreign matter (g)	12	0.2100	0.5000	0.3492	0.095
Grade 01 (g)	12	14.319	63.599	37.214	15.74
Grade 02 (g)	12	28.820	65.984	49.211	11.38
Grade 03 (g)	12	6.5620	19.966	12.665	4.731
Crude protein (g)	6	9.1065	9.6318	9.3691	0.183
Gross energy (MJ/Kg)	12	15.494	16.429	15.915	0.328

C. Pairwise Comparisons of Broken Rice Types

Post hoc tests were performed with Tukey HSD to find out the significant difference between Sudu Kekulu, red peacock and parboiled broken rice types for all the parameters investigated and the outcomes are given in Table 03 for the parameters found with statistically significance at P<0.05.

D. Mean Crude Protein Content

Though the difference in mean weight between Sudu Kekulu, red peacock and parboiled broken rice types were not significant (P<0.05) for crude protein, a column chart is presented to show the mean weight difference in Figure 01.

Table 03: Weight of foreign matter content and weight of different grades of Sudu Kekulu, red peacock, and par boiled broken rice types in grams.

Broken rice type	**Foreign matter content**	**Grade 01**	**Grade 02**	**Grade 03**
	Mean ± SE	**Mean ± SE**	**Mean ± SE**	**Mean ± SE**
Sudu kekulu (g)	0.450± 0.043[a]	53.662± 4.625[a]	38.410± 4.129[a]	38.410± 4.129[a]
Red peacock (g)	0.275± 0.043[b]	38.464± 4.625[b]	47.385± 4.129[a]	47.385± 4.129[b]
Par boiled (g)	0.322± 0.043[b]	19.516± 4.625[c]	61.838± 4.129[b]	61.838± 4.129[c]

The mean foreign matter content (Table 03) was significantly different (P<0.05) between Sudu Kekulu and red peacock as well as between Sudu Kekulu and parboiled broken rice types. However, it was not significantly different (P<0.05) between the red peacock and parboiled types. The quantity of grade 01 broken rice (Table 03) was significantly different (P<0.05) between Sudu Kekulu and red peacock, between Sudu Kekulu and parboiled and between red peacock and parboiled as well. According to the results obtained (Table 03), a significant difference (P<0.05) was found for grade 02 between Sudu Kekulu and parboiled broken rice types as well as red peacock and parboiled broken rice types. However, no significant difference was found between the red peacock and parboiled broken rice types. The differences between broken rice type i.e. Sudu Kekulu and red peacock, Sudu Kekulu and parboiled as well as red peacock and parboiled were significant at P<0.05 (Table 03).

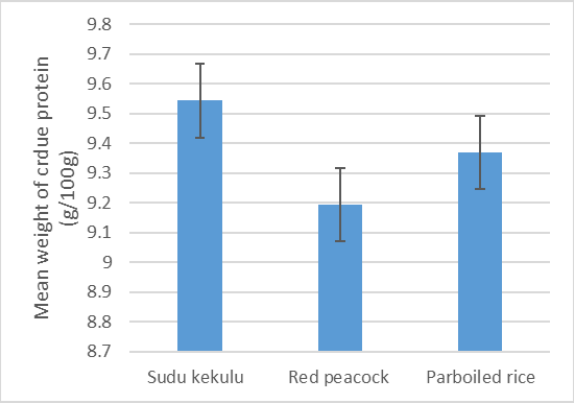


Figure 01: Mean weight of crude protein in different broken rice types

As per the results obtained in Figure 01, Sudu Kekulu was found with the highest crude content of 9.54g/100g of broken rice followed by parboiled and red peacock types.

IV. DISCUSSION

Considering the demand and price increase for conventional type energy ingredients such as maize grain for poultry feed, domestic level poultry farmers search for a novel type of feed ingredients. They utilize the broken rice domestically available as a replacement for maize.

The study found that parameters such as bulk density, ash content, crude protein and gross energy for Sudu Kekulu, red peacock and parboiled rice types are not significantly different at P<0.05 and the results obtained indicate that three broken rice types investigated are almost similar in these characteristics. The gross energy and crude protein content of broken rice are the two most important parameters investigated as a replacement to maize. Mean crude protein and gross energy values of three broken rice types (Table 01) are 9.36g/100 (9.36%) and 15.91 MJ/Kg respectively. According to Zhang et al. (2021), crude protein and gross energy content of broken rice are 10.24% and 15.57MJ/Kg respectively, which are almost in agreement with our findings. Though the difference between crude protein and gross energy content was not significant (P<0.05), Figure 01 indicates that Sudu Kekulu broken rice type contains the highest crude protein compared to red peacock and parboiled types. With regard to gross energy content,

parboiled and red peacock types contain equal gross energy that is higher than Sudu Kekulu.

The reason for the difference between the values of crude protein and gross energy in this study and the previous studies (Zhang *et al.*, 2021) and also the differences between the broken rice types in this study may be attributed to the milling process and the resultant grades (Table 01). The grades of broken rice depend on the size of the pieces including or excluding rice germ. Further, results indicate the significant difference in grades (grade 01, grade 02, and grade 03) may affect crude protein and gross energy content in broken rice types. The study found that the foreign matter is very low (0.45g/100g) in the locally available broken rice types indicating that the broken rice types are of an acceptable quality. It is noteworthy to indicate that authors could not find literature on the acceptable level of foreign matter content for broken rice.

Crude protein content in maize grain is 9.1% and gross energy content is 19MJ/Kg (Dei, 2015). The gross energy content in maize is significantly higher compared to broken rice (15.91MJ/Kg). However, the broken rice seems to be acceptable as an energy replacement for maize grain based on gross energy content. However, a feeding trial needs to be conducted on broken rice as an energy source to investigate the production performance of poultry chicken.

V. CONCLUSION

Based on the findings of the study, it is concluded that maize grain can be replaced by the domestically available broken rice types by considering their crude protein and gross energy content. However, it is suggested to conduct a feeding trial to investigate the production performance of poultry with broken rice as an energy source.

REFERENCES

Bruce, R.M., Atungulu, G.G. and Sadaka, S., 2020. Physicochemical and functional properties of medium-sized broken rice kernels and their potential in instant rice production. *Cereal Chemistry*, *97*(3), pp.681-692.

Chen, X., Yang, H., Xu, L., Wan, X. and Wang, Z., 2020. Effect of replacing dietary corn with broken rice on goose growth performance, body size and bare skin color. *Animals*, *10*(8), p.1330.

Dei, H.K., 2017. Assessment of maize (Zea mays) as feed resource for poultry. *Poultry science*, pp.1-32.

De Lange, C.F.M., 2000. Overview of determinants of the nutritional value of feed ingredients. *Feed evaluation: principles and practice*, pp.17-32.

Department of Census and Statistics, 2020. Department of Census and Statistics, http://www.statistics.gov.lk/Agriculture/StaticalInformation/rubpaddy. 10.05.2021.

Hardke, J. and Siebenmorgen, T., 2013. Rice grades. *Arkansas rice production handbook MP*, *192*, pp.163-166.

IRRI. (2021). http://www.knowledgebank.irri.org/step-by-step-production/postharvest/rice-by-products. Accessed on: 10.05.2021.

Jaelani, A. and Firahmi, 2007. The quality of the physical properties and nutrient content of palm kernel cake from a variety of processing crude palm oil. Al'Ulum, 33(3): 1-7.

Latimer G.W., 2016. Official Methods of Analysis of AOAC International. AOAC International; Gaithersburg, MD, USA.

Mir, N.A., Tyagi, P.K., Biswas, A.K., Tyagi, P.K., Mandal, A.B., Kumar, F., Deo, C. and Biswas, A., 2017. Effect of feeding broken rice and distillers dried grains with solubles in a flaxseed-based diet on the growth performance, production efficiency, carcass characteristics, sensory evaluation of meat, and serum biochemistry of broiler chickens. *Turkish Journal of Veterinary and Animal Sciences*, *41*(5), pp.583-589.

Mukhopadhyay, S. and Siebenmorgen, T.J., 2017. Physical and functional characteristics of broken rice kernels caused by moisture-adsorption fissuring. *Cereal Chemistry*, *94*(3), pp.539-545.

Omede, A.A., Okoli, I.C. and Uchegbu, M.C., 2011. Studies on the physical characteristics of some feed ingredients in Nigeria 2: Energy sources and novel feedstuffs. *Online Journal of Animal and Feed Research*, *1*(5), pp.198-204.

Omede, A.A., 2008. Critical issues in poultry feed quality evaluation in Nigeria. In *Book of Abstracts and Congress Proceedings, XXIII World's Poultry Congress* (Vol. 64, No. supplement 2, p. 455).

Rezaei, M., Fathi, M.K. and Kor, A.K., 2006. March. Use of broken rice in broiler diet. In *Proceedings of the British Society of Animal Science* (Vol. 2006, pp. 165-165). Cambridge University Press.

Syarif, R and Irawati, 1988. Knowledge of Ingredients for Agricultural Industry, Jakarta: Media Sarana Press.

Waller, A., 2007. Economic approach to broiler production. Roos Tech Notes, Sept. 2007.

Present Status of Village Chicken Farming System in Coastal Belt of Ampara District

S. Mokanapriya[1], A.T.A. Akram[2], A. Sharfan Ahamed[3] & Muneeb M. Musthafa[4*]

[1,2,3,4]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[3]*Department of Livestock Management, Faculty of Animal Production and Technology, University of Veterinary and Animal Sciences, Lahore, Pakistan*

[1]priyasivalingam77@gmail.com, [2]akram.at@seu.ac.lk, [3]asharfan91@gmail.com, [4*]muneeb@seu.ac.lk

Abstract*- The study was conducted to assess the characteristics of the village chicken farming system in the Ampara district. Data collection was carried out on 100 village chicken rearing farmers from five veterinary ranges in the Ampara district. Structured interviews, unstructured interviews with farmers, and field observations were the approaches used to collect the data on different farming practices. The average flock size per farm was 97.5±72.01. The number of birds in the house per farmer per year was 97.70±10.3. The average egg production per hen per clutch was 12.3±1.0. The major feed sources were rice bran (31.4%) and paddy (22.9%). Tap water (64%) was given Adlibitum (82%) throughout the day. The overall average annual egg production was 147.6±12.3. In this study, the hatchability rate of Village chicken was 80.53%. Half of the respondents purchasing chicks from the market for their farm. The average motility rate was 13.32%. The major causes of death of chickens during the study were gumboro disease, fowl cholera, fowl fox. The results of the analysis revealed that there is a significant relationship between gender and reason for rearing and between educational level and reason for rearing. The dominant village chicken farming system of the study area was Semi-intensive (54 %) farming system. The findings revealed that village chickens had a relatively good egg production potential. The mortality rate and feeding practices of village chicken farming in the study site still needed to be controlled by improving management practices and establishing an effective breeding system.*

Keywords: Ampara, Management practices, Production system, Village chicken

I. INTRODUCTION

In Sri Lanka, village poultry is one of the most significant livestock components of rural small-holder farming systems (Silva *et al.*, 2009), which contributes 0.38 percent of GDP and accounts for 64% of total livestock contribution (DAPH, 2020). Indigenous chicken contributes approximately 15% to egg production (Weerahewa, 2004) and has a population of about 1.3 million, accounting for around 11% of the total chicken population in the country (Silva *et al.*, 2016).

Traditional poultry production is almost an omnipresent practice among rural-based smallholders in most countries (Islam & Mustari, 2017). Village chicken production is one of a source of revenue and food for rural farm families. The essential characteristics of indigenous poultry, include disease resistance, hardness, the ability to eat low-quality feed, adapting well to rural environments, and adapting to changes in feed availability (Mufeeth *et al.*, 2018; Miriam *et al.*, 2020). These characteristics accounted for low-input production systems to achieve long-term sustainability (Silva *et al.*, 2016).

The body size, color, shape, and other phenotypic characteristics of village chickens differ widely. The most common village chicken breeds available in Sri Lanka are the normal village chicken with different plumage colors such as red, black, brown, and white or multicolor, the naked neck, the long-legged, the crown chicken, and the frizzled feathers (Silva *et al.*, 2016). In addition, a few distinct rare variants, such as black meat chicken, rumpless chicken, and boot chicken, were also discovered (Liyanage *et al*., 2015).

Different farming systems are used to raise village chicken include an extensive, backyard, semi-intensive and intensive. Based on a scale of operation, feeding practices, type of genetic resource used, disease prevention and control methods, production efficiency, and other management practices. FAO (2014) classified village poultry production systems into four

categories. Those were small-scale intensive, semi-intensive, extensive scavenging, and small-scale extensive scavenging. Semi-intensive poultry farming is a viable option for resource-constrained rural farmers. It is known to be a combination of comprehensive and intensive systems (Atapattu *et al.*,2016).

The current state of the indigenous chicken production system in Sri Lanka is poorly understood and defined. It is vital to understand and describe each component in the production systems (Silva *et al.*, 2016). In this context, the present study was formulated to investigate components of the village chicken production farming system of Sri Lanka include the present status of farm management practices such as housing, feeding, breeding, and level of health care.

II. LITERATURE REVIEW

The poultry sector in Sri Lanka has recently risen to a higher position, Due to its higher contribution to national GDP (Manjula *et al.*, 2018). In Sri Lanka, the poultry industry is regarded as a fast-growing, well-organized livestock subsector. Within the country, both poultry breeder farms and commercial ranches are in operation, demonstrating the importance of chicken production in the country (DAPH, 2018).

The ability to thrive in a harsh environment in tropical climatic conditions, as well as its adaptability to local nutritional and dietary practices, makes poultry species suitable for use in integrated farming systems in backyard operations throughout the country. which can be divided into four different production systems. Extensive free-range, extensive backyard, semi-intensive, and intensive (Sonaiya & Swan, 2004).

Around 99 percent of the population consists of country chickens and they are mostly managed by scavenging schemes, while the remaining birds are mostly managed intensively on private farms. Furthermore, traditional chicken production systems account for 98.4 percent of national egg production and 99.1 percent of national poultry meat production, respectively in Ethiopia (Hassen et al., 2006). Around 43% of the country's chicken products are consumed at a household level, and backyard poultry contributes to different non-monetary benefits (Liyanage *et al.*, 2015). Hardy, adaptable to rural conditions, able to survive on low inputs, and able to adapt to changes in feed availability are the main advantages of country chickens (Miriam et al., 2020).

Village chickens are generally multicolored, long-legged, and smooth feathered with a few fizzled feathered, naked necked, and dwarf birds (Olwande *et al.*, 2010). Nevertheless, they exhibit a wide range of appearances as well as production status. Some of the indigenous poultry breeds in Sri Lanka include the Naked leg, Giant, Deep brown, Orange tan, Black, Black with yellow silver, White, Light brown, and White brown (Abeykoon et al., 2013).

III. PROBLEM STATEMENT

Lack of knowledge about poultry farming management system, the occurrence of diseases (IBD, NCD, etc.) as well as institutional and socio-economic constraints remain major challenges in the village chicken production system in Ampara (Mufeeth *et al.*, 2018). The design and implementation of village-based chicken development programs that can support rural societies require knowledge and understanding of chicken production and utilization processes and opportunities and constraints.

IV. METHODOLOGY

A. Study area

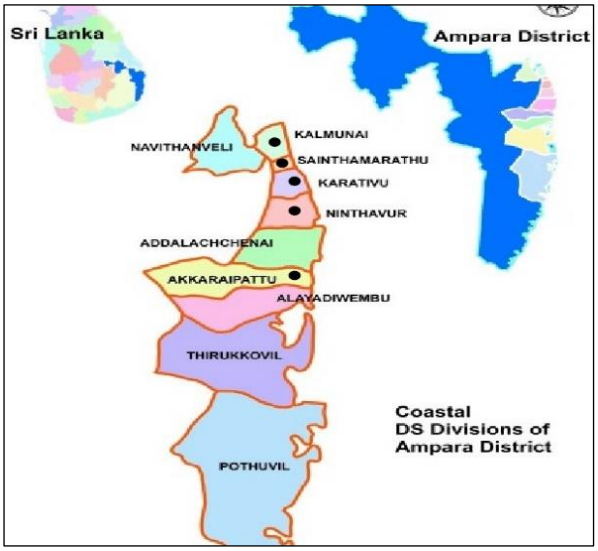


Figure 01: Location of the research sites

The study was conducted at Ampara district in coastal area government veterinary ranges namely Kalmunai, Sammanthurai, Karativu, Ninthavur, and Akkaraipattu.

B. Sample and data collection

A preliminary survey was carried out to determine the key locations of village chicken rearing in the Ampara district's coastal belt. Following that, a detailed survey was conducted from February to April 2021. A total of 100 village chicken rearing farms were visited in five veterinary ranges of the coastal belt of Ampara district. Three approaches were used to collect data: structured interviews, unstructured interviews with farmers, and field observations.

The size of the village chicken farm was determined based on the number of chickens kept in one farm unit. A small-scale farm is described as one with a population of fewer than 20 birds. Farmers with 20 to 50 village chickens were classified as medium scale, whereas those with more than 50 birds were classified as large scale (Sonaiya & Swan, 2004).

Secondary data were collected from Ampara district Government veterinary ranges, the Department of Animal Production, and Health-EP. Through both methods, data were obtained on rearing, feeding, body weight, hatchability (the percentage of eggs that hatched), overall productivity and sales of the village, mortality (number of birds died in a year), and health management.

C. Statistical analysis

The descriptive statistics such as mean, range, frequency and percentage, charts, were used to analyze the data using the SPSS software package (Version 25, IBM SPSS, Chicago, USA). Cross-tabulation and standard deviations were used to examine the village chicken production system as well as farmers' socio-economic characteristics.

V. RESULTS AND DISCUSSION

A. The present situation of the Village chicken farming system in the Ampara district

The study revealed that more than half (56%) of the village chicken farmers in the coastal belt of Ampara District are large-scale farmers and 44% of the respondents are doing on a medium scale. So far, there are no small-scale farmers have been recorded in the study area (Figure 02). According to Mandal *et al.* (2006), the majority (72.92%) of the village chicken farmers in Bareilly district in India are medium-scale (5-8 birds) farmers. whereas, 16.67% of the farmers were doing large-scale (>8 birds) farming and 10.41% of the respondents are small-scale (<5 birds) farmers.

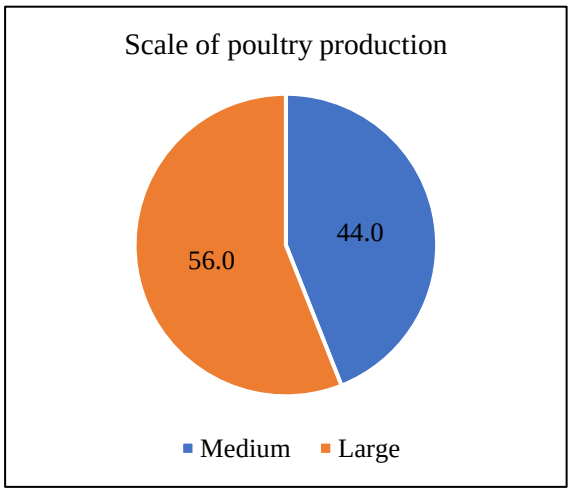


Figure 02: Scale of village chicken farming in Ampara district

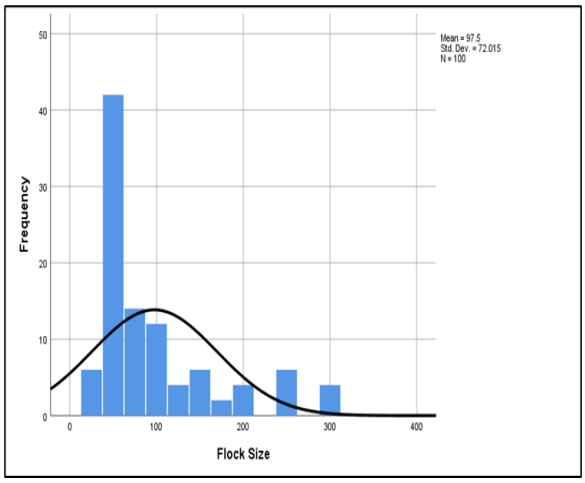


Figure 03: Flock size distribution pattern in Ampara district

Figure 03 shows the overall flock size distribution pattern in the coastal belt of the Ampara district. The flock size was distributed across the study area with a mean of 97.5±72.01.

B. Management practices

The majority of village chicken farmers practicing semi-intensive farming (54%) while, 32 percent of farmers were practicing intensive and 14 percent of farmers were doing extensive farming (Figure 04).

1) *Type of Feeds:* In the current study, the poultry farmers are providing different types of feeds (Figure 05). Most of the farmers (33.9%) using Booster for their chicks. Rice bran (31.4%) and paddy (22.9%) are fed by the farmers as major

feed. Only one farmer is providing Alzola for his village chicken (Figure 05). According to Moges et al. (2010), the supplementary feed was offered by the majority of chicken owners (97.5%). Grains and household residues were supplemented by chicken owners (56.4%) as major feedstuffs, from these majority of chicken owners (87.1%) used self-produced crop harvest as supplementary feeds.

2) *Feed Supply:* The majority of the farmers (74%) use the feeder for feeding while, 20 % of farmers are using trays for feeding. Few farmers practicing the floor feeding method. Concerning the frequency of feeding, most of the farmers feeding twice a day (64%), and some farmers feeding three times (36%). In Bangladesh, similarly, most of the families providing feed twice a day (72.10%) in the Sylhet region but some of the families providing feed twice (28.00%) and thrice (35.50%) a day (Islam & Mustari, 2017).

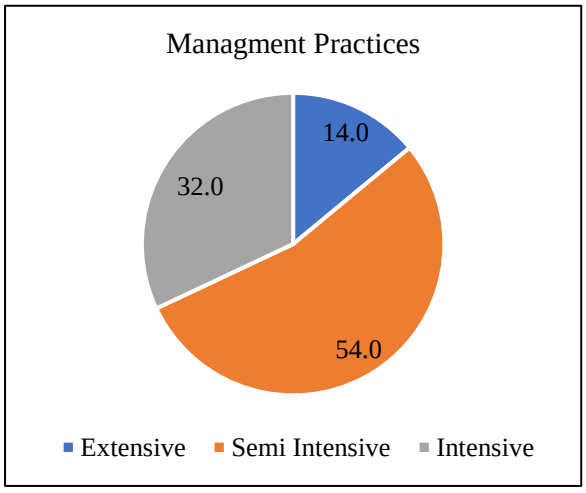


Figure 04: Management Practices

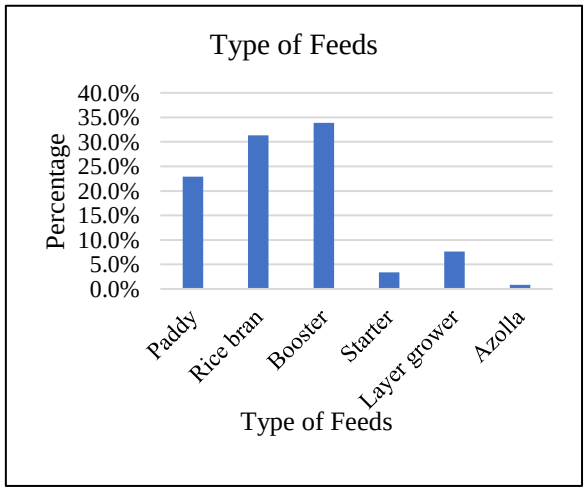


Figure 05: Type of Feeds

3) *Water Supply:* According to the current study, tap water (64%) and well water (36%) were the most common sources of water for village chickens in the study area. The majority of farmers are using waterers (82%) for the water supply of the chicken and 16% of the respondents had water trough. Few farmers were using nipple system 2%. According to Yosefe *et al.*, (2016), Broken clay materials (45.33%), wooden troughs (36%), and plastic-made troughs (11.33%) were the most commonly used forms of watering methods in South West Ethiopia.

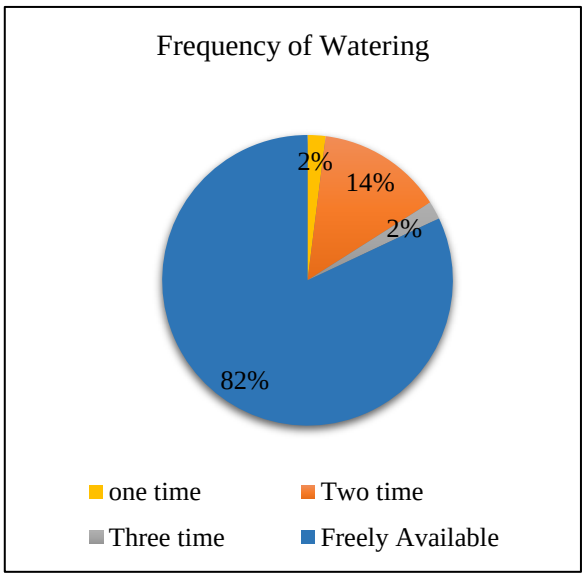


Figure 06: Water Supply

The current study indicated that the frequency of watering, most of the respondents (82%) providing water throughout the day (adlibitum). However, 14% of farmers providing water twice a day, and few farmers (2%) practicing three times and once a time per day (Figure 06). These findings agree with Leta & Endalew, (2010) that, 47% of the respondents providing water throughout the day, 14% once a day, 18% twice a day, 16% three times a day, 5% four times a day in Mid Rift Valley of Oromia, Ethiopia.

C. Productivity of village chicken Farming per Farmer

Table 01: Productivity of village chicken Farming Per Farmer

Production Parameters	Average/year ± S.E
No. of birds in the house	97.7 ± 10.3
Eggs per hen per clutch	12.30 ± 1.0
Egg Production	147.54 ± 12.3
Hatchability (%)	80.54 ± 1.47
Mortality (%)	13.32 ± 2.75

The productivity of village chicken farming per farmer is presented in Table 01. The number of birds in the house per farmer per year was 97.7±10.3. The average dimensions of the house: the height was 2.3 ± 0.14m, the width was 3.28 ± 0.36m and the length was 5.58 ± 0.57m. The average egg per hen per clutch was 12.30±1.0, which also fell within the range of 10-14 average egg/clutch/hen reported by Ssewannyana *et al.*, (2004) in Uganda. The overall average annual egg production was 147.54 ±12.3. According to the results, village chickens have a strong egg production potential in comparison with other studies. Gueye, (2003) reported 37-95 eggs for Africa, Barua and Yoshimura (2001) reported 44 eggs for Bangladesh and Ssewannyana *et al.* *(*2004) reported 40 -50 eggs for Uganda. In this study, the hatchability rate of Village chicken was 80.53% (Table 1). Similar results were reported by Kondombo, (2005) hatching rate of 83%, and Wantasen *et al.*, (2014) hatching rate of 79.3%. The mortality rate of village chicken farming in the study site still needed to be controlled with better management. A mortality rate of 13.32% was recorded in the study area.

D. Sources of chicks

Figure 07 shows the information regarding the source of chicks of the village chicken management system in the coastal belt of the Ampara district. For breeding purposes, farmers use eggs from their flock or eggs purchased from others. The majority of the farmers (50%) are purchasing chicks from the market. Whereas, 40% of the farmers practicing natural incubation and 10% of the farmers practicing artificial incubation

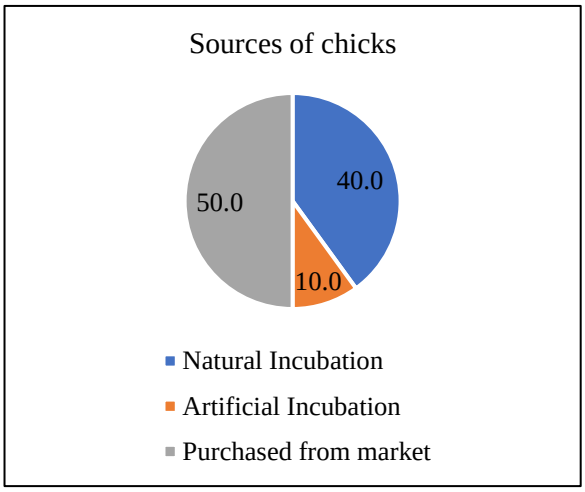


Figure 07: Source of chicks

using their own flock eggs. In Ethiopia, most of the respondents (91.9%) obtained the initial chicken stock by purchasing and the rest was by hatching (4.4%) and gift (3.7%) from parents or relatives (Morenda et al.,2013).

E. Disease

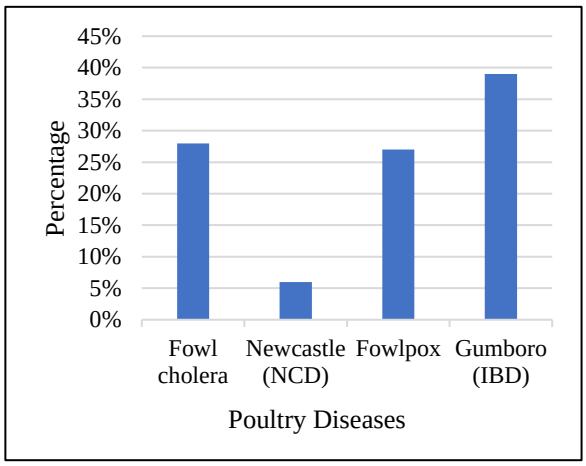


Figure 08: Poultry Diseases reported in Study Area

Figure 8 represents the prevalence of diseases in the study area. The farmers observed the health status of poultry on a daily basis, by judging the poultry from their external appearances and confirmed by the veterinary officers of relevant regions. Even though indigenous poultry has fewer disease outbreaks than commercial poultry, disease outbreaks can pose a significant threat to indigenous chicken management. The prevalence of diseases has been identified as a key issue in village chickens in a free-range environment which resulted in low productivity and significant financial losses

(Silva *et al.*, 2016). Gumboro (39%), Fowl cholera (28%), Fowlpox (27%), and Newcastle disease (6%) were seemed to be the most common disease condition in the study area. And many farmers did not aware of many diseases which are not common. Permin (2009), defined sickness in village chickens as "any change or impairment of normal body function that impacts the survival, growth, and reproduction of birds." Diseases, on the other hand, are frequently caused by a combination of variables including husbandry, nutrition, environmental factors, and flock management (Silva *et al.*, 2016).

F. Socio-economic factors

1) *Gender vs Reason of Rearing:* In this study, the majority of the male respondents (44%) were rearing village chicken as part-time and the majority of the female respondents (28%) were doing as full-time. only 4% of male respondents had a reason for rearing hobbies (Figure 9). These findings agree with Ullah *et al., (*2019) that, in Bangladesh, women play the main role in native chicken farming and they mainly rear the native chicken for home consumption and sell the surplus for income generation. Moreover, village chicken production is predominantly under the management of women in Kenya too (Justus et al., 2013).

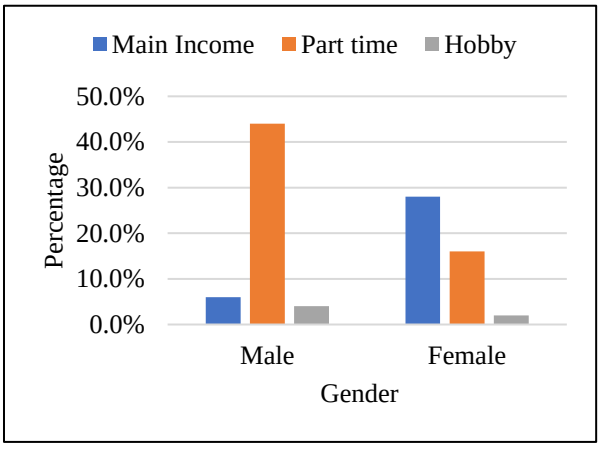


Figure 09: Gender vs Reason of Rearing; P=0.000 at a significant level of 0.05

2) *Education Level vs Reason of Rearing:* Education is one of the most important factors which accelerates the growth and development of enterprise. There is a significant relationship between the reason for rearing and the level of education. The majority of secondary (16%) and primary (10%) educated farmers were rearing village chicken as their main income. Farmers with education level of Advance level and above doing the farming as part-time. Only 6% of Tertiary educated respondents were rearing village chicken as a hobby. Prakash *et al.* (2003) stated that, in Meghalaya most (61.66%) of the respondents are none educated farmers, followed by 28.33% village chicken rearing farmers who had completed up to primary education while 10% of the respondents had completed up to high-level school and above. This reveals that, majority of the primary and secondary educated farmers doing poultry farming as their major income source.

VI. CONCLUSION

The village chicken farming system has great potential in the Ampara district and can improve the livelihood of poor farmers in the area. The egg production is considerably high, which can be used to increase the economic benefits to the rural farmers. The mortality rate and feeding practices of village chicken farming in the study site still needed to be controlled by improving management practices and establishing an effective breeding system.

REFERENCES

Abeykoon, M.N.D.F., Weerahewa, J. and Silva, G.L.L.P., 2013. Determinants of Market Participation by Indigenous Poultry Farmers: A Case Study in Anuradhapura District in Sri Lanka. *Tropical Agricultural Research*, 24(4), 347–361.

Atapattu, N.S.B.M., Saranga, K., Abeywickrama, L.M., Gunawardane, W.W.D.A. and Munasinghe, M., 2016. Contribution of Backyard Chicken Egg Production to Ful fill Household Nutrient Requirement: A Study in Southern Sri Lanka. *International Journal of Livestock Research* (7).

Barua, A. and Yoshimura, Y., 2001. Ovarian autoimmunity in relation to egg production in laying hens. *Reproduction*, 121(1), pp.117-122.

Department of Animal Production and Health (DAPH), 2020. Annual Report, Peradeniya: Livestock Planning and Economics Division.

Department of Animal Production and Health (DAPH), 2018. Annual Report, Peradeniya: Livestock Planning and Economics Division.

FAO, 2014. Family poultry development - Issues, opportunities and constraints, FAO Animal Production and Health Working Paper. No. 12. Rome.

Guèye, E.F., 2003. Gender issues in family poultry production systems in low-income food-deficit countries. *American Journal of Alternative Agriculture*, pp.185-195.

Hassen, H., Neser, F.W.C., Dessie, T., De Kock, A. and Van Marle-Koster, E., 2006. Studies on the growth performance of native chicken ecotypes and RIR chicken under improved management system in Northwest Ethiopia. *Development*, 18(6).

Islam, M.S. and Mustari, S., 2017. Management Practices and Feed Supplements on the Growth of Two Chicken Breeds (Gallus Domesticus L.) under Smallholders' Farm Conditions: Case of Rajshahi. *ABC Journal of Advanced Research*, 6(2), pp.99-112.

Justus, O., Owuor, G. and Bebe, B.O., 2013. Management practices and challenges in smallholder indigenous chicken production in Western Kenya. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)*, 114(1), pp.51-58.

Kondombo, S.R., 2005. Improvement of village chicken production in a mixed (chicken-ram) farming system in Burkina Faso. PhD Thesis, Wageningen Institute of Animal Sciences, Animal Nutrition Group, Wageningen University.

Leta, S. and Endalew, B., 2010. Survey on village-based chicken production and utilization system in mid Rift Valley of Oromia, Ethiopia. *Global Veterinaria (GV)*, *5*(4), pp.198-203.

Liyanage, R.P., Dematawewa, C.M.B. and Silva, G.L.L.P., 2015. Comparative study on morphological and morphometric features of village chicken in Sri Lanka. *Tropical Agricultural Research*, Vol. 26 (2): 261 – 273.

Manjula, P., Wijayananda, H.I., Gajaweera12, C., Lakmalie, D., Lee, S.H. and Heon, J., 2018. A Brief Review on Poultry Sector and Genetic Resources in Sri Lanka. *Journal of Animal Breeding and Genomics*, 3.

Mandal, M.K., Khandekar, N. and Khandekar, P., 2006. Backyard poultry farming in Bareilly district of Uttar Pradesh, India: an analysis. *Livestock Research for Rural Development*, 18(7), p.

Miriam, K. N., Agnes, N., Konyango, O., Jacob, J. J. and Gowland, M. J., 2020. Household Income Among Small-Scale Farmers in Mau-Narok. *International Journal of Research and Sustainable Development*, 7(1), pp. 97–112.

Morenda, E., Harrepal, S., Johanssen, A., Sisaye, T. and Sahile, Z., 2013. Characteristics of indigenous chicken production system in South West and South part of Ethiopia. *British Journal of Poultry Sciences*, 2, pp.25-32.

Moges, F., Mellesse, A. and Dessie, T., 2010. Assessment of village chicken production system and evaluation of the productive and reproductive performance of local chicken ecotype in Bure district, North West Ethiopia. *African Journal of Agricultural Research*, 5(13), pp.1739-1748.

Mufeeth, M. M., Korale-Gedara, P. M., Silva, G. L. L. P. and Rathnasekara, H., 2018. Determinants of Commercialization of Indigenous Poultry. *Sri Lanka Journal of Animal Production* (*SLJAP)*, 10, pp. 37–43.

Olwande, P.O., Ogara, W.O., Okuthe, S.O., Muchemi, G., Okoth, E., Odindo, M.O. and Adhiambo, R.F., 2010. Assessing the productivity of indigenous chickens in an extensive management system in southern Nyanza, Kenya. *Tropical Animal Health and Production*, 42(2), pp.283-288.

Prakash, N., Kumar, Rajesh and Pal, P. P., 2003. Backyard Poultry in Meghalaya, *Indian Journal of Animal Sciences*, **73** (4): 459-461.

Permin, A., 2009. Good practices in small scale poultry production. A manual for trainers and producers in East Africa, ECTAD Regional Unit for Eastern Africa, FAO. Rome, Italy.

Ssewannyana, E., Ssali, A., Kasadha, T., Dhikusooka, M., Kasoma and Kalema P. 2004. Characterization of indigenous chickens of Uganda, Kampala, Uganda. *Uganda Journal of Agricultural Sciences*, 8, pp.137-141.

Silva, P., Liyanage, R. P., Senadheera, S. and Dematawewa, C. M. B., 2016. Monograph on indigenous chicken in Sri Lanka. *UNEP-GEF-ILRIFAnGR Asia Project, University of Peradeniya, Sri Lanka*.

Silva, P., 2010. Indigenous Animal Genetic Resources in Sri Lanka: Status, Potential, and Opportunities. GEF/ILRI FAnGR Asia project, University of Peradeniya, Sri Lanka. https://doi.org/10.1017/S2078633611000129

Sonaiya, E.B. and Swan, S., 2004. Small-scale poultry production: Technical guide. Rome: Food and Agriculture Organization of the United Nations.

Ullah, M. N., Begum, M. I. A., Islam, M. R., Islam, M. S., Islam, M. H., Sarder, M. J. U. and Alam, M., 2019. Prevalence of diseases in backyard poultry concerning seasonal influences in Bogura Districts of Bangladesh. *Bangladesh livestock journal*, 1: 40- 44

Wantasen, E., Elly, F.H. and Santa, N.M., 2014. The Analysis of Semi Intensive Native Chicken Farming in Rural Communities. *Journal of the Indonesian Tropical Animal Agriculture*, 39(2), pp.126-133.

Weerahewa, J., 2004. Current and potential market supply and demand, marketing opportunities, and consumer preferences for indigenous animal products. International Livestock Research Institute, Nairobi, Kenya.

Yosefe, K., Abate, Z., Tarekegn, K., Fisseha, D., Tesfaye, D., Gizaw, H., Mengste, F., Habtegiyorgis, D., Gebreselase, T. and Rate, C., 2016. Poultry Production, Management and Marketing System at Selected Districts of Kafa and Benchmaji Zone, South West Ethiopia. *Journal of Biology, Agriculture and Healthcare*, *6*(11), pp.2224-3208.

TRACK - AGRICULTURE ECONOMICS AND ENTREPRENEURSHIP

Use of Delta-D Technology to Prevent Paddy Straw Burning and to Produce Paddy Straw Powder in the Paddy Field which can be used as Organic Fertiliser and A Low Cost, Renewable Fuel for Thermal and Electrical Power Generation

S.A.S. Perera[1*] & M.F.H.M. Aadhil[2]

[1,2]*Department of Chemical and Process Engineering, University of Moratuwa, Sri Lanka*

[1*]anulperera@yahoo.com, [2]adl.section@gmail.com

Abstract- *Coal is cheap compared to most other fossil fuels. However, the higher emission of CO2 has made coal, one of the major contributors to greenhouse effect, global warming and climate change on earth. Forest cover and agriculture are the main absorption systems that reduce CO2 in the atmosphere by photosynthesis. Sometimes forests are major contributors of CO2 to the atmosphere due to sporadic bushfires around the world. Agriculture, on the other hand, absorbs CO2, produces food, creates employment, and maintains a healthy, sustainable and safe eco system which never causes bush fires. Sri Lanka's major food crop is paddy, and the annual production is more than 3.5 million MT. Paddy straw (PS) is the major by-product and its annual production is more than 5 million MT. Presently, paddy is harvested by combined harvesters and after the harvest, straw stubble and cut pieces are scattered in the paddy field. Since PS is a major hindrance to field preparation for the next crop, with minimum turnaround time, most of the farmers burn PS, which causes atmospheric pollution due to emission of, heat, CO, CO2, SOx, NOx, Volatile Organic Compounds (VOC), and particulate matter. Delta-D Technology is a patented technology, invented by the author of this paper. By using Delta-D Technology all types of organic waste can be rapidly digested and converted into powder. This paper discusses research carried out by the author, to convert large quantities of PS, lying in the paddy field, into a paddy straw powder (PSP). PSP can be easily combusted in a furnace or a boiler by spraying into the combustion zone.*

Keywords: Coal alternative, paddy straw, Delta-D Technology, paddy straw powder, Solid waste

I. INTRODUCTION

Paddy is the major crop in Sri Lanka. The average paddy production is approximately 3.5 million metric tons per annum (Department of Census and Statistics, 2019). Paddy Straw (PS) is the main by-product of rice production. For every 1 MT of grain harvested, about 1.35-1.5 MT of PS remains in the paddy fields (Zhang, et al., 2013). Hence, annual production of paddy straw is around 5 million MT. This paddy straw can be used as a fuel source or as a raw material to produce organic fertilizer. PS has a very low density and has a very low commercial value because it is not used in industry or for other purposes. Hence, PS is burnt in the fields causing many environmental impacts. By using Delta-D Technology, which is described under Methodology PS can be converted into Paddy Straw Powder (PSP).

The density of PSP is 20 -25 times higher than PS (Zhang, et al., 2013). Hence, transport over long distances as well as storage and combustion of PSP becomes economically viable. It can be shown that if Delta-D Technology is used to convert 5 million MT PS into PSP and if PSP is used as a fuel to generate energy, it can produce energy equal to 3 million MT of Coal annually and also prevent emission of 8 million MT of CO_2 into the atmosphere due to PS burning in all the paddy fields in Sri Lanka.

Coal, which has a Gross calorific value (GCV) of around 6,300 kCal/kg, thermal energy of 1MT of coal is equal to around 1.6 MT of PS. Hence, 5 million MT of PSP is equivalent to around 3 million MT of Coal. However, PS has a very low density and comes out of the paddy field as large pieces. Hence, transportation, storage and combustion of PS to produce thermal and electrical energy is uneconomical. This is also another reason for burning PS in the field itself.
One of the main objectives of this research project was to ascertain whether PSP could be a substitute for coal in a coal power plant. The only coal power plant in Sri Lanka is the Lakvijaya Power Plant in Puttalam, which has a capacity of 900 MW and burns around 3 million MT of coal per annum emitting around 8 million MT of CO_2 in Sri Lanka.

At present, a significant amount of foreign exchange is spent on importing coal. In this study, PSP is introduced as an alternative source of fuel, because it has a high GCV. However, the convenience of logistics to use paddy straw as fuel can introduce many challenges. The study focuses on a method of converting the PS into a powder form that has higher density and can be stored and transported more conveniently.

Transport over long distances as well as storage and combustion of PSP becomes economically viable due to the higher density of PSP as opposed to PS. It can be shown that if Delta-D Technology is used to convert 5 million MT PS into PSP and if PSP is used as a fuel to generate energy, it can produce energy equal to 3 million MT of Coal annually and also prevent emission of 8 million MT of CO_2 into the atmosphere due to PS burning in all the paddy fields in Sri Lanka (Muhammad, et al., 2020).

II. RESEARCH PROBLEM

A. Paddy Straw Burning

PS is made up of 70% combustible organic matter, such as Cellulose ($C_6H_{10}O_5$) and others (Perera, 2008).

$$(C_6H_{10}O_5)_n + 6nO_2 \longrightarrow 6nCO_2 + 5nH_2O$$

According to the above equation, by burning 1MT of cellulose 1.63MT of CO_2 is produced. Therefore by burning about 6 million MT of paddy straw, about 8 million MT of CO_2 is emitted to the atmosphere annually. This significantly leads to global warming and climate change. If carbon trading is reintroduced, Sri Lanka can earn around USD 96 million per annum (at the past rate of USD 12 per ton of CO_2, due to the said reduction in the emission, saving, of CO_2 into the atmosphere.

B. Comparison of PS Burning and Coal Burning

$$C_{(s)} + O_{2\,(g)} \longrightarrow CO_{2\,(g)}$$

Sri Lanka imports about 3 million MT of coal per year for power generation. This amount is poised to increase with new expansion projects to increase coal-based power generation in Sri Lanka. Approximately 3.66 MT of CO_2 is produced by burning 1 MT of coal.
Hence, if we could replace coal by PS which is burnt in fields,

GCV of Coal = 6225 kcal/kg
GCV of Cellulose = 5746 kcal/kg

PS consists of 70% Cellulose;

GCV of Paddy Straw = 5746 kcal/kg × 70% = 4022 kcal/kg

Theoretical paddy straw requirement per kg of Coal = (6225 kcal/kg)/(4022 kcal/kg) = 1.54

C. Consequences of PS burning

Every year, farm fires including PS burning in the surrounding states in India, have continued to cause many problems for people, fauna and flora of India. Farmers often opt to burn paddy despite government recommendations to compost the waste due to practical reasons. Due to the low moisture content in the paddy and direct exposure to the sun, the retained moisture in dry straw is very limited. Due to this reason, naturally occurring microbial activity is highly restricted. Therefore, many farmers resort to burn the paddy straw to reduce the turnaround time in utilizing the land to cultivate more crops. Despite having in place regulations against stubble burning and paddy straw burning, it was reported that there were many incidents of farm fires in Haryana and Punjab contributing to the poor quality of air due to carbon particles, volatile organic particles and combustion gases (Ren, et al., 2019). The situation is similar though better in China, Stubble burning is still practiced.

Pollution from PS burning added to emissions from millions of vehicles, construction and road dust raise pollutants in Delhi's air by over six times the permissible limit. The smoke often rises and swarms over Delhi, especially during winters, when the city is most vulnerable to toxic smog. The smoke contains toxic substances, including particles that have diameter of less than 2.5 micrometres ($PM_{2.5}$), carbon monoxide (CO), methane (CH_4), carbon dioxide (CO_2) and oxides of nitrogen and sulpher (NO_x and SO_x) (Perera, 2001). The situation is similar in other mega cities, such as Mumbai and Calcutta.

It is estimated that approximately 200 million MT of PS is produced in India alone annually. Burning PS causes health problems such as breathlessness, asthma, chronic bronchitis and other respiratory disorders, besides eye irritation and reduced resistance to cold and lung infections. While inhaling, fog, smog or smoke components enter our lungs. It creates hypersensitivity in those already suffering from asthma bronchospasm, making it even more difficult for them to breathe

(Chawala & Sandhu, 2020) (Krutika & Arvind, 2020).

Figure 01: Paddy Straw and Stubble Burning causing the great Delhi Smog - Source: www.scroll.in

In 2017, Sri Lanka experienced an energy crisis due to the breakdown of 2 out of 3 generators in the Lakvijaya coal power plant in Sri Lanka. A root cause analysis carried out by the team of engineers attached to the CEB found out the particulate matter emitted during burning of paddy straw in a vast area may have contributed to damages causing the breakdown of a distribution station in the Ampara district which resulted in the island-wide power outage.

III. METHODOLOGY

A. Introduction to converting PS into PSP using delta d technology

In this research project, paddy straw power is used as the fuel source. After the converting process of paddy straw into their powder form density value is increased. Therefore, the transportation cost is reduced and the generating cost can be reduced. Also, straws are fluffy, flexible, bad floating; paddy straw could be twisted and jammed in feeding and conveying. But by using paddy straw powder above problem couldn't be occurred. Paddy straw powder can be fed into the boiler using high-pressure airflow rate as same the coal powder feeding.

B. Introduction to Delta- D Technology

Delta D technology is a patented technology developed by Perera, Author 1 of this paper. With the combination of Delta-D technology and solar energy, sunlight rapidly digests biomass. Delta-D has a chemical combination that can digest all types of natural organic matter by catalyzing it. So, when it is digested it becomes a powder without affecting the chemical composition. Leachate or an unpleasant odor is not created from it (Perera, 2012).

C. Types of Delta-D

Different types of Delta-D are available to choose based on the type of waste that has to be digested (Perera, 2007).

- Delta-D^C: This is specifically used for high cellulose materials such as straw, sawdust, grass, leaves of plants, waste paper, etc.
- Delta-D^P : This type is specifically used for high protein material, such as, excreta of animals, poultry farm waste, fish waste, slaughterhouse waste, etc.
- Delta-D^V :This type is used specifically for low cellulose high moisture material, such as fruit and vegetable waste, cooked food waste, etc.
- Delta-D^{USW} :This is used for urban solid waste, which is a mixture of, fruit and vegetable waste, cooked food waste, waste paper, etc.

In this research project, Delta-D^C will be used hereinafter termed as Delta –D.

D. Process of converting PS into PSP using Delta D technology

Recommended Method for Rapid Digestion of Rice Straw in Dry Zones
35 kg of dry rice straw is wetted with a solution of 1litre of Delta-D^C and mixed with 50 liters of water. The wetted straw is laid on plastic sheets and exposed to the sun for 3 days. After 3 days the straw crumbles into powder.

E. Recommended Method for Rapid Digestion of Rice Straw in Wet Zones

Even in the wet zones of Sri Lanka there is ample sun shine right through the year. Hence, above method can be practiced most of the time. However, if there are rains and it is not possible to expose the straw to sunshine, the following method should be followed

F. PSP production

Conversion of paddy straw into paddy straw powder could be done by mechanical grinding. However, it is challenging to grind paddy straw due to its elastic fibrous nature and inability to carry out grinding in-situ. Powder produced using the Delta-D technology can be used to produce fuel briquettes or high value-added products such as MDF (Medium Density Fibre) Boards, etc. Paddy straw can be converted into paddy straw powder within 2-4 days using a combination of

Delta-D Technology and solar energy (sunlight). (Perera, 2007a) (Perera, 2007b) (Perera, et. al.,2017).

Paddy straw is not used as a source of fuel due to its very low density. Therefore, transportation of paddy straw over long distances is not economically feasible. Converting PS to PSP using the Delta-D Technology at the Roof Top of Department of Chemical and Process Engineering of University of Moratuwa.

35 kg of dry paddy straw was wetted with a solution of 1litre of Delta-D[c] and mixed with 50 litres of water. The wetted straw is laid on plastic sheets and exposed to the sun for 3 days. After 3 days the straw crumbles into powder.

G. Determination of the Calorific Value of PSP

The produced paddy straw powder was compressed and pelletized. The gross calorific value of the paddy straw powder was obtained using ASTM D 5865 test method. The heat capacity of the calorimeter was determined by burning a specified mass of benzoic acid in oxygen. A comparable amount of the analysis sample was burned under the same conditions in the calorimeter. The calorific value of the analysis sample was computed by multiplying the corrected temperature rise, adjusting for extraneous heat effects, by the heat capacity and dividing by the mass of the sample.

H. Density of Paddy straw powder

The bulk density is determined by ASTM E873 method. This test method covers the procedure for the determination of bulk density of densified particulate biomass fuels with a maximum particle volume of 16.39 cm^3. An empty box with a known volume is taken and weighed and recorded its weight. Then the box is filled by pouring from a height of 610 mm above the top edge of the container. The box is dropped five times from a height of 150 mm on to a no resilient surface to allow settling. Then additional sample is added and stroke off the excess sample level with the top edge. Then the box and sample is weighted to and recorded the total weight. Finally dividing the biomass weight by volume of box, the bulk density of the biomass can be calculated.

I. Moisture Content of PSP

Moisture content is determined using the method of ASTM E790. An original sample was obtained and placed in an airtight container immediately after collection. Then an empty container with its cover was dried at 107±3 °C in the oven and then cooled in desiccator to room temperature for 15-20min. The covered container was weighed and recorded (W_c) to the nearest 0.01 g. Then approximately 1 g of sample is placed in the covered container and recorded the initial weight (W_i). The sample and uncovered container is placed in the preheated oven to 107±3 °C for 1h and final weight of sample, cover and container (W_f) is recorded after cooled in a desiccator. The moisture content can be calculated by following equation.

Moisture content

$$Moisture\ content\ of\ the\ smple = \left[\frac{(W_i - W_f)}{(W_i - W_c)}\right] \times 100\%$$

J. Volatile matter of PSP

The volatile matter is determined by ASTM E872 method. The crucible and cover is weighed to the nearest 0.01 g and recorded as crucible weight, W_c. Then approximately 1 g of sample is placed in the crucible, covered, and weighed the crucible, cover and sample to the nearest 0.01 g, and recorded as initial weight, (W_i). The covered crucible with the sample is placed at 950 ± 20 °C for 7 minutes then cooled in desiccator to room temperature. Then the final weight of crucible, cover and sample (W_f) is recorded. The volatile matter content is calculated by using below equations.

$$Weight\ loss = \left[\frac{(W_i - W_f)}{(W_i - W_c)}\right] \times 100\% = A$$

$$Volatile\ matter\ in\ the\ sample, \% = A - B$$

A= weight loss, %

B= moisture content, %

K. Ash content of PSP

The ash content is determined by using ASTM E830 method. The empty container and cover are dried at 107±3 ˚C in the oven and then cooled in desiccator to room temperature for 15-20 min. The covered container weight (W_c) is recorded to the nearest 0.01 g. Then a minimum of 1 g of sample is placed in the previously fired container and recorded the initial weight (W_i). After, the uncovered container containing the sample is placed in the furnace at low temperature and gradually heat to 575±25 ˚C for 1 hour.After Cooled in a desiccator to room temperature the final weight of sample, cover and container (W_f) is recorded.

The ash content in the sample can be calculated by following equation.

$$A = \left[\frac{(A-B)}{C}\right] \times 100\%$$

A = weight of container and ash residue
B = weight of empty container
C = weight of ash analysis sample

IV. RESULTS AND DISCUSSION

A. PSP production

Produced PSP was pelletized and PSP pellets were produced.

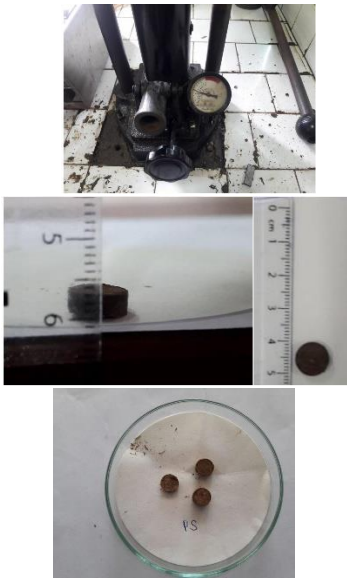


Figure 02: Produced PSP pellets

B. Calorific Value of PSP

The gross calorific value of the paddy straw powder was tested at ITI – Industrial Technology Institute and was found to be 3124 kcal/kg.

C. Density of PSP

The obtained values for the density values of PS and PSP are as follows:

Density of paddy straw = 20.4 kg/m^3
Density of paddy straw powder = 490 kg/m^3

After the converting process of paddy straw into its powder form, density value increases. Therefore the transportation cost can be reduced as the limiting factor is the transportable volume instead of transportable mass in this case. Paddy straw powder can be fed into boilers using high pressure air flow rates similar to coal powder feeding.

D. Moisture content, volatile matter and ash content of PSP

The moisture content values for PS and PSP were obtained as

Moisture content of paddy straw = 15.6 w/w

Moisture content of paddy straw powder = 23.85 w/w

Volatile matter = 43.20%

Ash content of paddy straw powder = 30.32%

Table 01: Summary of physical characteristics of paddy straw powder

Property	**Quantity**
Density	490 kg/m^3
GCV	3124 kcal/kg
Ash Content	30.32%
Moisture content	23.85%

E. Results of Field Trials Carried out to Determine Practical Use of Paddy Straw Powder in Boilers

i. Research Project at Sena Pura Rehabilitation Camp (SPRC) For Disabled Soldiers:

At the request of Major Piyumal Piyatissa, Acting CO of the SPRC, a project was carried out to convert PS into PSP. 1 acre of paddy was harvested manually and brought to land and was threshed with a machine to separate seeds from straw. PS was spread on land at a thickness of 1 inch. Delta-D was diluted with water at the ratio 1:50 and was sprayed on to PS and was subjected to direct sunshine for 2 days. After 2 days PS crumbled into a powder (PSP) and was sifted through a mesh of size 40 and the powder was packed into bags and weighed. The weight was 900 kg. This PSP was transported to a nearby Paddy Par Boiling Mill which a paddy husk had fired Cochran Boiler, which was operating at a pressure of 100 psig and was producing steam at a temperature on 140 ºC. With the consent of the owner of the mill and with the assistance of the boiler, PSP was fired in the boiler. It was found that PSP burnt better than Paddy Husk, since unburnt PSP was very low compared to burning of Paddy Husk, which had unburnt material, as much as 30% of the original weight. Steam production from 900 kg of PSP was around 3000 kg.

ii. Research Project at Embilipitiya:

A project was carried out to in a paddy field owned by Mr. Leonard, where PS from a 2 acre paddy field was converted into PSP using Delta-D^c. The 2 acre paddy field was harvested using a combined harvester. PS pieces were scattered in the paddy field and could not be collected into bags. Hence, using rakes PS was evenly spread in the paddy field to a thickness of 0.5 inches. Delta-D was diluted with water in the ratio 1:50 and was sprayed on to PS and was subjected to direct sunshine for 2 days. After 2 days PS crumbled into a powder (PSP) and was collected into bags using industrial vacuum cleaners and later was sifted through a mesh of size 40 and the powder was packed into bags and weighed. The weight was 1600 kg. This PSP was transported to a nearby Paddy Par Boiling Mill which had a paddy fired Boiler, which was operating at a pressure of 80 psig and was producing steam at a temperature on 110 ºC. With the consent of the owner of the mill and with the assistance of the boiler operator, PSP was fired in the boiler. Here again it was found that PSP burnt better than Paddy Husk, since unburnt PSP was very low compared to burning of Paddy Husk, which had unburnt material. Steam production from 1600 kg of PSP was around 4500 kg.

V. CONCLUSION

Since total paddy production in Sri Lanka is 5 million MT, approximately 2.5 million MT of imported Coal can be replaced from paddy straw, since, PSP has a gross calorific as 3124 kcal/kg, whereas, coal has a gross calorific value of around 6,200. Farmers burn PS in the paddy field itself, since. PS has a very low density and PS transport to a Paddy Parboiling mill or a furnace is uneconomical. PS burns very fast and temperature control is impossible. Delta-D technology can transform low density PS into a high density powder that can be economically transported to a boiler or cement kiln Compared to fossil fuel, such as, furnace oil or coal PSP is carbon neutral and is a good fuel to produce thermal or electric power generation. Preparation of PSP is cheap and no foreign exchange is involved. Converting PS to PSP is easy and handling, storage and transport is easy, since, no storage tanks, conveying systems are required. Since Paddy is a seasonal crop PS is also seasonal and PSP production is also seasonal. Hence, an efficient and low cost storage method should be developed, such as silo systems with safety aspects, preventing dispersion of powders in air and dust explosions. Pelletizing PSP is an attractive but expensive proposition. If PSP is to be used as a fuel, Biomass Boilers have to be modified to fire PSP efficiently, since, it is a fine powder compared to wood chips, paddy husk, etc., which are large particles. If PSP is used as a fuel, it can replace half its quantity of coal, thereby saving valuable foreign exchange and also preventing air pollution, due to haphazard burning of PS all over the country

REFERENCES

Chawala, P. & Sandhu, H., 2020. Stubble burn area estimation and its impact on ambient air quality of Patiala & Ludhiana district, Punjab, India. *Heliyon,* 6(I).

Department of Census and Statistics, 2019. *Agriculture/StaticalInformation/rubpaddy.*[Online]Available at:http://www.statistics.gov.lk/Agriculture/StaticalInformation/rubpaddy [Accessed 30 04 2021].

Krutika, P. & Arvind, C., 2020. *www.bbc.com.* [Online] Available at: https://www.bbc.com/news/world-asia-india-54930380#:~:text=Stubble%20burning%20in%20northern%20India,stop%20it%20fail%20every%20year.&text=According%20to%20some%20estimates%2C%20farmers,tried%20to%20stop%20the%20practice.[Accessed 17 06 2021].

Muhammad, I., Abdurrahman, Sukalpaa, C. & Gaurav, 2020. Stubble burning: Effects on health & environment, regulations and management practices. *Environmental Advances,* Volume 2.

National Fertilizer Secretariat, 2017. *http://www.nfssrilanka.org/fertilizer-guideline.* [Online] Available at: http://www.nfssrilanka.org [Accessed 2017].

Ongley, E. D., 1996. Fertilizers as water pollutants. In: *Control of water pollution from agriculture - FAO irrigation and drainage.* Rome: Food and Agriculture Organization of the United Nations, p. 55.

Organisation for Economic Co-operation and Development, 2017. *Test guideline No 203: Fish, Acute Toxicity Testing.* s.l.:OECD.org.

Perera, S., 2001. *Is Anaerobic Digestion of Market Garbage to Produce Biogas Technically and Economically Feasible.* Moratuwa, Engineering Research Unit, University of Moratuwa.

Perera, S., 2002. *Influence of Organic Fertiliser Fortified with Eppawela Rock Phosphate on the Cultivation of Spinach..* Colombo, Proceedings of The International Seminar on "The Engineer in Sustainable, Social and Economic Development – Regional Contribution Towards Agenda 21, organised by The Institution of Engineers Sri Lanka (IESL), World federation of Engineering Organisations .

Perera, S., 2007. *Delta-D Initiated Microorganic Digestion of Saw Dust into Organic Fertiliser – A Technically, Economically and Environmentally Feasible Solution to the Saw Dust problem in Sri Lanka.* Colombo, Journal of The Institution of Engineers, Sri Lanka.

Perera, S., 2007. *Delta-D Technology, a Technically, Economically and Environmentally Feasible Solution to the Urban Solid Waste (USW) Problem and the Fertiliser Problem in Sri Lanka.* Colombo, Annual Transactions of IESL.

Perera, S., 2007. *Manufacture of Organic Fertiliser from Vegetable Market Garbage (VMG) Using Eppawela Rock Phosphate and Its' Effects on Rice Cultivation.* Philadelphia, The Proceedings of the 22nd International Conference on Solid Waste Technology and Management .

Perera, S., 2007. *Patented Process for Rapid Digestion of All Types of Biomass into Organic Fertiliser, a Solution to the Urban Solid Waste (USW) and to the Fertiliser Problem in Sri Lanka.* Philadelphia, The proceedings of the of the 22nd International Conference on Solid Waste Technology and Management.

Perera, S., 2008. *Delta-D Technology – A Patented Technology That Could Be Used To Prevent Emission Of Green house gases from urban solid waste, agricultural waste and farm waste.* Chandigar, UNESCO and the Punjab state council.

Perera, S., 2009. *Conversion of Coconut Water Waste Produced in Desiccated Coconut Mills into Liquid Organic Fertiliser Using Delta-D Technology.* Philadelphia, The proceedings of the 24th International Conference on Solid Waste Technology and Management.

Perera, S., 2009. *Manufacture of Organic Fertiliser from Poultry Slaughterhouse Waste Rendering Plant Sludge Using Delta-D technology.* Philadelphia, 24th International Conference on Solid Waste Technology and Management .

Perera, S., 2012. *Delta-D Technology – A Green Solution to Unsorted Urban Solid Waste (USW) Disposal Problems in Sri Lanka.* Kandy, International Conference on Sustainable Built Environment.

Perera, S. & Aadhil, M., 2017. *Environmental impacts of organic fertilizer produced from industrial zone central effluent treatment plant sludge using the Delta-D technology.* Colombo, The proceedings of the 111th annual session of the Institute of Engineers, Sri Lanka.

Perera, S. A. S., 2012. Delta D Technology - A Patented Process for Rapid Digestion of All Types of Organic Wastes into Organic Fertiliser in 1 Day, an Ideal Solution to the Urban Solid Waste Problem and the Fertiliser Problem in Sri Lanka. *Delta - D Technology*, p. 3.

Prathapasinghe, D., Perera, M. & Ariyawansa, R., 2018. *Evolution of Condominium Market in Sri Lanka: A Review and Predict.* Colombo, 2nd International Conference on Real Estate Management and Valuation 2018.

Ren, J., Xu, X. & Yu, P., 2019. Straw Utilization in China—Status and Recommendation. *Sustainability*, 11(1762), pp. 1-17.

Waidyasekara, W. & Jayamal, K., 2008. *Opinion Study on Garbage Disposal System for Condominiums Using Quality Function Deployment.* Kandalama, CIB International Conference on Building Education and Research.

Zhang, Q., Zhou, D., Zhou, P. & Ding, H., 2013. Cost Analysis of straw-based power generation in Jiangsu Province, China. *Applied Energy, Elsevier*, 102(C), pp. 785-793.

Challenges and Constraints for Seed Paddy Farmers: A Case Study of the Ampara District, Sri Lanka

M.R. Roshana[1*], Musthapha Mufeeth[2], M.R.F. Rifna Banu[3], N. Nusrathali[4] & G.K.M.M.K. Ranaweera[5]

[1,2,3,4,5]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*]roshana@seu.ac.lk, [2]mufeeth.mohammathu@seu.ac.lk, [3]rifnabanu1@seu.ac.lk, [4]nusrathali@seu.ac.lk, [5]madhusankaranaweera111@gmail.com

Abstract- *The study investigated the problems faced by seed paddy farmers. The survey was conducted by taking a total of 120 seed paddy producing farmers between September 2020 to December 2020 at Akkaraipattu, Addalaichenai and Alayadivembu Divisional Secretariats (DS) areas in Ampara district. Respondent were selected based on the stratified sampling technique and randomly interviewed directly by preparing a semi-structured questionnaire. The results indicated that more than half of the seed paddy farmers faced labour shortage during the harvest (53.4%) where as 48.3% of them affected by the lack of seed paddy for their cultivation. The cost for controlling the weed, pest and diseases was higher compared to other activities (40%) whare as 70% of the seed paddy farmers were facing difficulties to get cleaned seed while only 5% of their lost the seed germination due to combine harvester. We concluded that the major problems faced by the seed paddy farmers were labour shortage, cultivation, management practices and harvesting problems. Therefore, this study suggests that most of the youngsters and educators should be motivated and trained about the seed paddy farming through extension services. Further, seed agencies should expand their distribution networks to ensure that quality seed is available to farmers quickly and easily in this surveyed area.*

Keywords: Ampara district, constraints, high-quality seeds, seed paddy farmers.

I. INTRODUCTION

Rice is Sri Lanka's most important crop, accounting for 40 per cent of the total cultivated area and serving as the country's staple food (USDA, 2020). Paddy crops are grown as wetland crops in every district. Around 1.8 million farm families practice paddy cultivation throughout the island. The extent of cultivation of paddy is 800,000 ha, the largest extent devoted to a single crop in Sri Lanka. Over 700,000 ha are planted in the Maha season and another 450,000 ha in the Yala. The national annual production of rough rice is 2.7 million tons, and it satisfies around 95 per cent of the domestic demand (DOA, 2019). The cost of production of seed paddy for the most productive regions in the country during Maha season around Rs. 73.00/kg for irrigated land and Rs. 63.00/kg for rain-fed areas (SEPC, 2019). There is a need for substantial increases in land and labour productivity to improve competitiveness against potential imports. Production of paddy is favoured in agricultural policy: the government gives support through land, free irrigation water, fertilizer subsidies, and price supports (USDA, 2020).

Seed quality is a key factor in rice production. It must be grown, harvested, processed, and stored correctly for the best yield and excellent results. Almost every farmer is aware of the need for good seed and its contribution to higher yields. Thus invariably, farmers attempt to obtain the best seed available within their capabilities. The average annual requirement of seed paddy is 130,000 MT which is sufficient to plant approximately 1 million hectares (NASTEC, 2019). There are mainly three seed supply systems distributing paddy seeds to the farmers. Around 15% of farmers' seed requirement is supplied through a formal seed supply system which is assured for its genetic and physical purities and germination capabilities. Another 35% of seed is supplied by private seed producers, who purchase basic seed from Department of Agriculture (DOA). The informal system supplies balance 50%, which is the majority of farmers use rice seed produced by themselves from their previous crop or borrow from neighbouring farmers and self-seed program organized by extension officers (Senevirathna *et al*., 2008). Although the targeted amount of seeds produced by DOA is around 25% of the national seed requirement, only 15% is being supplied.

The country's lack of seed processing capability was one of the major constraints to promoting high-quality rice seed production. Many private enterprises and farmers who came forward to produce rice seeds could not afford high-quality seed processing machinery and storage structures (Weerasena & Madawanarachchi, 2000).

Although the DOA gives support to those informal seed producers to increase the seed processing capacity by giving them imported medium-scale machinery, still gaps are prevailing within village level farmers to make use of the best paddy seeds. Therefore, this study was mainly focused on the problems faced by seed paddy farmers in some of the selected DS (Akkaraipattu, Addalaichenai and Alayadivembu) divisions in Ampara district.

II. LITERATURE REVIEW

In rice yield improvement, the supply of quality seeds will be of prime concern (Gunasena, 2004). The annual rice seed requirement of Sri Lanka approximates 1 million tons. The state farm was unsuccessful in supplying the required amount in the past for various reasons hence, the government intervened to expand Certified Seed Paddy (CSP) producers. Farmers usually obtain their paddy seeds from government farms, which are operated by the DOA). The DOA also produces paddy seeds through contract growers (out-growers). Since the capacity of government farms to meet the demand of all farming communities is limited, and since the areas in the north and east of Sri Lanka lack quality seeds for many years and DOA promotes seed paddy out-growing (FAO, 2018).

The general farm producer retained for seed cannot be substituted for quality seed as it generally lacks genetic vigour and has poor germination. One reason for the low replacement of certified seed could be its high price and non-availability at the proper place in time. It is particularly true in small farmers who generally have low availability of cash (Singh *et al*., 1990). Many factors influence the cost of cultivation. Input price, labour consumption and fluctuating wage rate during harvesting season, cost of hired machinery, land tenure and availability of capital on time are important factors. In case farmers are obtaining capital for farm inputs with delay, they are missing the suitable time for sowing. Consequently, this affects the cost of production and the yield, which in many instances coincides with the seasonal outbreak of diseases (Kahan, 2008).

The DOA can fulfil about 3% of the national seed paddy requirement while the balance is met by paddy farmers, farmer's organization, co-operatives and private companies. Only a part of the seed paddy production of these institutions had been certified by the DOA (Central Bank, 1997). In 2018, Agriculture accounted for 7.87% of the gross domestic production (GDP) in Sri Lanka, which 0.7% contributed by rice. However, in 2010 which was accounts for 1.8% of the total GDP (Plecher, 2019). When looking at the last couple of years (2011-2017) which is gradually decreasing trend as 1.5%, 1.4%, 1.6%, 1.2%, 0.9%, 0.6%, 0.5% respectively (Economic and Social Statistics of Sri Lanka, 2019). This emphasizes the need of upgrading the rice sector in Sri Lanka using appropriate technologies.

The National Seed Policy (NSP) of Sri Lanka was officially declared in 1997. The guideline has been provided to encourage private sector participation in producing the country's requirement of quality seed and planting material. In November 1997, the government announced in the 1998 budget, various measures that would be taken to make available an inadequate quantity of quality seed material. In seed paddy, in the 5 major rice-producing districts (Ampara, Anuradhapura, Polonnaruwa, Kurunagala and Hambantota) five acres of seed paddy among paddy farmers are to be developed to increase the seed production. The DOA expected to enhance, its extension service by a mobile agricultural technology service in these 5 districts to improve field-level testing, fertilizer application and use of quality seed that would result in increased yields (Central Bank, 1997).

III. METHODOLOGY

The survey was conducted by taking a total of 120 seed paddy producing farmers between September 2020 to December 2020 to collect the data from Akkaraipattu, Addalaichenai and Alayadivembu DS division in the Ampara district. Respondents were selected based on the stratified sampling technique. Thus, 60, 36, and 24 seed paddy farmers correspondingly from Akkaraipattu, Addalaichenai and Alayadivembu were randomly interviewed directly by preparing a semi-structured questionnaire. Farmers were inquired about their socio-economic characteristics, cultivation practices, cost components, and major constraints faced for seed production. Collected data were analyzed by statistical package for social science (SPSS) version 25.0.

IV. RESULTS AND DISCUSSION

A. Socio-Economic Characters of Seed Producer

On average, the farmers involved in seed paddy production were 50 years old with an average family size of four. Further, the average level of education was 10 years of schooling. However, some farmers were well educated, having a degree or diploma, and they had 19 years of mean farming experience. Income from farming through Maha and Yala was Rs 198,830.00 per annum, and the average monthly household income from other income sources was Rs 39,560.00. (Table 01).

Table 01: Socio-Economic Characteristics of Respondents

Attributes	**Mean ± SE**
Age (Years)	49.80 ± 1.08
Education level (Years of schooling)	9.83 ± 0.31
Farming income (Rs/Season)	198,830 ± 11946.65
Monthly household income (Rs/Month)	39,560 ± 1192.30
Farming experience (Years)	18.55 ± 1.14
Family size (Nos)	4.28 ± 0.11

Source: Field Survey Data, 2020

B. Extent and Land Ownership of Certified Seed Producers

The land is the main capital invested by a farmer to produce seed paddy. The average extent of paddy cultivation was 14.54 acres, while the average extent of seed paddy cultivation was 4.49 acres per seasons by a farmer (Table 02). Most of the seed paddy farmers in this region had their land (93.8 %). This reveals that the farmers cultivated in tenant land are not interested in seed paddy production as they need to expend additional money to provide a lease for the land.

C. Source of Irrigation Water of Seed Paddy Production

The cultivation practices of seed paddy production were very intensive compare to regular paddy cultivation. The majority of the farmers (92.7%) in all 3 DS areas were used water from irrigation channels, whereas only a few of them used other water sources, as indicated in Table 03. The quality of seed paddy produced was mainly impacted by agronomic practices (Tilman *et al*., 2002).

D. Ownership of Machinery

The 4-wheel tractors, water pumps and combine harvesters are the most prominent machinery used for paddy production in the Eastern part of Sri Lanka since the paddy plots are relatively bigger compared to other regions. All the farmers used four-wheel tractors for ploughing purpose. Among them, only 25.57% of farmers were having own tractors (Table 04). About half of the sample farmers did not have a water pump as their paddy field had irrigation facilities were available at a sufficient level. In this area, used combine harvester for harvesting, while an average of 19.96% of farmers had their combine harvester. In the Alayadivembu DS area majority of the farmers (28.9%) owned combine harvester, and ownership of 4-wheel tractor was higher in the Addalaichenai DS area (30.2%).

Table 02: Extent and Land Ownership

Land Extent and Ownership	**DS divisions**			
	Akkaraipattu (n = 60)	**Alayadivembu (n = 36)**	**Addalaichenai (n = 24)**	**Average (N = 120)**
Extent of normal paddy (acre/person/season)	14.18 ± 1.32	18.00 ± 3.18	10.13 ± 1.73	14.54 ± 1.25
Extent of seed paddy (acre/person/season)	4.28 ± 0.33	5.53 ± 1.17	3.29 ± 0.33	4.49 ± 0.39
Owned land (%)	92.7	91.4	97.3	93.8
Tenant land (%)	7.3	8.6	2.7	6.2

Source: Field Survey Data, 2020; Values are Mean ± Standard Error

Table 03: Source of Irrigation Water (% of Farmers Responding)

Irrigation sources	DS divisions			
	Akkaraipattu (n = 60)	**Alayadivembu (n = 36)**	**Addalaichenai (n = 24)**	**Average (N = 120)**
Irrigation Channel	92.4	94.4	91.4	92.7
River	3.2	5.6	0 .0	2.93
Tank	3.2	0.0	4.3	2.5
Agro wells	1.2	0.0	4.3	1.83

Source: Field Survey Data, 2020

Table 04: Ownership of Implements (% of Farmers Responding)

Implements owned	DS divisions			
	Akkaraipattu (n = 60)	**Alayadivembu (n = 36)**	**Addalaichenai (n = 24)**	**Average (N = 120)**
4 Wheel tractors	28.7	17.8	30.2	25.57
Water pumps	51.1	53.3	59.0	54.47
Combine harvesters	20.2	28.9	10.8	19.96

Source: Field Survey Data, 2020

E. Cost of Hired Implements

The farmers who did not have their machinery used hired machinery for cultivation activates. According to the data, the highest portion of machinery hiring cost was allocated to combine harvester this result is supported by Mufeeth *et al*. (2019). The hiring cost of the combined harvester was higher (Rs. 9,173.70/acre) in the Akkaraipattu DS area (Table 05) than other DS areas since the extent of muddy rice lands higher compare to other regions therefore, the farmers have to hire crawler type harvester which is expansive than tyre type. The cost of hiring the four-wheel tractor was higher (Rs. 6,815.40/acre) in the Alayadivembu DS area, where the plot size of rice is relatively smaller therefore, the drivers found it difficult to plough the land continuously. Further, the highest cost of hiring a water pump was observed in the Addalaichenai DS area (Rs. 970/acre) where the larger extent of paddy land become dry due to the unavailability of irrigation water during the Yala season.

Table 05: Cost for Hired Implements (Rs/Acre)

Implements hired	DS divisions			
	Akkaraipattu (n = 60)	**Alayadivembu (n = 36)**	**Addalaichenai (n = 24)**	**Average (N = 120)**
4 wheel tractors	6,620.70	6,815.40	6,812.8	6,780.00
Water pumps	968.18	966.67	1.100.00	970.00
Combine harvesters	9,173.70	8,772.70	8,800.00	8,988.6

Source: Field Survey Data, 2020

F. Major Challenges and Constraints Faced by the Seed Paddy Farmers

Labour shortage is a severe problem in these areas. Seed paddy cultivation requires hired male and female labour for sowing, weeding, harvesting, fertilizer and pesticide application. The hired labour obtained from the same villages or adjacent villages. The cost of hired labour varied from Rs 1,200.00 to Rs 1,500.00 per day. The seed paddy plot should be maintained as weed-free for every field inspection period. Therefore, during this period and harvesting period, labour shortage was higher. Around 97% of farmers stated that the labour shortage was affected their cultivation (Table 06). More than half of the seed paddy farmers faced labour shortage problem during the harvesting period.

Table 06: Period of Labour Shortage (% of Farmers Responding)

Challenges	Percentage
Labour shortage based on the period	
Beginning of cultivation	32.8
During cultivation	12.1
At the harvest time	1.7
Harvesting period	53.4
Cultivation problem	
Lack of seed paddy	48.3
Low seed quality	13.7
High cost of seed paddy	6.7
Unavailability of required seed paddy varieties	31.3
Management practices problem	
Control of weed, pest and disease	40.0
High labour requirement	10.0
Water shortage	34.2
Need different weedicide	15.8
Harvesting problem	
Loss of germination	5
More seed damage occur	25
Seed not cleaned well	70

Source: Field Survey Data, 2020

The quality of certified seed paddy (CSP) production mainly depends on the good quality planting material, but farmers face some difficulties in obtaining CSP from the DOA. Most of the farmers affected due to lack of seed paddy for their cultivation (48.3%) while, 31.3% of them cannot get the required seed paddy varieties in the Department of Agriculture, some of them (13.7%) of them got poor quality of seed paddy and few of them (6.7%) affected due to the high cost involved in obtaining seed paddy (Table 06).

Profit of seed paddy production mainly depends on the management practice expenditure. Seed paddy producers have commonly faced the cost of controlling weed, pest and diseases. The majority of the seed paddy farmers (40%) were faced with the higher cost involved in controlling the weed, pest and diseases (Table 06). while 34.2% of the farmers were affected by the shortage of required water during the chemical application, 15.8% of the farmers were required different weedicides to control and only 10% of the farmers affected by higher labour requirement.

Thus, control of weed and pest are the severe constraint among the seed paddy producers. Most of the farmers were using combine harvester for harvesting. The combine harvester caused mechanical damage to the seed during harvesting, which will affect the seed quality. In this surveyed area, most of the farmers were affected by this problem. Impacts due to the usage of combine harvester were loss of germination, seed damage and seed not cleaned well. 70% of the farmers were facing difficulties to get purely cleaned seed while 20% of them got damaged seeds and only 5% of their lost the seed germination due to combine harvester during harvesting (Table 06).

V. CONCLUSION

The survey study found the most of the farmers involved in seed paddy farming were old with lower level of education. The major challenges and constraints faced by the seed paddy farmers were labour shortage during the harvesting period, cultivation, management practices and harvesting problems. In this surveyed area, lack of seed paddy, low seed quality, high cost of seed paddy and unavailability of required seed paddy varieties were the major cultivation problems. Control of weed, pest and disease, water shortage, required different types of weedicide were the prominent crop management problems faced by seed paddy farmers. Therefore, this study suggests that most of the youngsters should be motivated and trained to involve in seed paddy farming through extension services, and seed agencies should expand their distribution networks to ensure that

quality seed is available to farmers quickly and easily in this surveyed area.

REFERENCES

Central Bank of Sri Lanka, (2016) Economic and social statistics of Sri Lanka 2016.

Department of Agriculture. (2019) Rice cultivation. Available at: https://doa.gov.lk/rrdi/index.php?option=com_sppagebuilder&view=page&id=42&lang=en. (Accessed: 15 April 2021).

FAO. (2018) "Country Gender Assessment of Agriculture and the Rural Sector in Sri Lanka". Food and Agriculture Organization of the United Nations, Colombo, 80 pp.

Gunasena, H. P .M. (2005) "Research needs assessment and prioritization of agricultural research for development: Sri Lanka". Research Need Assessment and Agricultural Research Priorities for South and West Asia.

Kahan, D. (2008). *Managing risk in farming*. Food and Agriculture Organization of the United Nations, Rome.

Mufeeth, M., Nusrathali, N. and Majeed, U. L. A. (2019) "Cost and benefits, marketing and profitability factors of registered seed Paddy farmers". SEUSL Journal of Marketing, *4*(2), pp.1-10.

National Science and Technology Commission. (2019) Performance review of the seed certification service of the Department of Agriculture, pp. 1–73. Available at: http://www.nastec.gov.lk/files/review_report/Performance_Review_SCS_Final. (Accessed: 10 April 2021).

Plecher, H. (2019) Share of Economic Sectors in the Gross Domestic Product (GDP) from 2008 to 2018. Available at: https://www.statista.com/statistics/728539/share-of-economic-sectors-in-the-gdp-in-sri-lanka/. (Accessed: 05 May 2021).

Senevirathna, J. G. D. T., Mettananda, K. A. and Bogahawatta, S. (2008) "A study on the present status of seed paddy production in Sri Lanka". Annals of the Sri Lanka Department of Agriculture, *10*, pp.177-189.

Singh, G., Asokan, S. R. and Asopa, V .N. (1990) "Seed Industry in India-A Management Perspective". Oxford & IBH Publishing Co. (Pvt.) Ltd., New Delhi.

Socio-Economics and Planning Centre, Department of Agriculture. (2019) Cost of cultivation of paddy. Available at: https://www.doa.gov.lk/ICC/images/publication/cost_of_cultivation/cost_of_cultivation_19.pdf. (Accessed: 06 June 2021).

Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R. and Polasky, S. (2002) "Agricultural sustainability and intensive production practices". Nature, *418*(6898), pp.671-677.

United States Department of Agriculture. (2020) Grain and feed annual. Available at: https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Grain%20and%20Feed%20Annual_New%20Delhi_Sri%20Lanka_03-27-2020. (Accessed: 30 March 2021).

Weerasena, S. L. and Madawanarachchi, W. P. (2000) Improving quality seed supply in rice. Available at: http://doa.nsf.ac.lk/bitstream/handle/1/2957/ASDA-2000-453.pdf?sequence=2&isAllowed=y. Accessed: 23 April 2021.

TRACK - BIOSYSTEMS ENGINEERING

Experimental Performance of a Passive Greenhouse Solar Dryer for Paddy

J.P.M.N. Dilrukshi[1*], A. Narmilan[2] & M.I.M. Mowjood[3]

[1,2]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*
[3]*Department of Agricultural Engineering, University of Peradeniya, Sri Lanka*

[1*]dilrunadeesha19@gmail.com, [2]narmilan@seu.ac.lk, [3]mmowjood@pdn.ac.lk

Abstract- *Sun drying is a popular post-harvest operation to maintain the quality of rice during the storage period. Farmers use different treatments and thicknesses for sun drying of paddy in Ampara district, Sri Lanka. A study was conducted to evaluate the drying treatments' suitability and effectiveness as practiced by local paddy farmers during the drying process. The grain with an initial moisture content of 28% (dry basis) was sun-dried with three types of drying treatment and three levels of thickness of grain. This experiment was conducted between 8.30 am and 4.30 pm at the South Eastern University of Sri Lanka in August 2020. Two dryers were fabricated, and it was found that the duration of drying of paddy from 28% to 13% moisture content on a dry basis was 300 to 660 minutes depending upon the drying treatments and thickness. The thermal storage greenhouse dryer is reasonable at shallow thickness with less time to reach the necessary moisture level than other drying treatments. A thermal storage greenhouse can be utilized for drying paddy at 4 cm thickness for 420 minutes. It was found that with an increase in the thickness of paddy from 2 cm to 6 cm, the drying time increases. A statistically significant interaction was obtained between drying treatments and thickness level on moisture removal of paddy. Therefore, the moisture removal rate differs from the paddy's drying treatments and thickness under thermal storage passive type greenhouse.*

Keywords: drying, drying rate, thickness, moisture

I. INTRODUCTION

Dying is a method that reduces grain wetness content to a level wherever it's safe for storage. Drying is the most crucial operation once gathering a rice crop. Delays in drying, incomplete drying, or ineffective drying can reduce grain quality and lead to losses. Drying and storage connected processes and might typically be combined in-store drying. Storage of incompletely dried grain with the next than acceptable wetness content can fail what storage facility is employed. Additionally, the longer the required grain storage amount, the lower the specified grain wetness content should be 14% (Purohit, Kumar and Kandpal, 2006). Solar drying involves the drying of the product inside a closed structure. The top surface of the drying is made transparent so that the radiations can be absorbed (Bala and Debnath, 2012) Various sorts of solar dryers are designed, developed, and tested within entirely different countries' regions for drying paddy. The two most dryers are natural convection dryers and compelled convection dryers. The air circulation is established by buoyancy induce air circulation and compelled convection dryers within natural convection dryers. The air circulation is provided by fan-operated either by electricity module or fossil fuels. Solar thermal technology may be a technology that is speedily gaining acceptance as associate energy-saving measures in agriculture applications. It is most well-liked to different alternative sources of energy like wind and sedimentary rock due to its inexhaustible, most popular, and non-polluting. Solar air heaters are simple devices to heat air by utilizing alternative energy. It is being used in several applications requiring low to moderate temperature 80^{o}C, like crop drying and air heating (Fudholi *et al.*, 2018).

The effectiveness of drying varies because of many factors like selection, gathering strategies, initial and final wetness substance, and drying strategies(Iguaz *et al.*, 2003). Sun-drying will increase the broken rice rate at the edge of the grain temperature gets to a high fault (Iguaz *et al.*, 2003). Among these factors, the ultimate wetness substance could be an essential issue deciding the self-life of rice throughout storage and alternative post-harvest practices because respiration within the grain at high grain status causes deterioration. High wetness content promotes the persecutor and malady attack within the grain. In distinction, if the wetness content in paddy is simply too low, the grains thus fragile once being polished. This could result in a better fraction of broken kernels. Keeping the paddy at acceptable wetness content will prolong storage time and forestall mould growth (Cheenkachorn, 2007). Therefore, the

desired wetness content is 12-14% for storage and 10-13% for an edge.

The thickness of paddy on the drying surface is another essential factor that determines the moisture removal of paddy. Most farmers are practicing different thickness levels according to the quantity of paddy, weather conditions, and availability of the labor without an understanding of the drying performances. Too thin layers tend to heat up very quickly, negatively affecting the head rice recovery. On the other hand, deep layers create dry grains on the top and wet grains on the base, which re-adsorbs moisture on subsequent stirring leads to high broken grains (Iguaz *et al.*, 2003)Thus, the paddy has to be dried in optimum thickness during the sun drying operation. Paddy is dried with different conditions in the Ampara district, one area with higher paddy production in Sri Lanka. Different drying treatments and thicknesses have been used traditionally depending on the quantity, labor availability, and surface area. However, the performance of drying under these conditions has not been studied. Therefore, the objectives of this study were to determine the suitable drying treatments and the optimum drying depth during sun-drying methods practiced by local paddy farmers in the Ampara District. To determine suitable drying techniques and the optimum drying thickness during sun drying, greenhouse without thermal drying, and greenhouse with thermal drying.

II. RESEARCH METHODOLOGY

A. Sample collection and experimental site

Freshly harvested paddy varieties AT 362 and BG94-1 commonly grown in the region were used in this study. Paddy harvested by combine harvester was procured from the paddy field at Malwaththa farm at Ampara district, Sri Lanka, during the *Yala* season. The grain sample was immediately transported from the paddy field to the experimental site. Without thermal storage bed and thermal storage bed, the sun-drying experiment was conducted between 8.30 am to 4.30 pm in February 2021 at the South Eastern University of Sri Lanka. (7°18'00.3"N and 81°51'41.8"E)

B. Experimental design

The different drying treatments were identified based on the open sun drying, without thermal storage bed and thermal storage bed greenhouse. This experiment was designed as a factorial randomization complete block design with different drying varieties and different drying thickness with three replications. Three levels of grain thickness, 2cm, 4cm, and 6cm, were prepared within one-meter square ($1m^2$) wooden frames, and AT 362 and BG94-1 used as different varieties.

C. Development of solar greenhouse dryer

A greenhouse with an effective floor coverage of $4\ m^2 \times 5\ m^2$ was constructed of PVC pipe and a UV film covering. After, an air vent was provided at roof level with a compelling opening of $0.4\ m^2$ for natural convection. The greenhouse was kept at an east-west orientation during the experiments. After constructing the solar greenhouse dryer, the thermal storage unit is stored inside the dryer to maximum efficiency. The sand was used as a sensible heat storage material. Sensible storage is the most robust and easiest to set up, so it appears better adapted to the technical constraints in Sri Lanka. Furthermore, this type of technology is the most suitable for this particularly isolated region, based on locally available materials. Indeed, sensible storage media can include water, rocks, or even soil in the case of a geothermal field (Bala and Debnath, 2012).

D. Sand storage

The sand were put inside the greenhouse dryer. The length of the drying bed was 3 m, the height of the sand bed was 12 cm, and the width of the drying bed was 2 m. Black soil were used for the experiment because it absorbs more heat during the daytime. The drying area was made with $1\ m^2$ wooden frames and high-density polyethylene bags.

E. Data collection

To analyze the performance of the proposed system, various parameters were calculated, including moisture content, temperature, and relative humidity. The moisture content of the grain was measured hourly using a calibrated digital grain moisture meter (model: LDS-1H) after stirred by hand raking. The atmospheric temperature and relative humidity were recorded at one-hour intervals during the drying. All the experiments were carried out in triplicate.

F. Data analysis

All data were subjected to analyze the variance and significant differences (0.05) among the treatments using SPSS version 26 for windows and R software

III. RESULTS AND DISCUSSION

A. Effects of different level of thickness on moisture removal with two varieties of paddy

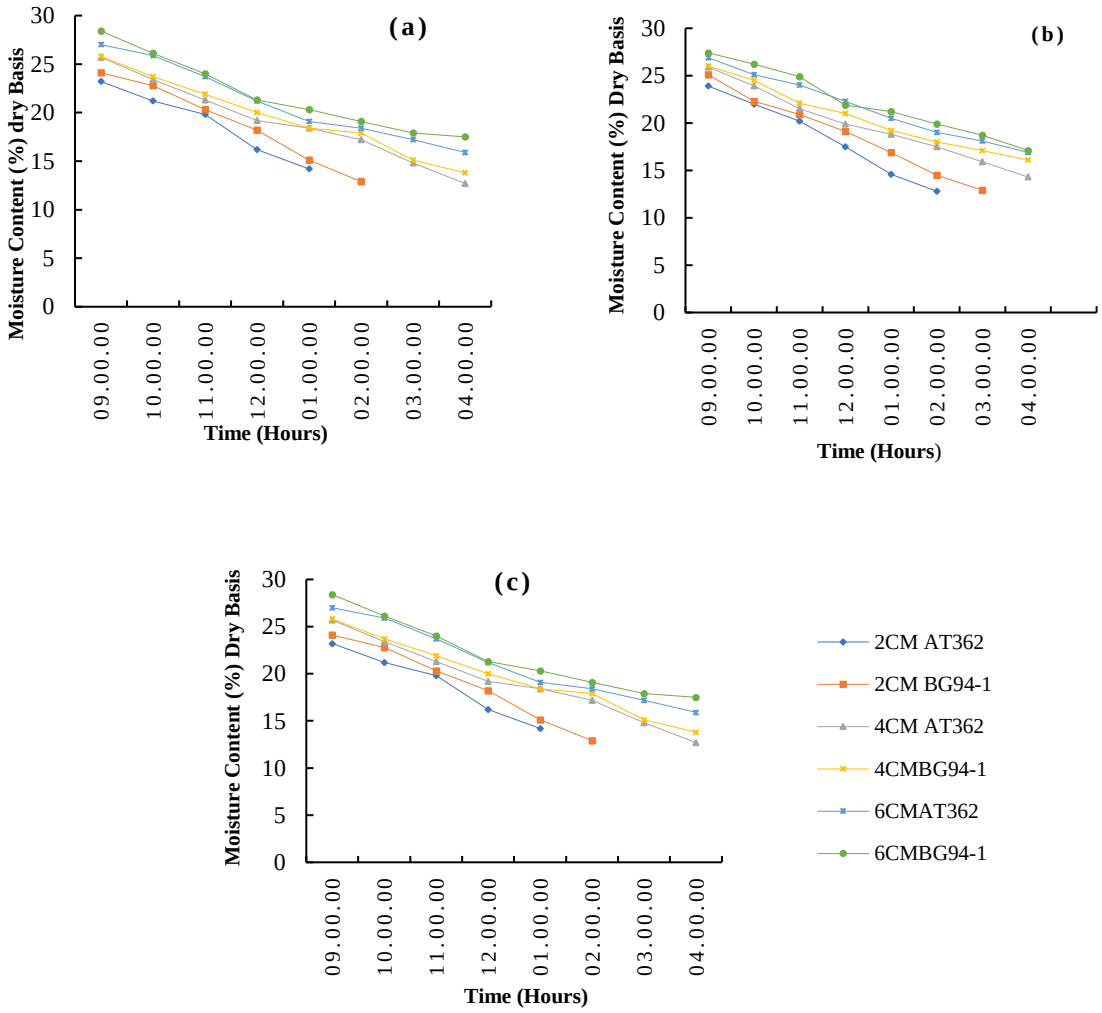


Figure 01: Moisture removal with different level of thickness (a) open sun drying, (b) greenhouse without thermal, and (c) greenhouse with thermal

This study has shown that drying AT362 paddy variety at 2cm thickness presented the best mill recovery, whole variety, and thickness levels. However, drying the paddy at these thicknesses takes (5hours) to reach the final moisture content. This becomes evidence because paddy dried at these drying thicknesses experienced the lowest fissure level. Farmers are busy on the farm and in their families, and hence, such an extended drying time may not be acceptable. This research continued with the research work to reduce the drying time of paddy. The paddy was dried at 2cm, 4cm, and 6cm in thickness. Results show that reduced thickness took less drying time to reach the 14 % (dry basis) final moisture content. There is no significant variation in the moisture content change of paddy variety using AT362 and BG94-1 in all the thickness levels. All paddy depths received the same quantity of solar radiation per unit area. At the same time, the deeper thickness needed more time to reach the recommended milling moisture content.(Nguyen-Van-Hung *et al.*, 2019) Reported that 7 to 8 days of drying is required for 7cm thickness. A similar study conducted in the Philippines said that the recommended paddy drying thickness using the open sun drying method is 2 to 4 cm. Therefore, a suitable thickness of drying paddy and efficient drying rate in open sun drying, greenhouse without thermal and greenhouse with thermal drying was 2cm thickness with AT362 variety.

B. Effects of different drying treatments on moisture removal with two varieties of paddy

paddy and moisture content change also showed not significant (p=0.273) interaction with moisture content change in this experiment. That means the difference in mean moisture content

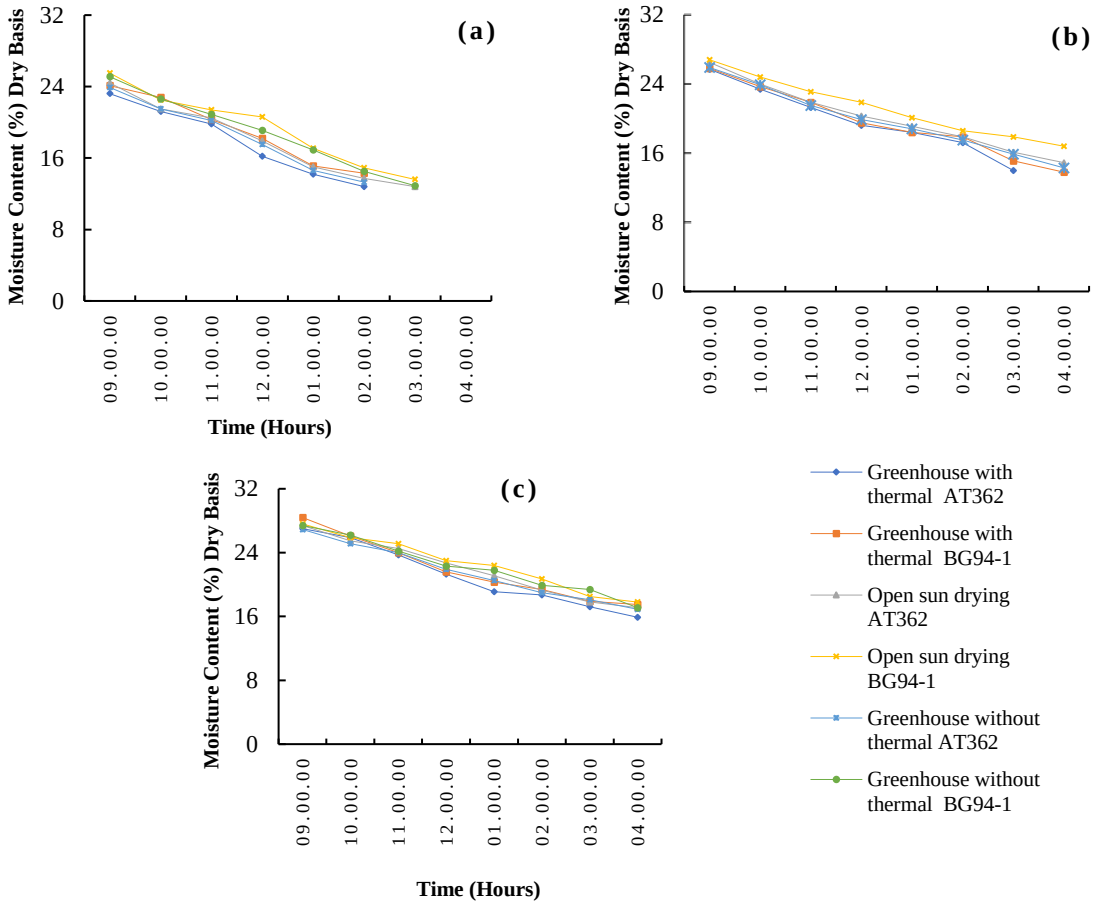


Figure 02: Different drying treatments on paddy moisture removal

C. Interaction effects of drying treatments, thickness, and time on moisture removal

Interaction effect of paddy varieties (AT 362 and BG 94-1), thicknesses (2cm, 4cm, and 6cm), and treatments (open drying, greenhouse without thermal storage and greenhouse with thermal storage) after moisture content change in four hours (day 1 9.00 am to 1.00 pm). Interaction between drying treatments and thickness on moisture content change was found as significant (p=0.000). The relationship between thickness and moisture content change also showed a significant (p<0.05) interaction with moisture content change. And the relationship between drying treatments and moisture content change also showed a significant (p=0.039) interaction with moisture content. Similarly, the relationship between a variety of paddy and moisture content change also showed not significant (p=0.273) interaction with moisture content change in this experiment relationship between a variety of change in paddy variety between AT 362 and BG 94-1 (p=0.207). The postdoc test using Duncan's multiple range (alpha= 0.05) results indicated no significant variation in the moisture content change using different treatments open drying, greenhouse without thermal storage, and greenhouse with thermal storage. Similarly, there was no significant variation in the moisture content change of paddy variety using AT 362 and BG 94-1 in all the thickness levels. Therefore, different drying treatments and thickness levels showed the moisture content change under 2 cm thickness and paddy variety AT 362.

D. Effect of atmospheric temperature and relative humidity for paddy drying

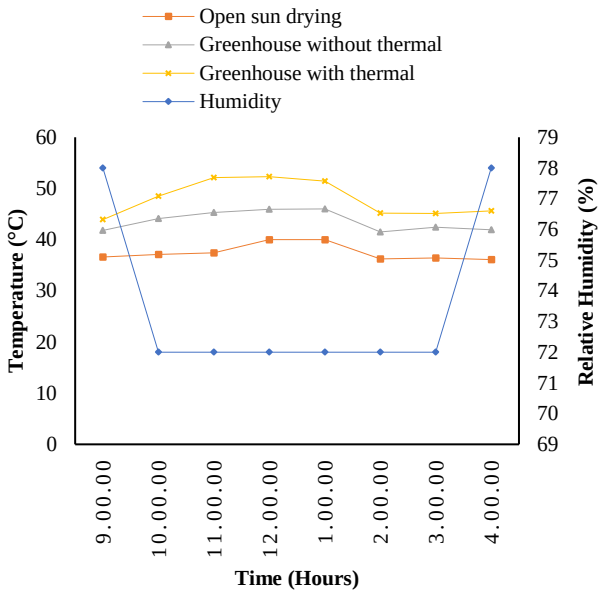


Figure 03: Variation of atmospheric temperature and relative humidity

The variation of atmospheric temperature in the experimental site during the sun drying, greenhouse without thermal, and greenhouse with thermal drying operations were recorded. Accordingly, temperature ranges between 29°C - 60°C, respectively. Around 12% of moisture content was removed from the paddy between 9.00 am to 4.00 pm in the treatments. If it is zero in larger populations, there is an 0% probability of finding this in the sample. The results demonstrated a significant effect of a greenhouse without thermal temperature compared to open sun drying temperature. The main reason for fast initial moisture removal before noon was due to high atmospheric temperature and low relative humidity in the experimental site. This was supported by (Pirasteh *et al.*, 2014) was external wetness would readily evaporate when the paddy is open to hot air. Still, interior moisture evaporates gently as it has to transfer away from the kernel to the exterior due to surface forces. According to (Panyoyai, Wongsiriamnuay and Khamdaeng, 2014), the mechanism of water evaporation in the material occurs through heat and mass processes simultaneously. The time is taken to reach the paddy's required moisture content ranges from 5 to 9 hours, depending on the air temperature in the experimental site. Better temperature regulation was achieved in the dryer with thermal storage greenhouse. When the solar intensity radiation was low at the end of the day, a near about constant was performed in the greenhouse thermal storage drying. This is a fact due to the release of sensible energy. In this study greenhouse, thermal storage drying was found suitable with less time to attain the required temperature level than open sun drying and greenhouse without thermal storage.

IV. CONCLUSION

Drying performance significantly varies with the drying treatments and thickness of the paddy. The time requirements to reach the required moisture content with a greenhouse with thermal and greenhouse without thermal were 240 to 720 minutes, respectively from 28% initial moisture content (dry basis). Greenhouse with thermal was found suitable at shallow thickness with a less amount of time compared to other drying treatments. In contrast, open sun drying treatment is not suitable for the high thickness of paddy. The time required to reach the required moisture content has increased with the increasing thickness level open sun drying, greenhouse with thermal and greenhouse without thermal treatments. There is no significant trend observed in open sun drying and greenhouse without thermal treatments with thickness. Greenhouse without thermal and greenhouse with thermal can be used for sun drying of paddy at 6 cm thickness with 240 minutes' duration under a sunny day. A statistically significant interaction was obtained between drying treatments and thickness level on moisture removal of paddy. The performance of existing solar dryers can still be improved upon especially in the aspect of reducing the drying time and probably storage of heat energy within the system by increasing the size of the solar collector or base area. Also, meteorological data should be readily available to users of solar products to ensure the maximum efficiency and effectiveness of the system. Technical improvement is necessary; the Capacity of the drier needs to be increased and should be affordable to the farmers. The electrical energy produced by solar panel can be used when sunlight is not available and temperature sensor and moisture sensor can be used which can control over heating of paddy.

REFERENCES

Bala, B. K. and Debnath, N. (2012) 'Solar Drying Technology: Potentials and Developments', *Journal of Fundamentals of Renewable Energy and Applications*, 2, pp. 1–5. doi: 10.4303/jfrea/r120302.

Cheenkachorn, K. (2007) 'Drying of rice paddy using a microwave-vacuum dryer', *In proceedings of Euro Congress Chemical Engineering Copenhagen,*

(September), pp. 16–20.

Fudholi, A. *et al.* (2018) 'Solar Drying Technology in Indonesia: an Overview', *International Journal of Power Electronics and Drive Systems (IJPEDS)*, 9(4), p. 1804. doi: 10.11591/ijpeds.v9.i4.pp1804-1813.

Iguaz, A. *et al.* (2003) 'Modelling effective moisture difusivity of rough rice (Lido cultivar) at low drying temperatures', *Journal of Food Engineering*, 59(2–3), pp. 253–258. doi: 10.1016/S0260-8774(02)00465-X.

Nguyen-Van-Hung *et al.* (2019) 'Best practices for paddy drying: case studies in Vietnam, Cambodia, Philippines, and Myanmar', *Plant Production Science*, 22(1), pp. 107–118. doi: 10.1080/1343943X.2018.1543547.

Panyoyai, N., Wongsiriamnuay, T. and Khamdaeng, T. (2014) 'Experimental study on the thermal performance of thermosyphon heat exchanger for rough rice drying', *International Conference on Science, Technology and Innovation for Sustainable Well-Being*, 6(January).

Pirasteh, G. *et al.* (2014) 'A review on development of solar drying applications', *Renewable and Sustainable Energy Reviews*, 31, pp. 133–148. doi: 10.1016/j.rser.2013.11.052.

Purohit, P., Kumar, A. and Kandpal, T. C. (2006) 'Solar drying vs. open sun drying: A framework for financial evaluation', *Solar Energy*, 80(12), pp. 1568–1579. doi: 10.1016/j.solener.2005.12.009.

Optimization of Irrigation Scheduling Under Kapuwaththa Irrigation Tank in Hambantota District, Sri Lanka

J.A. Apsara[1*], M.M.M. Najim[2] & S.L.R. Begum[3]

[1,3]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[2]*Department of Zoology and Environmental Management, Faculty of Science, University of Kelaniya, Sri Lanka*

[1*]apsaraachini54@gmail.com, [2]imara@seu.ac.lk, [3]mnajim@kln.ac.lk

Abstract- *Land use and irrigation management become vital for sustainable agriculture in the context of climate change. The model CROPWAT 8.0 was used in this study for the determination of crop water requirement and irrigation scheduling with the objectives to optimize irrigation scheduling under the Kapuwaththa irrigation tank and to recommend better water management options. Three years (2018-2020) of weather data, soil data and crop data from relevant sources were used as input in the model. The CROPWAT automatically calculated the daily soil moisture balance until the end of the growing season, the totals of effective rainfall and irrigations applied. Based on the modelling application, the respective water requirements per season were 691 mm and 830 mm for Maha and Yala seasons, respectively, whereas the actual amounts applied were 725 mm and 967 mm. The study indicates that the farmers over irrigated the fields by 5.0% and 16.5% in Maha and Yala respectively, when the irrigation efficiency of the scheme is 40%. If the actual application efficiency of the scheme is more, the over irrigation will be more than the amounts given by the model. CROPWAT model can be used as a good tool to schedule the irrigation for paddy under a village tank. The model could be used in optimizing the use of rainfall and saving water, but the effective rainfall calculation method needs to be applied with caution from place to place, and the coefficients of the dependable rainfall method needs to adjusted accordingly to get accurate results.*

Keywords: Crop water requirement, CROPWAT Model, Effective rainfall, Evapotranspiration, Irrigation scheduling, Rice

I. INTRODUCTION

Irrigated agriculture consumes about 70% of the world's freshwater withdrawals, making it largest user of water resources by far (Li et al., 2020). However, this amount is not good enough to meet actual irrigation needs, and it is expected to decline further in the coming years as competition with other users intensifies, especially in arid and semi-arid regions.

Irrigation scheduling ensures the reliable accessibility of water to the plants and its distribution in accordance with crop needs. Irrigation scheduling is used to assess the precise amount of water to apply to the field as well as the basic application preparation (Broner, 2005). Under and over application of water are the two aspects of bad irrigation scheduling. The water is applied either in inadequate amount or incorrect time during under irrigation meanwhile excessive and / or too often watering is done in over-irrigation. Both can result inefficient use of nutrients in turn lower the quality and yield of produce (Kumari, 2017). Proper scheduling applies water at the correct time and in correct amount to maximize production while minimizing negative environmental impacts. Irrigation scheduling optimization makes sure efficient water usage in cropping systems with the shortage of agricultural water resources (Li et al., 2020).

Irrigation scheduling helps farmers to reduce crop water stress while increasing yields; lower the farmers' water and labour costs by reducing irrigation and maximizing soil moisture storage; increase net returns by increasing crop yields and crop quality; and restrict water logging issues by declining drainage requirements (Pujara, 2016). Irrigation scheduling improves the quality of irrigation whereas definite measurement of the quantity or application depth of water is crucial. The amount of water applied is managed by using a model to determine irrigation requirements as well as the technique for application at a given situation. Lee *et al*. (2005) analysed water deliveries during pre-saturation and regular supply times, finding that pre-saturation should not be performed constantly to save scarce water and need to schedule the irrigation based on the available flow.

Rice is the main crop cultivated in Sri Lanka and irrigation plays an essential role in plant growth and agricultural production. According to the Razmy and Ahmed (2005) they reported that the maximum average yield in 2001 was obtained as 3954.3 Kiligrams per hectare (Kg/ha). Rice cultivation in Sri Lanka is hampered by rainfall variability and a lack of irrigation water, resulting in a variety of problems. Hambantota district in Sri Lanka is well known for agriculture where rice is the primary crop grown by the farmers as the economy and staple food requirement are dependent on it. The key factors to increase rice production are efficient use of water resources and partial water allocation with appropriate water management practices. In Kapuwaththa village, in Hambantota, the farmers and crops face various types of problems due to lack of specific water schedules, low water availability and poor water management. Zaman *et al*. (2017) addressed that the insufficient and unstable water supply are the main problems towards the equity of water distribution. While Donaldson (2013) stated that water losses in conveyance canals and field applications have huge impact on efficiency of irrigation system. Gamage and wijesekara (2017) had addressed that if better water management practices can be identified, these agricultural lands can contribute to Gross National Product (GNP) by achieving national food security. Improving the water supply management of irrigation tanks in Sri Lanka is a very important process to reach a higher crop intensity as a large number of irrigated lands are not being utilized deu to water scarcity from year to year. Bandara (2013) reported that the irrigation efficiency in Sri Lankan agricultural systems to change from 47.5% to 71.1%. Department of Agriculture (2004) revealed an average paddy yield of 1213.52 Kilograms per acre (kg/ac) which is lower than the average paddy yield (1857 kg/ac) obtained by farmers in Anuradhapura district in Maha season. Average paddy yield in Kapuwaththa in maha is 2800 kg/ac, which has potential to be increased. Hence, Overall irrigation efficiency of rice schemes is less than 50%, and lower in the wet than in the dry season (Haque *et al*., 2004). Accordingly, an irrigation water delivery schedule at Kapuwaththa area in Hambantota may assist the farmers to increase rice yields by efficiently water management practices. Considering this, the present study was done to optimize irrigation scheduling under the Kapuwaththa irrigation tank.

II. METHODOLOGY

A. Study Area

This study was conducted in Kapuwaththa village in Hambantota district, Southern province of Sri Lanka. The geographical coordinates of the centre of the Kapuwaththa village is 6° 22′ N (North), 81° 13′ E(East) and the altitude is 7.76 m. The location of the Kapuwaththa farming area with the irrigation tank considered for the study is shown in Figure 01. Hambantota district received the average annual rainfall was 1175 mm, average mean temperature was 28.3 celious (°C), average evaporation rate was 4.3 mm/day and average hours of sunshine per day was 6.9 hours (Ehelepola et al.,2021).

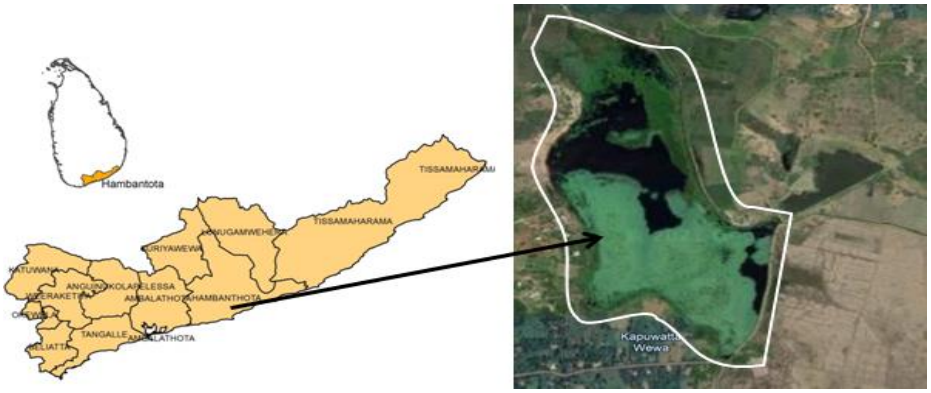


Figure 1: Location of the study area

Kapuwaththa tank covers an area of 60 hectares of irrigation tank and 32 hectares of rice field and nearly 8 hectares of upland crop area. Normally the farmers in the study area cultivate red rice varieties namely AT-362 (Red Nadu) based on their soil type, climate and relatively high yields comparing to the others.

B. Climate data

Monthly climatic data such as rainfall, temperature, humidity, wind speed, and sunshine hours were collected from the meteorological

station for the years of 2018 to 2020 and inter cropping season were collected for the Maha and Yala season. Maha season falls during north east monsoon from late September to March and yala season effective during the period from early April to early September. As the durations of these two seasons in order to explain the accurate relationship between the paddy acreage and rainfall variations in the respective seasons. Therefore the effective rainfall period of growing season is taken according to the crop calendar presented by Yoshino et al. (1983c).

C. Soil data

The important soil data such as Total Available Water (TAW), maximum infiltration rate, maximum rooting depth and initial soil moisture depletion were collected from published data (Narmilan and Sugirtharan, 2018). Hambantota district has Reddish Brown Earth soils in the upland crop areas. However, major soil type in paddy lands is Low Humic Gley soil. Soil data collected for the study area is given in Table 1.

Table 1: Soil data of study area

Description or parameter	**Data**
Type of soil	Clay
Total available soil moisture (mm/m)	150 mm/m
Max. rain infiltration rate (mm/day)	62 mm/day
Maximum rooting depth (cm)	60 cm
Initial soil moisture depletion (as % TAM)	0 %
Initial available soil moisture (mm/m)	150 mm/meter

(Source: Narmilan and Sugirtharan, 2018)

D. Crop data for rice

Crop coefficient values (Kc), critical depletion fraction and yield response factors were taken from accessible published informatio. In addition, planting dates (Yala-November 10, Maha-April 20), harvesting dates (Yala- February 22, Maha-August 2) and crop data for rice (rooting depth, and height for the crop) were collected from the farmers in Kapuwaththa village via a survey considering 2020 (Table 2)

Table 2: Crop data for rice (gain)

	Growth Stages				
	Initial	Development	Mid	Late	Total
Stage Lengths [Days]	20	25	35	25	105
Crop Coefficients (Kc wet)	1.05	1.10	1.20	1.05	-
Crop Coefficients (Kc dry)	0.30	0.50	1.05	0.7	-
Rooting Depths [m]	0.10	-	0.60	0.60	-
Depletion Levels	0.20	-	0.20	0.20	-
Yield Response Factors	1.00	1.09	1.32	0.50	1.10
Crop height [m]	0.2	0.6	1	0.9	1

(Source: Irrigation planing with the help of cropwat 2016, viewed 24 April 2021, https://www.slideshare.net/iamsidu/irrigation-planning-with-the-help-of-cropwat-80)

E. Estimation of crop water requirement (CWR)

CWR was estimated from crop evapotranspiration (ETc) using the equation below (Ewaid et al., 2019).

$$ET_c = K_c \times ET_o$$

where, Kc is the crop coefficient and ET_o is the reference evapotranspiration. ET_0 was estimated using the Penman-Monteith equation as below (Memon and Jamsa, 2018).

$$= \frac{0.408\,\Delta(R_n - G) + y\left(\frac{900}{T+273}\right)U_2(ea - ed)}{\Delta + y(1 + 0.34U_2)}$$

where ETo is reference crop evapotranspiration (mm/day), Rn is net radiation at the crop surface (MJ/m^2 /day), G is soil heat flux density (MJ/m^2 /day), T is air temperature at 2 m height (^oC), u_2 is wind speed at 2 m height (m/sec), es is mean saturation vapour pressure of the air (kPa), ea is mean actual vapour pressure of the air (kPa), (es – ea) is saturation vapour pressure deficit (kPa), D is slope of the vapour pressure curve ($kPa/^oC$), G is psychometric constant ($kPa/^oC$) and 900 is conversion factor.

Further, Crop Water Requirement (mm) was determined according to FAO (2005) as;

$CWR_i = \sum_{t=0}^{T} (Kc_i \,.\, ET_o - P_{eff.})$

where Kc_i is the crop coefficient of the rice during the growth stage t and T is the final growth stage and P_{eff} is effective monthly rainfall (mm).

The actual applied amount were calculated for yala and maha seasons separately by using data of flow rate of water in the canal and time duration of water supply. Then these were compaired with model calculated values and farmers applies actual amount for the decide water and losses from farmers.

F. Estimation of irrigation requirement (IR)

The CROPWAT model computed the daily water balance of the root zone by the following equation (Ewaid et al., 2019):

$$Dr_{,i} = Dr_{,i-1} - (P_i - RO_i) - I_i - CR_i + ET_{c\,i} + DP_i$$

where $Dr_{,i}$ is the root zone depletion at the day's end (mm), i (mm),$Dr_{,i-1}$ is the water content in the root zone at the previous day's end (mm), P_i is the precipitation on day i (mm), RO_i is the surface soil runoff on day i (mm), I_i is the net irrigation depth on day which infiltrates the soil (mm), CR_i is the capillary rise from the groundwater table on day i (mm), $ET_{c\,i}$ is crop evapotranspiration on day i (mm), and DP_i is the lost water of the root zone on day i (mm).

G. Irrigation scheduling

For the rice irrigation scheduling irrigates at fixed interval per stage separately for Maha (10 days) and Yala (7 days) season was set as the irrigation timing in the scheduling criteria. Irrigation application was done to refill to a water depth of 100 mm at an assumed irrigation efficiency of 40%. Scheduling options included the general settings for land preparation, which was set to FAO formula method. For the scheduling criteria of pre puddling, irrigation timing was assumed to irrigate at 25 % of depletion of field capacity and irrigation application was set to irrigate at fixed application depth (100 mm). Meanwhile, for the scheduling criteria of puddling, the irrigation timing and application were set at fixed water depths of 25 mm and 100 mm, respectively.

H. Simulations

The model was run for rice crop with monthly climatic data obtained for the study period and single scheduling criteria. The model results were analysed and the best fit irrigation scheduling option was selected.

III. RESULTS AND DISCUSION

A. Effective rainfall

Effective rainfall calculated under different methods (Table 03) indicates that maximum effective rainfall was obtained from USDA SC method and minimum result was from Dependable rain (FAO/AGLW formula) method. Furthermore, maximum Net Irrigation Requirement was noted in dependable rain method whereas the minimum was obtained from USDA SC method. Hence, net irrigation supplied by farmers (calculated by flow rates, irrigation timing and application frequency) in Kapuwaththa was approximately the same as net irrigation required from each method (Table 03) in the dependable RF method compared to other methods. Accordingly, dependable rainfall method was considered as a suitable method for effective rainfall estimation for irrigated paddy fields.

Table 3: Effective rainfall and net irrigation requirement from different effective rainfall methods

Month	RF (mm/month)	ETo (mm/month)	Effective rainfall (mm)				
			USDA	Fixed % (80%)	Dependable RF	Empirical	No Eff RF
Jan	16.9	115.01	16.4	13.5	0.1	3.4	0
Feb	29.4	123.6	28	23.5	7.6	9.7	0
March	32.6	137.64	30.9	26.1	9.6	11.3	0
April	99.2	117.88	83.5	79.4	55.4	89.4	0
May	50.1	117.18	46.1	40.1	20.1	55.1	0
June	22.4	108.9	21.6	17.9	3.4	6.2	0
July	32.5	115.01	30.8	26	9.5	11.3	0
Aug	72.5	124	64.1	58	34	70.8	0
Sep	174.7	117.3	125.9	139.8	115.8	142.3	0
Oct	170.4	115.63	123.9	136.3	112.3	139.3	0

Nov	125.9	109.2	100.5	100.7	76.7	108.1	0
Dec	153.7	105.71	115.9	123	99	127.6	0

Month	RF	ETo (mm/month)	Net Irrigation Requirement (mm/month)				
			USDA	Fixed %	Dependable RF	Empirical	No Eff RF
Jan	16.9	115.01	98.61	101.51	114.91	111.61	115.01
Feb	29.4	123.6	95.6	100.1	116	113.9	123.6
March	32.6	137.64	106.74	111.54	128.04	126.34	137.64
April	99.2	117.88	34.38	38.48	62.48	28.48	117.88
May	50.1	117.18	71.08	77.08	97.08	62.08	117.18
June	22.4	108.9	87.3	91	105.5	102.7	108.9
July	32.5	115.01	84.21	89.01	105.51	103.71	115.01
Aug	72.5	124	59.9	66	90	53.2	124
Sep	174.7	117.3	0	0	1.5	0	117.3
Oct	170.4	115.63	0	0	3.33	0	115.63
Nov	125.9	109.2	8.7	8.5	32.5	1.1	109.2
Dec	153.7	105.71	0	0	6.71	0	105.71

Table 4: Crop water requirement of rice in Maha

Month	Decade	Stage	Kc	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Oct	3	LandPrep	1.05	3.89	42.7	34.5	316.5
Nov	1	Initial	1.06	3.87	38.7	27.7	121.5
Nov	2	Initial	1.10	4.00	40.0	22.9	17.1
Nov	3	Developing	1.10	3.92	39.2	26.2	12.9
Dec	1	Developing	1.09	3.80	38.0	34.3	3.6
Dec	3	Mid	0.90	3.16	34.7	25.8	8.9
Dec	3	Mid	1.06	3.72	40.9	25.8	15.1
Jan	1	Mid	1.06	3.82	38.2	0.2	38.0
Jan	2	Mid	1.06	3.93	39.3	0.0	39.3
Jan	3	Late	1.06	4.06	44.7	0.0	44.6
Feb	1	Late	1.01	4.02	40.2	1.9	38.3
Feb	2	Late	0.95	3.92	39.2	2.8	36.4
Feb	3	Late	0.92	3.87	7.7	0.7	7.7
					483.5	215.9	691.0

B. The crop water requirement of rice in Maha season

Crops' water requirements vary with location, climate, soil, method of cultivation and effective rainfall. The water requirement of a crop differs with its growth stage. The model calculated the irrigation requirement (IR) for the entire growth period, in a decade wise pattern (10 days). The results obtained from the model are shown in Table 4 based on Dependable RF method.

A range of ETc values between 3.16 to 4.06 mm/day was recorded in Maha season. Total irrigation water requirement was 691.0 mm per decade and that value increases due to different reasons as bellow. In rice cultivation, crop water requirement increased from initial stage to end of the mid stage from 3.87 mm per day to 3.93 mm per day, respectively. Then, it increased from 3.92 mm per day to 4.06 mm per day during the middle of the late stage when the rice absorbs a lot of water for growth and reaches its maximum height. Finally, the water requirement of rice decreased to 3.87 mm per day at end of the late- season, which is the period of ripening. This is also the time for draining water in preparation for paddy harvesting. The initial and development stages do not need additional irrigation water since the demands were met from rainfall. In Maha season, the initial and development stages of paddy cultivation fall in November and December in

Table 5: Crop water requirement of rice in Yala season

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
				mm/day	mm/dec	mm/dec	mm/dec
Mar	3	Land Prep	1.05	4.58	4.6	0.6	28.5
Apr	1	Land Prep	1.05	4.50	45.0	15.9	299.5
Apr	2	Initial	1.06	4.44	44.4	22.3	139.3
Apr	3	Initial	1.10	4.48	44.8	17.1	27.7
May	1	Developing	1.10	4.32	43.2	10.0	33.1
May	2	Developing	1.08	4.09	40.9	5.8	35.0
May	3	Developing	1.05	3.91	43.0	4.3	38.7
Jun	1	Mid	1.02	3.76	37.6	2.3	35.3
Jun	2	Mid	1.02	3.71	37.1	0.1	37.0
Jun	3	Mid	1.02	3.73	37.3	1.1	36.2
Jul	1	Late	1.02	3.75	37.5	1.9	35.6
Jul	2	Late	0.98	3.64	36.4	2.3	34.1
Jul	3	Late	0.93	3.54	38.9	5.3	33.6
Aug	1	Late	0.90	3.50	7.0	1.4	7.0
					497.8	90.4	820.7

which highest rainfall was recorded during 2018 to 2020. Therefore, the additional irrigation was not done by farmers at these stages except during the land preparation period in 2020. Because of the land preparation takes mare water due to percolation and seepage, high evaporation and surface runoff in the land. Percolation occurs in vertical direction due to different topography , soil characteristics and depth of water table. Seepage occurs in horizontal movement of water affecting the normal flows in to soil surface or stream, drains while percolation from land.Due to low rainfall in the month of January and February, the mid and late stages require water and need to be supplied through irrigation. Similar to the present results, Narmilan and Sugirtharan (2018) also recorded that ETc values were ranged between 1.76 and 3.66 mm/day in Maha season during November to January in Batticaloa district. They also mentioned that in the early stages, rice only needs around 60 mm per decade to compensate for crop water requirements. During the growing season, rice's water demand declined from 56.2 mm to 46.7 mm at the end of the decade. Then, it increased from 39 mm to 48 mm at the start of the mid-season stage, when rice requires a lot of water to develop.

C. The crop water requirement of rice in Yala season

The model calculated the IR for the entire growth period, in a decade wise pattern (7 days) for Yala season. The results obtained from the model are shown in Table 5 based on Dependable RF method.

A range of ETc values between 3.50 and 4.58 mm/day were recorded in Yala season. Crop water requirement decreased from initial stage to mid stage from 4.44 mm per day to 3.76 mm per day, respectively in Yala season. Then, it further decreased from 3.76 mm per day to 3.50 mm per day during the late stage. This is the time for draining water for the harvesting of paddy. The initial and development stages do not need additional irrigation water since the demands were met from rainfall.

Similarly, Narmilan and Sugirtharan (2018) recorded the Crop evapotranspiration ($ET_{C)}$ values in between 2.13 and 4.5 mm/day in May to July during the Yala season. The total crop water requirement was 436.7 mm/ season through the growing season, but successful rainfall was only 133 mm/ season in their study. As a result, irrigation should be carried out in Yala to meet the paddy water demand.

D. Irrigation schedule for the rice in Maha

The Figure 2 represents the irrigation schedule obtained from CROPWAT model for rice at fixed interval (10 days). It was found that the gross irrigation was 2774.7 mm and total Net Irrigation Requirement (NIR) was 1109.9 mm.

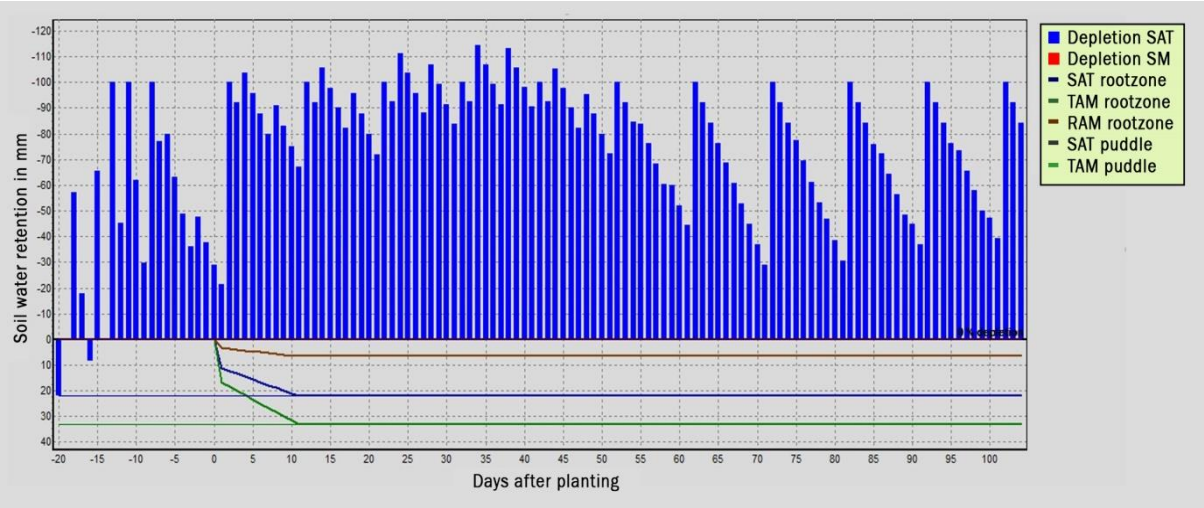


Figure 2: Irrigation schedule of Rice in Maha

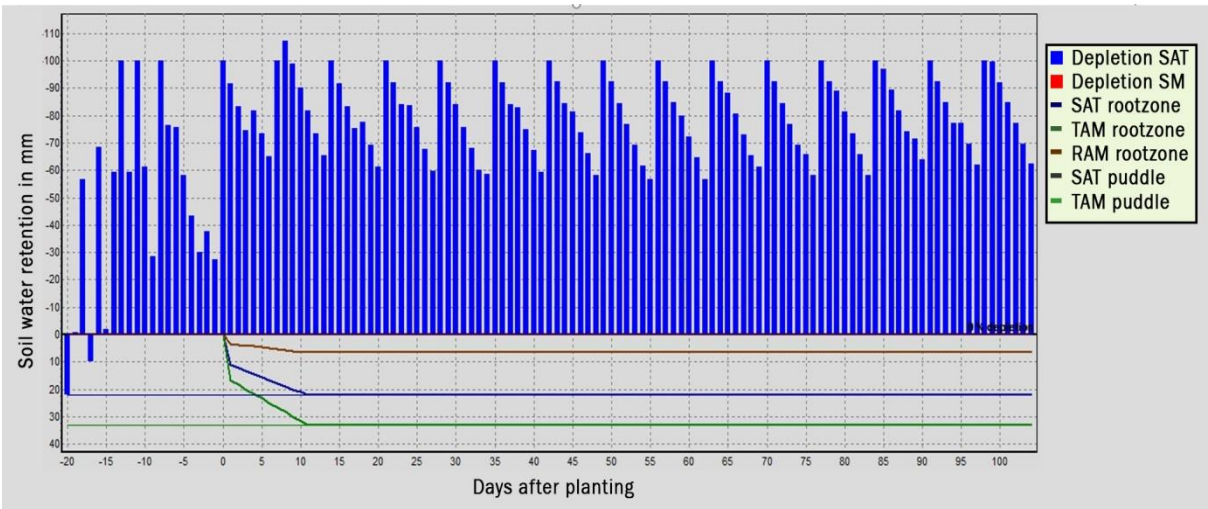


Figure 3: Irrigation scheduling of rice in Yala

E. Irrigation schedule for the rice in Yala

Figure 3 represents the irrigation schedule obtained from CROPWAT model for rice at fixed interval (7 days). It was found that the total gross irrigation was 3353.5 mm and total NIR was 1341.4 mm

F. Actual Irrigation requirement of Yala and Maha

Table 6: Comparison between actual IR and estimated IR

			Net schem Irr.Req		Irrigated area(% of ideal area)	Irr.Req for actual area l/s/h	Actual applied amount mm/month
		mm/ month	In mm/ day	In mm/ Month			
Rice Maha	Oct	316.5	10.2	316.5	100.0	1.18	145.08
	Nov	151.5	5.1	151.5	100.0	0.58	145.08
	Dec	18.7	0.6	18.7	100.0	0.07	145.08
	Jan	121.9	3.9	121.9	100.0	0.45	145.08
	Feb	82.5	2.9	82.5	100.0	0.34	145.08

Rice Yala	Mar	28.5	0.9	28.5	100.0	0.11	193.44
	April	466.5	15.5	466.5	100.0	1.80	193.44
	May	108.3	3.5	108.3	100.0	0.40	193.44
	Jun	112.8	3.8	112.8	100.0	0.44	193.44
	July	106.9	3.4	106.9	100.0	0.40	193.44
	Aug	7.1	0.2	7.1	100.0	0.03	193.44

According to 40% efficiency, actual applied amounts were 145.08 mm/month and 193.44 mm/month for Maha and Yala season, respectively (Table 6). Model calculated total irrigation requirement of Maha season is 691.1 mm for the land preparation to harvest. But farmers applied 725.4 mm in Maha season in 2020. According to the model, more water required for land preparation during the month of October, and month of February required low water amount because of the harvesting period. Also, in December 2020 calculated amount was 18.7 mm and farmers applied amount was 145.08 mm and it indicates over irrigation. This is because of irrigating the fields without considering the rainfall. Considering all the applied amounts and model calculated amounts, farmers applied 4.96 % more than the requirement in Maha season.

Model calculated total irrigation requirement of Yala season was 830.1 mm for the land preparation to harvest. But farmers applied 967.2 mm in the Yala season. According to the model, month of April required more water for land preparation. Considering all the amounts applied and model calculated amounts, farmers applied 16.51 % more than the requirement in Yala season.

IV. CONCLUSION

Dependable rain method is the best method to estimate effective rainfall at Kapuwaththa irrigation scheme. The USDA –SC method over predicts the effective rainfall hence it is not suitable for paddy irrigation. Based on the modelling application, the water requirement per season are 691 mm and 830 mm for Maha and Yala, seasons, respectively. The actual amounts applied to the fields are 725.4 mm and 967.2 mm per season for Maha and Yala seasons, respectively. Hence, the farmers over irrigate the fields by 4.96 % and 16.51% in Maha and Yala seasons, respectively, when the irrigation efficiency of the scheme is 40%. If the application efficiency of the scheme is more, the over irrigation will be more than the amounts given above. The model estimated irrigation practice can save water than existing farmer's practices. Since, the study area is facing water shortage, judicious use of irrigation water for maximization of the agricultural productivity can be a solution to safeguard the environment. The results of the study could also be used as a guide for the farmers in scheduling their irrigation and choosing a good irrigation practice. The study results can be extrapolated in the future and the future water demand of crops can be determined by using a probability analysis of irrigation requirement. Further, it can be assessed whether the future rainfall could meet the future water demand of crops or not.

REFERENCES

Bandara, K.M.P.S. (2003) 'Monitoring irrigation performance in Sri Lanka with high-frequency satellite measurements during the dry season'. Agricultural water management, 58(2), pp.159-170.

Broner, I. (2005) 'Irrigation Scheduling',Fact Sheet 4.708.

Department of Agriculture. (2004) 'Cost of Cultivation of Agricultural Crops- 2003/2004 Maha'. Socio Economics and Planning Centre, Department of Agriculture, Peradeniya.

Donaldson, M. (2013) 'Rehabilitation and modernisation of irrigation schemes',Proceeding of the institution of civil engineers-water management , 166(5),pp.242-253.

Ehelepola N.D.B.Ariyarathne, K. and Dissanayake, D.S. (2021) 'The inter relationship between meteorological parameters and leptospirosis incidence in Hambantota district, Sri Lanka 2008-2017 and practical implication',PLos one 16(1).

Ewaid, S. H., Salwan, A.A. and Nadhir A.A. (2019) 'Crop Water Requirements and Irrigation Schedules for Some Major Crops in Southern Iraq',Water, 11, 756.

Food and Agricultural Organization (2005) 'Irrigation potentials in Africa; a basin approach. Chapter 5: Irrigation water requirements',FAO corporate document repository. FAO, Rome.

Gamage P.R and wijesekara N.T.S. (2017) 'Attempting to improve seasonal performance of Land and water productivity through systematic analysis: Case study of Dahanaka Minor Irrigation Tank in Anuradhapura District of Sri Lanka', UMCSAWM Water Conference.

Haque, M.A. Najim, M.M.M. , and Lee, T.S. (2004) 'Modeling Irrigation Water Delivery Schedule for Rice Cultivation in East Coast Malaysia',Tropical Agricultural Research,16, 204-213.

Kumari, S. (2017) 'Irrigation scheduling using cropwat',Creative Research Thoughts,394–403.

Lee, T. S. Haque, M. and Najim, M.M.M. (2005) 'Modeling water resources allocation in a run-of-the-river rice irrigation scheme',Water resources management, 19(5), 571-584.

Li, J. Jiao, X. Jiang, H . Song, J. and Chen, L. (2020) 'Optimization of Irrigation Scheduling for Maize in an Arid Oasis Based on Simulation – Optimization Model',Agronomy, 10, 935.

Narmilan, A and Sugirtharan, M. (2018) 'Modelling the Crop Water Requirement in Batticaloa District, Sri Lanka', FAO-Cropwat Modelling for Rice,Proceedings of the 4th Jaffna University International Research Conference (JUICe2018), pp 19-24.

Pujara, M. (2016) 'Criteria for Scheduling Irrigation'.

Razmy A.M and Ahmed A. N. (2005) 'Trends in Paddy Production in Sri Lanka' Journal of Management Vol. III. No. pp 26.33.

Siddharthh, U. (2016) 'Irrigation planing with the help of cropwat', Available at https://www.slideshare.net/iamsidu/irrigation-planning-with-the-help-of-cropwat-80 (Accessed:24 april 2021).

Yoshino M. M. et al. (1983c) 'Climatic fluctuation and its effects on paddy production in Sri Lanka' Climat. Notes, 33, 9-32.

Zaman, A. et al. (2017) 'Water Resource Development and Management for Agricultural Sustainability', Journal of Applied and Advanced Research, 2(2),p.73.

Problems and Factors Influencing the Adoption of Micro Irrigation System in Crop Cultivation in Manmunai South Eruvil Pattu DS Division, Batticaloa

M. Janani[1], A. Narmilan[2] & M. Sugirtharan[3*]

[1,3]*Department of Agricultural Engineering, Faculty of Agriculture, Eastern University, Sri Lanka*
[2]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1]jananimanokaran680@gmail.com, [2]narmilan@seu.ac.lk, [3*]sugirtharanm@esn.ac.lk

Abstract- *This study was done to determine the factors influence the adoption of MIS and the problems faced by the farmers in practicing MIS for vegetable cultivation at three major vegetable cultivating GN divisions such as Cheddipalayam, Kaluthavalai and Kaluwanchikudy in Batticaloa district. A field survey was done with randomly selected 50 MIS and 75 non-MIS adopting farmers using structured questionnaire, direct observations as well as personal interview. Results indicated that all the selected MIS adopters are much educated with advanced level (54%) and 48% of them get higher income (>30000Rs) than non-MIS adopters. As far as the MIS adopters are concerned, 100% of farmers use sprinkler system only. It is also revealed that extent of crop cultivated under MIS is very less than the areas irrigated with non-MIS. Less labour cost (14%), support by NGOs (20%), high yield (12%), less water demand (8%) and wide extension services are the (8%) reasons behind the shift from non-MIS to MIS. However, lack of capital, knowledge and poor water quality are the major factors influencing on the adoption MIS in the study area. Therefore, the study suggests that regular extension services, training programs and supply of subsidies for establishing MIS will motivate the farmers for the adoption of MIS in the study area.*

Keywords: Micro irrigation system, sprinkler irrigation, water use efficiency

I. INTRODUCTION

Despite a large amount of public investment on irrigation infrastructure, Sri Lanka suffers from acute water shortages resulting mainly from a poor management of water resources. Most of the dry zone districts in Sri Lanka face either seasonal or year round severe water scarcities (Amarasinghe, Mutuwatta, and Sakthivadivel., 1999, p 21-23). Therefore, it is a challenge to improve the agricultural water use efficiency to increase or maintain crop yield. One of the methods available to improve the efficiency of water usage is the adoption of micro irrigation technologies to reduce losses at distribution and farm water management level. In India, it was found that the efficiency of the farm irrigation system was about 90 percent under a properly designed and managed drip irrigation system, 70 percent under sprinkler irrigation and only about 45 percent in the case of surface irrigation methods (Sivanappan, 1994, p.49-58). It is reported that the large scale adoption of water intensive cropping pattern acts as one of the major determinants in achieving higher agricultural growth rate in the North Gujarat and increasing the cropping intensity (Shah, 2009, p1-13; Viswanathan and Pathak, 2014, p. 380-432).

Batticaloa district is one of the important districts in Eastern province which contribute a lot to the agriculture sector of the nation. For an example paddy contributes nearly 4.9% to gross domestic production (District Secretariat, 2013). Since this district experienced prolong dry season (April to October) there is a huge problem of water scarcity for cultivation. Therefore, efficient use of water is essential to overcome the water scarcity problem to a certain extent. One of the technological interventions in agriculture to increase the water use efficiency is the adoption of micro-irrigation technologies. However, most of the farmers are still practicing the traditional surface irrigation and only few are adopting MIS. Therefore, this survey is intended to identify the factors influencing on the adoption of MIS and the constraints related with the adoption of MIS in selected GN divisions of Manmunai South Eruvilpattu D.S Division.

II. MATERIALS AND METHODS

A. Location and description of study area

Batticaloa district occupies the central part of Eastern province, Sri Lanka. It covers the land area of 2610 km^2 and the internal waterway of 244

km^2 (District Secretariat, 2016). The district accounts for 4.35% of the country total land area where the total population is 588 202. Batticaloa district is located in the dry zone of Sri Lanka experiences prolong dry season during the months of April to October.

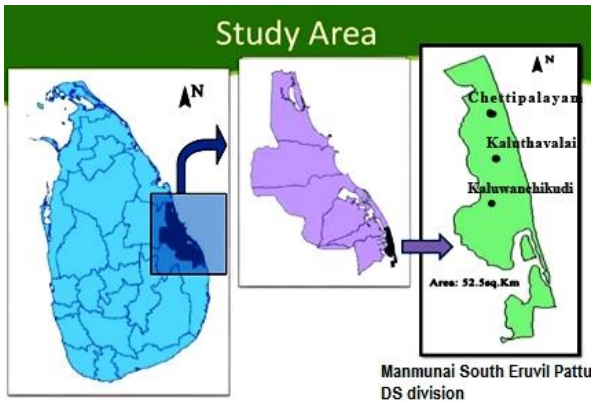


Figure 1: Location of the study area

B. Sampling and data collection

A field survey was done with randomly selected 50 MIS and 75 NON MIS adopting farmers from 3 major agricultural villages namely Cheddipalayam, Kaluthavalai and Kaluwanchikudy in Manmunai South Eruvil Pattu DS division during September 2017 to December 2017.

Primary data were collected from the farmers using pretested structured questionnaire, direct observation and personal interviews. Questionnaires were designed to collect data on factors influencing and the problems associated with the adoption of MIS in the study area. Further, socio economic condition of the farmers, cultivation information, existing irrigation methods and suggestions were also collected in the survey. Information on extent and limitations of cultivation were also collected by personal interview with Agriculture instructors who are working in the region. Secondary data were collected from Department of Agriculture and District Secretariat Office Batticaloa. Census and statistical report and published literatures were also used to get additional required information.

***C.** Data Analysis*

The completed questionnaires were checked and entered in the MS Excel 2007 to get descriptive statistics. Data were analyzed using SPSS software (version 19.0) for Windows.

III. RESULTS AND DISCUSSION

The survey conducted among the randomly selected 75 NON MIS adopters and 50 MIS adopters revealed that all MIS adopters are also practicing surface irrigation methods along with MIS. Lack of MIS units supply to cover the total land and higher cost of MIS unit are the predominant reasons for practicing surface irrigation methods along with MIS in the study area.

i. Socioeconomic characteristic of the vegetable farmers in study area

Table 1: Socio economics status of the farmers

Category	NON MIS adopting farmers (%)	MIS adopting farmers (%)
Age (in years)		
21 - 40	14.7	36.0
41 - 60	54.7	46.0
61 - 80	30.7	18.0
Sex		
Male	93.3	100.0
Female	6.7	0
household size		
0-3	9.3	14.0
4-7	88.0	84.0
8-11	2.7	2.0
Occupation		
Government	13.3	18.0
Private	5.3	6.0
Own business	5.3	12.0
Farmer	72.0	60.0
Other (daywage)	4.1	4.0
Education level		
Higher	4.0	12.0
Advanced	29.0	54.0
Secondary	54.7	34.0
Primary	12.3	0
Monthly income		
<Rs.10000	13.3	6.0
Rs.10000-20000	22.7	4.0
Rs.20000-30000	44.0	42.0
Rs.30000-40000	13.3	36.0
Rs.40000-50000	6.7	12.0

The analyzed data showed that most of the vegetable farmers were within the age category of 41- 60 years, include 54.7% of NON MIS adopters and 46% of MIS adopters. Also noted that, no any female famers were practicing MIS and for some

extent (6.7%) female farmers were engaged in agriculture with surface irrigation. In Nepal, the micro irrigation concept among poor women vegetable farmers is already established where, the main inducing factor for the new micro irrigation investment decision is not so much based on water scarcity but on generating significant household income (Shah and Keller, 2002, p. 165-183). Among the studied farmers, majority of the households were with the family size of 4-7. However, only one or two members are involved in farming activities in most families. Most of the farmers are doing Agriculture as full time occupation and 60% of the fulltime farmers are practicing MIS. In order to reduce the labour cost, increase the production and water use efficiency they installed MIS at their farm with the support of NGOs and Government.

Compared to NON MIS adopters, most of the MIS adopters were with higher educational background with advanced level (54%), considerable percentage of farmers completed higher studies (Table 1). However, most NON MIS farmers were with secondary education level (54.7%) while 29 percent of young NON MIS farmers also completed the advanced level. The educational background is playing major role in acceptance and implementation of new technologies for the production (Nagendran, Sugirtharan and Amuthenie, 2018, p 20-22)

As far as the monthly income level is concerned, it was higher among MIS adopting farmers than NON MIS adopters in the study area. The larger area under the MIS reduces the cost for labour, energy and increased yield that leads to higher income. The reduction of fertilizer requirement may also increase the income level through MIS which restrict nutrient leaching from the root zone. These results are in line with the results of Aheeyar, Manthrithilake and Pathmarajah., (2016, p 4-11) who reported that adoption of MIS has increased the net sown area and cropping intensity, resulting in significant economic returns and welfare gains at the Kalpitiya area and Polonnaruwa district.

ii. Type of water source for irrigation

Around 86% of the MIS adopters and 75% of the NON MIS adopters in the study area were using ground water from open wells and tube wells for irrigation. Tube wells are used by 57.1% of MIS adopters and 39.3% by NON MIS adopters. Most of the (76%) MIS adopters responded with sufficient water for irrigation while 62.7% of the NON MIS adopters reported about insufficient water for irrigation. Udagedara and Sugirtharan (2018, p.1-11) also reported that, water use efficiency is greater in MIS and wastage is high in surface irrigation methods in Polonnaruwa district, Sri Lanka. Therefore, it is possible to overcome the water scarcity problem to certain extent by adopting the MIS at the study area.

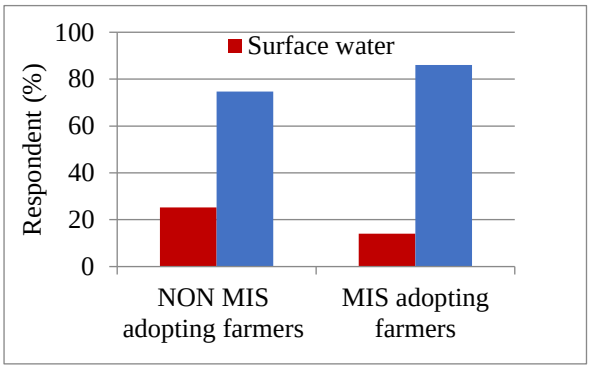


Figure 2: Type of water source used for irrigation

Study further revealed that, very few MIS adopters (14%) were using surface water from small ponds and tanks for irrigation purpose.

iii. Farmer's awareness on micro irrigation system

Most of the NON MIS adopters (53.3%) were not known about the MIS and 46.7% were known about the MIS. Of which, 80%, 5% and 15% of the NON MIS adopters are somewhat known, well known and very well known about MIS respectively. Lack of extension services, traditional attitudes and lack of enthusiasm were the main reasons for the lack of awareness. However, many young farmers are interested to update the modern irrigation technologies like sprinkler and drip irrigation systems at their farms.

iv. Sources of awareness on MIS

The study further revealed that, around 20% of the total people got to know about MIS through other people. Mostly, the MIS adopters were found in the young aged group. Hence, they were more enthusiastic and prefer to update with modern technologies. The leading farmers who were already practicing MIS in their field disseminate the information to others and promote the MIS system. About 18% of the respondents were aware about the MIS through private companies, 14% and 16% through internet and via agricultural officers respectively. In addition, about 12%, 8%,

6% and 6% of farmers gained information about MIS through television, school, radio, and newspapers respectively. The private companies also created awareness on the impacts of MIS, types of crop which can be cultivated under MIS and provide training opportunities in some places of the study area.

v. Factors influencing on the adoption of MIS in the study area

There are several factors influenced the farmers towards the adoption of MIS (Table 2). Based on the study, 65.3% of NON MIS adopting farmers stated more than one reason such as lack of capital, do not like to change the traditional method and water quality related problems for non adopting the MIS at their agricultural land. Apart from this, perception of farmers about MIS in a wrong way made them not to adopt MIS.

Table 2: Reason for non adoption of MIS

Factors	Percentage (%)
Lack of knowledge	4.0
Lack of capital	5.3
Water quality problems	8.0
Do not like to change from traditional method	12.0
Other	5.3
More than above one factors	65.3

As the study sites are located in the coastal region there is a possibility for the salt water intrusion when extracting the water from ground because most of the MIS users were dependent on the ground water for irrigation. Initial investment for establishing the MIS to field is also another constraint among the farmers. About 12% of the farmers don't like to change from traditional method of irrigation because they believed that they can't recover from any damages by adopting any new method of irrigation due to their poor economic status, which led to the non-adoption of MIS.

It is also observed that, among the farmers who adopted MIS, 100% of farmers were irrigating the crops only through sprinkler system. There were no any farmers found with the drip irrigation system. Lack of awareness on drip irrigation and the management problems with the clogging might also be the reason for not adopting drip in that area.

vi. Organizational support to establish MIS

About 58.7% of the total respondents mentioned that, they preferred to adopt MIS, if any organization supports to establish MIS at their farms.

Table 3: Organizational support to establish MIS

(Question: Will you adopt MIS, if any organization supports to establish MIS in you farm?)	**Percent (%)**
Yes	58.7
No	41.3
If no why?	
Lack of knowledge	54.8
Need to maintain continuously	16.1
Traditional thinking	19.4
Non reliability on Modern irrigation	9.7

Meanwhile 41.3% of farmers were not ready to change the irrigation type even they got support from any organization. Lack of knowledge (54.8%), requirement of continuous maintenance (16.1%), traditional way of thinking (19.4 %) and non reliability on modern irrigation were the reasons behind this (Table 3).

vii. Vegetable cultivation under MIS in Study area

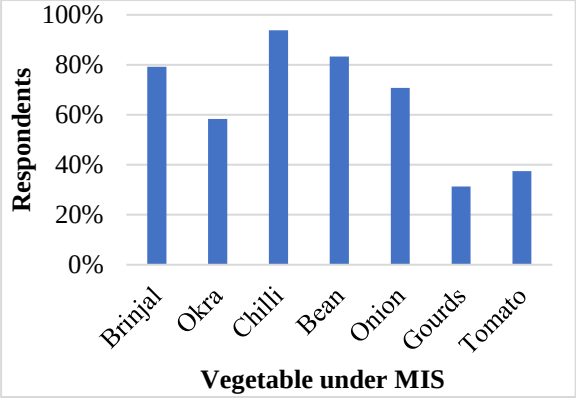


Figure 3: Vegetable cultivation under the micro irrigation system

Figure 3 depicted that, approximately 94% of MIS adopting farmers cultivated chilli under the MIS. Brinjal (79.2%), beans (83.3%), onion (70.8%), okra (58.3%), tomato (37.5%) and gourds (31.3%) were the other crops found with MIS. The majority of MIS farmers had not changed their traditional crops with the availability of MIS technology. Tomato crop is the less preferred crop in the study area under MIS as less market price and the management difficulties of that crop. The

total area of chilli cultivation was about 65 acres from which only about 27.65 acres were with MIS. About 17.5 acres of brinjal cultivated land was adopted with MIS in the study area. The MIS also installed to cultivate onion (16.5acres), bean (13.75 acres), okra (11.25acres), gourds (4.5 acres).

viii. Irrigation methods used before adopting MIS in the study area

Table 4: Previous irrigation methods

Method of irrigation	Percent (%)
Surface irrigation using Hosepipe	44.0
Surface irrigation using Bucket	8.0
Ridge and furrow	30.0
Basin type	6.0
Border irrigation	12.0

Table 4 shows that around 44% of the total respondents had used hose pipe as one of the irrigation tools before adopting MIS which was followed by ridge and furrow (30%), border irrigation (12%), using bucket (8%), and basin type (6%). High labour cost and insufficient water for irrigation and land preparation are the major factors influenced the farmers on the adoption of MIS from the above mentioned surface irrigation methods (Table 4) in the study area.

ix. Farmer's view on advantages and disadvantages of adopting MIS

Table 5: Advantages and Disadvantages of adopting MIS

	Percent (%)
Advantages of MIS	
High water use efficiency	16.0
Low labour cost	22.0
High profit	12.0
Easy to maintain	8.0
Ease of Fertilizer application	10.0
Uniform application, suitable for sandy soil	6.0
More than above one factor	26.0
Disadvantages of MIS	
High initial cost	26.0
Need technical skills	6.0
Difficult to repair	8.0
Traditional thinking not allowed	4.0
Poor service from company	6.0
Difficult in cultivation practices	10.0
More than above one factor	40.0

Most (40%) farmers came out with more than one disadvantage (Table 5). Higher initial cost of establishment was the major problem reported by farmers in relevant to MIS system. Some farmers (10%) stated that, having sprinklers inside the field is difficult to do some cultivation practices like weeding, hoeing etc. Most of the farmers change the main crop and substitute with other crops once after the harvest. Therefore, ploughing and other land preparation for next cropping becomes difficult when the sprinklers are installed at the field.

It was also observed that, main lines of the sprinklers are installed within the soil in some fields. In such conditions farmers mentioned that, it is very difficult for them to find the location of the problem/leakages happened in the water delivery system.

x. General opinion of MIS adopting farmers

General opinion of the MIS adopting farmers in the study area is given in Table 6 with its valid percentages.

1- Definitely true
2- True most of time
3- Neutral
4- Somewhat false
5- definitely false

Table 6: General opinion of MIS adopting farmers

Information	**Percent (%)**				
	1	**2**	**3**	**4**	**5**
S_1. Yield increased	54	46	0	0	0
S_2. Crop quality increased	50	34	16	0	0
S_3. Less water needed	56	20	18	6	0
S_4. Less electricity consumption	64	20	16	0	0
S_5. Fertigation possible so low cost for fertilizer application	50	26	24	0	0
S_6. Fertilizer wastage less	36	22	18	16	8
S_7 Irrigation easy	84	16	0	0	0
S_8. Time saving	70	20	10	0	0

S_1: Most of the respondents (54%) have got increased yield due to the timely application of required amount of water and fertilizer. Therefore, crops gained water in all growth stages

which led to less wilting and shows optimum growth performance.

S_2: About half of the studied farmers mentioned as definitely true about the increased crop quality with high water use efficiency than surface methods.

S_3: Nearly 56% of farmers mentioned that it is definitely true because it is apparent that the MIS avoid unnecessary loss of water compared with surface irrigation methods.

S_4: Most of the farmers (64%) were reported definitely true on less electricity for pumping than surface method of irrigation

S_5: Around 76% were mentioned about the easiness of fertilizer application to the crop because they are applying fertilizer with the irrigation water through sprinkler irrigation system. During the field visit, it is also noticed that most of the farmers used fertigation techniques to apply fertilizer for their field this leads to lower the cost for fertilizer application

S_6: 58% of the farmers stated that fertilizer wastage is less in MIS. Actually, many farmers were not satisfied on the amount of fertilizer applied through MIS because, they used to apply fertilizer directly to the root zone in the surface irrigation methods. Education and awareness training for farmers on this issue will rectify this problem.

S_7: About 84% of farmers were definitely true on the statement of easy irrigation. It is obvious that time and human power is saved by water application through MIS.

S_8: About 70% of the farmers were mentioned that definitely true on time saving. Most of the farmers saved valuable time by adopting MIS and utilizing that time for other farming practices. This may also help them to reduce the cost of production.

xi. Yield variation according to irrigation system

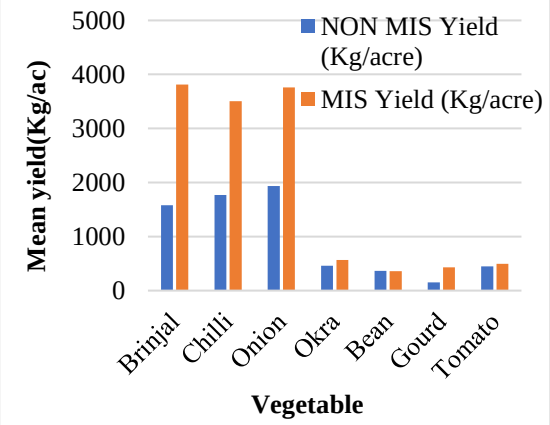


Figure 4: Yield variation according to irrigation system

According to the Figure 4, mean yields of most of the vegetables under MIS are higher than NON MIS. Increase in yield subjects to MIS adoption varies with types of crop. Rabbinge (2000, p22-206) also reported that the use of MIS increased the crop yield by 20-90%. Higher yield was also reported by the MIS adopted vegetable farmers at Polonaruwa district, Sri Lanka (Udagedara and Sugirtharan, 2018, p 1-11). Several factors such as fertilizer, pest attack, water stress, soil type, etc. may also contribute for this variation in the yield. This result gives an idea of which crop is suitable under MIS in the study area. Especially in MIS system, most of the time, root zone remains wet due to the slow rate of water application; adequate water supply to crops leads to reduced water stress thus increased the yield. Therefore, when proper measures are taken to improve the farmers' adoption on MIS more yield and income would be generated.

IV. CONCLUSION

Adoption of MIS in the study area is low due to lack of capital, high initial cost for the system and lack of spare parts availability in market. Further, education, age, gender, economic status, lack of knowledge, occupation and water resources are the determining factors for the adoption of micro irrigation system. Though, MIS is practiced in study area, the extent to which is shifted to MIS is very much less. But the yield gained is greater from MIS adopted farms than NON MIS farms. Motivation through raising awareness about advantages and effectiveness of MIS, valuable instruction and training on MIS, regular extension services and technical support can increase the extent of MIS in the study area. And this adoption of MIS will help to save water and increase cultivable area to produce more food and contribute to supply the food requirement of the Batticaloa district.

REFERENCES

Aheeyar, M. M. M., Manthrithilake, H. and Pathmarajah, S., 2016. Drivers of the adoption of farmer innovated sprinkler irrigation systems: Evidence from Kalpitiya, Sri Lanka, International perspective on water resource and the Environment, Colombo, Sri Lanka, January 4-6, pp 4-11.

Amarasinghe, U. A., Mutuwatta, L. and Sakthivadivel, R., 1999. Water Scarcity Variations within a Country: A Case Study of SriLanka. Research Report No. 32, International Water Management Institute, Colombo.

District Secretariat, 2016. Land use plan, Batticaloa district. p 1-92.

Nagendran V., Sugirtharan M., Amuthenie S., 2018. Determining factors for the adoption of sprinkler irrigation system in Navithanveli Divisional Secretariat areas of Ampara district, Sri Lanka. *Res. J. Agriculture & Forestry Sci.,* 6(4), p18-22.

Rabbinge, R. 2000. Pillar of Sand. Can the Irrigation Miracle Last?: S. Postel; WW Norton & Company, New York, and World Watch Institute, 1999, ISBN 0-393-31937-7, Agricultural Systems, Volume 66, Issue 3,p 205-206.

Shah, T., 2009. Climate change and groundwater: India's opportunities for mitigation and adaptation, *Environment Research Letter*, 4, p1-13.

Shah, T. and Keller, J., 2002. Micro irrigation and the poor: A marketing challenge in smallholder irrigation development. In Sally H. and Abernethy, C.L. (eds.) Private Irrigation in Sub-Saharan Africa: Regional Seminar on Private Sector Participation and Irrigation Expansion in Sub-Saharan Africa, Acra. Ghana, 22-26 October 2001. Colombo: IWMI;FAO; ACP-EU Technical Centre for Agricultural and Rural Cooperation, p. 165-183.

Sivanappan, R.K., 1994. Prospects of micro-irrigation in India, *Irrigation and Drainage Systems*, V.8 (1), p.49-58.

Udagedara, M. D. and Sugirtharan, M., 2018. Status of micro irrigation systems adopted for vegetable cultivation in Polonnaruwa district, Sri Lanka. *AGRIEAST* – 11 (2), Journal of the Faculty of Agriculture, Eastern University, Sri Lanka. p.27-32 DOI: http://doi.org/10.4038/agrieast.v11i2.34.

Viswanathan P.K. and Pathak, J., 2014. 'Economic Growth and the state of natural resources and environment in Gujarat: A Critical Assessment', in: Indira Hirway Indira, Amita Shah and Ghanshyam Shah (eds.), Growth or Development: Which Way Is Gujarat Going?, Oxford University Press, New Delhi, pp. 380-43

TRACK - CROP SCIENCE AND TECHNOLOGY

Electrophysiological and Behavioural Responses of Coconut Black Beetle (*Oryctes rhinoceros* L.) (Coleoptera: Scarabaeidae) to Selected Plant Volatiles

T.B.K.H. Neranjana[1], A.D.N.T. Kumara[2*], H.T.R. Wijesekara[3] & B. Ranaweera[4]

[1,3]*Crop Protection Division, Coconut Research Institute, Lunuwila, Sri Lanka*
[2]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*
[4]*Department of Horticulture and Landscape Gardening, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Sri Lanka*

[1]khneranjana@gmail.com, [2*]adntkumara@seu.ac.lk, [3]thusithwijesekara@yahoo.co.in, [4]branaweera@gmail.com

Abstract- *Rhinoceros beetle (RB) (Oryctes rhinoceros L.) is one of the devastating pests of coconut and other palm species. The main strategy for the management of RB is the use of highly toxic synthetic pesticides. However, banning of toxic pesticides in Sri Lanka urges finding alternative repellant materials. The use of semiochemicals especially behaviour-modifying plant volatiles is a recent trend in agriculture pest management. Therefore, this study was conducted to identify the repellent plant volatiles to formulate a semiochemical-based pest management strategy. Electroantennographic (EAG) technique employed to explore the antennal response of male and female RB to 12 plant volatiles using a commercially available EAG system. Results revealed that mean antennal responses were significantly higher ($p<0.05$) on both males and females to plant volatiles than control. The largest response evoked by aggregation pheromones (Male 0.7698 ± 0.130 mV, Female 0.9504 ± 0.232 mV) then evoked the higher responses by the male to Ethyl butyrate, Limonene (+), 1-Octane-3-ol, α-pinene, and Propyl butyrate. Whereas female evoked higher responses to 1-Octane-3-ol, Limonene (+), Citronella, and 3-Hexene-1-ol. The dose-response study indicated the male responses had decreasing trend with increasing doses from 1% to 10%, while the female was erratic. Moreover, dual choice olfactometer studies revealed that males and females were attracted to RB aggregation pheromone, Limonene (+), Ethyl propionate, and β-Myrcene where they were repelled by Citronellol, 2-hexane-ol, 1-Octane-3-ol, and α-Pinene. Therefore, Citronellol, 2-hexane-1-ol, α-Pinene and 1-Octane-3-ol, can be used as a potential plant volatile to formulate the repelling compounds to manage the O. rhinoceros.*

Keywords: Volatiles, EAG, Repellent, Rhinoceros beetle

I. INTRODUCTION

The Coconut rhinoceros beetle (RB), commonly known as Black beetle, *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae) is one of the devastating pests of coconut palms, prevalent in all coconut growing areas in Sri Lanka. There were several species of rhinoceros beetles of the family Scarabaeidae that are distributed throughout the world, such as *Oryctes boas*, *Oryctes Monoceros*, *Oryctes elegans*, *Scapanes australis* and *Strategus aloeus* (Singh and Rethinam, 2005). The metamorphosis of *O. rhinoceros* is complete with four stages; egg, larvae, pupa, and adult. The total cycle from egg to emergence of the adult from the pupal cocoon lasts 4 - 9 months, the mean period being about 6 months (Lever, 1969). In Sri Lanka the average period from egg to adult is thus 154 days (range 128 to 178 days). The adult life is on average 89 days (range of total life span 193 to 292 days) (Goonewardena, 1958). Although *O. rhinoceros* is found in several regions of the world, its shape, size, and colour are generally consistent (Manjeri et al., 2013). Both males and females possess a similarly sized horn used for leverage when moving within tightly-packed leaves or the cavities, they create in the crown of palms, the horn length is longer on average for males (Doane 1913). The antennae of the rhinoceros beetle, *O. rhinoceros* (Coleoptera: Dynastidae), comprise 4 parts: the scape, the pedicel, a funicle, and a club of 3 lamellate segments (Renou et al., 1988).

Oryctes rhinoceros mainly damages the young palms and seedlings and occasional death of seedlings occurs. The damage is caused by the adult beetle which bores and enters into the soft bud region, continues feeding on the soft tissues, resulting in damage to the unopened leaves and their petioles (Bedford, 2014). When the leaves grow out, the damage appears as V-shaped

geometric cuts or holes through the base of the fronds. If the damage to the petiole is extensive, breaking of the flag leaf could occur. The damage often causes choking of the developing leaves in seedlings, resulting in the formation of crooked and malformed leaves while the damage to the growing point leads to the death of seedlings (Dornberg, 2015). It may also provide an entry point for lethal secondary attacks by the red palm weevils or by pathogens. When the attack is on the unopened spathe, the inflorescence gets destroyed (Kumara, 2015).

The palms with 50 % frond damage corresponded to a reduction of 13 % leaf area caused a 23 % reduction in nut yield (Singh and Rethinam, 2005) as compared with undamaged palms. A recent survey conducted by the Coconut Research Institute revealed that the damage caused by black beetle is the most widespread pest damage in coconut. The survey further indicated that 72 % of growers claimed that the black beetle damage had existed in their lands, but only 52 % were aware that it is a serious problem in coconut cultivation (Peiris, *et al.*, 2006). For management of the *O. rhinoceros*, can be directed at either the larval or adult stage of the life cycle. Several control methods can be practiced such as cultural, chemical and biological but the integration of all these methods is the most effective way of managing the pest. Hence, it is urged to identify the new effective and environment-friendly compounds for repelling the beetle from the plantation. Mainly on the development of semiochemical based product used this pest management method. Semiochemicals are mainly emitted by plants or by an insect for inter and intraspecies communications. These are volatile compounds and are conspecific and behavioural modifying chemicals.

Mainly Electroantennogramme (EAG) technique and behavioural studies can be effectively used for identification of semiochemical responses. The responsive compounds act as attractants and some act as a repellent (Schneider, 1957; Schneider *et al*., 1967). Therefore, the objective of this study is identification of effective repellent plant volatiles through EAG and behavioural studies and thereby can be used effective environmentally friendly semiochemicals formulation as a green pest management product to management of *O. rhinoceros.*

II. MATERIALS AND METHODS

The following plant volatiles were used to investigate the EAG and Behavioural studies *i.e*. Limonene (+), α-pinene, Ethyl propionate, Nonanoic acid, 4-Phenyl-2-butanone, Propyl butyrate, 2-Hexene-1-ol, Citronella, 1-Octane-3-ol, β-Myrcene, 3-Hexene-1-ol, and Ethyl butyrate. While Black beetle pheromone lure (Recommended and commercially available), Hexane (Solvent) were used to compare the volatiles as controls.

A. Insect culture/ insect rearing

The late instar larvae of *O. rhinoceros* were collected from the field and reared in the insect rearing glass boxes by providing decaying organic manure especially coconut log pieces and coir dust. Subsequently, after the emergence of adults both male and female were separated and maintained separately for Electroantennogramme and behavioural studies.

B. Electroantennogramme (EAG) Studies

Electroantennogramme studies were conducted to determine the electrophysiological responses of both male and female antenna to selected plant volatiles. EAG studies were conducted using a commercially available SYNTEC EAG system at the electrophysiological study laboratory of the Coconut Research Institute, Lunuwila. Five microliters of each selected volatile solution were used for EAG and 1% solution of *O. rhinoceros* aggregation pheromone, fresh air and hexane were used as positive and negative control treatment respectively. The selected plant volatiles were diluted in Hexane to form a 1% solution. A filter paper (3 cm x 0.5 cm) was inserted into the Pasteur pipette. Then it was treated with 05 µl of the test solution which was either a volatile organic compound or a pheromone, and allow some time to evaporate the volatile. The beetle antenna was removed and the antenna was placed in between the two terminals of the forked type electrode which were fixed with electrically conductive gel (salt-free electrode gel) and adjustments were made under the medium power of a stereo microscope for further stabilization of the antenna (Kumara, 2015). The treated Pasteur pipette was inserted through the air-carrying duct in a way that the airflow could carry the volatile compound or the pheromone through the passage towards the antenna. An electric impulse was given just when the airflow was released towards the antenna. The electroantennogram for their relevant volatile cue or the pheromone was recorded by using Auto

spike software. Each volatile was replicated five times and the triggered voltage values were analyzed using One Way ANOVA followed by Tukey post hoc test.

C. Behavioural Studies for selected plant volatiles

A dual choice olfactometer study was conducted to determine the behaviour of the beetle against selected electrophysiologically active plant volatiles. The study was conducted at the behaviour testing laboratory in the Coconut Research Institute, Lunuwila using a dual choice behavioural testing olfactometer system developed by Kumara (2015).

The experiment was conducted for both males and females separately and a mixture of beetles. Five male beetles and five female beetles were transferred to the center of the apparatus from the rearing box. Freshly cut coconut frond pieces were placed equally at both the arms of the apparatus. Fifty microliters of 1 % volatile solutions were used for the behavioural studies. The coconut frond pieces, placed at the one arm was treated with the hexane which was considered to be the control, and the coconut frond pieces, placed at the other arm was treated with the test sample which was a volatile organic compound. The setup was kept overnight and observation of searching behaviours was recorded at 4 hrs. intervals. The number of beetles that could be recovered from each end and the center were recorded in the morning. Each test was replicated with 30 individuals and the number of responded beetles for the choices were compared using the chi-square test assuming equal probabilities for both ends.

D. Dose-response EAG for selected repellent plant volatiles

EAG studies were conducted to determine the effective dose of selected electrophysiologically active volatile compounds. Series of dilution were prepared *i.e*. 1 %, 5 %, 10 %, 15 %, 20 %, and 25% and EAG studies were conducted for both male and female beetles. A dose-response curve was prepared and the effective dose of maximum responses was determined.

III. RESULTS AND DISCUSSION

A. Electrophysiological responses of O.rhinoceros against selected plant volatiles

The depolarization response results showed that there were significant antennal responses against selected volatiles on both male and female beetles ($p < 0.05$) (Table 1) compared to the control (Air and Solvent). Both male and Female *O. rhinoceros* (Male, 0.7698 ± 0.130 mV, Female, 0.1982 ± 0.015 mV) gave the highest response for aggregation pheromone from the tested volatiles. The aggregation pheromone being more effective with obvious results to attract both male and female beetles in the fields and it is already recommended for commercial use in most coconut growing countries including Sri Lanka for trapping the *O. rhinoceros*. However, the highest response of aggregation pheromone was not significantly different with certain plant volatiles giving the highest responses. The response of female beetle antenna for aggregation pheromone followed by the plant volatiles *viz*. 1-Octane 3-ol, Limonene (+), Citranellol, 3- hexene – 1-ol, Propyl butyrate, α- pinene, and β- Myrcene respectively (Table 1). Whereas the male antennal responses were higher in aggregation pheromone followed by plant volatiles were Ethyl butyrate, α-pinene, Limonene (+), 1- Octane 3-ol, and Propyl butyrate respectively (Table 1). Considering the male and female responses against the number of volatiles, the male has a broader range of volatiles than the female. However, these results indicating that both male and female responses were common to certain plant volatiles *viz* Limonene (+), Propyl butyrate, and 1-Octan-3-ol.right-justified.

Table 1: EAG Responses of *O. rhinoceros* against plant volatiles

	Female	**Male**
Volatile	**Mean (mV) ± SE**	**Mean (mV) ± SE**
Air	0.1792 ± 0.014	0.1162 ± 0.030
Limonen (+)	0.7974 ± 0.184	0.6868 ± 0.137
α- Pinene	0.3696 ±0.024	0.7342 ± 0.153
B-Myrcene	0.5346 ± 0.186	0.5776 ± 0.103
Ethyl propionate	0.3572 ± 0.033	0.4580 ± 0.064
Nonanoic acid	0.4850 ± 0.192	0.4460 ± 0.072
4-Phenyl-2-butanone	0.4400 ± 0.174	0.4390 ± 0.170
Propyl butyrate	0.5012 ± 0.194	0.6874 ± 0.406
Ethyl butyrate	0.4958 ± 0.186	0.7358 ± 0.148
2-Hexene-1-ol	0.3060 ± 0.043	0.3264 ± 0.007
Citronella	0.6858 ± 0.204	0.4460 ± 0.051
1-Octain-3-ol	0.9260 ± 0.240	0.6842 ± 0.158
3-Hexene-1-ol	0.7286 ± 0.269	0.7116 ± 0.143
B/B Pheromone	0.9504 ± 0.232	0.7698 ± 0.130
Hexane	0.1982 ± 0.015	0.5466 ± 0.036

F value(df)	1.875 (12, 58)	1.693 (12, 58)
P value	0.020	0.044

Mean antennal response (mV) of males and females of RB for plant volatiles, SE indicate the standard error of the mean

B. Dose-response EAG studies of O. rhinoceros against selected plant volatiles.

Dose-response EAG results revealed that there was a decreasing trend across the increasing doses of selected volatiles for male. The maximum response was recorded for the 1 % volatile dose (Fig. 1) among the tested doses. However, the declining trend was seen up to 15 % dosage and again it increased with the 20% dosage. The results further indicated that the male beetles were highly sensitive to the above responsive volatiles and to take optimum dosage further studies are needed with doses below 1%. The females dose-response EAG indicating that increasing trend towards the increasing dose of volatiles up to 15 % and then it was seen in decreasing trends (Fig 2). To obtain optimum doses for responsive volatiles further studies are needed with a broad range of doses with all responsive chemicals.

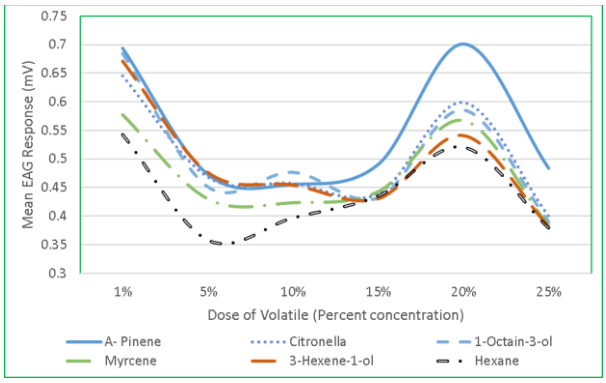


Figure 1: Antennal response of male *O. rhinoceros* for selected volatiles with different doses

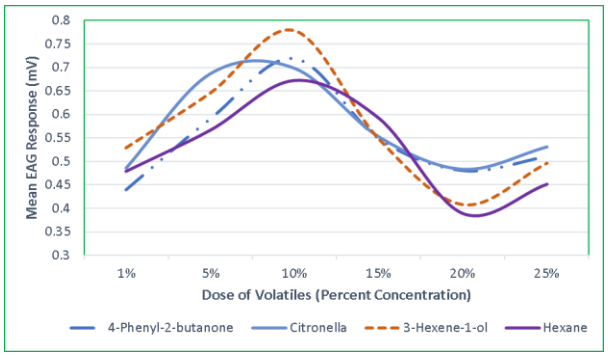


Figure 2: Antennal response of female *O. rhinoceros* for selected volatiles with different doses.

C. Behavioural Studies

Dual choice olfactometer studies were conducted to determine the behavioural response against the selected plant volatiles. Both male and female beetles responses were indicated two types of behaviours. Either the beetles were attracted towards the volatiles treated arm (Positive) called attraction behaviour of beetles were attracted towards the control arm (Negative) that indicating they were repelled from the volatile compounds. Male beetles showed the sensitive behaviour for selected all volatiles and maximum attraction behaviour reported towards the *O. rhinoceros* aggregation pheromone and followed by Limonene (+), Ethyl propionate, Myrcene, Propyl butyrate, and Ethyl butyrate. Whereas Citronellol, 2-Hexene-1-ol, 1-Octan-3-ol, and α – Pinene were repelled the male beetles (Fig. 3). Female beetles were more attracted towards the *O. rhinoceros* aggregation pheromone followed by β-Myrcene, Limonene (+) and Ethyl butyrate attracted the beetles. Whereas Citronellol, α-Pinene, 4-Phenyl-2-butanone and 2-hexane-ol were repelled the female beetles (Fig. 4).

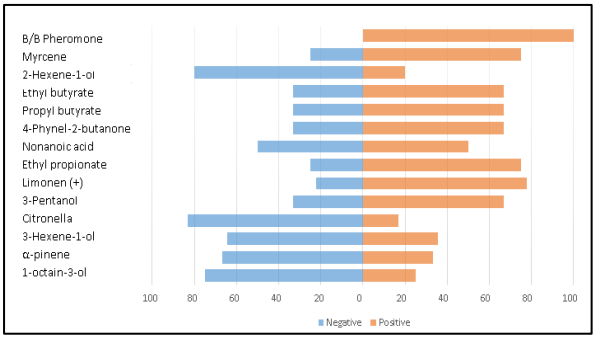


Figure 3: The behavioural response of male RB to the Plant volatiles. The bars indicate the percentage of beetle responses towards the tested volatiles, the negative indicates the beetle repel from the test volatile while positive indicates the attraction of beetles towards the volatile treated side of the Olfactometer.

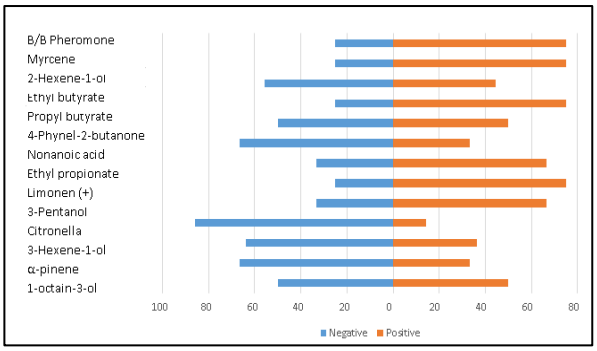


Figure 4: The Behavioural response of female RB to the Plant volatiles. The bars indicate the percentage of beetle responses towards the tested volatiles, the negative indicates the beetle repel from the test volatile while positive indicates the attraction of beetles towards the volatile treated arm of the Olfactometer.

For the management of the *O. rhinoceros* it is important to identify the repellence action of plant volatiles to formulate a semiochemical due to the availability of aggregation pheromone to attract and trap. Application of burnt engine oil to the leaf base, application of carbofuran granules to the leaf axis and application of naphthalene balls to the leaf axis are some recommended repellents used in the field for management of *O. rhinoceros*. However, banning toxic chemical pesticides, due to side effects of other recommended products, urged for finding out of alternative repellents. In this, study it was identified the repellent plant volatiles those were effective for both male and female such as Citranellol, 1-Octane-3-ol, α-Pinene, 4-Phenyl-2-butanone and 2-hexane-ol, which can be suggested as a potential plant volatile for the formulation of the repellence for management of *O. rhinoceros*. The dose-response studies revealed that there were no significant differences among the tested doses hence, further beetle can be responses of very low doses and it can be suggested to test low doses. Based on the tested doses, dose of 1% to 10 % can be suggested for formulating the green pesticides, as they will be environmentally and economically feasible for large-scale usage.

IV. CONCLUSION

Both male and female *O. rhinoceros* evoked the highest antennal response to their aggregation pheromone followed by electrophysiologically active plant volatiles *viz* 3-Hexen-1-ol, Limonene (+) and 1-Octan-3-ol. Whereas both male and female showed repellent behaviours against Citronella, α-pinene and 3-Hexene-1-ol plant volatiles. Based on the results of EAG, Olfactometer and dose-response studies, the repellent volatiles such as, Citronellol, 1-Octane-3-ol, 3-Hexen -1-ol and α-Pinene with the effective doses of 1% to 10 % concentrations can be used to formulate the repellent compounds as a green pest management strategies for the management of *O. rhinoceros* in coconut cultivation.

REFERENCES

Bedford, G.O. (2014). Advances in the control of rhinoceros beetle, *Oryctes rhinoceros* in oil palm, *Journal of Oil Palm Research*, vol. 26(3), pp. 183-194."

Doane, R.W. (1913). How *Oryctes rhinoceros,* a dynastid beetle, uses its horn. *Science, New Series* ,vol. 38.990, pp. 883.

Dornberg, M. (2015). Introduction-Distribution-Description-Biology-Host Plants-Economic Importance-Management and Control-Selected References, Division of Plant Industry, *Florida Department of Agriculture and Consumer Services*. EENY-629.

Goonewardena, H. F. (1958). The rhinoceros beetle (*Oryctes rhinoceros* L.) in Ceylon part I. Introduction, distribution and life history, *Trop. Agric. Ceylon* 114: pp. 39-60.

Kumara, A. D. N. T., Chandrashekharaiah, M., Kandakoor S. B., Chakravarthy, A. K. (2015). Status and Management of Three Major Insect Pests of Coconut in the Tropics and Subtropics, A. K. Chakravarthy (ed.), New Horizons in Insect Science: Towards Sustainable Pest Management, © *Springer*, pp 359-381.DOI 10.1007/978-81-322-2089-3_32

Kumara, A.D.N.T. (2015). Electrophysiological and Behavioural responses of Coconut black headed caterpillar *Opisina arenosella* Walker (Lepidoptera: Oecophoridae) to Plant semiochemicals, *Ph.D. Thesis*, University of Agricultural Sciences, Bangalore, pp 20-30.

Lever, R.J.A.W. (1969). Pests of coconut palm, *Food and Agriculture Organization of the United Nations*, Rome, ISBN 92-5-100857-4, pp. 125 – 133.

Manjeri, G., Muhamad R, Faridah, Q.Z., Tan, S.G. (2013). Morphometric analysis of Oryctes rhinoceros (L.) (Coleoptera: Scarabaeidae) from oil palm plantations, *The Coleopterists Bulletin* 67: pp. 194-200.

Peiris, T.S.G., Appuhamy, P.A.H.N., Nainanayake, N.P.A.D., Bandaranayake, C.K., Fernando, M.T.N. (2006). Coconut Research, Development and Dissemination of Technologies-Growers Perception, A Diagnostic Survey Report, *Coconut Research Institute, Lunuwila, Sri Lanka*. pp. 57 – 62.

Renou, M., Tauban, D., Morin, J.P. (1998). Structure and function of antennal pore plate sensilla of *Oryctes rhinoceros* (L.) (Coleoptera: Dynastidae), *International Journal of Insect Morphology and Embryology*, Volume 27, Issue 3, pp. 227-233.

Schneider, D. (1957). Elektrophysiologische Untersuchungen von Chemound Mechanoreceptoren de Antenne des Seidenspinners *Bombyx mori* L. Z. Vergl, *Physiol*, 40. pp. 8-41.

Schneider, D., Block, B.C., Boeckh, J., Priesner, E. (1967). The reaction of the male silk moth to Bombykol and its isomers: electro-antenna diagram and behavior, *Journal of Comparative Physiology, Olfaction and Taste: Proceedings of the Third International*. volume 54, pp 192 - 209.

Singh, S.P. and Rethinam, P. (2005). Rhinoceros beetles, *Asian Pacific Coconut Community. Jakarta, Indonesia*, pp. 21 – 22.

Laboratory Evaluation of Host Plant Resistance on Sri Lankan Maize Landraces to Fall Armyworm (*Spodoptera frugiperda* Smith) (Lepidoptera: Noctuidae)

M.G.C.D. Silwa[1], A.D.N.T. Kumara[2*], G.K.M.M. Ranaweera[3], K.D.S. Kaushalya[4] & A.N.M. Mubarak[5]

[1,2,3,4,5]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1]chathurikadilhani384@gmail.com,[2*]adntkumara@seu.ac.lk, [3]madhusankaranaweera111@gmail.com, [4]dilsarasavi36@gmail.com, [5]anmubarak@seu.ac.lk

Abstract- *Recently invaded fall armyworm in Sri Lanka has been regarded as a major maize pest and became a crucial pest with substantial yield losses. Management of the pest via sustainable environmentally friendly measures is essential and encourages rather than the usage of synthetic chemicals. The latent resistivity of traditional maize landraces, which are favoured by the Sri Lankan farmers has not yet been investigated. Thus, a laboratory experiment was designed to investigate the leaf-feeding and oviposition resistance of FAW in Sri Lankan maize landraces. Eight local (OP) maize landraces (SEU02, SEU06, SEU09, SEU14, SEU15, SEU16, and SEU17) with comercial varieties (Bhadra and GT722) were used. The feeding and oviposition preference assays were conducted and revealed that none of the accession showed complete resistance to FAW feeding, but detected differences in acceptance and preference with varying degrees. Nevertheless, a significant difference was observed in morphological traits viz. leaf trichomes density and leaf thickness. The Oviposition preference bioassay found that Bhadra ($\chi 2=5.4$, df =1, p=0.02,12/3) reported highly preferred by females as oviposition with the high mean number of eggs (638.40 ± 4.20), while SEU02, SUE06, SEU09, SEU10 and SEU17 ($\chi 2=5.4$, df=1, p=0.02, 3/12) reported with low preference. Our study provides insight into the density of trichomes on leaves does not seem to be linked to larvae feeding preferences at later stages of the larval phase.*

Keywords: Fall armyworm, landraces, oviposition preference, resistance

I. INTRODUCTION

Maize (*Zea mays* L.) is a cereal plant that belongs to the Poaceae family and second most important crop in Sri Lanka (Anon,2012) due to its importance as a food and feeds ingredient. As a feed, it is primarily used in the livestock industry, accounting for roughly a quarter of all poultry produced in the nation (Anon,1998). Fall armyworm (FAW) *Spodoptera frugiperda* Smith (Lepidoptera, Noctuidae) invasion has become the biggest threat to maize production and its rapid spread to almost all countries in the region and associated crop damage. Almost 50 per cent of maize cultivations were infested by FAW during the 2018/19 Maha season in Sri Lanka (Wijerathna *et al*.,2020). Buadron *et al*., (2019) reported that when there is 26.4 per cent to 55.9 per cent of pest incidence in maize then there is yield reduction under FAW damage.

The fall armyworm, *S. frugiperda* was first discovered in Sri Lanka in October 2018 as an invasive pest. FAW is a highly polyphagous insect pest that feeds on a variety of plants, including maize, sorghum, millet, sugarcane, and vegetable crops (Sisay *et al*.,2019). In addition, a higher reproductive rate and multiple generations of the pest would reason for significant crop damage in a single year. This large maize pest is difficult to control and can damage crops severely (Oliveria *et al*., 2018).

In Sri Lanka, FAW has been regulated through a variety of methods, including cultural practices, biological control, chemical control, and botanical pest control. The chemical insecticides have been become dominant mostly adopted by the farmers, which harm the environment, human health and can encourage the development of resistant populations (Paiva *et al*.,2016). Thus, management of the pest via sustainable environmentally friendly measures are essential and encourage.

Host plant resistance is a crucial part of integrated pest control (Mihm,1997). Landraces naturally possess morphological and genetic traits which are

resistant to certain pests. The host plant resistance (HPR) has been investigated as a potential strategy for controlling FAW in maize crops in recent years (Paiva *et al*., 2016). It is primarily due to the host plant's antibiosis and antixenosis characteristics, which alter the insects' feeding and behaviour. Finding FAW-resistance maize landraces may be a key component of developing long-term strategies to combat this voracious insect and reduce yield losses in low-input agriculture in developing countries (Mihm *et al*,1988). Since the 1950s, extensive screening for FAW-resistant maize germplasm has been carried out in the Americas (Wiseman *et al*.,1979). However, the most common maize landraces, which are grown by smallholder farmers in Sri Lanka, have not been tested for resistance to FAW yet. Smallholder farmers have grown these open-pollinated varieties (OPVs) for generations because they are drought and pest resistant, have low seed costs and produce fair yields under marginal environmental conditions without the use of fertilizers or pesticides (Odendo *et al*., 2001).

However, the latent capacity for resistance of traditional maize landraces, which are favoured by Sri Lankan farmers, has not yet been investigated. Thus, an experiment was designed to evaluate the leaf-feeding and oviposition preference of FAW against Sri Lankan maize landraces in the laboratory. It was hypothesized that FAW larval arrestment (*i.e*., behaviour that restricts the insect's movement to a limited area), feeding, development, and plant damage differ depending on maize landraces and that these variables could be used as a proxy for FAW resistance.

II. METHODOLOGY

A. Study Area

The experiments were conducted in the Crop science laboratory, Faculty of Technology, South Eastern University of Sri Lanka (7˚18ʹ00.3" N and 81º 51ʹ41.8" E), located in Ampara district which belongs to the low country dry zone (WL2b) during December 2020 to April 2021.

B. Planting materials

A total of eight local maize landraces viz. SEU02, SEU06, SEU09, SEU10, SEU14, SEU15, SEU16, SEU17 which were collected major maize growing areas in Ampara, Moneragala, and Badulla districts were used for the study (Mufeeth *et al*., 2020). Seeds of selected landraces with commercial varieties, GT 722 and Bhadra were sawn in polythene pots (8L) and small disposal cups (150 ml). The media consisted of sand: topsoil: compost 1:1:1 ratio. Crops were managed without applying any synthetic chemicals and plants were at V3-V4 stages were used for the bioassay.

C. FAW Culture

The rearing of FAW was conducted at particular conditions as temperature (27 ± 2 ºC), 70-75 % RH, and a photoperiod of 14:10 (L: D) (Murua *et al*.,2008). The Egg masses were collected from infected maize plants at Agro Tech Park, Malwatta, and kept inside plastic bottles (2.5 L) with proper ventilation. To keep fresh, a wet tissue paper was kept inside the plastic bottle before introduction eggs. The 3rd instar larvae were transferred to individual cups (150 ml) and maintained separately to avoid cannibalism. Leaf was renewed daily and the amount of leaf provided was altered during the development of the caterpillars, to avoid any insufficiency of foods and a clean culture environment to avoid contaminations. After 50% of the pupation, they were sex separated (Sharanabasappa *et al*., 2018) and adults were kept in plastic bottles (2.5L) by feeding 10% sucrose solution, and muslin cloths were provided as the oviposition substrate.

D. Leaf morphological traits

The experiment was laid out on a completely randomized design (CRD) with 3 replications and plant morphological characteristics of selected ten accessions were recorded at the V7 stage. Leaf thickness (LT) was measured from the 15 leaves using the vainer calliper average was calculated. Similarly, Leaf trichomes density (LTD) was measured using size (1 cm x 1 cm) leaf samples from each accession were counted under a stereo zoom microscope. measurements were replicated five times.

E. Larval feeding bioassay

The study was designed to evaluate the feeding preference of the FAW larvae under laboratory conditions. The third instar larvae were introduced individually into the small plastic bottles. Each larva was provided with an adequate amount of leaf dishes (2 cm x 2 cm) from the V3 stage of selected eight landraces separately. Leaf dishes were renewed daily and to keep the freshness, wetted tissue papers were laid on the bottom of plastic bottles. The experiment was replicated six times and the following data were recorded. Leaf area consumption (LAC) was evaluated daily

throughout the larval phase, determination of LAC was determined as the difference between leaf area offered and leaf area consumption after 24 hours. The larval weight (LW) (g) at 3-day intervals and pupal weight (PW) (g) were measured using an electric balance. Moreover, larval duration (LD) and pupal duration (PD) (days) were recorded. The dry weight of faeces (DWF) was measured in weekly intervals.

F. Four choice oviposition preference study

Oviposition preference for the gravid females to oviposition was assessed using four-choice oviposition chambers prepared by OHP transparent sheets (Fig 01). The rectangular shape boxes and cylinders were connected to each side. Four plants (V3-V5) from each landrace were kept on each side and ten gravid females were released into the middle of the oviposition chamber. Plants were replaced 24 hours after the moths introduction and the number of eggs/egg masses was counted using a Seteriozoom microscope. The end of each bioassay oviposition chamber was turned 180° from the position to prevent the effect of position. The study was replicated fifteen times for each landrace.

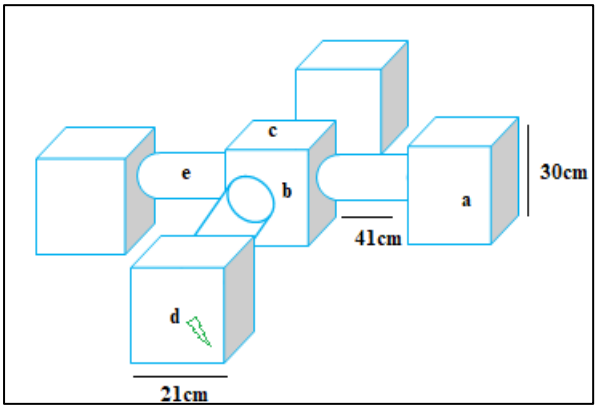


Figure 1: Four choice oviposition chamber

a. Rectangular shape box, b. Middlebox ,c. The honey solution,b. Maize plants, and e. Cylinder

G. Statistical analysis

Data were subjected to analysis of variance (ANOVA) procedure and the means were separated by Tukey post hoc test at p-value equal to 0.05, using IBM SPSS (version 25) statistical package. The varietal preference for oviposition was determined by the Chi-square test.

III. RESULTS

A. Leaf morphological traits

The results showed that significant differences ($p < 0.05$) in leaf thickness (LT) and leaf trichomes density (LTD) among the tested landraces. LT was significantly higher in the commercial variety GT 722 (4.14 ± 0.35 cm) compared to the SEU 10 which showed the least (2.78 ± 0.26 cm) (Fig.2). Whereas LTD was significantly higher in the SEU02 (124.20 ± 8.45) compared to the GT722 (59.00 ± 3.98) and SEU10 (59.20 ± 2.22) and which were the lowest than rest of the local landraces (Fig.3).

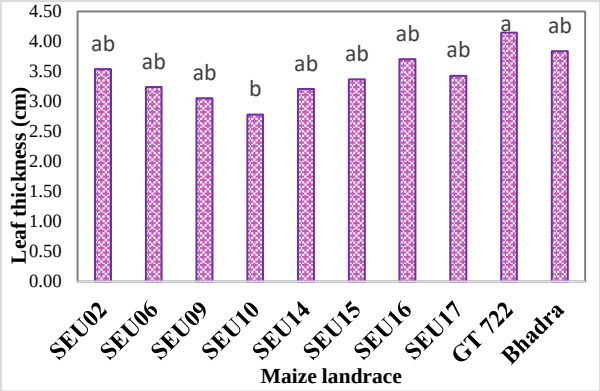


Figure 2: Leaf thickness of selected maize landraces.

Each column represents the mean leaf thickness (cm), followed by the same letter in the columns are not significantly different by the Tukey post hoc test at 0.05 significant level (n =06).

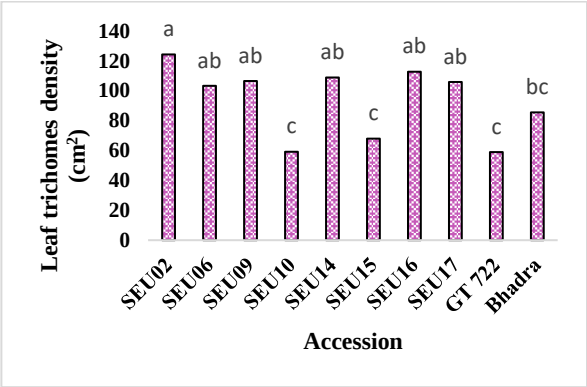


Figure 3: Leaf trichomes density of selected maize landraces.

Each column represents the mean number of trichomes present in the one square cm of the leaf blade. The same letter followed by the columns is not significantly different by the Tukey post hoc test at 0.05 significant level (n = 6).

B. Four choice oviposition preference study

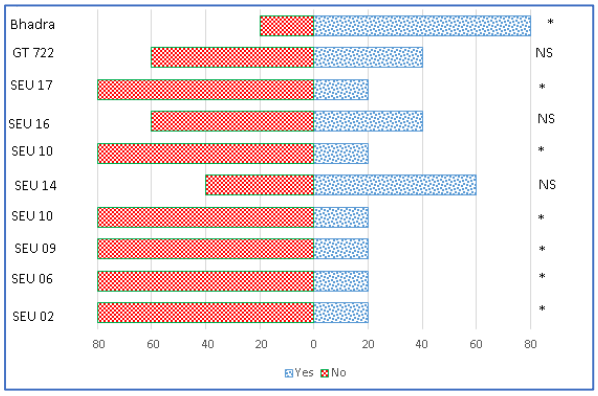


Figure 4: The oviposition preference among maize accessions in four-choice oviposition experiment after 24 hours.

Asterisks represent significant differences (* $p \leq 0.05$) and (ns) represent no significant difference between landraces (n = 15), based on the Chi-square test.

The results of gravid female's preference for oviposition among the selected accessions indicated that three out of ten which GT722, SEU16 and SEU14 having a neutral preference for egg-laying. However, remaining accessions SEU02, SUE06, SEU09, SEU10 and SEU17 ($\chi 2$=5.4, df= 1, p=0.02, 3/12) were significantly lower preference. Eighty per cent females were repelled by these accessions compare to the other three accessions in the arms. Nevertheless, Bhadra ($\chi 2$=5.4, df =1, p=0.02,12/3) reported an inverse relationship where 80% of the females were more willing to select those plants as their egg-laying substrate (Fig.3).

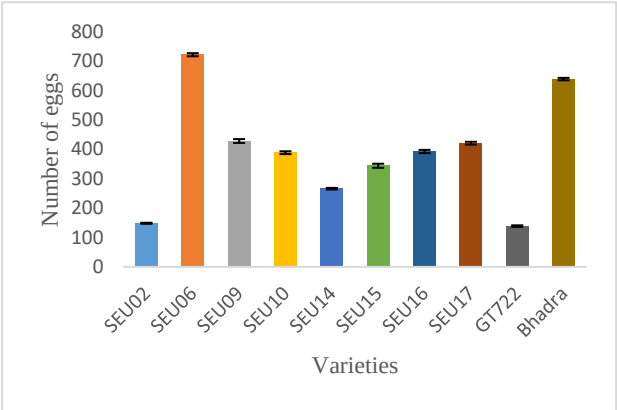


Figure 5: The number of FAW eggs were not statistically different between maize varieties.

The mean number of eggs of a 24-hour duration period among accessions showed SEU06 (721.20 ± 5.23) and Bhadra (638.40 ± 4.20) were higher whereas GT722 (138.60 ± 2.63) and SEU02 (148.20 ± 1.75) were lower.

C. Larval feeding bioassay

None of the landraces was reported significant differences ($p<0.05$) for the evaluated larval parameters. The mean larval weight (LW) was varying 0.22-0.36g among the accessions and which showed highest at SEU06 (0.36±0.00 g) and the lowest weight were at SEU17(0.22 ± 0.03 g) (Table 01). The mean Fecal weight (FW) of accession showed that SEU16 (0.72 ± 0.05g) was weightiest as well SEU09 (0.28 ± 0.02g) was the lowest (Table 01). There was no apparent significant difference among the leaf area consumption (LAC) by the larvae on each accession. The mean LAC of the lifetime of the larvae were varied from 101.8 -137.05 mm^2. The commercial elite variety GT722 (101.68±14.10mm^2) was highly resistant to leaf-feeding compared to other tested accessions. (Table 01). As same as per the other measured larval traits the mean PW of varieties showed a lack of significant difference among the accessions however apparent differences were observed among SEU14 (0.178±0.007g) and the SEU10 (0.150±0.017g) (Table 01). The Larval duration (LD) are almost similar among the accessions and it was between 7.6-8.6 days (Table 01).

Table 01: Different parameter under larval feeding bioassay on selected maize landraces

Varieties	Larval weight(g)	Fecal weight(g)	Leaf area consumption (cm^2)	Larval duration (days)	Pupal weight (g)
SEU02	0.30±0.03	0.45±0.16	123.94±9.15	8.33±0.66	0.17±0.01
SEU06	0.36±0.00	0.31±0.09	121.97±4.77	7.66±0.33	0.16±0.00
SEU09	0.30±0.02	0.28±0.02	102.97±10.76	8.33±0.33	0.17±0.00
SEU10	0.24±0.02	0.38±0.04	137.05±14.82	8.66±0.33	0.15±0.00
SEU14	0.27±0.05	0.41±0.10	131.42±16.08	8.66±0.33	0.17±0.00
SEU15	0.28±0.02	0.44±0.13	133.16±8.88	8.33±0.33	0.16±0.01
SEU16	0.25±0.05	0.72±0.05	117.01±7.54	8.00±0.00	0.17±0.00
SEU17	0.22±0.03	0.52±0.05	109.40±12.82	8.66±0.33	0.16±0.00
GT722	0.29±0.05	0.56±0.04	101.68±14.10	8.00±0.00	0.17±0.00
Bhadra	0.26±0.02	0.61±0.13	116.90±15.33	8.66±0.33	0.16±0.00

The values of respective colums indicated the mean ± SE, (n = 15)

IV. DISCUSSION

The ten maize landraces with two commercial varieties (GT 722 and Bhadra) were assessed in the experiments in laboratory and field studies. Landraces were rigorously evaluated for several aspects of resistance to FAW feeding. However, none of the landraces was found to be fully resistant to FAW larvae feeding but some differences in acceptance and preference were observed under experiments. In Larval feeding bioassay, larval weight, pupal weight, leaf area consumption, larval duration and faecal weight were also measured. According to findings feeding pattern on maize landraces by third instar larvae were not statistically different. However, there was a trend with larvae consuming relatively more leaf area of SEU 10 variety compared to GT722. Furthermore, many factors unrelated to choice affect how much an insect eats; for example, larvae will consume more of a low-protein or high-protein inhibitor-rich plant to compensate for its lower nutritional value (Knolhoff and Heckel.,2014).

Through experiments investigating insect weight gain, we show that FAW larvae gained more weight on the SEU06 variety compared to the same instars developed on the rest of the accession. Indeed, several studies have shown that certain maize cultivars have an impact on larvae weight (Wiseman *et al*.,1996), development period (Wiseman *et al*.,1986), and mortality of FAW larvae (Wiseman *et al*.,1986) when used as food. Some forms of Flavones-C-glycosides and chlorogenic acid, for example, have been shown to have antibiosis activity in maize plants. (Mihm.,1997). FAW feeding activates other defence mechanisms, such as maize defence genes (Chuang *et al*.,2014) or toxic proteins (Chuang *et al*.,2014). Characteristics of plant cultivars that impart partial insect resistance often affect their biology and subsequent performance (Gatehouse.,2002). The same pattern was also observed for the pupal weight. The mean PW on varieties showed that SEU14 was higher among the SEU10 was the lower. The selection and acceptance of a host plant by an insect is the product of the integration of the insect's internal physiological state parameters and involves several behavioural steps (Knolhoff *et al*., 2014). Initially, when an insect touches a plant, it evaluates physical and chemical plant traits which are often used to make an initial behavioural decision on whether to accept or reject a plant. During the evaluation process, insects restrict their movement to a smaller location, a behaviour known as arrestment. The insect will then test-bite the plant, and if its nervous system considers the sensory information to be positive, the final decision will be taken, the host plant will be accepted, and food intake will begin (Schoonhoven *et al*.,2017). Plant organs and tissues, as well as secondary toxic metabolites including trichomes, wax crystal structures, leaf thickness and longevity, and silica material, may influence host-plant selection actions and are part of the plant's array of direct defences

(Gatenhouse.,2002). Several characteristics of maize cultivars have been reported to confer resistance to FAW damage. Cuticular lipids in maize leaves, for example, have been found to influence FAW larvae performance. FAW larvae that were fed leaves without cuticular lipids weighed more and grew faster than those that were fed leaves with cuticular lipids. (Yang *et al*.,1993). FAW neonate larvae migrated longer distances and crawled faster on upper leaves with a smooth appearance than on lower leaves with a thick array of wax crystals, according to another report. (Yang *et al*.,1993). The Leaf trichomes density and leaf thickness were all calculated as part of the morphological character measurement experiment. The results showed that significant differences ($p < 0.05$) in leaf thickness (LT) and leaf trichomes density (LTD) among maize tested plants. LT was significantly higher in the commercial variety GT 722 compared to the SEU 10. LTD was significantly higher in SEU02 compared to the GT722 and SEU10. Lipophilic constituents of leaf surfaces (alkenes, esters, and fatty acids) and secondary plant metabolites, on the other hand, have been shown to encourage test-biting and subsequent feeding in a variety of insects. (Schoonhoven *et al*.,2007). Four choices oviposition preference experiment number of eggs/egg masses were counted. The mean percentage of female moths were significantly different such as SEU02, SEU06, SEU09, SEU10, SEU15, SEU17 and Bhadra landraces. Thus this could be more favourable volatiles include in the Bhadra variety compare to others. Finally, we could not have identified distinct high levels of resistance accessions to larvae feeding in our analysis of FAW larval preferences on Sri Lankan maize landraces. Thus to trap latent genetic diversity trials should be extended to landraces of remaining maize growing areas in Sri Lanka. Moreover, field trials will be conducted under natural infestation.

V. CONCLUSION

These results indicate that the tested maize landraces do not have full resistance to FAW larval feeding. Certain maize cultivars, however, have different levels of acceptance and preference. The density of trichomes on maize leaves does not seem to be linked to larvae feeding preferences after the later stages of the larval phase. It could be the Bhadra variety contains more desirable volatiles for the gravid female attractant compounds.

REFERENCES

Anonymous., (2012). AgStat. The pocket book of agriculture statistics. Socio Economic and Planning Centre, Department of Agriculture, Peradeniya, Sri Lanka, 21p.

Anonymous.,1998).Saubhagyamath Sri Lankawak Sandaha. Crop recommendations. (In Sinhala medium) Department of Agriculture, Sri Lanka, pp. 7-9.

Baudron, F. Zaman-Allah, M.A. Chaipa, I.; Chari, N.; Chinwada, P. (2019). Understanding the factors influencing fall armyworm (Spodoptera frugiperda J. E. Smith) damage in African smallholder maize fields and quantifying its impact on yield. A case study in Eastern Zimbabwe. *Crop Prot*., 120, 141–150.

Chuang, W.P.; Herde, M.; Ray, S.; Castano-Duque, L.; Howe, G.A.; Luthe, D.S. (2014). Caterpillar attack triggers accumulation of the toxic maize protein RIP2. *New Phytol.*, *201*, 928–939.

Chuang, W.P.; Ray, S.; Acevedo, F.E.; Peiffer, M.; Felton, G.W.; Luthe, D.S. (2014) Herbivore cues from the fall armyworm (*Spodoptera frugiperda*) larvae trigger direct defences in maize. *Mol. Plant Microbe Interact*, *27*, 461–470.

Costa, E.N., Fenandes, M.G., Medeiros, P.H., Evangelista, B.M.D. (2020). Resistance of maize landraces from Brazil to fall armyworm (Lepidoptera:Noctuidae) in the winter and summer seasons. *Bragantia*, 79(3), 377-386.

Gatehouse, J.A. (2002). Plant resistance towards insect herbivores: A dynamic interaction. *New Phytol*., *156*, 145–169.

Knolhoff, L.M., Heckel, D.G. (2014). Behavioral assays for studies of host plant choice and adaptation in herbivorous insects. *Annu. Rev. Entomol.*, *59*, 263–278.

Malaviarachchi, M.A.P.W.K., Costa, W.A.J.M., Fonseka, R.M., Kumara, J.B.D.A.P., Abhayapala, K.M.R.D., Suriyagoda, L.D.B. (2014). Response of maize (*Zea mays* L.) to a temperature gradient representing long-term climate change under different soil management systems. *Agricultural Research*., 25 (3): 327 – 344.

Murua, M.G., Vera ,M.T., Abraham, S., Juarcz, M.L., Prieto, S., Head, G.P., Willink, E. (2008). Fitness and mating compability of Spodoptera fruigiferda (Lepidoptera:Noctudia) Populations from different host plant species and rigons in Argentina. *Annals of the Entomological Society of America*., 3:639-649.

Mihm, J.A. (1997). Insect Resistant Maize-Recent Advances and Utilization; Mihm, J.A., (Ed.) *CIMMYT: El Batan*, Mexico, p. 304.

Muffeth, M., Mubarak, A.N., Ranaweera, G.K.M.M.A., Nusrathali, N., Roshana, M.R., RifnaBanu, A.R.F., Kumara, A.D.N.T. (2020). Characterization of morphometric,physiological and biomass production in local maize(Zea mays L.)

landraces of Sri Lanka. *Sri Lankan Journal of technology*, 1(1): 21-29.

Midega, C.A.O., Pickett, J.A., Hooper, A., Pittchar, J.O., Khan, Z.R. (2016). Maize landaraces are less affected by Striga hermonthica relative to hybrids in Western Kenya. *Weed Technol*. 30, 21–28.

Odendo, M., de Groote, H., Odongo, O.M. (2001). Assesment of farmers' preferences and constraints to maize production in the moist mid-altitute zone of Western Kenya. *Afr. Crop Sci. Conf. Proc*. 5, 769–775.

Prasanna, B.M., Bruce, A., Winter, S., Otim, M., Asea, G., Sevga, S., Ba, M. (2018). Host plant resistance to fall armyworm. Fall Armyworm in *Africa.A guide for Integrated Pest Management*, 45-62.

Paiva, L.A., Correa, F., Silva, F.C., da Silva Araujo, M., de Jesus, F.G. (2016). Resistance of corn genotypes to fall armyworm Spodoptera frugipereda (Lepidoptera:Noctuidae).*African Journal of Biotechnology*,15(35),1877-1882.

Ranaweera, N.F.C., de Silva, G.A.C., Fernando, M.H.J.P., Hidagala, H.B.(1984). Maize production in Sri Lanka. *CGPRT*., pp86-90

Sisay, B., Tefera, T., Wakgari, M., Ayalew, G., Mendesil, E.(2019). The efficacy of selected synthetic insecticides and botanicals agaist fall armyworm, *Spodoptera frugiperda*, in maize .*Insects*,10(2),45.

Schoonhoven, L.M., van Loon, J.J.A., Dicke, M. (2007). *Insect-Plant Biology*, 2nd ed.; Oxford University Press: New York, NY, USA, p. 421.

Tamiru, A., Bruce, T.J.A., Midega, C.A.O., Woodcock, C.M., Birkett, M.A., Pickett, J.A., Khan, Z.R. (2012). Oviposition Induced Volatile Emissions from African Smallholder Farmers' Maize Varieties. *J. Chem. Ecol*., 38, 231–234.

Wijerathna, D.M.I.J., Ranaweera, P.H., Perera, R.N.N., Dissanayake, M.L.M.C., Kumara, J.B.D.A.P. (2020). Biology and feeding preferences of Spodoptera frugiperda (Lepidoptera: Noctuidae) On maize and selected vegetable crops. The Journal of Agricultural Sciences - Sri Lanka. Pp 126-134.

Wiseman, B.R., Davis, F.M., Williams, W.P., Widstrom, N.W. (1996). Resistance of a maize population, FAWCC(C5), to fall armyworm larvae (Lepidoptera: Noctuidae). Fla. Entomol. 79, 329–336.

Wiseman, B.R., Widstrom, N.W. (1986). Mechanisms of Resistance in 'Zapalote Chico' Corn Silks to Fall Armyworm (Lepidoptera: Noctuidae) Larvae. *J. Econ. Entomol. 79*, 1390–1393.

Wiseman, B.R., Davis, F.M. (1979). Plant Resistance to Insects Attacking Corn and Grain Sorghum. *Fla. Entomol*. 62, 123–130.

Yang, G., Wiseman, B.R., Isenhour, D.J., Espelie, K.E. (1993). Chemical and ultrastructural analysis of corn cuticular lipids and their effect on feeding by fall armyworm larvae. *J. Chem. Ecol*. 19, 2055–2074.

Host Plant Volatiles Released by *Bracharaira brizantha* and *Desmodium* spp. and Their Effects on the Behaviour of Fall Armyworm

K.D.S. Kaushalya[1], A.D.N.T. Kumara[2*], G.K.M.M.K. Ranaweera[3], R.M.P.P. Rathnayaka[4], M.G.C.D. Silwa[5] & A.N.M. Mubarak[6]

[1,2,3,4,5,6]*Department of Bio Systems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1]dilsarasavi36@gmail.com, [2*]adntkumara@seu.ac.lk, [3]madhusankaranaweera111@gmail.com, [4]pulara3434@gmail.com, [5]chathurikadilhani384@gmail.com, [6]anmubarak@seu.ac.lk

Abstract- *Desmodium spp. and Napier-like grasses are widely used as push-pull systems for mange fall armyworm (FAW) in Africa. However, the responsible cues for the olfactory responses of the FAW was not been identified yet. Hence, this study was conducted to identify volatile compounds release by Desmodium spp. and Bachiraria brizantha plants and determine their role on behaviour modification of FAW adults and the larvae. Four different plant species i.e., B. brizantha, Desmodium heterophullum, D. triflorum and D. interim were collected, and volatiles were extracted using dynamic head space and solvent extraction methods. The chemical compounds were identified using GC-MS. Behavioural studies were conducted for selected volatiles based on availability. This study identified 29 volatile compounds released by Desmodium spp. where 30 compounds were identified from B. brizantha. Behaviour study results indicated that females were attracted to n-hexane (72.73%) and Limonene (-) (66.67%), where naphthalene (70%) showed a repellent behavior. Males were significantly repelled by 3-Hexen-1-ol, Limonene (-), and Limonene (+). Neonates significantly attract to Limonene (-) (69.23%) and repel by 1-Octen-3-ol. Therefore, it can be concluded that this behavior modified volatile compounds can be used to develop semiochemical based green pest management strategies.*

Keywords: Pest management strategy, Host plant volatiles, Desmodium, Push-pull system

I. INTRODUCTION

Fall armyworm (FAW) *Spodoptera frugiperda* Smith *(*Lepidoptera, Noctuidae*)*, is a native pest of America, widely spread throughout the tropical and subtropical areas and it has been recognized as an economical pest of maize for more than decades (Groote *et al*., 2020). The polyphagous nature of the larvae feeds on a variety of crop species, other than maize *i.e.* sorghum, millet, and cotton, sugarcane, and vegetable crops. The damage beyond the American and African continent appeared on the Indian subcontinent in Asia in May 2018, and it has since spread across India, Nepal, Bangladesh and Sri Lanka (Lamsal *et al*., 2020) and presently become a major concern in food security in these countries. In 2017, Centre for Agriculture and Bioscience International (CABI) estimated that, due to unavailability of effective control methods, FAW causes annual maize yield losses of 8.3 to 20.6 million tons (that equal to feed 40.8 to 101 million people) which estimated 2.5-6.2 USD billion in 12 African maize-producing countries (Day *et al*., 2017). To control the pest, farmers have been tried several methods including the application of chemical pesticides, biopesticides, genetically improved plants containing Bt genes. Even though access is easy to chemical pesticides, it may cause development of resistant populations, reduction of natural enemies moreover lack of awareness on proper use, consistency of use, low purchasing power and the limited choice of pesticide products (Midega *et al*.2017) becoming the chemical control less effective. Hence Integrated Pest Management packages with minimizing pesticide application and use of natural enemies becoming popular among farmers in Africa and identified as a suitable and cost-effective method is known as the push-pull system (Day *et al*.,2017) The "Push-Pull" also known as stimulus-deterrent diversionary strategy technique to control the pest through using both strategies at the same time as employing attracting and repellent from the crops (USAID, 2021). In push-pull strategy, they used Napier grass as the border crop with silver leaf desmodium (*Desmodium uncinatum*) as the intercrop with maize. In push-pull strategy, they used Napier grass as the border crop with silver leaf desmodium (*Desmodium uncinatum*) as the intercrop with maize. The desmodium plant emits volatile compounds that are disgusting to behave female moths hence acting as a ‘push’ whilst a grass such as Napier emits attractive chemical

compounds that 'pull' and attract the moths towards itself. Volatiles, (E)-ocimene and (E)-4,8-dimethyl-1,3,7-nonatriene emitted by the desmodium repel (push) the stemborer pests while chemicals produced by Napier and Sudan grasses attract (pull) moths to lay eggs in the grass instead of maize. Further, hexane, (E)-2, hexenal (Z),-3, Hexen-1-ol have been shown in Napier grass than maize or sorghum in host plants to produce higher levels of attraction for Stem borers(Khan *et al*., 2011). According to Ayurvedic Plants of Sri Lanka: Plants List in Sri Lanka listed several spp of desmodium viz. *Desmodium heterophyllum* (Maha udupiyaliya), *D. gangeticum* (Shaliparni), *D.triflorum* (Heen udupiyaliya) and *D. uncinaium* (Jayawardana, 1985) present in Sri Lanka and similar volatiles can be found from them. As same *Brachiaria brizantha* (Signal grass) is one of the major pasture grasses largely grown in the country (Fernando *et al*.,1958) may having similar volatiles to the napier grass due to one of the host plant of FAW may be having the potential to use as push pull systems with using identified volatile cues. Therefore, this study was conducted to identify volatile compounds released by *Desmodium* spp and *B. brizantha* plants and effect of their behavior modification of FAW neonates and moths.

II. MATERIALS AND METHODS

A. Plant materials and insect culture

The plant materials of *B. brizantha*, *D. heterophullum, D. triflorum* and *D. intortum* were collected from different locations of Sri Lanka from September 2020 to February 2021. Healthy leaf samples which were well exposed to light and free from disease and insects, weather or mechanical injury were used for volatile extraction.

FAW larvae were collected from maize fields at Agrotec park, Malwatte and reared on natural diets as a method given by Du Plessis *et al*., (2020) in particular conditions in the laboratory as 12 L:12D photoperiods under 30℃ temperature and 70-75% RH condition until moth emerge. Then the moths were placed in the 2.5 L plastic bottles while providing the 10 % honey solution. The lid of the bottle was covered with muslin cloth to facilitate the ventilation and substrate for egg laying. After laying egg, egg masses were kept separately in the new bottles as same above and were monitored daily until hatching, as soon as the first instars emerged, they were provided fresh leaves from maize seedlings until third instar. To avoid the cannibalism third instar larvae were placed individually in ventilated small plastic jars (150 ml capacity) while providing fresh maize leaves. The pupae were separated male and female under the dissecting microscope following the method described by Sharanabasappa *et al*., (2018). Adult males and females were mixed in oviposition cages by providing 10 % honey solution and freshly mated females were obtained for behavior studies after two days of emergence.

B. Volatile collection

The solvent extraction and dynamic headspace collection methods were used to extract volatiles. Insolvent extraction method 50g of each sample was measured using an electronic balance (KERN $_{PFB}$) and cut into small pieces (<1 cm). Then samples were transferred to the reagent bottles and 50 ml 99.9% purity dichloromethane (DCM) HPLC grade was added and kept overnight at room temperature for the extraction completion. Extractions were filtered through a silica gel column to remove impurities. In the headspace collection method, leaf samples were placed in a desiccator and a gently filtered airstream was allowed to pass through the sample. The odour captured air was trapped to porapak Q absorbent (Supelco) 30 mg (50-80 mesh size) with glass wool by aiding the laboratory suction pump. The collection was made 12 hours and trapped volatiles in the absorbent was eluted to 2 ml DCM HPLC grade. The extractions were concentrated using gent nitrogen flow and stored in chromatography vials at -20 ℃ until bioassay.

C. GC-MS analysis

The chemical analysis of extracts was carried out using the Agilent Gas Chromatography (GC 8890) coupled Mass Spectrometry (5978B MSD) system at chemical ecology laboratory. The carrier gas Helium (99.999%) was used with a flow rate of 1ml/min in the split mode (10:1). An aliquot of 2µl of eluted sample was injected into the column with the injector temperature at 280ºC. GC oven temperature-programmed initially at 50 ºC and hold for 2 min and it was raised to 180 ºC at the rate of 10 ºC/min, and hold 5 min. Then raised to 250 ºC at the rate of 7 ºC/min and hold for 5 min and increase up to 280 ºC and hold for 9 min with a program rate of 5 ºC/min. The injector and detector temperatures were set at 280ºC and 280ºC respectively. The mass data of samples was gained through electron ionization at 70 eV process and the mass detector was operated in scan mode up to 450 amu. The total running time was 50 min. The

obtained masses were identified by comparing NIST libraries using chem station software.

D. Chemicals and behavioural studies

The selected pure synthetic (99.99%) chemicals identified from the GCMS analysis purchased from sigma Aldrich were used for the olfactometer studies, it was carried out to check moth behavior against the volatiles using dual choice olfactometer (Figure 1). Selected chemicals with 1% concentration were made dissolving in a solvent (hexane, HPLC grade). The prepared test chemical 100µl was placed one arm of the olfactometer was served as treatment and the other arm was as control. Five insects were placed in the middle of the chamber and the movement of insects was observed and recorded in their active period at night. The bioassay was replicated ten times for each volatile for males and females separately. The end of the bioassay olfactometer was turned 180º from the position to eliminate side effects and at the end of each bioassay, olfactometer was cleaned using 90% ethanol (v/v).

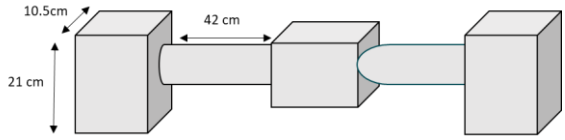


Figure 1: Dual choice olfactometer made up using transparent OHP sheets

E. Olfactometer studies for neonates

The same pure volatile compounds used for the above experiment were used for this study. A dual choice olfactometer test was carried out. The 100 µl of the volatile was sprayed on maize leaf sample and kept on one side of the end of the arm and unsprayed same type of maize leaves were kept on the other side as the control. Ten Neonates were released into the middle of each cylinder and movement of the neonates after 24 hours were recorded. The bioassay was replicated 6 times per each selected volatile (Sisay *et al*., 2019).

F. Data analysis

The Percentage responses of moths to the behavioural studies were compared using Chi-square test as assuming the equal probability (50:50) for both test and control arms using IBM SPSS version 25.

III. RESULTS AND DISCUSSION

The replicated GC-MS analysis results indicated that, 30 volatile compounds from *B. Brizantha* and 29 compounds of all types of *Desmodium spp*. These volatiles consist the alcohols, aldehydes, ketones and esters. Caryophyllene, 1,6,10-Dodecatriene, 7,11-dimethyl-3-methylene-, Hentriacontane, Pentadecane, 1,4-Benzenedicarboxylic acid, dimethyl ester, Oxalic acid, 2-Ethylhexyl tetradecyl ester, Benzoic acid, 4-ethoxy-, ethyl ester, Dodecane, Oxalic acid, allyl hexadecyl ester, Pentanoic acid, 2,2,4-trimethyl-3-carboxyisopropyl, isobutyl ester were the major component in *B. brizantha* (Table 1 and Figure 3). The volatile compounds *i.e.* Pentadecane, 1,4-Benzenedicarboxylic acid, dimethyl ester, Oxalic acid, 2-Ethylhexyl tetradecyl ester, Cyclooctane, 1,4-dimethyl-, cis-, Benzoic acid, 4-ethoxy-, ethyl ester, 2-methylhexacosane, Oxalic acid, allyl pentadactyl ester, 2,2,4-Trimethyl-1,3-pentanediol diisobutyrate, Heptadecane released by the desmodium spp (Table 2 and Figure 2). According to Khan, *et al* (2007) Africa, molasses grass and *Desmodium uncinatum* (Jacq), releases repellent volatiles to reduce pest populations in maize crops. Forage grasses showed a greater diversity of volatile compounds after damage, including menthone, eucalyptol and camphor while (E)-ocimene and (E)-4,8-dimethyl-1,3,7-nonatriene, released by the desmodium (Silva *et al*., 2019). However, *plant induces leaf volatiles* such as (E)-4, 8-Dimethyl-1, 3, 7-nonatriene, Decanal, (E)-Caryophyllene, Linalool, linalool (plus Nananal), E-β-farnesene, Methyl salicylate and (3E, 7E)-4, 8, 12-trimethyl-1, 3, 7, 11-tri-decatetraene were released by the *B. brizantha* plants when intercropping with *B. brizantha* (Magara *et al*., 2013).

Table 1: Volatile compounds present in *B. Brizantha* identified by GC-MS analysis

Volatile compound	RT	Area
Ethylene oxide	1.3	0.09
Methane, bromo-	1.4	0.17
beta.-Myrcene	10.2	0.21
Octanal	10.5	0.40
3-Hexen-1-ol, acetate, (E)-	10.7	1.58
Eucalyptol	11.4	2.75
D-Limonene	11.2	0.09
1,3,6-Octatriene, 3,7-dimethyl-, (Z)-	11.9	0.27
1,6-Octadien-3-ol, 3,7-dimethyl-	13.4	0.22
Nonanal	13.5	0.75
(E)-2-Butenoic acid, 2-(methylenecyclopropyl)prop-2-yl ester	13.8	1.36
Levomenthol	15.3	1.13
Naphthalene	15.6	0.29
Decanal	16.1	0.46
Pentadecane	19.0	0.24
Caryophyllene	21.2	0.25
1,6,10-Dodecatriene, 7,11-dimethyl-3-methylene-	21.9	0.17
Hentriacontane	22.7	0.16
Pentadecane	22.7	0.30
1,4-Benzenedicarboxylic acid, dimethyl ester	22.8	0.21
Oxalic acid, 2-Ethylhexyl tetradecyl ester	22.9	0.19
Benzoic acid, 4-ethoxy-, ethyl ester	23.3	1.03
Dodecane	23.6	0.32
Oxalic acid, allyl hexadecyl ester	23.8	0.30
Pentanoic acid, 2,2,4-trimethyl-3-carboxyisopropyl, isobutyl ester	24.7	2.53
Heptadecane	26.8	0.45
n-Hexane	1.8	22.08
Ethyl Chloride	1.9	0.72
Toluene	3.4	0.42
3-Hexen-1-ol, acetate, (E)-	10.7	0.16

Table 2: Volatile compounds present in *Desmodium spp* identified by GC-MS analysis

Volatile compound	RT	Area
2-Hexenal, (E)-	5.6146	0.45
1-Octen-3-ol	9.7736	2.50
3-Octanone	10.0169	0.84
Cyclotetrasiloxane, octamethyl-	10.5001	0.63
Eucalyptol	11.3337	1.51
2(3H)-Furanone, 5-ethyldihydro-	12.0266	0.36
Nonanal	13.475	0.49
Cyclohexanol, 5-methyl-2-(1-methylethyl)	15.296	0.75
Naphthalene	15.5372	0.98
Decanal	16.1354	0.25
Eicosane	17.9348	0.29
2-Decene, 7-methyl-, (Z)-	18.5433	0.40
Ketone, methyl 2,2,3-trimethylcyclopentyl	18.7397	0.28
Pentane, 3-methylene-	18.9321	0.26
2-Bromo dodecane	18.999	0.61
Decane, 3,7-dimethyl-	19.4273	0.30
Benzeneacetaldehyde, .alpha.,2,5-trimethyl-	19.7759	0.42
Hentriacontane	22.6558	0.36
Pentadecane	22.7111	0.53
1,4-Benzenedicarboxylic acid, dimethyl ester	22.7613	0.40
Oxalic acid, 2-Ethylhexyl tetradecyl ester	22.8801	0.41
Cyclooctane, 1,4-dimethyl-, cis-	23.2281	0.26
Benzoic acid, 4-ethoxy-, ethyl ester	23.2826	0.91
2-methylhexacosane	23.5571	0.68
Oxalic acid, allyl pentadecyl ester	23.7676	0.59
2,2,4-Trimethyl-1,3-pentanediol diisobutyrate	24.7208	3.68
Heptadecane	26.8146	0.49
Butane, 2-chloro-2-methyl-	2.192	0.36
Propanoic acid, 2-methyl	24.7287	1.25

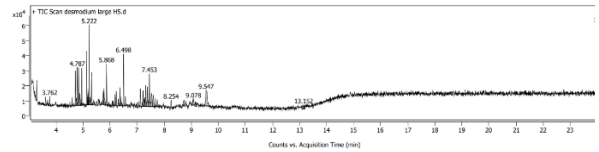


Figure 2: Total ion chromatogram (TIC) obtained by coupled GC-MS analysis of *Desmodium heterophyllum* volatiles

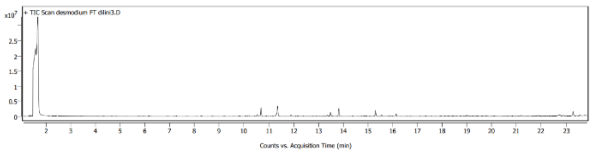


Figure 3: Total ion chromatogram (TIC) obtained by coupled GC-MS analysis of *Brachiaria brizantha* volatiles

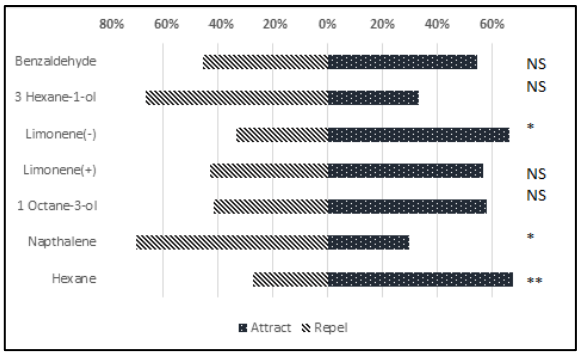


Figure 4: Behavioural response of FAW virgin females to plant volatiles; bars indicate the mean percentage moths found on each sides. * Percentage response between source and control is significantly different at p<0.05 and ** at p<0.01 and NS = non-significant.

Behavioural responses of female for selected volatiles observed a significantly different (p<0.05) with compared to the control. Among them significant proportion of females were attracts towards the hexane (72.73%) ($\chi2 = 6.81$, df = 1, p = 0.009) and Limonene(-) (66.67%)($\chi2 = 4.00$, df = 1, p = 0.046) at the same time naphthalene ($\chi2 = 4.80$, df = 1, p = 0.028) showed a repellent behaviour by repelling 70% of the female moths form the volatile. However, tested other volatiles showing a neutral effect (Figure. 4).

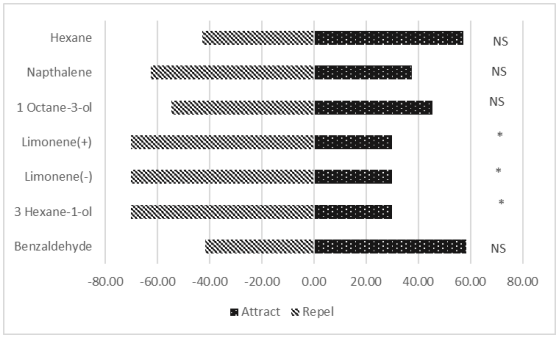


Figure 5: Behavioural response of FAW virgin males to plant volatiles; bars indicated the mean percentage moths found on each side. * Percentage response between source and control is significantly different at p<0.05 and ** at p<0.01 and NS = non-significant.

The behavioural responses of male moths revealed a significantly different repulsive behaviour for selected volatiles i.e. 3-Hexen-1-ol, Limonene (-) and Limonene (+) ($\chi2 = 4.80$, df = 1, p = 0.028) where, others showed a neutral behavior (Figure 5).

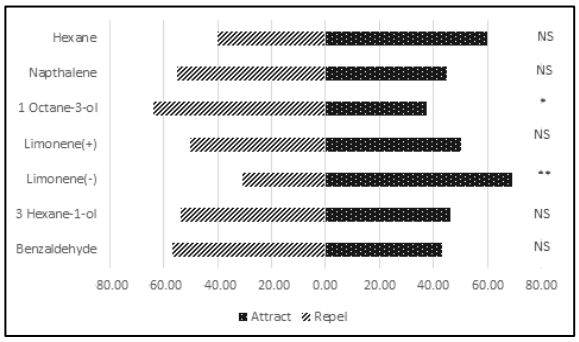


Figure 6: Behavioural response of FAW neonate larvae to plant volatiles; bars indicted the mean percentage moths found on each side. * the bars indicating percentage response between source and control is significantly different at p<0.05 and ** at p<0.01 and NS = non-significant.

The behaviour studies for FAW neonates showed a non-significant neutral effect for the Benzaldehyde, 3 Hexen-1-ol, Limonene (+), Naphthalene and n-Hexane however, higher attraction (69.23%) was reported towards Limonene (-) ($\chi2 = 11.538$, df =1, p = 0.001). Meanwhile significant amount of neonates (63.75%) was repel from the 1-Octen-3-ol ($\chi2 = 5.44$, df = 1, p = 0.02) (Figure 6).

Generally, lepidopteran larvae including FAW are considered as less mobile stages and inability to long-distance movements, so mothers host selection behavior where female moth is mainly

responsible for host selection for their progeny survival (Rojas *et al*., 2018). The host finding for the egg-laying and feeding may be correlated thus we use both adults and larvae for the study. Early instar larvae were used due to later stages of FAW larvae known to be less mortality and confined their selected niche where neonatal choices regarding host finding must be important. According to neonate larvae are believed to disperse randomly from plants because they engage in ballooning (Zalucki *et al*., 2002). But available studies had not addressed whether neonate larvae disperse randomly, nor whether larvae that initially colonize an unsuitable host will disperse further, either directionally or randomly. But our study was found that they use chemical cues for host selection. Further, we got the idea for females to use chemical cues for host selection and we found that some chemicals use to attract the host and some are showing repulsive behavior. To confirm the results further studies is needed and have to use more volatile chemicals and different blends due to we selected only a few chemicals and plants not release volatiles as individual compounds and releases at a various rate of combinations and ratios (McCormick *et al*., 2012).

IV. CONCLUSION

Our study can be concluded that n-hexane is a significant attraction for females while male neonates showing an attractant movement which is the major component in *B. brizantha*. Moreover, limonene (+) and limonene (-) both showing a repellent property for males which is the major volatile component in *Desmodium spp*. In the case of neonates 1-octane 3-ol showing significant repellent properties. These identified volatile compounds can be used to develop behavioural modifying pest management strategies.

REFERENCES

Afidchao, M.M., Musters, C.J.M., de Snoo, G.R. (2013). Asian corn borer (ACB) and non-ACB pests in GM corn (Zea mays L.) in the Philippines. *Pest management science*, *69*(7), pp.792-801.

Ashley, T.R. (1979). Classification and distribution of fall armyworm parasites. *Florida Entomologist*, pp.114-123.

Åsman, K., Ekbom, B., Rämert, B. (2001). Effect of intercropping on oviposition and emigration behavior of the leek moth (Lepidoptera: Acrolepiidae) and the diamondback moth (Lepidoptera: Plutellidae). *Environmental Entomology*, *30*(2), pp.288-294.

Barr, K.L., Hearne, L.B., Briesacher, S., Clark, T.L., Davis, G.E. (2010). Microbial symbionts in insects influence down-regulation of defense genes in maize. *PLoS One*, *5*(6), p.e11339.

Bateman, M.L., Day, R.K., Luke, B., Edgington, S., Kuhlmann, U., Cock, M.J. (2018). Assessment of potential biopesticide options for managing fall armyworm (Spodoptera frugiperda) in Africa. *Journal of Applied Entomology*, *142*(9), pp.805-819.

Bernardi, D., Salmeron, E., Horikoshi, R.J., Bernardi, O., Dourado, P.M., Carvalho, R.A., Martinelli, S., Head, G.P., Omoto, C. (2015). Cross-resistance between Cry1 proteins in fall armyworm (Spodoptera frugiperda) may affect the durability of current pyramided Bt maize hybrids in Brazil. *PloS one*, *10*(10), p.e0140130.

Carroll, M.J., Schmelz, E.A., Meagher, R.L., Teal, P.E. (2006). Attraction of Spodoptera frugiperda larvae to volatiles from herbivore-damaged maize seedlings. *Journal of chemical ecology*, *32*(9), pp.1911-1924.

Cheruiyot, D., Midega, C.A., Pittchar, J.O., Pickett, J.A., Khan, Z.R. (2020). Farmers' Perception and Evaluation of Brachiaria Grass (Brachiaria spp.) Genotypes for Smallholder Cereal-Livestock Production in East Africa. *Agriculture*, *10*(7), p.268.

Dandekar, R., Fegade, B. and Bhaskar, V.H. (2015). GC-MS analysis of phytoconstituents in alcohol extract of Epiphyllum oxypetalum leaves. *Journal of pharmacognosy and phytochemistry*, *4*(1).

Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y., Corniani, N., Early, R., Godwin, J., Gomez, J. (2017). Fall armyworm: impacts and implications for Africa. *Outlooks on Pest Management*, *28*(5), pp.196-201.

Du Plessis, H., Schlemmer, M.L., Van den Berg, J. (2020). The effect of temperature on the development of Spodoptera frugiperda (Lepidoptera: Noctuidae). *Insects*, *11*(4), p.228.

Early, R., González-Moreno, P., Murphy, S.T., Day, R. (2018). Forecasting the global extent of invasion of the cereal pest Spodoptera frugiperda, the fall armyworm.

Fatouros, N.E., Lucas-Barbosa, D., Weldegergis, B.T., Pashalidou, F.G., van Loon, J.J., Dicke, M., Harvey, J.A., Gols, R., Huigens, M.E. (2012). Plant volatiles induced by herbivore egg deposition affect insects of different trophic levels. *PLoS one*, *7*(8), p.e43607.

Fernando, G.W.E. (1958). Grassland farming in the dry zone. *Trop. Agric. Mag. Ceylon agric. Soc*, *114*, p.183.

Gahukar, R.T. (2014). Potential and utilization of plant products in pest control. In *Integrated Pest Management* Academic Press (pp. 125-139).

De Groote, H., Kimenju, S.C., Munyua, B., Palmas, S., Kassie, M., Bruce, A. (2020). Spread and impact of fall

armyworm (Spodoptera frugiperda JE Smith) in maize production areas of Kenya. *Agriculture, ecosystems & environment*, *292*, p.106804.

Goergen, G., Kumar, P.L., Sankung, S.B., Togola, A., Tamò, M. (2016). First report of outbreaks of the fall armyworm Spodoptera frugiperda (JE Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in West and Central Africa. *PloS one*, *11*(10), p.e0165632.

Gurr, G., Wratten, S.D., Altieri, M.A. eds. (2004). *Ecological engineering for pest management: advances in habitat manipulation for arthropods*. Csiro Publishing.pp43-58

Hailu, G., Niassy, S., Zeyaur, K.R., Ochatum, N., Subramanian, S. (2018). Maize–legume intercropping and push–pull for management of fall armyworm, stemborers, and striga in Uganda. *Agronomy Journal*, *110*(6), pp.2513-2522.

Harrison, R.D., Thierfelder, C., Baudron, F., Chinwada, P., Midega, C., Schaffner, U., Van den Berg, J. (2019). Agro-ecological options for fall armyworm (Spodoptera frugiperda JE Smith) management: Providing low-cost, smallholder friendly solutions to an invasive pest. *Journal of Environmental Management*, *243*, pp.318-330.

Hiroyoshi, O., Kazuaki, O. (2019). Desmodium (Leguminosae tribe Desmodieae) of Africa, Madagascar and the Mascarene Islands. *J. Jpn. Bot*, *94*(3), pp.135-148.

Jayasuriya, K.G., Wijetunga, A.S., Baskin, J.M., Baskin, C.C. (2013). Seed dormancy and storage behaviour in tropical Fabaceae: a study of 100 species from Sri Lanka. *Seed Science Research*, *23*(4), p.257.

Jayawardana, A.B.P. (1985). Pastures in Sri Lanka. International symposium on pastures in the tropics and subtropics. *Tropical Agriculture Research Series (Japan). 18.pp 124-136*

Liu, Z., Scheirs, J., Heckel, D.G. (2012). Trade-offs of host use between generalist and specialist Helicoverpa sibling species: adult oviposition and larval performance. *Oecologia*, *168*(2), pp.459-469.

Lohn, A.F., Trtikova, M., Chapela, I., Van den Berg, J., Du Plessis, H., Hilbeck, A. (2020). Transgene behavior in Zea mays L. crosses across different genetic backgrounds: Segregation patterns, cry1Ab transgene expression, insecticidal protein concentration and bioactivity against insect pests. *PloS one*, *15*(9), p.e0238523.

Khan, Z.R., Ampong-Nyarko, K., Chiliswa, P., Hassanali, A., Kimani, S., Lwande, W., Overholt, W.A., Picketta, J.A., Smart, L.E., Woodcock, C.M. (1997). Intercropping increases parasitism of pests. *Nature*, *388*(6643), pp.631-632.

Khan, Z.R., Midega, C.A., Wadhams, L.J., Pickett, J.A., Mumuni, A. (2007). Evaluation of Napier grass (Pennisetum purpureum) varieties for use as trap plants for the management of African stemborer (Busseola fusca) in a push–pull strategy. *Entomologia Experimentalis et Applicata*, *124*(2), pp.201-211.

Khan, Z., Midega, C., Pittchar, J., Pickett, J., Bruce, T. (2011). Push—pull technology: a conservation agriculture approach for integrated management of insect pests, weeds and soil health in Africa: UK government's Foresight Food and Farming Futures project. *International Journal of Agricultural Sustainability*, *9*(1), pp.162-170.

Khan, Z.R., Pickett, J.A., Berg, J.V.D., Wadhams, L.J., Woodcock, C.M. (2000). Exploiting chemical ecology and species diversity: stem borer and striga control for maize and sorghum in Africa. *Pest Management Science: Formerly Pesticide Science*, *56*(11), pp.957-962.

Kazuaki, O., Hiroyoshi, O., Tomoyuki, N., Chika, A., Hayato, K., Koji, N., Hironori, O., Kana, Y. (2018). Phylogenetic analyses for classification of the Desmodium group of Leguminosae tribe Desmodieae 2. Two new genera separated from Desmodium and two new combinations in Grona and Sohmaea. *J. Jpn. Bot*, *93*(5), pp.293-306.

Keller-Grein, G., Maass, B.L., Hanson, J. (1996). Natural variation in Brachiaria and existing germplasm collections. *Brachiaria: biology, agronomy and improvement*, *1*.

Kurian, G.A., Suryanarayanan, S., Raman, A., Padikkala, J. (2010). Antioxidant effects of ethyl acetate extract of Desmodium gangeticum root on myocardial ischemia reperfusion injury in rat hearts. *Chinese medicine*, *5*(1), pp.1-7.

Lamsal, S., Sibi, S., Yadav, S. (2020). Fall Armyworm in South Asia: Threats and Management. *Asian Journal of Advances in Agricultural Research*, pp.21-34.

Lenné, J.M., Julie, M. (1990). Diseases of Desmodium species. *Tropical Grasslands*, *24*, pp.1-14.

Long, W., Li, Q., Wan, N., Feng, D., Kong, F., Zhou, Y., Yuan, J. (2020). Root morphological and physiological characteristics in maize seedlings adapted to low iron stress. *PloS one*, *15*(9), p.e0239075.

Ma, X., Zheng, C., Hu, C., Rahman, K., Qin, L. (2011). The genus Desmodium (Fabaceae)-traditional uses in Chinese medicine, phytochemistry and pharmacology. *Journal of ethnopharmacology*, *138*(2), pp.314-332.

Magara, H.J.O., Midega, C.A., Otieno, S.A., Ogol, C.K.P.O., Bruce, T.J., Pickett, J.A., Khan, Z.R. (2015). Signal grass (Brachiaria brizantha) oviposited by stemborer (Chilo partellus) emits herbivore-induced plant volatiles that induce neighbouring local maize (Zea mays) varieties to recruit cereal stemborer larval parasitoidCotessia sesamiae. *International Journal of*

Sciences: Basics and Applied Research, *19*, pp.341-357.

Malo, E.A., Castrejón-Gómez, V.R., Cruz-López, L., Rojas, J.C. (2004). Antennal sensilla and electrophysiological response of male and female Spodoptera frugiperda (Lepidoptera: Noctuidae) to conspecific sex pheromone and plant odors. *Annals of the Entomological Society of America*, *97*(6), pp.1273-1284.

McCormick, A.C., Unsicker, S.B., Gershenzon, J. (2012). The specificity of herbivore-induced plant volatiles in attracting herbivore enemies. *Trends in plant science*, *17*(5), pp.303-310.

Midega, C.A., Pittchar, J.O., Pickett, J.A., Hailu, G.W., Khan, Z.R. (2018). A climate-adapted push-pull system effectively controls fall armyworm, Spodoptera frugiperda (JE Smith), in maize in East Africa. *Crop protection*, *105*, pp.10-15.

Nanayakkara, D., Jayatilake, D., Kodithuwakku, S. (2020). Development of a single nucleotide polymorphism-based DNA marker for fall armyworm (Lepidoptera: Noctuidae) biotyping: a case study from the fall armyworm outbreak in Sri Lanka. *The Canadian Entomologist*, *152*(6), pp.762-771.

Preeti, S., Deo, S.B. and Nath, T.K. (2014). Comparative in vitro regeneration study of mature and juvenile nodal explants and extraction, isolation, characterization of bio-active constituents from leaves of an endangered medicinal plant Desmodium gangeticum (L.) DC. *Research Journal of Chemistry and Environment*, *Vol*, *18*, p.2.

Sadek, M.M. (2003). Antifeedant and toxic activity of Adhatoda vasica leaf extract against Spodoptera littoralis (Lep., Noctuidae). *Journal of applied entomology*, *127*(7), pp.396-404.

Sermakkani, M. and Thangapandian, V. (2012). GC-MS analysis of Cassia italica leaf methanol extract. *Asian J Pharm Clin Res*, *5*(2), pp.90-94.

Sharanabasappa, P.H. and Adiveppar, M.M.N. (2018). Efficacy of different newer insecticides against mango leaf hoppers. *J Entomol Zool Studies*, *6*, pp.834-837.

Sharma, A., Shrestha, G. and Reddy, G.V. (2019). Trap crops: how far we are from using them in cereal crops?. *Annals of the Entomological Society of America*, *112*(4), pp.330-339.

Sisay, B., Tefera, T., Wakgari, M., Ayalew, G. and Mendesil, E. (2019). The efficacy of selected synthetic insecticides and botanicals against fall armyworm, Spodoptera frugiperda, in maize. *Insects*, *10*(2), p.45.

Yu, S., Xiong, G., Cheng, H., Cheng, S., Xiao, L., Wu, Z. and Zhu, W. (2014). Influence of different extraction methods on Perilla frutescens leaf volatile components. *Journal of Southern Agriculture*, *45*(1), pp.108-111.

Zalucki, M.P., Clarke, A.R. and Malcolm, S.B. (2002). Ecology and behavior of first instar larval Lepidoptera. *Annual review of entomology*, *47*(1), pp.361-393.

Zhi, K.K., Yang, Z.D., Shi, D.F., Yao, X.J. and Wang, M.G. (2014). Desmodeleganine, a new alkaloid from the leaves of Desmodium elegans as a potential monoamine oxidase inhibitor. *Fitoterapia*, *98*, pp.160-165.

.

Field Assessments of Bell Pepper Varieties Produced in the Dry Zone of Sri Lanka

Musthapha Mufeeth[1*] & A.N.M. Mubarak[2]

[1,2]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*]mufeeth.mohammathu@seu.ac.lk, [2]anmubarak@seu.ac.lk

Abstract- *Bell pepper is a high valued crop that is commonly grown in controlled environments in the wet and intermediate zones of Sri Lanka. However, lesser efforts have been made in evaluating the field performances in the dry zones, hence, this study aims to elucidate the field performances of three commercial elite varieties of bell pepper viz Ganga (green), Indra (red), and Polarized (yellow). The field experiments were carried out at Agrotech park, Malwatta in the Ampara district was laid out in a randomized complete block design with three replicates in each plot size of 2.25m x 2.25m. The plant morphological and fruit characteristics were analysed at the harvesting stage. The results showed that the variety Ganga (green) performed superior to the remaining two varieties as it possessed improved field plant survival rates (78.6 %), fruit set, and significantly improved the number of fruits (7 Nos/plant) hence, the overall highest number of yields per plant (394.6 g/plant). Therefore, this study hints that the farmers in the dry zone may cultivate successfully the green bell pepper varieties (var. Ganga) at home garden levels or as commercial cultivation in the open fields, which may serve as an alternative viable source of income than the conventional cash crops. Moreover, to confirm the quality of fruits produced in this region, further researches are needed to elucidate the fruit quality through sensory evaluations and fruit pericarp chemical compositions at laboratory levels.*

Keywords: Bell pepper, dry zone, open field, yield

I. INTRODUCTION

Bell pepper (*Capsicum annum* L.) belongs to the family Solanaceae and native to Mexico, Central and South America (Echer *et al*., 2002). The plant produces fruits in a variety of colours, including red, yellow, orange, green, white, and purple cultivars, and the fruits are botanically classified as berries. At present, the bell pepper is vastly produced in China, Mexico, Turkey, Indonesia, Spain and United States (FAOSTAT, 2017). In Sri Lankan context, the bell pepper is grown mostly in the intermediate and wet zone under the protected agricultural systems in polytunnel with the provision of drip irrigation combined with expensive Albert hydroponic solutions to promote quality and fruit yield. Therefore, this crop is recognized as a high valued crop as it requires expensive structural facilities with sophisticated set-ups to maintain the temperature within 21^{o} C to 25 ^{o} C (Department of Agriculture Sri Lanka (DOA), 2015), relative humidity(>70%), proper air circulation within the crop canopies and the optimal supply of nutrient solutions to the root zone. Locally, the bell pepper has an increasing demand and the extent of cultivation is rising in wet zones under the provision of such sophisticated plant growth conditions. In a recent study, it has been shown that the bell pepper was cultivated in 3,678 hectares and annual production was 32,309 Metric tons (Department of Census and Statistics, 2019). The fresh yellowish and greenish bell pepper have export potential in Sri Lanka. Therefore, it is considered one of the potential crops to boost the economic growth of the country.

The economically important part of this crop is demanded as a key ingredient for the preparation of premium foods like salads, stews, salsa, and pizzas etc. in star hotels and fast-food chains. Consumers prefer this fruit owing to its health benefits as the fruit contains vitamin A, vitamin C, potassium and a healthy dose of fibre, folate, and iron (Denev *et al.*, 2019). Further, the fruit is widely used for diverse applications as food additives, health and cosmetic products, pest control agents in agricultural fields, etc

The exploration of morphological characteristics is considered an important avenue to understanding the diversity among crops (Assefa *et al.*, 2014). In recent years, morphological characteristics of 25 genotypes of bell pepper have been investigated in the open field condition in dry zones of India (Sood, Sood and Vidyasagar, 2011) and reveal that diverse morphological variations were observed in plant growth and branching

habit, fruit shape and colour. Moreover, phenotypic diversity and capsaicinoid content for nine chilli pepper landraces from the western Yucatan peninsula in Maxico is reported to show the diversity among landraces. (Castillo-Aguilar *et al.*, 2021). Similarly, the fruit characteristics of green, yellow and red varieties grown inside poly-tunnel were reported and seem to have significant morphological differences among capsicum species (Zhigila *et al*., 2014). Moreover, bell peppers have the potentials to grow organically, and a recent study revealed that composted farmyard manure treatment enhanced bell pepper growth and yield, as the application of organic matter improves soil properties (Gopinath *et al.*, 2009).

In this context, the dry zone of Sri Lanka has massive potentials for growing vegetables as this region contains a vast area of arable land with the availability of ample labour force compared to the other two regions. As outline earlier, bell pepper cultivation in polytunnels is largely ignored and a less popular crop in dry zones as the initial cost for constructing polytunnels are far expensive than conventional farming, non-affordable by a poor farmer, require sound technologies with efficient energy management strategies. Moreover, it is presumed that such high valued crops cannot be grown in the open fields and the predicted yield performance and quality of produces may be in a dilemma when the quality is concerned by local consumers and the food industries. Therefore, this research aims to explore the potentials for growing elite bell pepper varieties in the open fields and to systematically analyze the morphological and fruit characteristics produced such conditions in the Ampara district.

II. METHODOLOGY

A. Field Condition

A field trial was carried out between October 2018 to January 2019 at the Agro Tech Park, Malwatta (7°20'N and 81°44'E altitude 16.0 m above sea level) located in the Ampara district of Sri Lanka. Monthly average rainfall and temperature data were collected for five years (2012 to 2017) from the nearest metrological station at Pottuvil, Department of Metrology Sri Lanka Furthermore, Photo synthetically Active Radiation values (PAR) were recorded by employing an external light sensor of ceptometer (SC-1, Decagon Devices Inc, USA) throughout the trial period.

B. Field Establishment

Three varieties viz Ganga (green), Polarized (yellow), and Indra (red) of bell pepper plants (*Capsicum annuum L.*) were established in germination trays and maintained in propagators to ensure high humidity and optimal temperature to promote uniform germination. Then, seedlings were field transplanted at the six leaves stage with the spacing of 45 x 45 cm. The field experiment was laid out in randomized complete block design with three replicates containing each plot size of 2.25m x 2.25m. Then the standard agronomic practices of Chili recommended by DOA were practiced. Because there is no such recommendation has been released for open field bell pepper cultivation. Hence, the basal dressing was applied at the rates of 100kg/ha of P_2O_5, and 50 kg/ha of K_2O. Subsequently, applied urea as a top dressing in four splits at 2, 4, 8, and 12th weeks after field planting at a rate of 475kg/ha. In addition, MOP at the rate of 50 kg/ha was applied with the third top dressing. Plants were irrigated manually as per the crop requirement.

C. Data Collection

At the flowering stage, the plant height was measured using 1 mm least count measuring tape and the number of survived plants were counted in each plot. Subsequently, at post-flowering stage, five plants per treatment were randomly selected and following measurements were taken. (i) The number of productive branches based on the fruit set per branch (ii) at two-week interval, number of mature fruits and yield per plant.

Then the fruit characteristics at physiological maturity stage were collected. Twenty-five fruits of each variety were randomly selected from the harvest. Then individual weight of fruits was measured using 0.001 gram least count electronic digital balance. The longitudinal length of the fruit was measured using a 1 mm least count foot ruler. The fruit circumference was measured by tightly wrapping the fruit with a single strand thread, and then the actual length of tread was taken. Then the fruit was transversely cut opened to measure the pericarp thickness and the breadth, were measured by 0.02 mm least count veneer caliper. Finally, the number of lobes per fruit was counted. The collected data of each parameter were used to test their significant differences among the bell pepper varieties using SPSS statistical software. The hypothesis were statistically tested using one-way ANOVA with Tukey's post-hoc test at 5 % significant level.

III. RESULTS AND DISCUSSION

A. Climatic Condition during Experimental Period

The natural weather condition during the experimental period (October 2018 to January 2019) is displayed in Table 01.

Table 01: Mean rainfall received and daily recorded temperature at Agro-Tech Park

Month	Rainfall (mm)			Temperature (^{0}C)		
	Mean ± SD	Min	Max	Mean ± SD	Min	Max
October	152.37 ± 82.01	12.80	249.50	32.51 ± 1.01	31.35	33.79
November	299.90 ± 144.13	84.30	496.80	30.77 ± 0.45	30.20	31.52
December	341.43 ± 210.19	39.40	658.90	29.95 ± 0.91	28.86	31.03
January	235.90 ± 184.84	7.00	433.90	29.96 ± 0.71	29.31	30.94

Table 02: Plant phenotypic characteristics of three bell pepper varieties

Characteristics		Indra (Red)	Polarized (Yellow)	Ganga (Green)	P - Value
	n	Mean ± SE	Mean ± SE	Mean ± SE	
Plant height (cm)	28	30.61 ± 1.55 [a]	32.07 ± 1.56 [a]	31.84 ± 0.91 [a]	0.721
Number of productive branches	28	6.93 ± 0.63 [a]	7.24 ± 0.52 [a]	7.09 ± 0.39 [a]	0.915
Seedling Survival Rate (%)	15	64.30 ± 7.82[a]	57.14 ± 3.91[a]	78.57 ± 8.14[b]	0.048

The superscript with different letters indicates significant differences between bell pepper varieties (p-value < 0.05)

The average mean monthly rainfall was ranged from 152 – 235 mm, and temperature ranged from 30 – 32.5 ^{0}C respectively. This result reveals the experimental site was experiencing typical dry zone climatic conditions with intermitted rainfall. Through supplying the regular intervals of irrigation, crop water requirements can be substituted. Similarly, the high intensive solar radiation is another avenue to consider when open cropping is considered. Here, the average PAR value during the experimental period was 1856.4 µmol m^{-2} s^{-1} (Data is not shown) which may promote photosynthesis to a certain extent in crops. Though, the extreme levels of PAR can cause photo oxidative stress in crops. Hence, bell pepper varieties with improved physiological characteristics may perform well under high sunlight intensities.

B. Morphological Characteristics of Plants

Bell pepper seedling survival rate was assessed one month after field planting. The result revealed that the variety Ganga showed a significantly ($p<0.05$) higher survival rate (78%) whereas var. Polarized (yellow) and Indra (Red) displayed 58 % and 64 %, respectively (Table 02).

The mean plant height of each variety was ranging from 30 cm to 32 cm, and there were no significant differences seen among the three varieties. Moreover, the number of productive branches per plant showed insignificant differences among tested varieties (7 per plant). In previous open field studies, it has been noted that the bell pepper genotypes plant height varied from 31 to 70 cm whereby all genotypes produced were blocky shape fruits (Sood, Sood and Vidyasagar, 2011).

C. Fruit and yield characteristics

The fruit characteristics of all three bell pepper varieties were compared at their physiological maturity. The most important commercial trait for bell pepper relies on its fruit characteristics. Here, the variety Ganga possessed significantly higher ($p<0.05$) and had approximately 5 lobs per fruit compared to the remaining two varieties (Table 03). Conversely, fruit length had displayed insignificant differences. Interestingly, there were significant differences were seen for fruit circumferences and as for the fruit breadth. Variety Ganga produced the highest circumferences and (211.50 mm, $p<0.05$) and fruit breadth (64.36 mm) among the tested lines -

Table 03: Fruit characteristics of three bell pepper varieties

Characteristics	Indra (Red)	Polarized (Yellow)	Ganga (Green)	P-Value
	Mean ± SE	Mean ± SE	Mean ± SE	
Number of lobs (locules)	3.8 ± 0.27 [a]	3.96 ± 0.23 [ab]	4.83 ± 0.29 [b]	0.023
Length (mm)	59.75 ± 2.07 [a]	60.22 ± 1.84 [a]	60.98 ± 1.76 [a]	0.899
Circumference (mm)	189.74 ± 5.08 [a]	197.40 ± 5.49 [ab]	211.67 ± 3.32 [b]	0.007
Breadth (mm)	56.64 ± 1.87 [a]	57.50 ± 1.77 [a]	64.36 ± 1.19 [b]	0.002
Weight (g/fruit)	67.95 ± 4.86 [a]	72.62 ± 4.93 [ab]	84.45 ± 3.76 [b]	0.037

The superscript with different letters indicates significant differences between bell pepper varieties (p-value < 0.05), (n = 5).

The pericarp of the fruit is a crucial parameter in determining fruits' pungency, taste, and crispiness. Moreover, it is more closely related to the fruit yield (Weryszko-chmielewska and Micha, 2011). In addition, the level of chemical composition and synthesis rates is determined by the pericarp thickness. Here, the variety Indra possessed the thickest pericarp while the green variety had displayed the second-highest thickness. The present study further revealed that the inverse relationship between pericarp thickness and the yield were observed.

In a previous study, the green, red, and yellow varieties' average fruit lengths were 71.36 mm, 42.35mm and 126.69 mm, respectively. Similarly, the corresponding average fruit breadth was 45.37 mm, 35.57 mm and 44.94 mm, respectively (Sood, Sood and Vidyasagar, 2011).

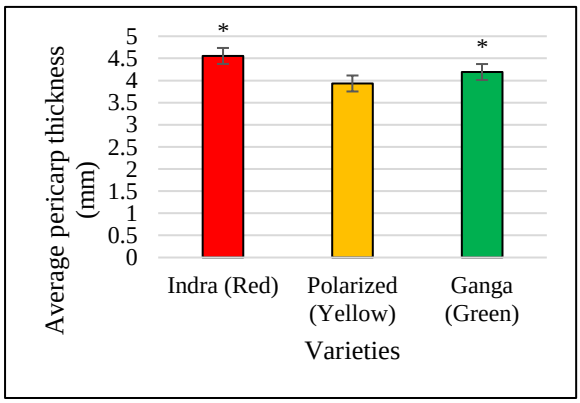


Figure 1: Pericarp thickness of three varieties of bell pepper fruits. The symbol (*) indicates significant differences between bell pepper varieties (p-value <0.05), (n=5)

Moreover, Ballina-Gómez *et al*., (2013) studied 47 morphological characteristics of bell pepper accessions grown in a controlled environment and reports that the optimized number of fruit locules (3 Nos) with fruit length (50 mm) and thickness (2.0 mm) is produced. These findings are in line with our present study emphasizing quality of filed grown bell pepper can be maintained.

The fruit yield was compared. It was observed that significantly ($p<0.05$) higher yield per plant was obtained in green varieties (394.6 g/plant). However, the yield of yellow and red plants was relatively lower in the open field conditions (Figure. 2). Similarly, the variety Ganga produced significantly ($p<0.05$) increased fruits weight (84.45g/fruit) than the counterparts, while the second-highest was seen in variety Polarized (72.6g/fruit) (Table 03). These findings elucidate, the Ganga bell pepper variety has the potential to grow in open fields of dry zones conditions, specifically in DL 2 band as it seems to possess fairly improved drought tolerance characteristics.

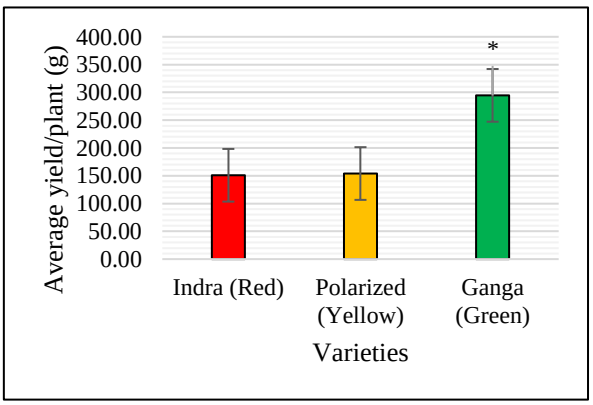


Figure 2: Average yield per plant of three bell pepper varieties. The symbol (*) indicates significant differences between bell pepper varieties (p-value <0.05), (n=5)

In a previous study conducted by Sood *et al.* (2009) reported that the bell pepper cultivated under an open field and humid temperate climatic condition, the green and yellow varieties yielded 336.5 g/plant and 222.3 g/plant, respectively. This shows that field-grown bell peppers particularly variety Ganga has the potential to produce acceptable fruit size and yield per plant compared

to other varieties. This may contradict the observations that field-grown bell pepper produces relatively smaller fruits than that grown under optimally controlled polytunnel environments (Singh, Singh and Gupta, 2011).

Therefore, the above observation reported in the present experiment may be a result of variations in the genetic make-up of the tested varieties as most of the plant physiological characteristics are determined by dozens of genes. For the adaptation of dry zones, optimal leaf stomatal conductance and the presence of optimal cuticle wax on greener surfaces assist to maintain increased photosynthetic rates while to minimize water losses (transpiration). In recent studies, the studies with the green bell pepper varieties seem to possess more chloroplast in mitochondria than red and yellow fruits hence the metabolic enzyme in the peroxisome are high and respond positively in fruit quality (Palma *et al*., 2015). Similarly, it may also be speculated the leaf level mechanism may also be possible to minimize photooxidative stresses in the high performing bell pepper varieties. Moreover, drought resistance may also rely on root trait as well, deeper root systems with efficient absorption of water and nutrients have advantageous over the traits with shallow rooting systems. However, the present studies were not focused on these avenues to validate the predictions.

Fruit characters are been controlled by three to ten pairs of genes with a heritability value of 40 to 50 per cent in Capsicum (Zhigila *et al*., 2014). Moreover, the fruit traits might also have been the direct influence of agronomic practices and the prevalence of environmental conditions. Typically, bell pepper grown in increased humidity seems to produce succulent and larger fruit, while in this study, the green variety produced relatively larger and eye-appealing fruit characteristics compare to the other tested lines. This occurrence may have a direct impact on dry zone farmers that can speculate that bell peppers can be successfully grown under open fields in dry zones.

IV. CONCLUSION

Bell pepper is a high valued crop that is commonly grown in controlled environments in the wet and intermediate zones of Sri Lanka. Here, we showed that certain bell pepper varieties, in fact, can be successfully grown in open field condition in the dry zones of Sri Lanka with no detrimental impacts on either crop physiological processes or the fruit harvest. Although we applied minimal level of inexpensive fertilizer dosages while excluding the classical Albert hydroponic solution that ensures minimal impacts on environment. Hence, these observations have some profound implications for the local farmers. First, green bell pepper varieties (var. Ganga) can be successfully grown at home garden levels or be practiced as commercial farming in the dry zones, which may serve as an alternative crop for conventional cash crops such as chilli, okra, and brinjal. Second, there is an opportunity to improve the income of local farmers as the bell pepper offers premium prices than conventional cash crops. However, our researches have been limited to crop yield trials, though any future avenues in organic farming, sensory evaluations, assessing chemical composition of fruit pericarp produced in the dry zone will increase the promotion of bell pepper further.

REFERENCES

Assefa, Y. *et al.* (2014) 'Corn and Grain Sorghum Morphology, Physiology, and Phenology', in *Corn and Grain Sorghum Comparison*. Elsevier, pp. 3–14. doi:10.1016/B978-0-12-800112 7.0000 2-9.

Ballina-Gómez, H. *et al.* (2013) 'Morphological characterization of Capsicum annuum L. accessions from southern Mexico and their response to the Bemisia tabaci-Begomovirus complex', *Chilean Journal of Agricultural Research*, 73(4), pp. 329–338 doi:10.4067/S0718-58392013000400001.

Castillo-Aguilar, C. C. *et al.* (2021) 'Phenotypic diversity and capsaicinoid content of chilli pepper landraces (Capsicum spp.) from the Yucatan Peninsula', in *Plant Genetic Resources*. Cambridge University Press, pp. 1–8.

Denev, P. *et al.* (2019) 'Phytochemical composit -ion and antioxidant activity of 63 Balkan pepper (Capsicum annuum L.) accessions', *Journal of Food Measurement and Character ization*, 13(4), pp. 2510–2520. doi:10.1007/s1169 4-019-00171-y.

Department of Census and Statistics (2019) *Highland Crops*. Available at: http://www.statist ics.gov.lk/agriculture/hcrops/index.html (Accesse -d: 19 November 2019).

Echer, M. M. *et al.* (2002) 'Evaluation of Capsicu -m genotypes for resistance to the broad mite', *Hortic. Bras*, 20(2), pp. 217–221.

FAOSTAT (2017) *Production quantities of Chillies and peppers, dry by country*. Available at: http://www.fao.org/faostat/en/#data/QC/visualize (Accessed: 19 November 2019).

Gopinath, K. A. *et al.* (2009) 'Bell pepper yield and soil properties during conversion from conventional to organic production in Indian Himalayas', *Scientia Horticulturae*, 122(3), pp. 339–345. doi: 10.1016/j.scienta.2009.05.016.

Palma, J. M. *et al.* (2015) 'Physiology of pepper fruit and the metabolism of antioxidants: Chloroplasts, mitochondria and peroxisomes', *Annals of Botany*, 116(4), pp. 627–636. doi: 10.1093/aob/mcv121.

Singh, A. K., Singh, B. and Gupta, R. (2011) 'Performance of sweet pepper (Capsicum annum) varieties and economics under protected and open field conditions in Uttarakhand', *Indian Journal of Agricultural Sciences*, 81(10), pp. 973–975.

Sood, S. *et al.* (2009) 'Genetic Variation and Association analysis for fruit yield, agronomic and quality characters in bell pepper', *International Journal of Vegetable Science*, 15(3), pp. 272–284. doi: 10.1080/19315260902875822.

Sood, S., Sood, R. and Vidyasagar (2011) 'Morphological characterization of bell pepper (Capsicum annuum var. grossum) genotypes and their application for distinctness, uniformity and stability testing', *Indian Journal of Agricultural Sciences*, 81(3), pp. 240–246.

Weryszko-chmielewska, E. and Micha, Z. (2011) 'Anatomical traits of sweet pepper (Capsicum annuum L.) fruit', *Acta Agrobotanica*, 64(4), pp. 181–188.

Zhigila, D. A. *et al.* (2014) 'Fruit morphology as taxonomic features in five varieties of capsicum annuum L. solanaceae', *Journal of Botany*, 4(1), pp. 1–6. doi: 10.1155/2014/540868.

Morphological Characterization of Selected *Capsicum* Accessions and Development of Species Identification Key for Chili

M.G.S.S. Mulathagedara[1], M.N.F. Nashath[2], D.S. Kekulandara[3] & A.N.M. Mubarak[4*]

[1,2,4]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*
[3]*Plant Genetic Resources Centre Gannoruwa, Peradeniya, Sri Lanka*

[1]sachinisamanthikaa25@gmail.com, [2]nasath17.mn@seu.ac.lk, [3]deepthikasaman@gmail.com, [4*]anmubarak@seu.ac.lk

Abstract- *Capsicum is widely grown as an essential spice crop in Sri Lanka. The existing germplasms of Capsicum conserved at Plant Genetic Resource Centre (PGRC), Gannoruwa were initially identified as two species, Capsicum annuum, and Capsicum frutescens, instead, it is hypothesized that there may be additional genotypes within the existing germplasm collections. Hence, the present study was focused on evaluating twelve Capsicum accessions and to characterize morphologically including 24 qualitative and seven quantitative traits to assess the genetic diversity among plants. The experiments were carried out at the open field and protected house of PGRC, Gannoruwa by randomized complete block design with four replicates. Morphological characters were analyzed using analysis of variance (ANOVA) and multivariate methods. Significant variance among genotypes was obtained for most of the quantitative characteristics ($p<0.05$). Early flowering (41d) and fruiting (69d) was observed in accessions C-2018-12-232, NM-9-3-R1, NM-6-2-R2-B, and ACC# 1249B, while the remainder accessions exhibited late flowering (>47d) and harvest (>75d) nature respectively. Principal component (PC) analysis explained more than 73.12 % of total variability for the first three components. PC1 was highly positively correlated with seed beak prominence, corolla color, and seed shape, while PC2 was highly correlated positively with fruit color, shape at the blossom end, and fruit positions. Hence this study attempted to develop a species identification key for chili species by employing morphological traits, though seed shape can be considered as a power tool. Moreover, the dendrogram confirmed that the germplasms resemble into three chili species as C. annuum, C. chinense, and C. frutescens.*

Keywords: Capsicum accessions, Germplasms, Morphological characterization, Principal component analysis

I. INTRODUCTION

Capsicum spp. (2n=24), commonly called chili pepper is one of the most cultivated spice crops belongs to family Solanaceae. It is grown worldwide for its high economic importance as a spice and vegetable crop (Orobiyi *et al*., 2013). Genus *Capsicum* consists of around 32 species, among five of them (*C. Annuum, C. frutescens, C. chinense, C. baccatum, and C. pubescens*) were domesticated (Jing *et al*., 2013). Global estimated average production of chili peppers is 34.5 million tons (FAOSTAT, 2018). *Capsicum* is a great source of vitamins, minerals, amino acids and secondary metabolites such as carotenoids, ascorbic acid and flavonoids which have both nutritional and medicinal values (Pawar *et al*., 2011).

It is an evidence that chili pepper was originated in South America in 7500 BC (Andrews, 1999). During 15th and 16th centuries chili pepper was introduced to the Europe, Africa, and Asia. It was used as a substitute for expensive "Black Pepper" imported from Asia. Historically, chili pepper was utilized for decoration and seasoning purposes and now it is used in medicine and pharmaceutical industries (Paran and Van Der Knaap, 2007). The main chemical compound in chili pepper is capsaicin which is a lipophilic chemical (Lu *et al*., 2020; Zhang *et al*., 2020). Medicinally, capsaicin is being used to treat pain (Hall *et al*., 2020). At present, it is the most recommended tropical medication for arthritis (Kwenin *et al*., 2011). Further, various chili pepper varieties contain high levels of antioxidant vitamins A, C and E. *Capsicum* is rich in vitamin C, pro vitamin A, E, P (citrin), B1 (thiamine), B2 (riboflavin), and B3 (niacin) (Samira *et al*., 2013; Gupta, 2015). Antioxidants in foods have been the subject of extensive studies for cancer prevention (Antonious *et al*., 2009).

In Sri Lanka, chili pepper is an important cash crop cultivated especially in the northern and north-central provinces. Currently, the chili

pepper growing regions are Anuradhapura, Moneragala, Ampara, Puttalam, Vavuniya, Kurunegala, Hambantota and Mahaweli System H (DOA, 2020). Commonly cultivated chili pepper species are *Capsicum annuum* and *Capsicum frutescens*. They are consumed as spices for their specific flavor, aroma and pungency (Menike e*t al*., 2018). According to the Department of Agriculture (2020), Sri Lanka, annual per capita consumption of dry chili pepper is estimated as 2.84 kg and the national annual requirement of dry chili pepper is around 57,400 Mt. Although chili pepper is widely grown for dry chili production, a portion of the crop is harvested as green pods. Currently, the average area under chili pepper cultivation is around 13, 000 ha, with 2/3 of that being cultivated during *Maha* season (DOA, 2020).

Evaluation of genetic diversity is an essential tool for crop breeding programs to develop improved varieties having enhanced productivity and resistance to biotic and abiotic stresses. There are more than 600 accessions of *Capsicum* conserved at Plant Genetic Resource Centre (PGRC), Gannoruwa, Sri Lanka. Initially, these germplasms were identified as two species, *Capsicum annuum* (Amu miris) and *Capsicum frutescens* (Nai miris and Kochchi miris). But, it is hypothesized that there may be additional species within existing germplasm collections. It is necessary to correctly define and evaluate these accessions conserved in the gene bank in order to make them available for crop breeding programs. Genetic diversity of a population can be studied through germplasm characterization that can be performed using morphological, biochemical and molecular techniques. Plant Genetic Resources Centre, Gannoruwa is the main germplasm collection center of Sri Lanka and PGRC has developed species identification keys for several crops, but not for chili germplasms. Therefore, this study was aimed to characterize 12 *Capsicum* accessions conserved in PGRC, Gannoruwa morphologically to identify the diversity and latent potentials for use in *Capsicum* improvement program in Sri Lanka and to develop a key for easy identification of chili species.

II. MATERIALS AND METHODOLOGY

A. Experimental site and planting materials

A field trial was established at Plant Genetic Resources Center (PGRC), Gannoruwa, Sri Lanka (7^{o} 27'N and 80^{o} 60'E; altitude 473 m above sea level) from December 2020 to April 2021 with a total of twelve *Capsicum* accessions including *C. Annuum, C. frutescens* and *C. chinense* (Table 1) conserved at PGRC, Gannoruwa. Initially, *Capsicum* seeds were grown in germination trays inside a greenhouse. After three weeks, seedlings were transplanted to the raised type of field plots. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replicates. Seedlings were grown according to the recommendation of DOA, Sri Lanka (45 cm X 60 cm).

Table 1: Accessions of Capsicum annuum, Capsicum frutescens and Capsicum chinense used in this study

No	Accessions	Treatments	Species
1	ACC# 1249B	T1	*Capsicum annuum*
2	NM-9-3-R1	T2	*Capsicum annuum*
3	NM-6-2-R2-B	T3	*Capsicum annuum*
4	C-2018-12-232	T4	*Capsicum annuum*
5	NM-3-2-R1	T5	*Capsicum chinense*
6	NM-6-2-R2-A	T6	*Capsicum chinense*
7	NM-3-4-R1	T7	*Capsicum chinense*
8	NM-6-R-2	T8	*Capsicum chinense*
9	C-2018-11-139	T9	*Capsicum frutescens*
10	C-2019-4-165	T10	*Capsicum frutescens*
11	ACC# 08149	T11	*Capsicum frutescens*
12	C-2018-12-246	T12	*Capsicum frutescens*

Table 2: Descriptors of qualitative and quantitative morphological traits used to characterize chili in Plant Genetic Resources Centre, Gannoruwa.

Parameter	Descriptors
Qualitative characters	
(SBP) Seed beak prominence	1:Nub, 2: Medium
(CC) Corolla color	1:White, 2: Light yellow, 3: Yellow, 4: Yellow-green, 5: Purple with white base, 6: White with purple base, 7: White with purple margin, 8: Purple, 9: Other (specify)
(SS) Seed shape	1: Reniform, 2: circular with fish mouth, 3: teardrop
(CM) Calyx margin	1: Entire, 2:Intermediate, 3: Dentate
(LC) Leaf color	Recorded when in 50% of the plants the first fruit has begun to ripen. Based on 10 leaves on the main branches of the plant.
(PGH) Plant growth habit	Observed when 50% of the plants bear ripe fruits. 1: Prostrate, 2: Intermediate (compact), 3: Erect, 4: Other (specify)
(LS) Leaf shape	1: Deltoid, 2:Ovate, 3: Lanceolate
(FS) Fruit set	Recorded before harvest. 1: Low, 2: Intermediate, 3: High
(NA) Nodal anthocyanin (whole plant)	1: Green, 3: Green with purple, 4: Purple, 5: Dark purple
(BH) Branch habit	1: Sparse,2:Intermediate, 3:Dense
(LP) Leaf pubescence	Observed on the youngest mature leaves. Same stage as in 10.1: Sparse, 2: Intermediate, 3: Dense
(FCM) Fruit color maturity (ripe fruit color)	1: White, 2: Lemon-yellow,3: Pale orange-yellow, 4: Orange yellow, 5: Pale orange, 6: Orange, 7: Light red, 8: Red, 9: Dark red, 10: Purple, 11: Brown, 12: Black, 13: Other (specify)
(FS) Fruit shape	1: Elongate, 2: Almost round, 3: Triangular, 4: Campanulate, 5: Blocky, 6: Other (specify)
(FSB) Fruit shape at blossom end	Average of 10 fruits.1: Pointed, 2: Blunt, 3: Sunken, 4: Sunken and pointed., 5: Other (specify)
(FP) Fruit position	1: Up, 2: Down
(FCI) Fruit color at intermediate stage	Recorded on fruits just before the ripening stage. 1: White, 2: Yellow, 3: Green, 4: Dark green, 5: Orange, 6: Purple, 7: Deep purple, 8: Other (specify)
(FSP) Fruit shape at pedicel attachment	1: Acute, 2:Obtuse, 3: Truncate, 4:Cordate, 5: Lobate
(FP) Flower position	Recorded at anthesis.1: Pendant, 2: Intermediate, 3: Erect
(SP) Stem pubescence	Recorded on mature plants, excluding the first two nodes below the shoot. 1: Green, 3: Green with purple, 4: Purple, 5: Dark purple
(AC) Anther color	Observed immediately after blooming before anthesis. 1:White, 2:Yellow, 3:Pale blue, 4:Blue, 4:Purple, 5:Other (specify)
(SC) Stem color	Recorded on young plants before transplanting 1:Green, 2:Green with purple stripes, 3:Purple, 4:Other (specify)
(SE) Stigma excretion	In relation to anthers at full anthesis. Average of 10 stigmas from representative flowers selected from 10 random plants. 1:Inserted, 2:Same level, 3:Exerted
(CAC) Calyx annular constriction	At junction of calyx and pedicel. Observed at mature stage 1:Absent, 2:Present

(AS) Anthocyanin spots or strips on the fruit	Recorded just before the ripening stage 0:Absent, 1:Present
Quantitative characters	
(DF) Days to flowering (Days)	Number of days from sowing/ transplanting until 50 % of plants have at least one open flower.
(DF)Days to fruiting (Days)	Number of days from transplanting until 50 % of the plants bear mature fruits at the first and second bifurcation.
(NFA) Number of flowers per axil	1: One, 2: Two, 3: Three or more, 4: Many flowers in bunches but each in individual axil (fasciculate growth), 5: Other (specify)
(LW) Leaf width (cm)	Same stage as in 10 Measured on the widest part of the leaf. Use same leaves as in 13.
(MLL) Leaf length (cm)	Same stage as in 10. Average of 10 leaves.
(PH) Plant height (cm)	At flowering stage 1: <25, 2: 25-45, 3: 46-65, 4: 66-85, 5: >85
(TSW) Thousand seed weight (g)	(100×10)

B. Crop management

Field was fertilized with Urea, TSP and MOP at the rate of 200 Kg/ha, 220 Kg/ha and 130 Kg/ha respectively. Half of the urea, MOP and entire quantity of TSP were applied as basal dose and remaining 50 % of urea and MOP were added four weeks after planting. Plants were watered twice a day and weeding was done once a week manually. Gap-filling was done by replacing the unhealthy seedlings with healthy plants whenever necessary.

C. Data collection and statistical analysis

Data were recorded on 24 qualitative and 7 quantitative morphological characters (Table 2) and analyzed using Statistical Package for Social Sciences (SPSS). Analysis of variance and two multivariate analysis methods: Principal Component Analysis (PCA) and hierarchical cluster analysis were performed to analyze the data.

III. RESULTS AND DISCUSSION

A. Analysis of variability in quantitative morphological traits

Analysis of variance revealed significant differences among genotypes for most of the quantitative characteristics viz; plant height, leaf length and width, days taken to flowering and fruiting, number of flowers per axil and 1000 seed weight at 0.05 % probability level (Table 3). Chili accession NM-6-2-R2-B (T3) had the highest plant height (74.5 cm) while NM-3-4-R1 (T7) and NM-6-R-2 (T8) both had the lowest value (35.25 cm). It shows that the former accession seems to display tall and bushy types while the latter two were with dwarf appearances. The mean length and width of leaves were also showed diversified in nature. The highest leaf length (13.13 cm) and width (8.93 cm) was noticed in T8 while the lowest length (7.83 cm) and width (2.6 cm) was observed in ACC# 08149 (T11) and C-2018-12-232 (T4) respectively. This indicated that the T8 possessed broader long leaves, while on contrary, T11 and T4 had narrower short leaves. The 50% flowering dates showed an interesting feature, the accessions ACC# 1249B (T1), NM-9-3-R1 (T2), NM-6-2-R2-B (T3) and C-2018-12-232(T4) had displayed early flowering nature (41 days) whilst the remainder treatments required greater than 47 days (Table 3). The diversified nature in this greater important agronomic trait elaborates the persistence of two distinct groups can be seen within the tested chili accessions viz; the early flowering versus the late flowering habits. Moreover, the number of flowers per axil were compared, four accessions displayed significantly lower number of flowers with one flower per axil (T1, T2, T3 and T4), while T5 and T7 had produced an average of 2.75 flowers per axil. Similar trends were also be seen for the days taken for fruiting. Typically, early flowering accessions had produced physiologically matured pods at around 69 days, conversely, the remainder treatments required greater than 75days to harvest. From these observations, it can be elucidated that both groups of chili accessions require additional 28 days from flowering, to obtain the first harvest, hence it seems that both growth and development of pods constricted within a month. In recent

studies, it has been reported that the commercial elite varieties of chili cultivated by Sri Lankan farmers require 63 to 80 days taken for 50 % flowering while fruiting is expected to obtain between 75 to 110 days after field planting respectively (DOA, 2020). The remarkable finding of our present study elucidates the latent potentials of chili accessions preserved in the PGRC, Gannoruwa in early flowering and fruiting which is considered as preferred traits than those of requiring increased days, thus, these promising lines can be used in crop improvement programs.

Further, the dried seeds were obtained through processing the physiologically matured pods and significant differences were seen for seed traits. The highest 1000 seed weight (5.96 g) was recorded in T3 whilst the lowest (1.64 g) was recorded in T5. These observations may be explained that the T3 was an early flowering with lower number of flowers per axil (one per axil), in contrary, T5 displayed with late flowering (>47d) and produced increased number of flowers per axil (2.75), hence the photosynthetic resource allocation may differ as a result of sink size. Thereby T3 had greater chances for producing larger sized seeds than that of T5 accession. Aminifard *et al*. (2010) state that heavier seeds may provide superiority in germination and the establishment as they have more resources to enable them to emerge from greater depth. Even though same soil and other environmental conditions were been applied throughout this study, chili accessions showed significant differences in most of the morphological characteristics, suggesting that the promising traits displayed by the germplasms were due to the variations in genetic make-up among the accessions. Considering the above morphological and important agronomic traits, chili accessions can be selected for the crop improvement programs.

B. Principal component analysis of morphological traits

Genetic relationship among *Capsicum* spp. was investigated using Principal Component Analysis (PCA) that is used to describe grouping of variables. The Eigenvalues revealed that the first 3 principal components accounted for 73.12% of the total variance. Component 1, 2, and 3 accounted respectively, for 45.37%, 19.45%, and 7.93 % of the total variance (Table 4).

Table 4: Eigenvalues and percentage of total variance explained by the first 3 components of PCA

	Component 1	**Component 2**	**Component 3**
Eigen values	11.89	5.05	2.06
Variance explained %	45.37	19.45	7.93
Cumulative variance %	45.37	65.18	73.12

Table 3: Average performance of quantitative characteristics in Capsicum accessions used in this study

Treatment	**Plant height (cm)**	**Mature leaf length (cm)**	**Mature leaf width (cm)**	**Days taken to flowering (Days)**	**No. Flower/Axil**	**Days taken to fruiting (Days)**	**1000 seed weight (g)**
T1	56.2±0.8^{a}	8.5±0.1^{ab}	2.8±0.1^{a}	43.0±1.1^{ab}	1.0±0.0^{a}	72.0±1.1^{ab}	3.98±0.052^{d}
T2	52.5±1.0^{b}	9.8±0.1^{abc}	3.2±0.1^{a}	40.5±0.5^{a}	1.0±0.0^{a}	69.5±0.5^{a}	4.56±0.083^{e}
T3	74.5±0.6^{a}	11.4±0.1^{cde}	4.2±0.1^{ab}	40.75±0.5^{a}	1.0±0.0^{a}	69.5±0.5^{a}	5.96±0.077^{f}
T4	52.5±1.0^{b}	8.5±0.0^{a}	2.6±0.0^{a}	40.0±0.0^{a}	1.0±0.0^{a}	68.0±0.0^{a}	2.48±0.182^{b}
T5	40.0±1.0^{c}	10.9±1.5^{bcd}	6.3±1.4^{cd}	50.0±1.0^{c}	2.7±0.2^{c}	79.0±1.0^{c}	1.64±0.124^{a}
T6	41.5±0.6^{c}	11.7±0.2^{cde}	7.7±0.2^{cd}	49.2±1.2^{c}	2.2±0.2^{c}	79.2±1.2^{c}	3.47±0.102^{c}
T7	35.2±0.6^{d}	12.1±0.2^{cde}	8.1±0.2^{cd}	48.0±1.1^{bc}	2.7±0.2^{c}	78.0±1.1^{c}	3.65±0.111^{cd}
T8	35.2±0.7^{d}	13.1±0.1^{e}	8.9±0.3^{d}	50.0±1.1^{c}	2.5±0.3^{c}	78.0±1.1^{c}	2.43±0.103^{b}
T9	57.7±0.5^{a}	11.6±0.2^{cde}	6.4±0.2^{bc}	47.5±1.4^{bc}	2.5±0.3^{c}	75.5±1.4^{bc}	3.61±0.078^{cd}
T10	56.2±0.5^{a}	11.4±0.1^{cde}	6.4±0.1^{bc}	50.5±1.4^{c}	2.2±0.2^{c}	80.5±1.4^{c}	3.63±0.043^{cd}
T11	42.2±0.8^{c}	7.8±0.1^{a}	2.8±0.1^{a}	49.2±1.2^{c}	2.5±0.3^{c}	76.2±1.2^{bc}	2.89±0.133^{b}
T12	55.7±0.5^{ab}	12.0±0.2^{cde}	7.0±0.2^{cd}	49.0±0.0^{c}	2.0±0.4^{ab}	78.0±0.0^{c}	3.43±0.040^{c}

The values are means of replicates ± standard error mean (SEM); Within a column, means followed by the same letter are not significantly different at p=0.05.

Table 5: Values represent the correlation coefficients for the three first principal components in the chili accessions. Correlation with absolute values ≥0.5 in bold, Principal Component with the Eigenvalue of <3 was not considered

Traits	**Component 1**	**Component 2**
Seed beak prominence	**.961**	.241
Corolla color	**.961**	.241
Seed shape	**.946**	-.256
Calyx margin	-.946	.256
Leaf color	-.906	-.221
Days to flowering	**.857**	.242
Days to fruiting	**.835**	.283
Number of flowers axil	**.772**	.326
Plant growth habit	-.719	-.674
Leaf shape	-.719	-.674
Mature leaf width	**.658**	.534
Fruit set	-.570	-
Nodal anthocyanin	-.479	-.142
Mature leaf length	.460	.341
Branch habit	-.446	-
Leaf pubescence	.362	-
Fruit color maturity	.283	**.927**
Fruit shape	.283	**.927**
fruit shape at blossom end	.262	**.833**
Fruit position	-.450	**.798**
Plant height	-.386	-.708
Fruit color intermediate	-	**.620**
fruit shape at pedicel attachment	.253	**.606**
Flower position	.486	-.600
Thousand seed weight	-.371	-.474
Stem pubescence	.128	-.306

The first principal component (PC1) was positively correlated with traits (Table 5) such as seed beak prominence (r=0.961), corolla color (r=0.961), seed shape (r=0.946), days to flowering (r=0.857) and days to fruiting (r=0.835) and a mild positive correlation was observed in mature leaf width (r=0.658). This suggests that these traits vary together, if one increases the remaining one tend to increase as well. Based on the correlation of 0.961 and 0.946, this PC1 is primarily a measure of seed beak prominence, corolla color and seed shape. Calyx margin (r= -0.946), leaf color (r= - 0.906), plant growth habit (r= -0.719), leaf shape (r= -0.719), fruit set (r= -0.570), nodal anthocyanin (r= -0.479), branch habit (r= -0.446), fruit position (r= -0.450), plant height (r= -0.386) and thousand seed weight (r= -0.371) were negatively correlated with PC1. The second principal component (PC2) was positively correlated with fruit color maturity (r=0.927), fruit shape (r=0.927), fruit shape at blossom end (r=0,833) and fruit position (r=0.798) and had mild positive correlation with fruit color intermediated (r=0.620) and fruit shape and pedicel attachment (r=0.606). Negative correlation was showed by seed shape (r= -0.256), leaf color (r= -0.221), plant growth habit (r= -0.674), leaf shape (r= -0.674), nodal anthocyanin (r= -0.142), plant height (r= -0.708), flower position (r= -0.6), thousand seed weight (r= -0.474) and stem pubescence (r= -0.306) (Table 5).

C. Hierarchical cluster analysis of quantitative traits

The genotypes were grouped into two major clusters and 4 sub-clusters. Cluster one contained

2 sub-clusters and one of them had 5 accessions (one *C. frutescens* accession *and* four *C. chinense* accessions). Though accession ACC# 08149 belongs to *C. frutescens* species, it showed close relationship with *C. chinense*. The other one was further divided into two sub-clusters where each of them contained 3 accessions (three *C. frutescens* and three *C. annuum*). Cluster 2 had only one accession (NM-6-2-R2-B) that was *C. annuum* (Figure 1).

D. Hierarchical cluster analysis of qualitative traits

Cluster analysis of qualitative traits grouped genotypes into two major clusters and they were further divided into 3 sub-clusters. Cluster one contained 2 sub-clusters, each having 4 accessions (4 *C. frutescens* accessions *and* 4 *C. chinense* accessions) and cluster 2 consisted 4 accession (*C. annuum)*. These findings confirm that there are three species of chili as *C. annuum* (Amu miris), *C. chinense* (Nai miris) and *C. frutescens* (Kochchi miris) conserved at PGRC gene bank which was initially identified as two species *C. annuum* (Amu miris) and *C. frutescens* (Nai miris and Kochchi) (Figure 2). The distance parents that have different genetic constitution could be used in breeding programs in future.

E. Development of species identification key

Plant Genetic Resources Centre, Gannoruwa is the main germplasm collection center of Sri Lanka. So far PGRC has developed species identification keys for several crops but not for chili germplasms. In this research, species identification keys for chili was developed (Figure 3) by studying the published scientific literatures (Sudré *et al*., 2010; Mongkolporn and Taylor, 2011; Ibiza *et al*., 2012; Ballina-Gomez *et al*., 2013; Carrizo *et al*., 2013; Nsabiyera *et al*., 2013; Occhiuto *et al*., 2014).

If any chili accession has Calyx annular constriction present, intermediate flower and fruit position, calyx small teeth, seed shape circular with fish mouth morphological characters, it can be grouped as ***C. chinense*** species while the chili plant with calyx annular constriction absent, teeth lacking, pedicel slender, erect flower, seed shape teardrop morphological characters, it can be ***C. frutescens*** species.

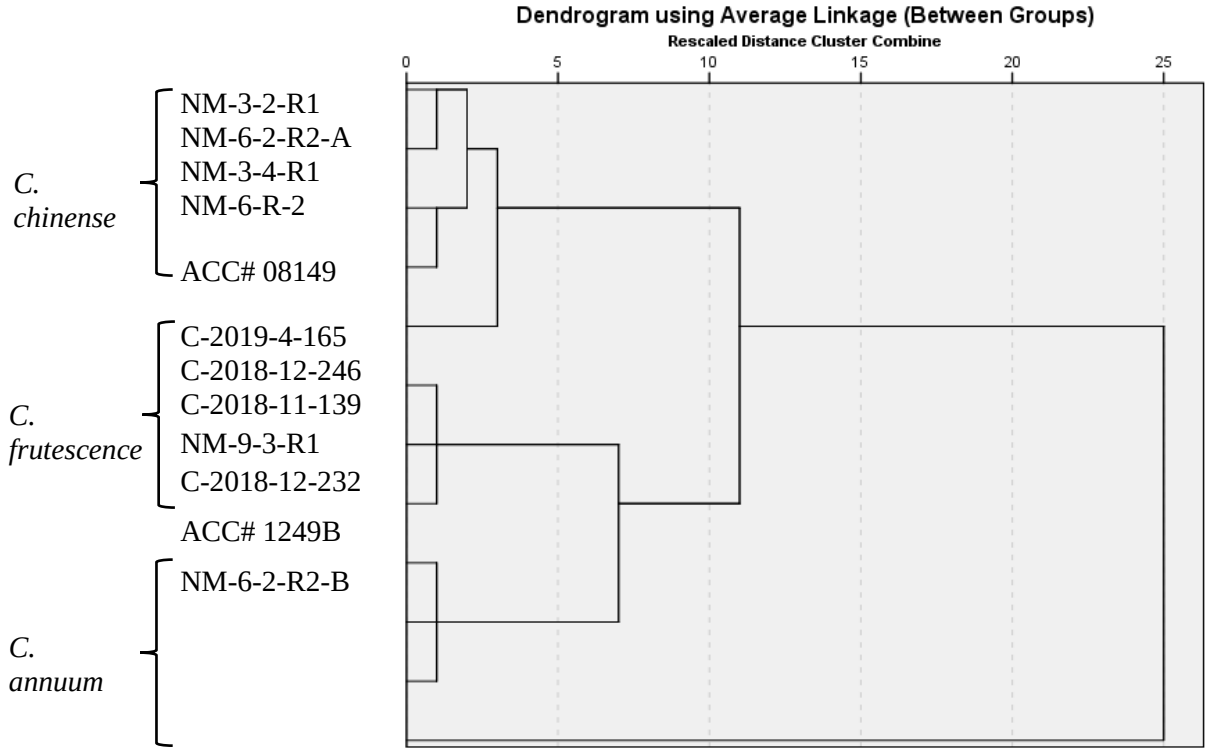


Figure 1: Dendrogram generated based on quantitative characteristics in 12 *Capsicum* accessio

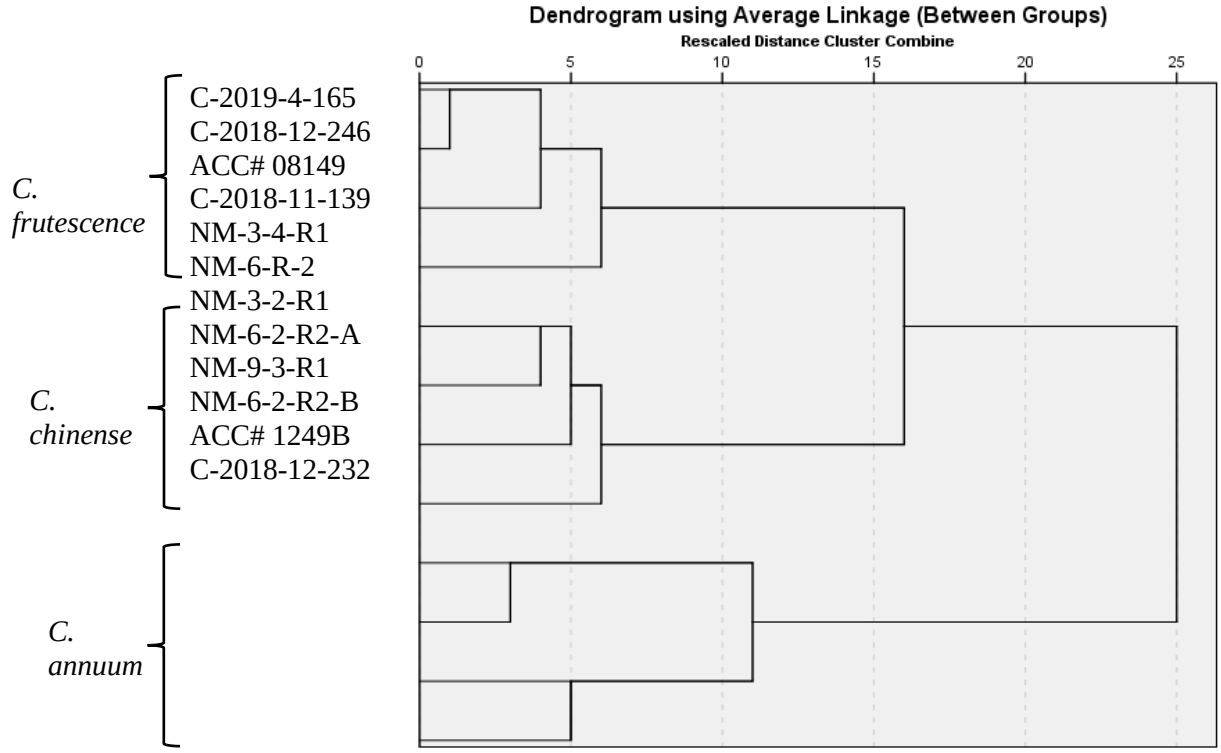


Figure 2: Dendrogram generated based on qualitative characteristics in 12 Capsicum accessions

a. Calyx annular constriction present, intermediate flower and fruit position, calyx small teeth, seed shape circular with fish mouth …..……..….**1. *C. chinense***
a. Calyx annuler constriction absent
b. Calyx teeth lacking, pedicel slender, erect flower, seed shape teardrop…….**2. *C. frutescens***
b. Calyx large teeth, pendent and erect flower position, seed shape reniform……...…….**3. *C. annuum***

Figure 3: Species development key for chili

Chili plant having calyx annular constriction absent, small teeth, pendent and erect flower position, seed shape reniform morphological characters, it can be ***C. annuum*** species.

After developing this key diagram, it was used to separate the accessions in to species. This developed "key" is useful for identify chili species by looking morphological characters. This technique is quick, scientific, consistent and inexpensive. Also this characterization is useful for varietal improvement, seed certification, and seed production programs.

IV. CONCLUSION

Here, a method for detecting species identification key for chili was developed based on the morphological characteristics. This provides the first stage toward linking plant growth and morphological traits in which seed traits can be used as a powerful tool to determine the types of crop plant either belonging to one of such three groups, viz; *Capsicum annuum* (Amu miris), *Capsicum chinense* (Nai miris) and *Capsicum frutescens* (Kochchi miris). Although, the present analysis based on morphological traits may be crude and time-consuming, while there are precise and rapid cutting-edge technologies for genetic diversity analysis, dealing with DNA molecular markers and further database generated through

such techniques will increase the precision for chili characterization in future.

REFERENCES

Aminifard, M.H., Aroiee, H., Karimpour, S. and Nemati, H., 2010. Growth and yield characteristics of paprika pepper (*Capsicum annum* L.) in response to plant density. *Asian journal of plant sciences*, *9*(5), p.276.

Andrews, J., 1999. *The pepper trail: History and recipes from around the world*. The University of North Texas Press. 1(1), pp. 107-110.

Antonious, G.F., Lobel, L., Kochhar, T., Berke, T. and Jarret, R.L., 2009. Antioxidants in Capsicum chinense: Variation among countries of origin. *Journal of Environmental Science and Health, Part B*, *44*(6), pp.621-626.

Ballina-Gomez, H., Latournerie-Moreno, L., Ruiz-Sanchez, E., Perez-Gutierrez, A. and Rosado-Lugo, G., 2013. Morphological characterization of *Capsicum annuum* L. accessions from southern Mexico and their response to the Bemisia tabaci-Begomovirus complex. *Chilean journal of agricultural research*, *73*(4), pp.329-338.

Bosland, P.W. and Votava, E.J., 1999. *Peppers: vegetable and spice capsicums*. USA: CABI publishing

Cichewicz, R.H. and Thorpe, P.A., 1996. The antimicrobial properties of Chile peppers (*Capsicum* species) and their uses in Mayan medicine. *Journal of Ethnopharmacology* 52, pp.61-70.

Carrizo García, C., Sterpetti, M., Volpi, P., Ummarino, M. and Saccardo, F., 2013. Wild Capsicums: identification and in situ analysis of Brazilian species. *Breakthroughs in the genetics and breeding of Capsicum and eggplant. Edited by S. Lanteri, and GL Rotino, 2013*, pp.205-213.

DOA. 2020. *Chili*, Field Crop Research and Development Institute, Department of Agriculture, Sri Lanka, viewed 06 May 2021, <https://www.doa.gov.lk/EtC/index.php/en/crop/178-2-4#> .

FAOSTAT. 2018. *Production data*, viewed 12 May 2021, <http://faostat.fao.otg/default.aspx>.

Gupta, D., 2015. An overview of capsicum. *International Journal of Pharmaceutical and Biological Science Archive*, *3*(4), pp. 212-217.

Hall, O.M., Broussard, A., Range, T., Turpin, M.A.C., Ellis, S., Lim, V.M., Cornett, E.M. and Kaye, A.D., 2020. Novel Agents in Neuropathic Pain, the Role of Capsaicin: Pharmacology, Efficacy, Side Effects, Different Preparations. *Current Pain and Headache Reports*, *24*(9), pp.1-12.

Howard, L.R., Smith, R.T., Wanger, A.B., Villalon, B. and Burns, E.E., 1994. Provitamin A and ascorbic acid content of fresh pepper cultivers (*Capsicum annuum*) and processed jalapenos. *Journal of Food Science* 59, pp. 362-365.

Ibiza, V.P., Blanca, J., Cañizares, J. and Nuez, F., 2012. Taxonomy and genetic diversity of domesticated Capsicum species in the Andean region. *Genetic resources and crop evolution*, *59*(6), pp.1077-1088.

Jing, Z., Huo-lin, S., Wen-Cai, Y., Fang, T., Yin-lei, W. and Shuang, G., 2013. Analysis of Genetic Diversity of *Capsicum* Germplasm by Using SSR Markers. College of Agricultural and Biotechnology, Agricultural University, Bei-jing, China. *Acta Agriculturae Boreali-Sinica*. 24, pp. 62-67.

Kwenin, W.K.J., Wolli, M. and Dzomeku, B.M., 2011. Assessing the nutritional value of some African indigenous green leafy vegetables in Ghana. *CSIRSpace Ghana*, 3(4), pp. 776-778.

Lu, M., Chen, C., Lan, Y., Xiao, J., Li, R., Huang, J., Huang, Q., Cao, Y. and Ho, C.T., 2020. Capsaicin—the major bioactive ingredient of chili peppers: bio-efficacy and delivery systems. *Food & function*, *11*(4), pp.2848-2860.

Menike, B.S., Dhammika, W.A.R., Senanayake, D.M.J.B., Weerakoon, W.M.W., Perera, A.M., Wasala, S.K., Gamage, M.G.R.U.A. and Bandara, H.M.S., 2018. Assessment of genetic diversity of selected Capsicum chinense and C. frutescens accessions derived through morphological and molecular characterization. *Tropical Agricultural Research and Extension*, *21*(1-2), pp. 445-449.

Nsabiyera, V., Logose, M., Ochwo-Ssemakula, M., Sseruwagi, P., Gibson, P. and Ojiewo, C.O., 2013. Morphological characterization of local and exotic hot pepper (*Capsicum annuum* L.) collections in Uganda. *Bioremediation, Biodiversity and Bioavailability*, *7*(1), pp.22-32.

Occhiuto, P.N., Peralta, I.E., Asprelli, P.D. and Galmarini, C.R., 2014. Characterization of Capsicum germplasm collected in Northwestern Argentina based on morphological and quality traits. *Agriscienta*, 2(1), pp. 34-38.

Orobiyi, A., Dansi, M., Assogba, P., Loko, L.Y., Vodouhe, R.S., Akouegninou, A. and Sanni, A., 2013. Chili (*Capsicum annuum* L.) in southern Benin: production constraints, varietal diversity, preference criteria and participatory evaluation. *International Research Journal of Agricultural Science and Soil Science*, 3(4), pp. 107-120.

Paran, I. and Van Der Knaap, E., 2007. Genetic and molecular regulation of fruit and plant domestication traits in tomato and pepper. *Journal of Experimental Botany*, *58*(14), pp.3841-3852.

Pawar, S.S., Bharude, N.V., Sonone, S.S., Deshmukh, R.S., Raut, A.K. and Umarkar, A.R., 2011. Chillies as food, spice and medicine: a perspective. *Int. J. Pharm. Bio. Sci*, *1*(3), pp.311-318.

Samira, A., Woldetsadik, K. and Workneh, T.S., 2013. Postharvest quality and shelf life of some hot pepper varieties. *Journal of food science and technology*, *50*(5), pp.842-855.

Zhang, S., Wang, D., Huang, J., Hu, Y. and Xu, Y., 2020. Application of capsaicin as a potential new therapeutic drug in human cancers. *Journal of clinical pharmacy and therapeutics*, *45*(1), pp.16-28.

Evaluation of Morphological and Yield Characteristics of Selected Local Pumpkin Accessions in Sri Lanka

W.M.R. Darshani[1], M.N.F. Nashath[2], H.M.L. Niran[3] & A.N.M. Mubarak[4*]

[1,2,4]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*
[3]*Agriculture Research and Development Center, Girandurukotte, Sri Lanka*

[1]renukadarshani84@gmail.com, [2]nasath17.mn@seu.ac.lk, [3]lahiru0225@gmail.com, [4*]anmubarak@seu.ac.lk

Abstract- *Pumpkin is a popular vegetable cultivated worldwide for its high nutritional value and health benefits. The lack of locally developed elite germplasms has led farmers in Sri Lanka to adopt imported hybrid varieties. This implies the necessity of strengthening breeding programs for promoting local pumpkin germplasms. Hence, the present study was focused on evaluating seven pumpkin accessions obtained from Plant Genetic Resource Centre, Gannoruwa and to characterize morphologically and to assess their yield potentials. A field experiment was carried out by implementing a randomized complete block design with three replicates. Quantitative morphological traits were analyzed by ANOVA techniques. Accordingly, the vine length at flowering ranged between 2.5 m- 3.9 m ($p<0.05$), the shortest stem was produced by T1 while the longest were observed in T4 and T6. Interestingly, the number of days taken to male and female flowering ranged between 33-36d ($p<0.05$), denoting that all accessions had displayed early flowering character than the commercial pumpkin varieties (55d). At harvest, the highest fruit yield was recorded in accessions Thirunaweli (9.6 kg/plant) while the remainder counterparts had displayed half of the yielding capacity ($p<0.05$). Moreover, the analysis qualitative trait revealed that accession Wellawaya produced distinct ovate leaf shapes and fruits skin color (cream), while in Thirunaweli, had displayed unique cylindrical-shaped fruits. Moreover, Principal component analysis revealed that accessions Thirunaweli had distinct cluster form the remainder germplasms. Hence, based on the results it was found that the overall performance of Thirunaweli and Wellawaya accessions were superior and suggested to introgress with the local crop improvement programs.*

Keywords: Crop improvement program, Pumpkin accessions, Qualitative and quantitative characteristics

I. INTRODUCTION

Pumpkin (*Cucurbita maxima*, 2x = 2n = 40), belongs to Cucurbitaceae family, is an important commercial crop widely cultivated in many tropical and sub-tropical region of the world as vegetable and an ornamental plant (Dhiman *et al*., 2009). Due to its high nutritional value and health benefits, nowadays it has gained a great concern compared to other crops (Yunli *et al*., 2020). Studies on pumpkins have demonstrated their health benefits to human such as reducing blood glucose level and make insulin available in diabetic patients (Caili *et al*., 2006). There are mainly five cultivated *Cucurbita* species around the world *viz; Cucurbita maxima, Cucurbita moschata, Cucurbita pepo, Cucurbita ficifolia* and *Cucurbita mixta* (Naik *et al*., 2015). The former species, *Cucurbita maxima* is considered to be originated and domesticated from South America. Since then, these cucurbits have been associated with human nutrition and culture for more than 12,000 years (Castellanos-Morales, 2019).

In the local context, pumpkin is a popular vegetable in Sri Lanka which is grown during *Maha* and *Yala* seasons all year across the island (DOA, 2020). The major pumpkin growing areas are Mathale, Anuradhapura, Batticoloa, Mahaweli system H, Kurunegala, Monaragala, Hambanthota, Rathnapura and Badulla (Pushpakumari *et al*., 2006). This crop utilized as a vegetable is becoming an important ingredient in daily diet, but relativity little attention has been paid towards development of new varieties rich in carotenoids with high yielding capacities.

Morphologically, this crop species have prostrate spreading growth habit and can grow up to 25 feet long when the ideal field conditions are met. The leaves having three or five lobes are produced at the leaf axils. The root system is extensive and shallow (Kiramana and Isutsa, 2018). Pumpkins are monoecious crop having male and female flowers in separate structures on the same plant (Kiramana and Isutsa, 2018). Flowers consisted of

five petals that vary in size, shape and color with different shades of yellow (Aruah *et al*., 2010) and the ratio of male to female flowers ranges from 4: 1 to 17: 1 per plant (Agbagwa *et al*., 2007). The crop is considered as the largest fruit-bearing habit in the plant kingdom and the weight of the spherical fruits ranges between 0.5 kg to 50 kg (DOA, 2020), with moderately hard rind, thick, edible flesh and a central seed cavity with numerous tan or soft-white seeds, covered with a protective testa (Robinson and Decker-Walters, 1997). Distinction of pumpkin cultivars is easiest by observing the morphological characteristics *viz;* fruit shape, size, stalk, stems and leaves, flesh quality, color and thickness, seed number and size (Paris, 2000; Hernandez *et al*., 2005).

The major limitation in pumpkin cultivation is known to be the shortage of improved varieties. To date, there is only one recommended pumpkin variety has been released by the Department of Agriculture namely ANK Ruhunu (Pushpakumari *et al*., 2006). Most of the farmers who cultivate pumpkin in Sri Lanka prefer hybrid variety- 'Arjuna', owing to their superior agronomic and yield characteristics. This situation has been alleviated due to the lack of locally developed promising varieties. Hence, farmers have to recurrently purchase seeds for every season hence, leading to high cost of production, while on the other hand, some imported varieties show low adaptability to local conditions. (Pushpakumari *et al*., 2006). This situation implies the necessity of a successful local breeding program for developing pumpkin varieties.

Collection and characterization of germplasms are essential for any crop improvement program to develop varieties focusing on improved yield and quality (Upadhyaya, 2008). Morphological description using qualitative and quantitative traits can be used to provide information on genetic variability, identification and classification of crops (Bianchi *et al*., 2016). Even though a wider number of pumpkin germplasms are available in Sri Lanka, proper characterization and evaluation have not been performed until recently. Therefore, the objectives of the present study were to morphologically characterize pumpkin accessions obtained from Plant Genetic Resource Centre, Gannoruwa, to evaluate their yield characteristics and to identify the best germplasm for future crop improvement programs.

II. MATERIALS AND METHODOLOGY

A. Experimental site and treatments

The research study was carried out at Agriculture Research and Development Center, Girandurukotte which is situated in the intermediate low country dry zone (IL_2) during the *Maha* season of 2020. Land was ploughed to fine tilt for easy and uniform germination of pumpkin seeds. The topsoil was mixed with 5kg of compost and raised beds were prepared with designated planting holes. A total of seven pumpkin accessions (Table 2) were obtained from Plant Genetic Resource Centre, Gannoruwa. Fields experiment was arranged in a Randomized Complete Block Design (RCBD) having three replicates. The unit plot size was 7.5m x 7.5m and pumpkin seeds were sown with the spacing of 2.5 m x 2.5 m. Prior to this, basal dressings were applied five days before seeding with Urea, TSP, MOP at the rates of 75 (kg/ha), 195 (kg/ha) and 60 (kg/ha) respectively. Subsequently, first and second top dressings were done with Urea and MOP at the rates of 75 (kg/ha) and 60 (kg/ha) at 4 weeks and 8 weeks after planting. Manual irrigation was practiced in accordance with the prevailed weather conditions and crop growth and developmental stages. The remaining all agronomic practices were followed according to the recommendations of Department of Agriculture, Sri Lanka.

B. Data collection and statistical analysis

Data collection was initiated from the onset of flowering stage and recorded from each pumpkin accession from the field plots. The quantitative crop traits were recorded in the following manner. The vine length, leaf length and width were measured from the average of five leaves per plot. Subsequently, data on number of days taken to 50 % flowering (male and female flowers) were recorded. At physiological maturity stage, the fruits were harvested and data related to fruit characters and yield were recorded. Fruit circumference, flesh thickness at maximum fruit diameter, mature fruit weight and yield per plant from the average of five fruits were recorded as previously mentioned by Pushpakumari *et al*. (2006). The fruit sample weights were measured using an electronic weighing balance.

Moreover, the qualitative crop characteristics were also recorded (Table 1). Leaf shape and flower colour and fruit characteristics at physiologically matured stage were assessed.

Table 1: Descriptors of qualitative characteristics used to characterize pumpkin accessions, (IPGRI, 2007)

Characteristics	**Descriptors**
Fruit shape	1.Globular, 2.Flattened, 3.Disk, 4.Oblong blocky, 5.Elliptical, 6.Acron, 7.Pyriform, 8.Dumb- bell, 9.Elongation form, 10.Turbinate superior, 11.Crowned, 12.Turbinate inferior, 13.Curved, 14.Crooked neck
Fruit ribs	0.No ribs, 1.Rounded, 2.Intermediate, 3.Deep
Shape of fruit ribs	0.No ribs, 2. Rounded, 2. Intermediate, 3.V-shaped
Flower color	1.Orange, 2.yellow
Predominant fruit skin color	1.Green, 2.Blue, 3.Cream, 4.Yellow 5.Orange, 6.Red, 7.Pink, 8.Brown, 9.Grey, 10.Black, 11.Other
Secondary fruit skin color	0.No secondary skin color, 1.White, 2.Green, 3.blue, 4.Cream, 5.Yellow, 6.Orange, 7.Red, 8.Pink, 9.Other (specify)
Flesh color	1. White, 2.Green, 3.Yellow, 4.Orange, 5.Salmon.
Seed color	1.White, 2.Cream, 3.Yellow
Leaf shape	1.Reniform, 2.Ovate

The guide for the scoring of leaf shapes, fruit shape, fruit ribs characters, predominant and secondary skin color, flesh color, seed color were assessed based on the International Plant Genetic Resources Institute (IPGRI) descriptors for *cucurbitaceae* (IPGRI, 2007). Moreover, a reference color chart was used to determine the color of flower, fruit and seeds.

Finally, the data generated from the experiment were statically analysed using SPSS statistical software. The quantitative data of each parameter were tested using one-way ANOVA and treatment means were separated by Duncan's Multiple Range Test (DMRT) at a 5 % significant level. Then for qualitative data were analysed by employing two multivariate analysis methods *viz*; Principal Component Analysis (PCA) and hierarchical cluster analysis and based on the outcomes, the experimental results were interpreted.

III. RESULTS AND DISCUSSION

A. Quantitative characteristics related to vine and leaf

The quantitative characteristics of pumpkin accessions were responded to differently and are shown in Table 2 &3. The vine length varied from 2.5 m to 3.9 m and showed significant variations among genotypes (p<0.01, Table 2). Accessions ACC# 132 (T4) and Thirunaweli (T6) had the higher vine length (3.9 m) while accession SPK# 05 (T1) had produced the shortest (2.5 m). The leaf parameters were measured, according to the data, accessions ACC# 516 (T2) and Wellawaya (T7) recorded the highest leaf length (19.5 cm), while Thirunaweli (T6) recorded the lowest (14.3 cm, p<0.01). Similarly there were significant variations were displayed for leaf diameter (p<0.01) ranging from 12.0 – 21.5 cm (p<0.01) where the difference was seen around 9cm. The highest leaf diameter was observed in ACC# 135 (T5, 21.5 cm) while the lowest in ACC# 00088 (T3, 12.0 cm).

According to the analysis, the variations exists among the pumpkin accessions for vine length, leaf parameters which may result in diverse in leaf number, size and shape, as a result, this may lead to provide variations among green area obtained for a particular plant accession. This may have a direct impact on determining plant photosynthesis and carbohydrate metabolisms and eventually crop yield. Interestingly, accession Thirunaweli recorded the lowest leaf parameters though the vine length was higher, hence, it is presumed that more leaves can be produced along the vine compare to other accessions, thereby that may contribute to improved photosynthesis. The variation in vine length further exhibit the diversity among the accessions to plant breeders and farmers, elucidating that new pumpkin varieties can either be produced with longer or relatively shorter size canopies.

B. Days taken to 50 % flowering

Based on the results of the present study, there were significant variation observed for the days taken to 50% flowering of female flowers (pistilated flower) among the genotypes (p<0.01, Table 2). According to the analysis, the number of days taken ranged between 33 to 36 days. Accession ACC# 516 (T2) required the maximum

number of days (36 days) to flower whilst earliest (33d) was observed in accessions ACC# 132 (T4), ACC# 135 (T5) and Thirunaweli (T6). Though, no significant differences were observed in days taken to male flowering (staminated flower) among the genotypes (34d).

These observation contradicts to the existing knowledge, that most of the pumpkin requires 52 to 88 days to flower from the date of field planting (Pushpakumari *et al*., 2006; Mendligner *et al.*, 1992; Ahamed *et al*., 2012). According to these analyses, our tested accessions seems to flower much earlier (33 to 36 days) than the commercial varieties.

Table 2: Leaf, stem parameters and flowering dates of seven pumpkin accessions tested in the field.

Treatments	Pumpkin accessions	Vine length (m)	Leaf Length (cm)	Leaf Diameter (cm)	Days to Flowering (Male)	Days to Flowering (Female)
T1	SPK# 05	2.5±0.1^{a}	15.2±0.2^{ab}	12.4±0.2^{a}	34±0.0^{a}	35.3±0.3^{a}
T2	ACC# 516	3.1±0.1^{bc}	19.5±0.6^{d}	12.8±1.9^{a}	34.7±0.3^{a}	35.7±0.3^{a}
T3	ACC# 00088	2.7±0.1^{ab}	16.2±0.1^{bc}	12.0±0.2^{a}	34±1.0^{a}	34.7±0.3^{c}
T4	ACC# 132	3.9±0.0^{c}	17.4±0.3^{c}	13.9±0.2^{ab}	33.7±0.7^{a}	33±0.0^{b}
T5	ACC# 135	2.7±0.1^{ab}	15.5±0.3^{ab}	21.5±0.3^{c}	34.3±0.7^{a}	33±0.0^{b}
T6	Thirunaweli	3.9±0.0^{d}	14.3±1.1^{a}	12.5±0.0^{a}	34.7±0.3^{a}	33±0.0^{b}
T7	Wellawaya	3.2±0.3^{c}	19.5±0.7^{bc}	15.3±0.2^{b}	34.7±0.3^{a}	34±0.0^{d}
Mean		3.1	16.4	14.4	34.3	34.1
F-value (df)		11. 003 (20)	11.324 (20)	19.051 (20)	0.517 (20)	27.778 (20)
P-value		<0.001	<0.001	<0.001	0.786	<0.001
C.V		15.9	10.8	23.4	2.6	3.3

The values are means of each quantitative parameter ± standard error mean (SEM). The superscript with different letters indicates significant differences exists between pumpkin accession (p-value < 0.05), means followed by the same letter in each column are not significantly different by Duncan's multiple range test at p=0.05.

Table 3: Fruit characteristics of seven pumpkin accessions tested in the field.

Treatments	Treatments	Fruit circumference (cm)	Flesh thickness (mm)	Yield (kg/plot)	Yield per plant (kg)
T1	SPK# 05	54.7±0.9^{a}	1.9±0.2^{ac}	23.7±5.9^{ab}	4.7±1.1^{ab}
T2	ACC# 516	65.3±0.9^{a}	2.0±0.0^{abc}	27.8±2.3^{b}	5.6±0.5^{b}
T3	ACC# 00088	60.0±2.3^{a}	2.4±0.1^{c}	15.0±2.8^{a}	3.0±0.6^{a}
T4	ACC# 132	62.0±1.5^{a}	2.3±0.1^{bc}	20.3±2.3^{ab}	4.1±0.5^{ab}
T5	ACC# 135	63.0±2.3^{a}	2.0±0.2^{ab}	21.1±4.8^{ab}	4.2±0.1^{ab}
T6	Thirunaweli	64.7±4.8^{a}	2.3±0.0^{bc}	47.9±2.7^{c}	9.6±0.5^{c}
T7	Wellawaya	61.7±0.9^{a}	2.3±0.1^{bc}	28.2±2.9^{b}	5.6±0.6^{b}
Mean		61.6	2.2	26.3	5.3
F-value (df)		2.289 (20)	2.990 (20)	8.444 (20)	8.440 (20)
P-value		0.095	0.043	0.001	0.001
C.V		7.8	12.6	43.1	43.2

The values are means of each quantitative parameter ± standard error mean (SEM). The superscript with different letters indicates significant differences exists between pumpkin accession (p-value < 0.05), means followed by the same letter in each column are not significantly different by the Duncan's multiple range test at p=0.05.

C. Quantitative characteristics related to yield

Pumpkin accessions were significantly differed in yield ranging from 9.6 to 3.0 kg. Based on the experiment, Thirunaweli (T6) gave the highest yield (9.6 kg/plant) followed by Wellawaya (T7) (5.6 kg/plant) and ACC# 516 (T2) (5.6 kg/plant), while the least yield was obtained in ACC# 00088 (T3) (3.0 kg/plant), hence it was found that Thirunaweli had produced the double the yield than the other tested counterparts (Table 3). According to the analysis, there were no significant variations were observed in fruit circumference (p=0.09), though, flesh thickness were significantly varied (p<0.05), ranged between 1.9 – 2.4 mm where, the lowest thickness was seen in SPK# 05 (T1) (1.9 mm) and the highest thickness was seen in ACC# 00088 (T3) (2.4 mm) followed by ACC# 132 (T4), Thirunaweli (T6) and Wellawaya (T7).

Overall, the exploration of local accessions was vital as it identifies the latent potentials of pumpkin accession, Here it was evident that germplasm Thirunaweli has the similar yielding capacity same as the elite commercial hybrid 'Arjuna' (9.83 kg/plant) in the local climatic conditions. According to Grubben and Ngwerume, (2004), pumpkin varieties yield range from 1 – 10 kg per plant. The observations can be explained in the basis of plant physiology, crop yield can have a direct correlation between the canopy size and the amount of photosynthates produced within the plant. The larger the green canopies are preferred, in Thirunaweli germplasm possessed with long vines with numerous smaller leaves may have led to increased leaf area. So as a consequence produced a remarkably increase in fruit yield compared to the other pumpkin accessions.

D. Qualitative characteristics of pumpkin accessions

The qualitative traits expressed by the pumpkin accessions were differed from each other and some of them showed interesting features. The reniform leaf shape was prominent among six accessions, while for accession Wellawaya had produced leaves with unique ovate shape. Hence, this germplasm can be easily distinguished at the early stages of crop development based on the unique leaf morphology. According to the recorded data, all accessions had produced yellow flowers and no variations were seen (Table 4). Then the fruit morphological characteristics were analyzed. The predominant shape of the fruit was flattened and observed in five accessions (Table 4). However, a unique fruit shape was observed in ACC# 516 (globular) and Thirunaweli (cylindrical). Hence, accessions ACC# 516 and Thirunaweli can be easily identified based on the fruit shape. According to Xolisa (2002), reports that fruit shape ranged from cylindrical, oblate, flattened and globular to elliptic. In addition, Labrada *et al*. (1997), reported pyriform and crookneck types are some of the main fruit shapes in pumpkins.

Table 4: Qualitative characteristics of seven pumpkin accessions tested in the field

Accession	Leaf shape	Flower color	Fruit characteristics			Fruit skin color			Seed color
			Shape	No. of Ribs	Ribs shape in cross Section	Predominant	Secondary	Flesh color	
Spk#05	Reniform	Yellow	Flatten	Intermediate	Rounded	Green	Cream	Yellow	White
ACC# 516	Reniform	Yellow	Globular	Intermediate	Rounded	Cream	Cream	Yellow	Cream
ACC# 00088	Reniform	Yellow	Flatten	Intermediate	Rounded	Green	Orange	Yellow	Yellow
ACC# 132	Reniform	Yellow	Flatten	Intermediate	Rounded	Green	Orange	Yellow	Yellow
ACC# 135	Reniform	Yellow	Flatten	Intermediate	Rounded	Green	Cream	Orange	Yellow
Thirunaweli	Reniform	Yellow	Cylindrical	Intermediate	Rounded	Green	Cream	Orange	Yellow
Wellawaya	Ovate	Yellow	Flatten	Intermediate	Rounded	Cream	Cream	Orange	Cream

Qualitative traits were assessed based on the International Plant Genetic Resources Institute (IPGRI) descriptors for *cucurbitaceae* (IPGRI, 2007). A reference color chart was used to determine the color of fruit, flower and seeds.

Moreover, based on the present investigations, the predominant fruit skin color was ranged from green to cream color and the secondary fruit skin color ranged from orange to cream. In accession ACC# 516 and Wellawaya, the prominent and secondary skin were same and expressed a unique crème colour than the other tested germplasms. Mladenovic *et al*. (2014) reported that predominant fruit skin color ranges from green to orange, and secondary pattern from speckled to stripe. Ahamed *et al*. (2012) reported that the fruit color range from green yellow to brown. Furthermore, Paris and Brown (2005) reported that the color of fruit skin is controlled by 3 loci (*Gr, Mldg* and *B*). Dominant *Gr* results in green fruits, *Mldg* mottled immature fruit color and *mldg* non-mottled rind, while B (*Bicolor)* gene confers a precocious yellow color. Hence the interaction of the above three genes might have produced the unique crème colour in accession ACC# 516 and Wellawaya.

The color of internal flesh varied from yellow to orange. Accession ACC# 135, Thirunaweli and Wellawaya had produced orange colored internal flesh while the remainder accessions had yellow. Though, Ahamed *et al*. (2012) reports and the flesh color may range from whitish to greenish in pumpkin accessions. Moreover, based on the results, all tested pumpkin accessions had produced intermediate and rounded type of fruit ribs and there were no differences were seen for this morphological trait. Hence, fruit characteristics such as flesh thickness, color, and fruit rib morphologies cannot be used to identify the pumpkin accessions used in this study.

The seed morphology were assessed. The predominant seed coat color ranged from white and cream to yellow. A unique white-seed coat was produced by accession SPK# 05, though ACC# 516 and Wellawaya had expressed cream color (Table 4). According to Kiramana and Isutsa (2018), cream-yellow colored seed coats in most promising among the pumpkin accessions while Aruah *et al*. (2010) reported obtaining brown and light-brown seeds are also possible.

E. Hierarchical cluster analysis of qualitative traits

According to cluster analysis, the pumpkin genotypes were grouped into two major clusters and 3 sub-clusters based on qualitative traits. Cluster one contained 2 sub-clusters and one of them had 3 accessions (ACC# 00088, ACC # 132 and ACC# 135). The other one had displayed with accessions ACC# 516, Wellawaya and SPK# 05. Interestingly, Cluster 2 had only one unique accession, Thirunaweli (Figure 1).

F. Hierarchical cluster analysis of quantitative traits

Based on the Cluster analysis of quantitative traits, pumpkin genotypes were classified into two major clusters and they were further divided into 4 sub-clusters. Cluster one contained 3 sub-clusters, each having 2 accessions ACC# 516 and Wellawaya), 3 accessions (ACC# 00088, ACC # 132 and SPK# 05) and 1 accession (ACC# 135) respectively. Importantly, Cluster 2 consisted only one accession Thirunaweli (Figure 2). Based on these findings, it clearly shows that accession Thirunaweli has unique qualitative and quantitative characteristics than that of other germplasms, hence the morphological characteristics can be used to distinguish from each other.

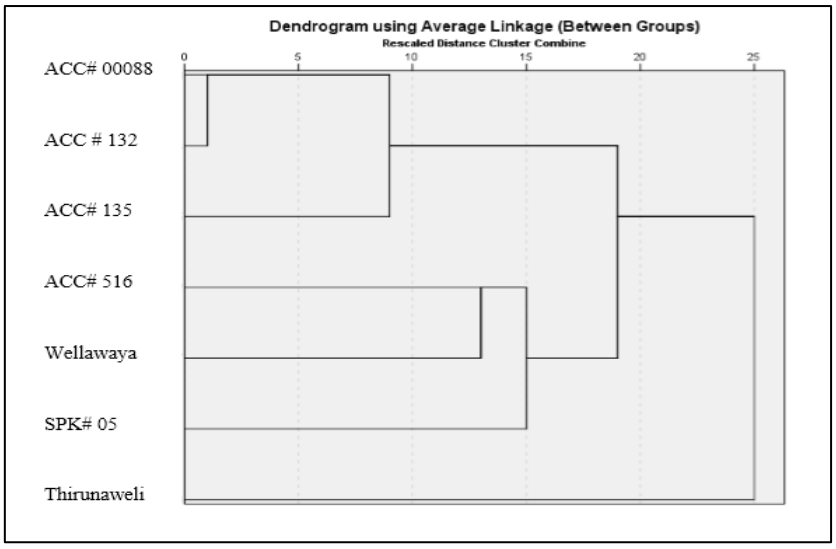


Figure 1: Dendrogram generated based on qualitative characteristics in 7 pumpkin accessions

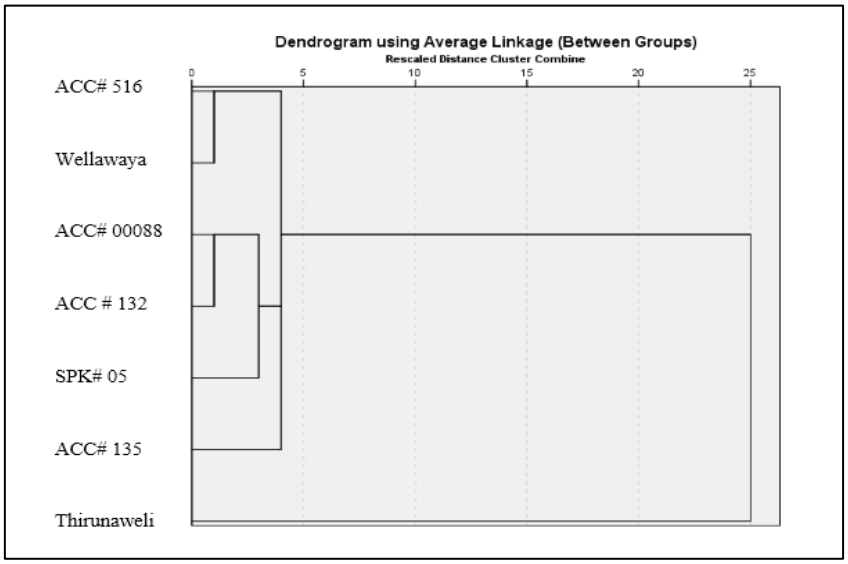


Figure 2: Dendrogram generated based on quantitative characteristics in 7 pumpkin accessions

IV. CONCLUSION

Seven pumpkin accessions from Plant Genetic Resource Center, Gannoruwa were characterized for morphological and yield traits. It was found that significant variations were seen among tested germplasms for their morphological and yield traits. Therefore, it can be concluded that pumpkin accession can be characterized according to morphological traits such as leaf traits, fruit skin colour, and the nature of seed coat. Based on the overall performance, accessions Thirunaweli and Wellawaya produced improved crop yield and can be suggested for crop improvement programs. Moreover, this study did not focus on measuring the crop resource uses efficiency to water, fertilizer and sunlight, or tolerance to biotic and abiotic stress, Hence, future efforts addressing such avenues combined with DNA profiling techniques is vital.

REFERENCES

Agbagwa, I.O., Ndukwu, B.C. and Mensah, S.I., 2007. Floral biology, breeding system, and pollination ecology of *Cucurbita moschata* (Duch. ex Lam) Duch. Ex Poir. Varieties (Cucurbitaceae) from parts of the Niger Delta, Nigeria. Turkish Journal of Botany, 31(5), pp.451-458.

Aruah, C.B., Uguru, M.I. and Oyiga, B.C., 2010. Variations among some Nigerian Cucurbita landraces. *African Journal of Plant Science*, *4*(10), pp.374-386.

Bianchi, P.A., Dutra, I.P., Moulin, M.M., Santos, J.O. and Santos Júnior, A.C., 2016. Morphological characterization and analysis of genetic variability

among pepper accessions. *Ciência Rural*, *46*(7), pp.1151-1157.

Caili, F.U., Huan, S. and Quanhong, L.I., 2006. A review on pharmacological activities and utilization technologies of pumpkin. *Plant foods for human nutrition*, *61*(2), pp.70-77.

Castellanos-Morales, G., Ruiz-Mondragón, K.Y., Hernández-Rosales, H.S., Sánchez-de la Vega, G., Gámez, N., Aguirre-Planter, E., Montes-Hernández, S., Lira-Saade, R. and Eguiarte, L.E., 2019. Tracing back the origin of pumpkins (*Cucurbita pepo* ssp. pepo L.) in Mexico. *Proceedings of the Royal Society B*, *286*(1908).

Dhiman, A.K., Sharma, K.D. and Attri, S., 2009. Functional constituents and processing of pumpkin: A review. *Journal of Food Science and Technology*, *46*(5), p.411.

DOA. 2020. *Pumpkin,* Horticultural Crop Research and Development Institute, Department of Agriculture, Sri Lanka, viewed 06 May 2021, <https://www.doa.gov.lk/HORDI/index.php/en/crop-2/21>.

Hernandez, S.M., Merrick, L.C. and Eguiarte, L.E., 2005. Maintenance of squash (Cucurbita spp.) landrace diversity by farmers' activities in Mexico. Genetic Resources and Crop Evolution, 52(6), pp.697-707.

IPGRI. 2007. Descriptors for *Cucumis melo* L. International Plant Genetic Resources Institute, Rome, Italy, viewed 14 November 2020, <https://www.Biodiversityinternationals.org/oploads/tx_news/ Descriptors_ for melon Cucumis melo L._906.pdf>.

Grubben, G.J.H. and Ngwerume, F.C., 2004. *Cucurbita moschata* Duchesne In: Grubben, G.J.H. & Denton, O.A. PROTA 2: Vegetables/Légumes, Wageningen, Netherlands.

Kiramana, J.K. and Isutsa, D.K., 2018. Genetic diversity of pumpkin accessions in Kenya revealed using morphological characters, diversity index, CATPCA and factor analysis.

Labrada, H.R., Almirall, A.F. and De La Carrera, O.B., 1997. Cuban pumpkin genetic variability under low input conditions. *Report-cucurbit genetics cooperative*, *20*, pp.48-49.

Mendlinger, S., Chweya, J., Benzioni, A., Seme, A., Ventura, M., Lungaho, C. and Okoko, V. 1992. Collections, evaluations and breeding of African edible vegetables. BGUN- ARI-25-92. Annual report. AID-CDR programme, Beer-Sheva, Israel.

Mladenović, E., Berenji, J., Ognjanov, V., Ljubojević, M., Čukanović, J. and Salamun, T., 2014. Genetic diversity in a collection of ornamental squash (*Cucurbita pepo* L.). *Genetika*, *46*(1), pp.199-207.

Naik, M.L., 2015. Studies on Genetic divergence in Pumpkin (*Cucurbita moschata* Duch. ex Poir.). *Electronic journal of plant breeding*, *6*(4), pp.1088-1095.

Nesom, G.L., 2011. New state records for Citrullus, Cucumis, and Cucurbita (Cucurbitaceae) outside of cultivation in the USA. *Phytoneuron*, *1*, pp.1-7.

Ng, T.J., 1993. New opportunities in the Cucurbitaceae. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York. pp. 538-546

Paris, H.S. and Brown, R.N., 2005. The genes of pumpkin and squash. *HortScience*, *40*(6), pp.1620-1630.

Pushpakumari, O.P.G., Siriwardhane, K.P.D. and Rathnayake, R.H.M.K., 2006. Formulation of a fertilizer package for hybrid varieties of pumpkin (*Cucrbita maxima*). 6th Agricultural Research Symposium 22nd-23rd November 2006: p.243-246

Robinson, R.W. and Decker-Walters, D.S., 1997. *Cucurbits*. Cab International, Wallingford, Oxon, New York.

Upadhyaya, H.D., 2008. Crop germplasm and wild relatives: a source of novel variation for crop improvement. *Korean journal of crop science*, *53*, pp.12-17.

Xolisa, N., 2002. Characterization of maize and cucurbit landraces of the "TRANSKEI" region of the Eastern Cape, Republic of South Africa. A Master of Science Thesis, University of Fort Hare, Private Bag X, 1314.

Yunli, W., Yangyang, W.A.N.G., Wenlong, X., Chaojie, W., Chongshi, C. and Shuping, Q., 2020. Genetic diversity of pumpkin based on morphological and SSR markers. *Pak. J. Bot*, *52*(2), pp.477-487.

TRACK - FOOD SCIENCE AND TECHNOLOGY

Effect of Fractional Crystallization on Fatty Acid and Triacylglycerol Compositions of Selected Native Lipids: An Overview

J.M.N. Marikkar[1*], Y.C. Lim[2] & B.S.K. Ulpathakumbura[3]

[1,3]*National Institute of Fundamental Studies, Kandy, Sri Lanka*
[1,2]*Department of Biochemistry, Universiti Putra Malaysia, Selangor, Malaysia*

[1*]nazrim.ma@nifs.ac.lk, [2]yclim77@hotmail.com, [3]savaa4.ulpathakumbura@gmail.com

Abstract- *Fractional crystallization has been recognized as a technique commonly used for modifying animal and plant lipids. When applied for semi-solid fats, fractional crystallization could yield a solid fraction called stearin and a liquid fraction known as olein. These derived lipid fractions were found to show remarkable differences from their parent lipids with regard to physico-chemical characteristics, fatty acids, and triacylglycerol compositions. Investigations on changes of chemical composition and the subsequent impact on physical characteristics are necessary for novel fat formulations in the oils and fats industry. In this overview, we tried to analyze the compositional changes caused by the fractional crystallization of avocado (Persea Americana) fat, engkabang (Shorea macrophylla) fat, lard, and mee fat (Madhuca longifolia). It is hoped that a critical discussion on this topic could provide some insight and future directions for the fractionation of several other unexploited native lipids.*

Keywords: Fractional crystallization, lipid stearin, lipid olein, tropical fats

I. INTRODUCTION

Fractional crystallization is a lipid modification process which is applied to several native plant and animal lipids to isolate novel fat products (Timms, 2005). The process of fractionation is generally divided into two major categories: dry fractionation and solvent fractionation. When compared to dry fractionation, solvent fractionation has been known to yield better recoveries of liquid olein and solid stearins (Marikkar and Ghazali, 2011). In the solvent crystallization approach, the lipid sample is generally mixed with a solvent medium and left at low temperature to crystallize. The precipitated fat at the bottom of the container will be filtered off to recover the high-melting fraction (HMF). After several rounds of recrystallization and filtration, the mother-liquor left in the process is evaporated to produce liquid called low-melting fraction (LMF) (Yanty, *et al.*, 2011a; Yanty, *et al.*, 2011b; Yanty, *et al.*, 2013; Marikkar, *et al.*, 2010). This process would normally cause tremendous changes in the composition and properties of the parent lipid. The triacylglycerol (TAG) molecules of the parent lipids will have different physico-chemical properties than those of the fat derivative obtained. The natural characteristics of the lipids would allow TAG molecules with lower melting point (MP) to remain in the liquid phase while those with higher MP tend to crystallize at certain temperature. After the phase separation become stabilized, it is possible to isolate the low-melting component known as olein (high in oleic acid) and high-melting component called stearin (high in stearic acid) (Yanty, *et al.*, 2011a; Yanty, *et al.*, 2011b; Yanty, *et al.*, 2013; Marikkar, *et al.*, 2010).

The information on lipid derivatives obtained from the fractionation of lipids could help in product development activities. For instance, palm stearin (used in shortening and margarine), and palm mid-fraction (used in cocoa butter substitutes) are examples of useful products produced generated from fractional crystallization of palm oil. Some confectionary fats and oils having high oxidative stability are also produced by fractional crystallization (Jin, *et al.*, 2018). Besides this, the fractional crystallization has helped to identify the changes in fatty acid and TAG compositions of the modified forms of lard such as lard stearin and lard olein (Marikkar and Yanty, 2014). This knowledge could help food control authorities to detect occurrence of the modified forms of lard in food systems (Yanty, *et al.*, 2011b). Fractionational crystallization would become the way forward in the future as it has the several advantages over both hydrogenation and interesterification. The foremost advantage is the fact that it is entirely a physical process with a low environmental impact (Timms, 2005). This overview intends to compare the varying nature of fractional crystallization behavior of four different native lipids, which has led to several novel fat products.

II. EXPERIMENTAL METHODOLOGY

A. *Sampling and fat extraction*

Mee fat was extracted from seeds of *Madhuca longifolia* collected from the North Central Province of Sri Lanka. Mee fat extraction from finely ground samples of dried *Madhuca longifolia* was carried out via the soxhlet extraction method using petroleum ether (at 40-60 °C) for 8 h (Marikkar, et al., 2010). Enkabang fat was extracted from seeds of *Shorea macrophylla* collected from Sarawak region of Malaysia. Enkabang fat extraction from finely ground samples of dried Engkabang seeds was carried out via the soxhlet extraction method using petroleum ether (at 40-60 °C) for 8 h (Nur Illyin, et al., 2013). Avocado fat was extracted from the flesh of mature avocado fruits collected from the Peninsular region of Malaysia. Fat extraction from finely ground samples of dried avocado fruits was carried out by soxhlet extraction method using petroleum ether (40–60°C) (Yanty, et al., 2011a). Lard was extracted from the adipose tissues of swine collected from the Peninsular region of Malaysia. After rendering the adipose tissues in an oven at 60°C for few hours, lard was squeezed out using a piece of muslin cloth as described previously by Marikkar et al (2001).

B. *Fractionation procedure*

The procedures for obtaining high melting and low-melting components from all the four fats were roughly similar, but with slight variations. Briefly, a portion of the melted sample of individual fat was mixed with acetone in 1:2 (w/v) ratio. The solution was boiled at 60°C until it became uniformly dissolved, and then it was cooled and left at 5±1°C for 2 hours to crystallize. The precipitated fat was filtered off to give a high melting fat fraction called stearin. After removing the precipitate, the mother-liquor was evaporated under reduced-pressure to yield a liquid fraction called olein (Yanty, et al., 2011a; Yanty, et al., 2011b; Yanty, et al., 2013; Marikkar, et al., 2010).

C. *Analytical work*

Cloud point (CP), slip melting point (SMP) and iodine value (IV) of the fat samples were determined according to AOCS method Cc.6.25, AOCS method Cc.3.25, and AOCS method Cd Id-92, respectively (AOCS, 1999). The TAG compositional analyses were carried out on a Waters Model 510 liquid chromatography equipped with a differential refractometer Model 410 as a detector (Waters Associates, Milford, MA) using Merck Lichrosphere RP-18 column (5 µm) (12.5 cm × 4 mm i.d.; Merck, Darmstadt, Germany). The mobile phase was a mixture of acetone: acetonitrile (63.5:36.5 v/v) and the flow rate was 1.5 mL/min (Marikkar and Ghazali, 2011; Marikkar, et al., 2013; Yanty, et al., 2013a; Yanty, et al., 2013b; Marikkar, et al., 2010). Fatty acid methyl esters analyses were performed on a gas chromatograph (Agillent Technologies, Singapore) fitted with a FID detector using the polar capillary column RTX-5 (0.32 mm internal diameter, 30 m length and 0.25 µm film thickness; Restex Corp., Bellefonte, PA) (Marikkar and Ghazali, 2011; Marikkar, et al., 2013; Yanty, et al., 2013a; Yanty, et al., 2013b; Marikkar, et al., 2010).

III. RESULTS AND DISCUSSION

A. Impact of fractionation on physico-chemical parameters

The physical properties of food lipids are of primary determining factors to fulfill the processing requirements of novel product formulations. The data presented in Table 1 shows the data related to cloud point (CP), slip melting point (SMP) and iodine value (IV) of the selected food lipids and their fractions (Yanty, et al., 2011a; Yanty, et al., 2011b; Yanty, et al., 2013; Marikkar, et al., 2010). These are, in fact, some of the important analytical parameters that would be related to the TAG composition and fatty acid distribution in them. The four native lipids selected for this study were found to display considerable differences with regard to these parameters (Table 1). Hence, their fractionated components were also expected to show remarkable differences. One of the thermal characteristics of olein fractions is described by CP since they exist in the liquid form at room temperature. By definition, CP is the temperature at which seeds of crystals are found to emerge leading to a cloudy appearance (AOCS, 1999). The CP value of mee fat olein (MFO) (10.5 °C) and lard olein (LO) (3.25 °C) were within the range found in most of the commercially available palm olein samples. The oleins are generally expected to display some resistance to clouding phenomenon, and therefore

would be advantageous to use them as cooking oil (Marikkar, et al., 2010).

The IV of lipids are generally used to determine the degree of unsaturation in fatty acids. Higher the IV, the more were C=C bonds present in the lipid systems (Yanty, et al., 2011b). Among the lipids selected for the discussion, avocado fat (AB) had the highest IV (84.3), followed by lard (LD) (73.8), mee fat (MF) (61.1) and engkabang fat (EF) (30.5). This indicated that a high amount of unsaturated fatty acids were found in avocado fat when compared to any other lipids. After fractionation, the IV of low-melting components (olein) of the lipids were found to increase remarkably, while the IV of high-melting components (stearin) were decreased with respect to the corresponding native lipid samples. This *happened* to be the direct consequence of the migration of more unsaturated fatty acids into the liquid olein phase and more saturated fatty acids into the solid stearin fraction.

The SMP is one of the basic physical characteristics that refer to conventional melting point of both food lipids and waxy solid (Marikkar et al., 2010). The SMP of AB was the lowest (30 °C) among plant-lipids such as EF (37.25 °C) and MF (35.5 °C), but comparably similar to LD (27.5 °C). The SMP value being below the physiological temperature would normally indicate its suitability for edible applications such as fat substitute in confectionery industry (Marikkar et al., 2010). After fractionation, the stearin isolated from the native lipids were found to possess higher SMP value than the parent lipid. Owing to higher SMP value and harder nature, the lipids stearins may be useful as raw materials for preparation of sticks, hard margarine, commercial shortening and other solid formulations (O_Brien, 1998).

B. Impact of fractionation on fatty acid composition

The fatty acid distributions of AB, EF, LD, MF and their fractions have been presented in Table 1. Among the native lipid samples, higher amounts of unsaturated fatty acids were found with AB, MF and LD. In contrast, EF was found to have more saturated fatty acids than unsaturated fatty acids. Upon fractionation, the lipid stearins were found to possess increased amounts of saturated fatty acids with respect to their corresponding native samples. As shown Table 1, the nature of fatty acid distributions in lipid oleins were the other way around when compared to lipid stearins (Yanty, et al., 2011a; Yanty, et al., 2011b; Yanty, et al., 2013; Marikkar, et al., 2010). The oleins in general experienced increases in unsaturated fatty acids. During crystallization, TAG molecules with more saturated fatty acids would undergo precipitation easily; as such considerable amount of saturated fatty acids would migrate into the solid phase, while leaving behind more unsaturated fatty acids in the liquid phase (Yanty, et al., 2011a; Yanty, et al., 2011b; Yanty, et al., 2013; Marikkar, et al., 2010). Owing to this situation, the thermal stability of lipids stearins and oleins would be changed in accordance with the changes in the degree of unsaturation .

In this study, oleic acid (44.65%) was the major fatty acid of AB, followed by palmitic acid (30.37%). The fatty acid profile of AB of this study has been in agreement with the foundlings published in several other reports (Azizi and Najafedh, 2008). Percentage increase of palmitic acid (59.63%) was remarkable in avocado stearin (AS) while fatty acid such as oleic (29.28 %) and linoleic (5.62%) were declined considerably (Table 1). In fact, the changes in fatty acid distribution tended to decrease the iodine value while causing an increase in slip melting point of AS. In avocado olein (AO), oleic is the major fatty acid (60.51%) which has increased with respect to sample AB (Table 1). While palmitic acid (26.2 %) got reduced indicating the migration of more palmitic acid into the solid phase, the liquid phase would become more enriched with oleic acid. This was very much similar to the fatty acid changes happened during the fractional crystallization of MF. For instance, the distributions and changes of fatty acids in mee fat stearin (MFS) and mee fat olein (MFO) are similar to those of AS and AO except the increases noticed in linolenic acid percentage of MFO (Table 1). The distribution of fatty acids in EF was remarkably different from those of AB and MF. This could be due to the fact that it was a fat hard and brittle in nature, which was extracted from a tree species of different subclass. Stearic acid was the most dominant in EF (47.83%) while oleic acid was the major fatty acid in both AB (43.65%) and MF (44.02%). This contrasting feature would have strong influence on its fractionation behavior. When fractionated under similar conditions described before, the yield recoveries of the solid and liquid components were not quite comparable to those of AB and MF. Upon fractionation, the differences in fatty acids were only slight as for instance in engkabang fat stearin

(EFS), palmitic acid (16.92%) and stearic acid (49.12%) increased only slightly. In enkabang fat olein (EFO), on the other hand, the increases in the percentage of *unsaturated* fatty acids caused oleic acid to become the major fatty acid (44.29 %) (Table 1).

Table 1: Basic physico-chemical characteristics and fatty acid compositions (%) of some native lipids and their olein and stearin fractions[1].

Sample	Cloud point (°C)	Iodine value (g I_2/ 100 g)	Slip melting point (°C)	Fatty acid (%)								
				C 14:0	C 16:0	C 16:1	C 18:0	C 18:1	C 18:2	C 20:0	SFA	USFA
AB	-	84.30 ± 0.14	30.00 ± 0.71	-	30.37 ± 0.06	5.20 ± 0.02	1.30 ± 0.01	43.65 ± 0.04	17.45 ± 0.04	-	31.67 ± 0.07	68.33 ± 0.07
AS	-	42.80 ± 0.20	42.50 ± 0.71	-	59.63 ± 0.05	2.26 ± 0.01	2.88 ± 0.00	29.08 ± 0.04	5.62 ± 0.00	-	62.51 ± 0.05	37.50 ± 0.05
AO	-	103.70 ± 0.15	-	-	26.20 ± 0.04	6.08 ± 0.03	1.10 ± 0.02	60.51 ± 0.06	5.90 ± 0.03	-	27.30 ± 0.06	72.70 ± 0.06
EF	-	30.50 ± 0.71	37.25 ± 0.45	-	16.58 ± 0.35	-	47.83 ± 0.13	32.49 ± 0.06	1.00 ± 0.02	2.10 ± 0.01	66.51	33.49
EFS	-	28.10 ± 0.57	38.50 ± 0.35	-	16.92 ± 0.22	-	49.12 ± 0.04	30.92 ± 0.04	1.00 ± 0.01	2.04 ± 0.01	68.08	31.92
EFO	-	44.75 ± 0.64	25.50 ± 0.71	-	21.48 ± 0.13	-	24.87 ± 0.01	44.29 ± 0.03	8.26 ± 0.01	1.10 ± 0.00	47.45	52.55
LD	-	73.80 ± 0.34	27.50 ± 0.71	1.24 ± 0.01	22.68 ± 0.48	1.42 ± 0.05	12.70 ± 0.28	38.24 ± 0.13	20.39 ± 0.04	-	-	-
LS	-	45.98 ± 0.02	45.75 ± 0.35	1.23 ± 0.15	31.68 ± 0.81	0.72 ± 0.05	25.15 ± 0.11	24.97 ± 1.00	14.04 ± 0.06	-	-	-
LO	3.25 ± 0.35	103.00 ± 0.06	-	1.46 ± 0.15	21.76 ± 0.01	2.30 ± 0.01	6.38 ± 0.03	42.76 ± 0.18	23.62 ± 0.03	-	-	-
MF	-	61.10 ± 0.35	35.5 ± 0.50	-	20.88 ± 1.51	-	22.05 ± 0.90	44.02 ± 1.10	7.85 ± 0.77	-	43.40 ± 2.15	51.85 ± 2.55
MFS	-	47.05 ± 0.05	46.5 ± 0.70	-	25.28 ± 1.33	-	29.01 ± 0.84	38.38 ± 1.60	5.72 ± 0.56	-	54.28 ± 2.46	44.10 ± 2.86
MFO	10.50 ± 0.50	64.40 ± 0.45	-	-	19.28 ± 1.20	-	16.20 ± 0.67	53.12 ± 0.95	9.61 ± 0.88	-	35.48 ± 2.60	62.73 ± 2.58

Each value in the table represents the mean of two replicates. Abbreviations: AB, avocado butter; AS, avocado butter stearin; AO, avocado butter olein; EF, engkabang fat; EFS, engkabang fat stearin; EFO, engkabang fat olein; L, lard; LS, lard stearin; LO, lard olein; MF, mee fat; MFS, mee fat stearin; MFO, mee fat olein; SFA, saturated fatty acid; USFA, unsaturated fatty acid

This clearly *demonstrated* the fractional crystallization behavior of EF was somewhat different from those of AB and MF.

LD being an animal fat did not display a contrast to the fractional behaviors of three plant fats discussed earlier. Under similar fractionation conditions described before, the *yield* recoveries of the solid and liquid components were quite comparable to those of AB and MF. The fatty acid profile of LD used in this study was roughly similar to those reported by other researchers previously (Marikkar, et al., 2021). In LD, oleic acid (38.24%) was the dominant fatty acid, followed by palmitic acid (22.68%) and linoleic acid (20.39%). However, palmitic acid became the most dominant fatty acid in lard stearin (LS) (76.57%) followed by stearic acid (25.15 %). Meanwhile, in LO, there was increased in the proportions of the unsaturated fatty acids such as oleic (42.76 %) and linoleic (23.62%).

C. Impact of fractionation on triacylglycerol composition

A comparison of the TAG distribution profiles of AB, EF, LD, MF and their fractions is shown in Table 2. When these lipids were subjected to fractional crystallization, the majority of the tri-saturated and di-saturated TAG molecules would migrate into their respective solid phases, leaving behind most of the mono-saturated and tri-unsaturated TAG molecules in the solvent phase. Nevertheless, the way of migration of different TAG species present in the individual fat might differ drastically. Hence, the solid and liquid fractions would display drastic differences in the TAG compositions when compared to the parent native lipids. In the original form of AB, the most dominant TAG molecule was POO (22.76 %), followed by POL (19.29 %) and PPO (12.43 %). After fractionation, in the solid fraction AS, the amounts of TAG molecules such as tri-palmitin (PPP) (38.31%) and oleo-dipalmitin (PPO) (30.08%) were increased with concurrent reductions in linoloyle-diolene (OOL) (1.1%), linoloyle- palmitoyle-olene (POL) (1.64%), and tri-olene (OOO) (5.28) (Table 2). This resulted in the increase of SMP with a decrease in iodine value of AVS. On the other hand, liquid fraction AO contained POO, OOO, OOL, and POL as major TAG molecules. The percentage increases of TAG moleules such as OOO (22.40%) and OOL (16.99%) in AO were relatively higher than the same TAG molecules found in either AB or AS (Table 2).

MF is pale yellow in color and remains as a semi-solid under the tropical temperature conditions. As shown in Table 2, the TAG profile of MF is compatible to that of crude palm oil. It can be reduced that the combination of TAG molecules formed by palmitic, oleic and steric acids could be responsible for the semi-solid nature of MF. According to the data presented in Table 2, OOP was the most dominant TAG molecule of MF followed by POS and OOS. Other TAG molecules such as POP, POS, and SOS were also present in MF in considerable amounts (Table 2). Upon fractionation, in the liquid fraction mee olein (MFO), the TAG molecular species such as OOO, OOP and OOS experienced increments while TAG species such as POS and SOS undergone decreases. In the solid fraction mee stearin (MFS), TAG molecular species such as POP, POS, and SOS experienced increments while there were considerable decreases in the proportion of OOS, OOP, OOO, and PLO.

Among the food lipids selected in this overview, EF is considered to be the hardest in its physical nature. Although the composition and thermo-physical properties of EF have been extensively discussed in a previous report (Nur Illiyin et al., 2013), its fractional crystallization behavior was not received adequate attention. In the composition (96.8 %) of EF, the disaturated TAG molecular species becoming predominant was a noteworthy feature. Upon fractionation, this type of TAG molecules increased slightly in the stearin fraction (EFS) (97.12 %) with respect to the native sample. Meanwhile in the olein fraction (EFO), diunsaturated TAG molecules (49.38 %) increased by replacing the disaturated TAG molecules. This might be due to the significant increases in the proportion of di-oleo stearin (OOSt) in the composition (29.66 %) of EFO as opposed to EF (1.38 %).

LD was the only animal fat selected for the discussion in this overview. According to the data presented in Table 2, LPO, OPO, PPO and SPO were the major TAG molecular species comprising 61.5% of the total. As shown in Table 2, these four were also the predominant TAG molecular species of LS, but the amount of PPO and SPO have increased remarkably with concurrent reductions in the amounts of LPO and OPO. Some remarkable differences were also seen in the distribution of OOS, SPO, and PPS in LS. With respect to native LD, the TAG composition of LO was found to deviate considerably as it was

Table 2: Triacylglycerol (TAG) compositions (%) of some native lipids and their olein and stearin fractions

TAG	AB	AS	AO	EF	EFS	EFO	LD	LS	LO	MF	MFS	MFO
LLLn	1.87±0.00	2.67±0.13		-	-	-	1.54±0.21	0.22±0.00	2.29±0.01	ND	ND	ND
LLL	0.85±0.07	0.47±0.03	1.17±0.08	-	-	-	0.68±0.21	0.23±0.00	1.43±0.01	ND	ND	ND
OLL	3.23±0.02	0.47±0.03	6.00±0.15	-	-	-	4.68±0.08	2.11±0.01	6.01±0.01	ND	ND	ND
OOA	-	-	-	-	-	1.70 ±0.08	-	-	-	-	-	-
OOL	9.00±0.03	1.10±0.00	16.99±0.24	-	-	0.44±0.01	6.93±0.04	3.40±0.02	8.48±0.01	3.00±0.26	1.45±0.00	2.60±0.10
OOO	11.42±0.01	5.28±0.01	22.40±0.43	0.12±0.01	0.36±0.01	3.27±0.01	4.33±0.21	2.46±0.04	5.61±0.07	9.85±0.22	3.47±0.04	12.56±0.05
OOS	0.52±0.01	0.64±0.11	1.14±0.13	-	-	-	-	-	-	-	-	-
OOSt	-	-	-	1.38±0.01	1.28±0.01	29.66±0.05	3.62±0.04	1.79±0.01	4.30±0.02	17.80±00	7.42±0.02	24.05±0.07
OPO	22.76±0.02	12.29±0.08	8.83±0.17	0.68±0.01	0.41±0.01	15.99±0.01	20.67±0.11	9.48±0.03	26.11±0.01	22.92±0.88	9.00±0.01	28.65±0.06
Others	6.83±0.04	2.25±0.88	21.01±1.66	-	-	-	-	-	-	-	-	-
PLL	5.63±0.11	0.18±0.04	5.63±0.11	-	-	0.29±0.12	7.05±0.06	3.26±0.01	9.33±0.04	ND	ND	ND
POL	13.16±0.20	1.64±0.01	13.16±0.20	-	-	1.74±0.22	20.00±0.30	9.32±0.00	24.52±0.11	4.26±0.37	1.77±0.00	2.59±0.15
POSt	-	-	-	35.58±0.07	38.20±0.08	12.28±0.03	-	-	-	-	-	-
PPL	4.03±0.06	1.65±0.05	0.17±0.01	0.15±0.00	0.14±0.01	3.12±0.12	2.62±0.04	3.96±0.01	2.63±0.03	1.19±0.04	0.35±0.03	Tr.
PPO	12.43±0.00	30.08±0.38	0.22±0.01	7.27±0.04	7.33±0.03	16.53±0.04	10.63±0.01	22.87±0.03	3.05±0.05	11.92±0.66	13.95±0.06	12.07±0.02
PPP	2.88±0.06	38.31±0.56	0.61±0.01	-	-	-	ND	ND	ND	Tr.	0.20±0.10	Tr.
PPS	0.11±0.01	3.97±0.07	-	-	-	-	-	-	-	-	-	-
PPSt	-	-	-	0.28±0.01	0.23±0.02	0.98±0.04	0.81±0.00	2.53±0.04	ND	Tr.	1.76±0.04	Tr.
SPO	0.57±0.02b	1.71±0.02	-	-	-	-	-	-	-	-	-	-
StOA	-	-	-	3.82±0.12	3.69±0.11	-	-	-	-	-	-	-
St PO	-	-	-	-	-	-	12.52±0.12	30.19±0.01	2.16±0.00	19.34±0.44	35.09±0.04	14.05±0.00
StStO	-	-	-	49.98±0.13	47.76±0.05	2.65±0.01	0.83±0.01	2.29±0.01	ND	9.74±0.58	23.78±0.04	3.45±0.20

StStSt	-	-	-	0.33±0.02	0.33±0.02	-	1.31±0.01	4.14±0.01	ND	ND	ND	ND
Unknown	-	-	-	0.41	0.24	11.35	1.84±0.09	1.78±0.02	4.12±0.35	-	1.86±0.1	-
SSS	-	-	-	0.59	0.61	0.98	2.12	6.67	-	-	1.96	-
USS	-	-	-	96.8	97.12	34.58	26.6	59.31	7.84	42.19	73.17	30.20
UUS	-	-	-	2.06	1.69	49.38	51.34	23.85	64.26	44.98	18.19	55.29
UUU	-	-	-	0.12	0.36	3.71	18.16	8.42	23.82	12.85	4.92	15.16

Each value in the table represents the mean ± standard deviation of two replicates. Abbreviations: O, oleic; P, palmitic; L, linoleic; Ln, linolenic; St, stearic; Tr., trace; ND, not detected; UUU, triunsaturated; UUS, diunsaturated; USS, disaturated; SSS, triunsaturated. For other abbreviatios see Table

found to possess OOL, OPO, LPO, and PLL as dominant TAG molecules, but almost negligible amounts of the TAG molecules di-palmito-stearin (PPS), oleo-distearin (SSO), and tri-stearin (SSS).

V. CONCLUSION

This overview shows that fractional crystallization behavior of individual native lipid is tightly-dependent on the nature of distribution of their TAG composition. Because of this reason, EF was found to exhibit a completely different fractionation behavior when compared to the other three native lipids. During crystallization, TAG molecular species with low-degree of unsaturation will go into the solid phase leaving behind the TAG molecules with high-degree of unsaturation. Hence, determining the composition of food lipids subjected for fractional crystallization is important to have a clear picture of fractionation behavior. Owing to the migration of different TAG molecules between the solid and liquid phases, the degree of unsaturation or unsaturated to saturated fatty acid ratio were greatly affected. Therefore, it shows that there were distinguishable differences among the four native lipids and their solid and liquid fractions based on basic physico-chemical characteristics, fatty acid composition and tri-acylglyceride profile. As a result, in all four lipids, stearin component obtained were found to display high melting point and low iodine value while olein components displayed low melting point and high iodine value. This may have important implications on the oxidative stability, nutritional values, and product applications of the derived fractions.

REFERENCES

AOCS. 1999. Official methods and recommended practices of the American Oil Chemists' Society. 5th ed. Champaign, IL: American Oil Chemists' Society.

Azizi S.N., Najafzadeh S. (2008) Fatty acids and volatile compounds in avocado cultivated in North of Iran. World Appl Sci J 5: 1–4.

Jun Jin, Liang Jie, Liyou Zheng, Min Cheng, Dan Xie, Qingzhe Jin, Xingguo Wang (2018) Characteristics of palm mid-fractions produced from different fractionation paths and their potential usages. *International Journal of Food Properties* 21:1, 58-69.

Marikkar, J. M. N., Yanty, N. A. M. (2014). Effect of chemical and enzymatic modifications on the identity characteristics of lard: A review. *International Journal of Food Properties*, *17*(2), 321–330.

Marikkar, J. M. N., Yanty, N. A. M. (2012). Seed fat from *Madhuca longifolia* as raw material for halal alternative fats. *Borneo Science* 31, 84–94.

Marikkar JMN, Lai OM, Ghazali HM, Che Man YB (2001) Detection of lard and randomized lard as adulterants in refined-bleached-deodorized palm oil by differential scanning calorimetry. *J Am Oil Chem Soc* 78: 1113–1119.

Marikkar, J. M. N., Ghazali, H. M. (2011). Effect of *Moringa oleifera* oil blending on fractional crystallization behavior of palm oil. *International Journal of Food Properties*, *14*(5), 1049–1059.

Marikkar, J.M.N., Ghazali, H.M., Long, K. (2010). Composition and thermal characteristics of *Madhuca longifolia* seed fat and its solid and liquid fractions. *Journal of Oleo Science*, *59*(1), 7–14.

Nur Illiyin, M.R., Marikkar, J.M.N., Shuhaimi, M., Mahiran, B., Miskandar, M.S. (2013). A comparison of the thermo physical behaviour of engkabang (*Shorea macrophylla*) seed fat - canola oil blends and lard. *J. Am. Oil Chem. Soc.* 90, 1485–1493.

O_Brien, R. D. (1998). Baking shortening. In: Fats and oil: formulating and processing for applications (pp. 343–382). USA: Technomic Publishing Co. Inc.

Timms, R. E. (2005). Fractional crystallization - the fat modification process for the 21st century. *European Journal of Lipid Science and Technology* 107:48-57.

Yanty, N. A. M., Marikkar, J. M. N., Che Man, Y. B. (2011a). Effect of fractional crystallization on composition and thermal characteristics of avocado (*Persea americana*) butter. *Journal of Thermal Analysis and Calorimetry*, *111*(3), 2203–2209.

Yanty, N. A. M., Marikkar, J. M. N., Shuhaimi, M. (2013). Effect of fractional crystallization on the composition and thermal properties of engkabang (*Shorea macrophylla*) seed fat and cocoa butter. *Grasas Y Aceites* 64: 546–553.

Yanty, N. A. M., Marikkar, J. M. N., Man, Y. B. C., & Long, K. (2011b). Composition and thermal analysis of lard stearin and lard olein. *Journal of Oleo Science*, *60*(7), 333–338.

Consumption Pattern of Soft Drinks and Awareness on Traffic Light Labelling System of Prepacked Soft Drinks Among Young Adults in the Ampara District

Ahamed Rifath[1*] & M.B.F. Jemziya[2]

[1,2]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*]ahamedrifath9@gmail.com, [2]jemziya@seu.ac.lk

Abstract- *The survey was carried out to evaluate the soft drink consumption pattern and the awareness of the traffic light labelling system among the young adults' consumers in Ampara district. There were 204 young adult consumers used as the sample population. The self-administered questionnaire was assessed based on socio-demographics, anthropometric measurements, consumption habits, awareness of traffic light labelling system, and awareness of adverse health effects due to soft drinks consumption. The results revealed that a higher number of consumers (48.53%) were concern about the health and nutritional benefits of soft drinks while purchasing, and 43.63% of the population were consuming soft drinks for leisure purposes. Further, 73.5% of the consumers were consuming fruit juice/drinks frequently, and 26.5% fractions were consuming carbonated beverages. Further, most of the consumers (78.43%) were consuming soft drinks 1-2 times per weekly basis. There were 80.4% of the consumers aware of the traffic light labelling system, and most of them (72%) were purchasing the soft drink based on the sugar level. Hence, 71.5% of the population were consuming medium sugar levels. 81.4% of the population was aware on type 2 diabetes is related to a higher level of sugar. Eventually, most of the consumers considered their health and nutritional aspects during the purchasing by selecting a medium level of sugar and consuming 1-2 times per week. Along with, a larger proportion had aware of the traffic light labelling system for sugar-based soft drinks and were consuming considering the sugar level of soft drinks.*

Keywords: soft drinks, traffic light labelling system, consumption pattern, awareness, young adults.

I. INTRODUCTION

Soft drinks are non-alcoholic drinks that mainly include fruit juices and carbonated drinks. Carbonated drinks consisting of a different chemical mixture of natural or artificial sweeteners, caffeine, water, color, flavoring agents, and chemical preservatives, injected with CO_2 gas (Shahjahan *et al*., 2019). Sri Lanka's overall demand for soft drinks costs around US $80 million, and its fruit juice market share is worth $12 million. The fruit beverage industry holds a market share in Sri Lanka worth $12 million with an annual growth rate of 12% (Niroshan *et al*., 2008; Rambukwella *et al*., 2015).

Soft drinks are consumed mainly for leisure purposes and an essential contributor to hydration (Shahjahan *et al*., 2019). Soft drinks can be an important part of hydration strategies for weight reduction (Ferry, 2005). The intake of soft drinks is rising across the globe daily. Increasing income, urbanization, and population growth are significant factors that include a high proportion of adolescents who are more likely to consume soft drinks (Shahjahan *et al*., 2019). Besides, increasing domestic demand, the hot climate, and insufficient access to clean drinking water are other factors conducive to soft drink consumption (Silva and Premathilaka, 2016).

Sugar-sweetened drinks have adverse effects on general health and oral health (Ratnayake and Ekanayaka, 2012). Consumption of soft drinks associated with increased body weight and reduced nutritional consumption can lead to the generate different non-communicable diseases such as cancer and heart disease (Shahjahan *et al*., 2019). The high prevalence of diabetes, cardiovascular disease (CVD) and early mortality, bring a major economic and health cost to society (Pallegedara, 2018). Sugar-sweetened carbonated beverages in children and teens encourage weight gain and obesity (Malik *et al*., 2006). Studies have shown that the consumption of soft drinks in children and teenagers can decrease the dietary intake of vitamins A and C, calcium, magnesium, and riboflavin. In comparison, calorie consumption can rise, and overnutrition can grow

into obesity, raising the risk of bad health for children (Guthrie and Morton, 2000).

An effective food labelling system can help to decrease obesity and facilitating consumers to make healthier purchasing choices (Machín *et al*., 2010). It is also essential that all customers can comprehend food labelling schemes (Carbone and Zoellner, 2012). Traffic light product labels have been shown to help consumers make healthier choices when consuming food (Morley *et al*., 2013; Roberto *et al*., 2012; Thorndike *et al*., 2012).

Experts concentrated on product labelling as a critical method to teach people and help them make healthier choices. As previous works show, it guarantees that product labelling is an essential information source that can impact consumer decision-making (Trudel *et al*., 2015). The health ministry unveiled a 'Traffic Light Color Code Scheme", which adopted three colours for displaying its sugar level, according to an end to non-communicable diseases in Sri Lanka. Red, amber, and green are used to explain the meaning: red refers to heavy sugar levels, amber represents medium sugar levels, and green to low sugar levels and free soft sugar drinks that are healthier (Weerasinghe and Selvarajan, 2018). This study aims to determine the soft drink consumption pattern and the awareness of the traffic light labelling system among the young adults in the Ampara district.

II. METHODOLOGY

This study was a population-based survey, which was carried out in Ampara district, Sri Lanka. This survey was carried out from November 2020 to January 2021, using groups of consumers from different retail shops located in the Ampara district. This research's focus participants were young adults; soft drink consumers, aged between 18 to 40 years. A review in the census report indicated that around 25% of the Sri Lankan population are aged between 18 to 40 years (Census of Population and Housing, 2012). Therefore, to calculate the sample size of this study, the Ampara district's population size is considered 610,719, according to the latest census report (Census of Population and Housing, 2012). The sample size was 204 at the confidence interval of 95% and accepting a sampling error of 5%, and simple random sampling technique was implemented to collect the data.

A datasheet was given, and verbal consent was received from all participants before the invitation to participate in the survey. The anonymity of the researchers was maintained during the analysis in order to uphold ethics. To ensure the readability and accurate administration of data collection forms, data obtained via the questionnaire was pre-tested on ten consumers. The items in the questionnaire were kept simple for the convenience of consumers. The self-administered questionnaire assessed socio-demographics, anthropometric measurements, consumption habits, awareness of traffic light labelling system, and awareness of adverse health effects due to soft drinks consumption. Accordingly, the following hypotheses were developed to test the predictions.

H_0: There is no relationship between awareness of traffic light color labelling and the BMI of the customers
H_1: There is a relationship between awareness of traffic light color labelling and the BMI of the customers

The descriptive statistics used to analyze the frequency distribution and Pearson chi-squared test employed to test the hypothesis. The analysis of data was analyzed by SPSS statistical package (SPSS 20.0, IBM, New York, NY, USA).

III. RESULTS AND DISCUSSION

The mean values of body mass index (BMI) of the men and women population were 22.67 and 21.63, respectively, as normal weight. The mean BMI of men were comparably higher than the women. However, higher proportion of women (65.1%) categorized under normal body weight compared to men (62.1%) (Figure 01). All participants of 35-40 aged group people categorized as normal BMI and 50% of 30-35 age group had normal body weight. According to the BMI cut-off for South Asians (WHO expert consultation, 2004), a considerable amount of the population BMI categorized as normal (63.2%) and few were categorized as obese (3.5%) (Table 01).

Table 01: BMI distribution between age groups of the population

		BMI Range			
		Underweight (%)	Normal weight (%)	Overweight (%)	Obesity (%)
Age	15-20	0.0	75.0	25.0	0.0
	20-25	20.4	64.7	12.8	1.9
	25-30	9.8	63.4	22.0	4.9
	30-35	0.0	50.0	50.0	0.0
	35-40	0.0	100.0	0.0	0.0
Total Population		17.6%	63.2%	15.7%	3.5%

N = 204
(Source; Field survey, 2021

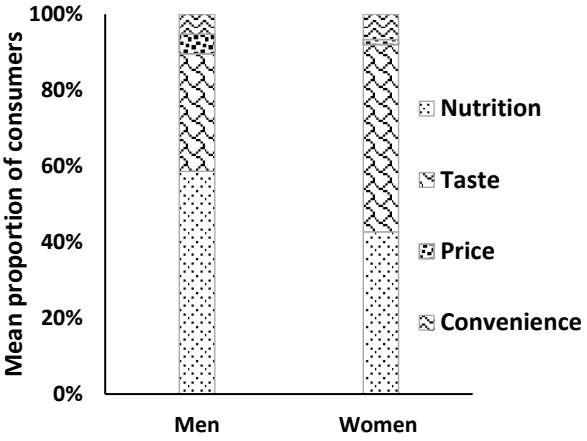


Figure 01: Gender-based BMI distribution of population

According to the survey data, the participants gave priority (48.53%) for looked on the health and nutritional benefits of soft drinks, while few of the population (2.5%) considered the cost of the soft drink during the purchasing (Table 02). The finding of Sonnenberg *et al*., (2013) also demonstrated that health and nutritional aspects are the important factors during the purchasing point. The gender-based analysis exhibits that men gave priority to the health and nutritional aspects (58.62%) while female population (51.37%) was priority to the taste of the soft drink (Figure 02). At the same time, the aged based analysis explains, the 15-20, 25-30, and 35-40 age group population were selecting the soft drink to taste however, 20-25 and 30-35 age group of people considered the health and nutritional aspect of soft drinks. The sensory and social interactions are major factor associated with the consumption pattern of soft drinks (Pachucki *et al*., 2011; Sartor *et al*., 2011). The comparisons of factors affecting the purchasing of soft drink in contrast to the BMI showed that underweight, normal and overweight range people were mostly selecting their soft drink based on the taste however obese people were selecting based on health and nutrition (Table 02).

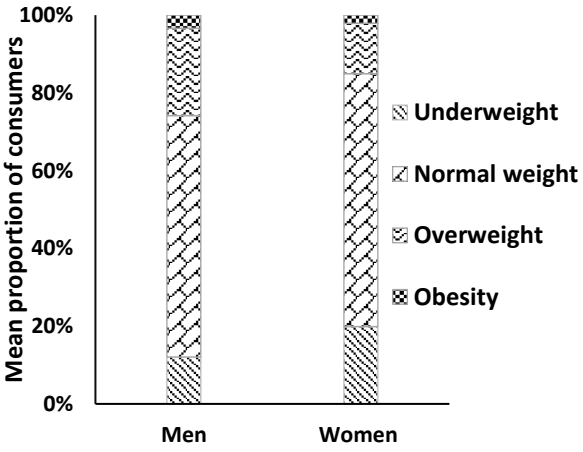


Figure 02: Gender-based analysis of factors affecting the purchasing of soft drinks

When considering the purpose of consumption among the populations, 43.63% of the population were consuming soft drinks for leisure, and a smaller fraction of the population (4.41%) were consuming soft drinks to give a company for their friends (Table 03). The gender-based analysis also yielded the same result as both men (32.7%) and women (47.95%) were consuming soft drink for leisure purposes (Figure 03). Furthermore, 15-20 and 35-40 age groups were consuming the soft drink for fulfilling the energy requirement and 20-25 and 25-30 age groups consuming mainly for their leisure while 30-35 age group shared the proportion equally (Table 03) for energy

Table 02: Determination of the factors on the purchasing of soft drinks

		Factor considered on purchasing			
		Nutrition (%)	Taste (%)	Price (%)	Convenience (%)
Age	15-20	25.0	50.0	25.0	0.0
	20-25	51.3	45.5	0.6	2.6
	25-30	39.0	46.3	7.3	7.3
	30-35	100.0	0.0	0.0	0.0
	35-40	0.0	100.0	0.0	0.0
BMI	Underweight	44.4	50.0	0.0	5.6
	Normal	9.9	87.8	0.8	1.5
	Overweight	40.6	50.0	3.1	6.3
	Obese	80.0	0.00	20.0	0.0
Total Population		48.5%	45.5%	2.5%	3.5%

N = 204
(Source; Field survey, 2021)

consumption and giving company to their friends. Benajiba and Eldib (2018) explained that indispensable during the social gathering and leisure purpose are also the factors considered during the purchasing of the sugar sweeten soft drinks. The fraction of the population who consume soft drink for leisure purpose mostly occupy underweight, normal and overweight categories of BMI ranges. Furthermore, obese people were selecting their soft drink for energy need.

Table 03: Determination of the purpose to consume the soft drinks

		Purpose of the soft drink consumption				
		Energy (%)	Companion (%)	Taste (%)	Digestion (%)	Leisure (%)
Age	15-20	50.0	0.0	25.0	25.0	0.0
	20-25	18.6	2.6	25.0	6.4	47.4
	25-30	19.5	9.8	22.0	12.2	36.6
	30-35	50.0	50.0	0.0	0.0	0.0
	35-40	100.0	0.0	0.0	0.0	0.0
BMI	Underweight	22.2	0.0	13.9	2.8	61.1
	Normal	19.8	4.6	26.7	6.9	42.0
	Overweight	15.6	9.4	25.0	15.6	34.4
	Obese	40.0	0.0	20.0	20.0	20.0
Total Population		20.1%	4.41%	24.02%	7.84%	43.63%

N = 204
(Source; Field survey, 2021)

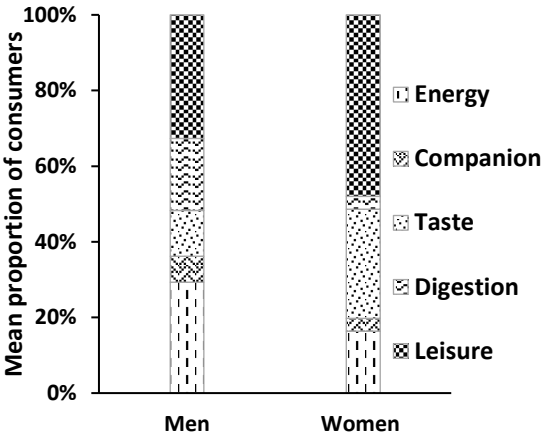


Figure 03: Gender base analysis of purpose to consume the soft drinks

Among the population, most of them were consuming fruit juice and drinks frequently (73.5%), and a lesser proportion consumed carbonated beverages (26.5%) (Table 04). According to the findings of Ratnayake and Ekanayaka (2012), adolescents of Sri Lankan population consumed sugar-sweetened carbonated drinks more than sugar-sweetened fruit drinks once weekly or more often. Further, the gender-based analysis explains that both male (63.79%) and female (77.4%) were consuming the fruit juice mostly (Figure 04). The age groups of lower third were mostly consuming the fruit juice and drinks frequently; however, 35-40 age group peoples were consuming the carbonated beverages frequently. Meanwhile, the youngest age group shared the proportion equally for both fruit juice and drinks and carbonated beverages. The population bellowed to obese BMI range were mostly consuming fruit juices while obese people

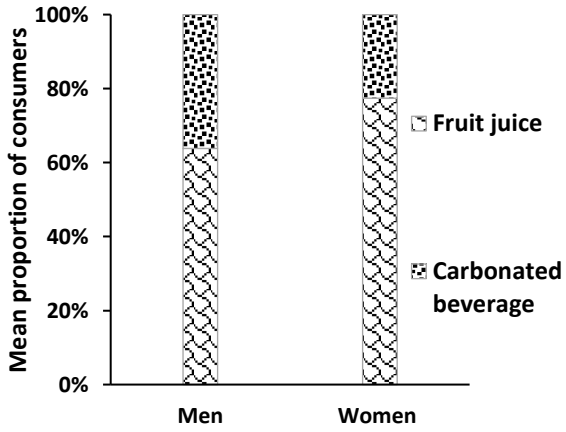


Figure 04: Gender-based analysis of type of soft drinks frequently consumed

were mainly consuming carbonated beverages frequently (Table 04).

A larger fraction of young adult population of the Ampara district (78.43%) were consuming the soft drink 1-2 times per week. Further, few of them were consuming up to 4-6 (3.92%) and more than seven (7) times (4.9%) in weekly basis. Nearly 82% of the adolescents of Sri Lanka consumed sugar-sweetened soft drinks once weekly or more often, and of these 2% are daily consumers (Ratnayake and Ekanayaka, 2012). The gender-based analysis also exhibited both men (72.4%), and women (80.0%) were consuming soft drinks 1-2 times per week (Figure 05). The age and BMI based analysis also yielded the same result as all age groups of young adults, and all BMI ranges were consuming soft drinks 1-2 times per week. (Table 05).

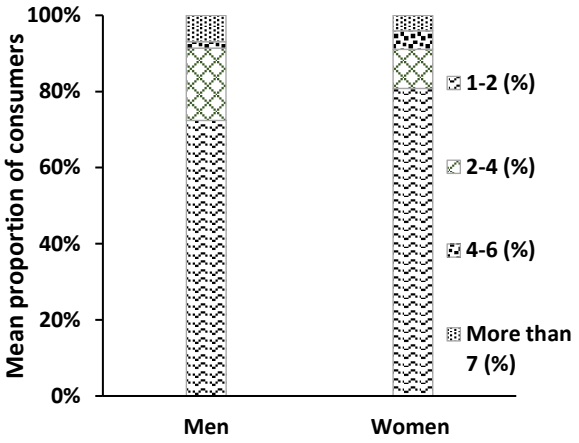


Figure 05: Gender-based analysis of consumption frequency of soft drink

Further, a considerable amount of consumers out of the population (80.4%) had aware of the traffic light labeling system imposed on sugar-sweetened products. Among them, both men (81%) and women (80.1%) were well aware of the traffic light labelling system for soft drinks (Figure 06). Meanwhile, the age-based analysis resulted that all age groups of young adults in Ampara districts were considerably aware of the traffic light labeling system for soft drinks. The comparison in related to the BMI ranges and awareness on traffic light labelling system demonstrated that the consumers with various BMI ranges had an awareness of traffic light labelling system (Table 06).

Table 04: Determination on the consumption of type of soft drink

		Type of soft drink	
		Fruit juice (%)	Carbonated beverage (%)
Age	15-20	50.0	50.0
	20-25	75.6	24.4
	25-30	68.3	31.7
	30-35	100.0	0.0
	35-40	0.0	100.0
BMI	Underweight	72.2	27.8
	Normal	76.3	23.7
	Overweight	68.8	31.3
	Obese	40.0	60.0
Total Population		73.5%	26.5%

N = 204
(Source; Field survey, 2021)

Table 05: Determination of the consumption frequency of soft drink

		Frequency of consumption in a week			
		1-2 (%)	2-4 (%)	4-6 (%)	More than 7 (%)
Age	15-20	50.0	50.0	0.0	0.0
	20-25	81.4	9.6	4.5	4.5
	25-30	70.7	19.5	2.4	7.3
	30-35	50.0	50.0	0.0	0.0
	35-40	100.0	0.0	0.0	0.0
BMI	Underweight	75.0	19.4	5.6	0.0
	Normal	77.9	11.5	3.1	7.6
	Overweight	84.4	9.4	6.3	0.0
	Obese	80.0	20.0	0.0	0.0
Total Population		78.43%	12.75%	3.92%	4.9%

N = 204
(Source; Field survey, 2021)

Table 06: Determination of awareness on traffic light labelling system

		Awareness	
		Yes (%)	No (%)
Age	15-20	50.0	50.0
	20-25	80.1	19.9
	25-30	82.9	17.1
	30-35	100.0	0.0
	35-40	100.0	0.0
BMI	Underweight	72.2	27.8
	Normal	80.9	19.1
	Overweight	87.5	12.5
	Obese	80.0	20.0
Total Population		80.4%	19.6%

N = 204
(Source; Field survey, 2021)

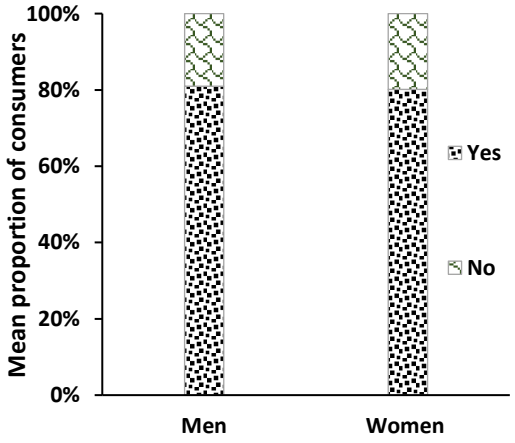


Figure 06: Gender-based analysis of awareness on traffic light labelling system

In general, most consumers purchasing soft drinks based on the sugar level of the drink (Sonnenberg *et al*., 2013). According to this study, considerable amount of the population (71.5%) was drinking a medium level of soft drink. Among them, both men (63.8%) and women (74.7%) were selecting medium sugar level of soft drink for the consumption (Figure 07). The age-based analysis of the population shows that lower third age groups were mostly drinking medium levels of soft drinks. Furthermore, the 35-40 age group people selecting a low level of sugar level and 30-35 age group equally share the proportion for both low and medium level of soft drinks (Table 07). According to the labelling regulation of Sri Lanka for sugar sweeten beverages, more than 11 g of sugar per 100 ml categorized as high level of sugar, 2-11g/100ml and less than 2g/100ml are medium and low level of sugar category respectively (Weerasinghe and Selvarajan, 2018).

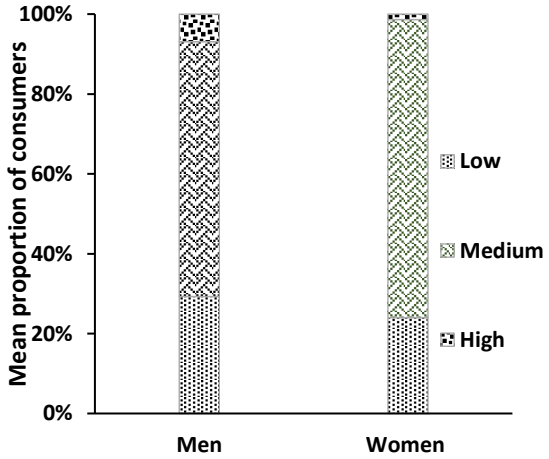


Figure 07: Gender-based analysis of consumption of soft drink based on the sugar level

The survey results show that a higher proportion of the population (81.4%) had well aware on type 2 diabetes is related to higher sugar level of foods. Gender-based analysis showed that both men (68.97%) and women (86.30%) were aware on type 2 diabetes is related to higher sugar level in foods (Figure 08). The all age grouped consumers with various BMI ranges of young adults were also well aware of type 2 diabetes (Table 08).

Table 07: The consumption of soft drink based on the sugar level

		Sugar level of soft drink		
		Low (%)	Medium (%)	High (%)
Age	15-20	0.0	100.0	0.0
	20-25	25.6	72.4	1.9
	25-30	24.4	68.3	7.3
	30-35	50.0	50.0	0.0
	35-40	100.0	0.0	0.0
BMI	Underweight	22.2	75.0	2.8
	Normal	22.9	74.0	3.1
	Overweight	37.5	59.4	3.1
	Obese	40.0	60.0	0.0
Total Population		25.5%	71.5%	3%

N = 204
(Source; Field survey, 2021)

Table 08: Awareness of type 2 diabetics and high sugar level

		Awareness	
		Yes (%)	No (%)
Age	15-20	100.0	0.0
	20-25	84.0	16.0
	25-30	73.2	26.8
	30-35	80.0	20.0
	35-40	100.0	0.0
BMI	Underweight	86.1	13.9
	Normal	82.4	17.6
	Overweight	71.9	28.1
	Obese	80.0	20.0
Total Population		81.4%	18.6%

N = 204
(Source; Field survey, 2021)

According to the results, null hypothesis was not rejected as there was no evidence to reject the null hypothesis (p>0.05) (Table 09) Therefore, it concluded that there was a no relationship between awareness of traffic light color labelling and the BMI of the customers. Increased usage of traffic light labeling and its prevalence might be a cost-effective obesity prevention method (Sacks *et al*., 2011).

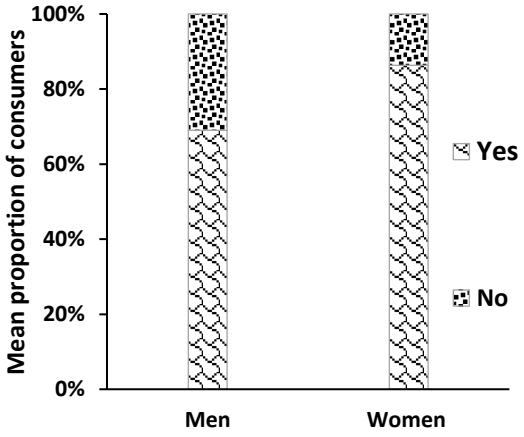


Figure 08: Gender-based analysis of awareness on type 2 diabetics and high sugar level

However, in this study, consumers of Ampara district have no relationship with the awareness of traffic light color labelling system and BMI.

Further, the age group of the consumers had a significant relationship with awareness on traffic light color labelling and awareness on type 2 diabetics related with higher sugar level (p<0.05). Likewise, gender and awareness of type 2 diabetics related to a higher sugar level had a significant relationship at p<0.05. When considering the relationship with the consumption pattern of the population and selected variables, gender had a significant relationship with the type

of soft drink consumed ($p<0.05$) (Table 10). Shin et al., (2016) reported that the frequency of consumption had a significant relationship with the obesity of individual.

Table 09: Pearson chi-squared analysis for predicted hypothesis

Hypothesis	$\chi 2$	df	*p*
Awareness about traffic light color labelling vs BMI	2.573	3	0.462

df; degree of freedom, $\chi 2$; chi-squared value, *p*; asymptotic significance(2-sided)

Table 10: Significance on awareness and soft drink consumption pattern

Variables	Awareness	$\chi 2$	df	*p*
Age group	Traffic light color labelling	12.398	4	0.015*
	Sugar level of soft drink	1.222	4	0.875
	Type-2 diabetics	12.398	4	0.015*
Gender	Traffic light color labelling	0.021	1	0.527
	Sugar level of soft drink	3.243	1	0.072
	Type-2 diabetics	8.230	1	0.004*
BMI	Sugar level of soft drink	2.068	3	0.559
	Type-2 diabetics	2.543	3	0.468
	Consumption pattern			
Age group	Frequency of consumption	12.015	12	0.444
	Type of soft drink	5.571	4	0.234
	Consumption of sugar level	8.490	8	0.387
Gender	Frequency of consumption	4.490	3	0.213
	Type of soft drink	3.947	1	0.047*
	Consumption of sugar level	5.459	2	0.065
BMI	Frequency of consumption	8.845	9	0.452
	Type of soft drink	3.825	3	0.281
	Consumption of sugar level	3.809	6	0.703

df; degree of freedom, $\chi 2$; chi-squared value, *p*; asymptotic significance(2-sided),
* denotes the significance at 95% confidence level

IV. CONCLUSION

It was evident that most of the young adults of the Ampara district were consuming soft drinks considering their health and nutritional benefits. A larger proportion of the population had well aware of the traffic light labeling system and consuming the soft drinks based on the sugar level. Even though the rest of the young adult population of the Ampara district needed to receive proper awareness on the traffic light labelling system and the health consequences due to the consumption of higher level of sugar levels contained soft drinks. However, in this study, consumers of Ampara district have no relationship with the awareness of traffic light color labelling system and BMI as hypothesis was rejected.

REFERENCES

Benajiba, N. and Eldib, R.S., 2018. Exploring attitudes related to sweetened soft drinks consumption among adults in Saudi Arabia. *Nutrition & Food Science*.

Carbone, E.T. and Zoellner, J.M., 2012. Nutrition and health literacy: a systematic review to inform nutrition research and practice. *Journal of the Academy of Nutrition and Dietetics*, *112*(2), pp.254-265.

Consultation, W.E., 2004. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet (London, England)*, *363*(9403), pp.157-163.

DCS, 2012. Sri Lanka Report on Census of Population & Housing 2012. Colombo: Department of Census and Statistics.

Ferry, M., 2005. Strategies for ensuring good hydration in the elderly. *Nutrition reviews*, *63*(suppl_1), pp. S22-S29.

Guthrie, J.F. and Morton, J.F., 2000. Food sources of added sweeteners in the diets of Americans. *Journal of the American Dietetic Association*, *100*(1), pp.43-51.

Machín, L., Aschemann-Witzel, J., Curutchet, M.R., Giménez, A. and Ares, G., 2018. Does front-of-pack nutrition information improve consumer ability to make healthful choices? Performance of warnings and the traffic light system in a simulated shopping experiment. *Appetite*, *121*, pp.55-62.

Malik, V.S., Schulze, M.B. and Hu, F.B., 2006. Intake of sugar-sweetened beverages and weight gain: a systematic review–. *The American journal of clinical nutrition*, *84*(2), pp.274-288.

Morley, B., Scully, M., Martin, J., Niven, P., Dixon, H. and Wakefield, M., 2013. What types of nutrition menu labelling lead consumers to select less energy-dense fast food? An experimental study. *Appetite*, *67*, pp.8-15.

Niroshan, M.G.A., Bernard, D.T.K. and Dissanayake, S.N., 2008. An Empirical Investigation of Beverage Market of Sri Lanka with Perspective to Ready to Drink Fruit Beverages.

Pachucki, M.A., Jacques, P.F. and Christakis, N.A., 2011. Social network concordance in food choice among spouses, friends, and siblings. *American journal of public health*, *101*(11), pp.2170-2177.

Pallegedara, A., 2018. Impacts of chronic non-communicable diseases on households' out-of-pocket healthcare expenditures in Sri Lanka. *International journal of health economics and management*, *18*(3), pp.301-319.

Rambukwella, R., Priyadarshana, D. and Vidanapathirana, R., 2015. *Comparative Study on Consumer Preference of Fruit Drinks and Carbonated Drinks in Sri Lankan Beverage Market*. Hector Kobbekaduwa Agrarian Research and Training Institute.

Ratnayake, N. and Ekanayake, L., 2012. Soft drink consumption in Sri Lankan adolescents. *Public health nutrition*, *15*(8), pp.1333-1337.

Roberto, C.A., Bragg, M.A., Schwartz, M.B., Seamans, M.J., Musicus, A., Novak, N. and Brownell, K.D., 2012. Facts up front versus traffic light food labels: a randomized controlled trial. *American journal of preventive medicine*, *43*(2), pp.134-141.

Sacks, G., Veerman, J.L., Moodie, M. and Swinburn, B., 2011. 'Traffic-light'nutrition labelling and 'junk-food'tax: a modelled comparison of cost-effectiveness for obesity prevention. *International Journal of Obesity*, *35*(7), pp.1001-1009.

Sartor, F., Donaldson, L.F., Markland, D.A., Loveday, H., Jackson, M.J. and Kubis, H.P., 2011. Taste perception and implicit attitude toward sweet related to body mass index and soft drink supplementation. *Appetite*, *57*(1), pp.237-246.

Shahjahan, M., Hossain, M.Z., Khatun, T., Hossain, S., Rashid, H.A. and Ahmed, K.R., 2019. Soft Drink Consumption and its Influence on BMI and Academic Performance among Selected School Children in Dhaka City of Bangladesh. *Current Research in Nutrition and Food Science*, *7*(3), p.791.

Shin, S., Kim, S.A., Ha, J. and Lim, K., 2018. Sugar-sweetened beverage consumption in relation to obesity and metabolic syndrome among Korean adults: a cross-sectional study from the 2012–2016 Korean national health and nutrition examination survey (KNHANES). *Nutrients*, *10*(10), p.1467.

Silva, G.M.S.W. and Premathilaka, U.L.R.R.W., 2016. Factors associated with soft drink consumption in preschool-aged children in Sri Lanka.

Sonnenberg, L., Gelsomin, E., Levy, D.E., Riis, J., Barraclough, S. and Thorndike, A.N., 2013. A traffic light food labeling intervention increases consumer

awareness of health and healthy choices at the point-of-purchase. *Preventive medicine*, *57*(4), pp.253-257.

Thorndike, A.N., Sonnenberg, L., Riis, J., Barraclough, S. and Levy, D.E., 2012. A 2-phase labeling and choice architecture intervention to improve healthy food and beverage choices. *American journal of public health*, *102*(3), pp.527-533.

Trudel, R., Murray, K.B., Kim, S. and Chen, S., 2015. The impact of traffic light color-coding on food health perceptions and choice. *Journal of Experimental Psychology: Applied*, *21*(3), p.255.

Weerasinghe, K.P.W.D.R. and Selvarajan, P., 2018. Buyers' Awareness of the Traffic Light Color-Coding System Introduced for Packages of Soft Drinks A study conducted in Kekirawa Town Area

Development and Quality Evaluation of Blue Butterfly Pea Flower (*Clitoria ternatea* L.) Extract Incorporated Jelly

U.A.A.D. Madukokila[1*], M.B.F. Jemziya[2], R.M.N.A. Wijewardhane[3] & M.R.A. Rifath[4]

[1,2,4]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*
[3]*Institute of Postharvest Technology, Anuradhapura, Sri Lanka*

[1*]madukokila444@gmail.com, [2]jemziya@seu.ac.lk, [3]nilanthiwijewardana@yahoo.com, [4]ahamedrifath@seu.ac.lk

Abstract- *Blue butterfly pea (Clitoria ternatea L.) flower (BPF) is an underutilized plant known for several health benefits. BPF can be used for increasing consumer demand for healthy foods by replacing artificial flavours and colours. This study was carried out to develop and evaluate commercially potential jelly incorporated with BPF extract. The dried BPF extract was obtained by the aqueous extraction method. Fruit pulp and BPF extract incorporated different jelly formulations were developed. Further, it was evaluated for colour, pH, moisture, titratable acidity, fibre, ash, and energy value. The sensory evaluation for different treatments was carried out using a 9-point hedonic scale test for taste, texture, colour, smell, appearance, and overall acceptability. The results showed significant differences ($p<0.05$) observed in different treatments for colour, pH, moisture, titratable acidity, fibre, ash, energy value, and sensory attributes. The moisture content of jelly formulated with different formulations was ranged from 13.1% to 20%. When considering ash content, it is considerably higher in the only BPF added jelly. The fibre content of the jelly samples ranged from 0.7% to 2.7% while higher fibre content was observed in banana pulp incorporated jelly. Energy value of jelly samples ranged from 357.03 to 428.66 J/100g and the titratable acidity of the jelly ranged from 0.02% to 1.023%. The sensory analysis exhibits that watermelon and BPF extract incorporated jelly obtained higher ranks. Eventually, the jelly formulations produced with BPF extract received a higher mean score for sensory analysis and had a good proximate figure for nutritional values.*

Keywords: Clitoria ternatea L, composite jelly, fruit pulp, proximate analysis, sensory qualities

I. INTRODUCTION

Clitoria ternatea L. is a well-known herb that belongs to the family Fabaceae. The blue butterfly pea is a legume plant with a long, thin, climbing herbaceous vine with five leaflets, white to purple flowers, deep roots, and growing wild and in gardens in tropical regions (Morris, 2009). Blue butterfly pea flower (BPF) has solitary flowers with vivid, deep-blue, and white colouration (Loñez and Banwa, 2021). The butterfly pea flower is full of health-promoting antioxidants, flavonoids, and peptides as a natural remedy for various health complaints and *it* has historically been used as a laxative, purgative, diuretic, inflammation, indigestion, constipation, headache, arthritis, eye ailments, sore throat, and anthelmintic, as well as to relieve gastrointestinal swelling, sore throat, and mucous dysfunction (Gollen *et al.*, 2018). The BFP is commercially valued for natural food colouring, pea tea, dried flowers used for beauty products (Nair and Reghunath, 2008).

The use of food colourant in food products is important in increasing product appeal. Food colourants are broadly categorized into natural and artificial food colours. The synthetic food colourants showed an adverse effect on human health. Some alternative to synthetic dyes includes anthocyanins, lycopene, turmeric, and chlorophyll. One of the leading available natural blue sources is that the *C. ternatea* flower. The food industry traditionally used blue dye aqueous extract from the petal of butterfly pea as a confectionary colouring and natural colourant for drinks (Loñez and Banwa, 2021).

This edible natural colourant can be used in any food compound, replacing synthetic colourants in colour, taste, and cost economy (Loñez and Banwa, 2021). There are many different products formulated from BPF extract in the market nowadays. Natural jelly candies with high antioxidant properties and medicinal properties are not commercially available at low cost. The antioxidant-enriched jelly with free radical scavenging activity is rarely found on the market. Jelly candy equally attracts children and adult age people and has little nutritional value (Loñez and Banwa, 2021). This study aims to develop the

potential commercial jelly enriched with antioxidant potential using natural BPF colour extract by replacing artificial colourants.

II. METHODOLOGY

A. *Study area*

The experiment was conducted at the Food Science and Technology Laboratory, Faculty of Technology, South Eastern University of Sri Lanka.

B. *Procurement of raw materials*

Blue-coloured, fully bloomed, disease-free, and undamaged healthy flowers of *Clitoria ternatea* obtained from home gardeners of Hanwella, Awissawella, Sri Lanka. Other ingredients like agar-agar, fruits like banana, watermelon, and orange, sugar, sugar syrup, and salt were purchased locally in Akkaraipattu, Sri Lanka.

C. *Preparation of dried BPF flower*

The BPFs were washed and placed on an aluminium tray and directed to the hot humid tropical sun for drying (31±5 °C, RH: 67±5%). The BPFs were dried until the flower's petals felt like parchment and were no longer soft or wet. Afterwards, dried flowers were grounded and packed in an airtight container and stored under ambient conditions (27 °C) until further use.

D. *Extraction of anthocyanin content*

The aqueous extraction method was performed to extract the anthocyanin from dried BPF (Lakshan *et al.,* 2019). The 5 g of dried BPF powder was added to100ml hot water and mixed for 30 minutes and then the extract was filtered.

E. *Preparation of fruit pulps*

The fully ripened healthy, and fresh fruits were washed thoroughly with potable water and the skin was removed. The fruits were ground using a domestic grinder (Model-TL740B, India) and fruit pulp was obtained.

F. *Experimental design*

Treatments

T1; BPF extraction 200 ml
T2; Orange 200 ml
T3; Banana 200 ml
T4; Watermelon 200 ml
T5; BPF and orange pulp; 100 ml: 100 ml
T6; BPF and watermelon pulp; 100 ml: 100 ml
T7; BPF and banana pulp; 100 ml: 100 ml

G. *Preparation of jelly*

The BPF extract and fruit pulp were mixed with agar-agar powder (2 g), gelatin (10 g), sugar (50 g), sugar syrup (15 g), and salt (0.5 g). The mixture was stirred well before heating. During the heating, BPF extract was added gradually and mixed well, and bring it up to a boiling point. The mixture scooped into jelly molds. The jelly was set aside to cool in the refrigerator (4 °C) for about 2 hours.

H. *Colour measurement*

The colour of jelly was measured using a colorimeter (CHN Spec, CS 10, China). The colorimeter was calibrated with a white surface. Measurements were recorded as L (lightness), +a (redness), +b (yellowness) CIE color co-ordinates.

I. *pH measurement*

The benchtop pH meter (Starter 3100, OHAUS, USA) was used to measure the pH at 27 °C (AOAC, 2002).

J. *Moisture content*

The empty weight of the oven-dried moisture cans was measured. Then, the five grams of sample was transferred into the moisture cans and weighed. The samples were oven-dried at 105 °C for four hours. The moisture cans were transferred into a desiccator and weighed quickly as soon as they cooled. The oven-drying process was repeated until the constant weight was observed (AOAC, 2020).

$$\text{Moisture content } \% = \frac{W1 - W2}{W1} \times 100$$

Where,
W1 = Initial weight
W2 = Oven dried weight

K. *Ash content*

The weight of the oven-dried empty crucibles was measured. Then, the five grams of sample was put into the crucibles and weighed. The samples were kept in a muffle furnace at 550 °C for five hours. The crucibles were transferred into a desiccator and weighed quickly as soon as they cooled. Finally, ash content was recorded (AOAC, 2020).

$$\text{Ash } (\%) = \frac{W1 - W2}{W3} \times 100$$

Where,
W1=Weight of crucible with ash *(g)*

W2 =Weight of crucible *(g)*
W3 =Weight of sample *(g)*

L. *Fibre content measurement*

The weight of the oven-dried empty crucibles was measured. Then, the five grams of samples were transferred into the 500 ml beaker. After, 0.125 N 200 ml H_2SO_4 was added to the beakers and boiled for half an hour, and it was filtered through a muslin cloth. Afterwards, it was washed with distilled water to render it free of acid and checked the filtrate with blue litmus paper. After, the residue was transferred into a 500 ml beaker. Then 0.125 N, 200 ml NaOH was added to the beakers and boiled for half an hour. Then it was filtered through a muslin cloth. Afterwards, it was washed with hot water to render free of base and checked the filtrate with red litmus paper. Finally, the residue was placed in the crucible and oven-dried at 105 °C for two hours, after which the crucibles were placed in the desiccator and weighed after cooling. The samples were kept in a muffle furnace at 450 °C for three hours. The crucibles were transferred into a desiccator and weighed quickly as soon as they cooled. Finally, fibre content was recorded (AOAC, 2020).

$$\text{Crude fibre (\%)} = \frac{W1-W2}{W3} \times 100$$

Where,
W1=Weight of crucible with oven dried sample (g)
W2=Weight of crucible with ash (g)
W3 =Weight of sample (g)

M. *Energy value*

In a crucible, 1 g of dried sample was obtained, and cotton thread was attached to the fuse wire that was in contact with the dried sample. The sample-loaded crucible was placed inside the bomb, along with 5 ml of distilled water. The bomb was then placed inside the bomb calorimeter (IKA C6000, India). Following that, a bomb calorimeter was started the operation by selecting appropriate set orders (Aggarwal *et al*., 2016). The results were obtained from the calorimeter as J/100g values.

N. *Sensory evaluation*

Sensory analysis was done using 20 untrained panelists by scoring different attributes based on a 9-point hedonic scale. The jellies were rated for their sensory attributes like taste, texture, colour, smell, appearance, and overall acceptability.

O. *Statistical analysis*

The data were analyzed using SPSS statistical package (SPSS 20.0, IBM, New York, NY, USA). The Analysis of Variance (ANOVA) was used to find the significant differences, and means were compared using Tukey's post hoc test at 5% significant level.

III. RESULTS AND DISCUSSION

A. Moisture content

Moisture content is crucial in determining the jelly quality, particularly in determining the texture (Dewi *et al*., 2018). The moisture content of jelly developed with different formulations was ranged from 13.1% to 20%. There was a significant difference (p<0.05) observed between the treatments for moisture content. The lower moisture content was recorded for orange pulp incorporated jelly. But the higher moisture content was marked for BPF extract and watermelon incorporated jelly (Table 01). Delgado and Bañón, (2015) also reported that the average moisture content of gummy jelly produced was around 21%. The jelly is an intermediate moisture food that is hygroscopic and hard to dry (Delgado and Bañón, 2015).

B. *Ash content*

The ash content of the food reduces with the increment of the moisture content (Delgado and Bañón, 2015). The percentage of ash content of the jelly samples ranged from 0.67% to 2.29% with a significant difference (p<0.05) between the treatments. Ezzudin and Rabeta, (2018) reported the ash content of *Clitria terntia* L. flower has 0.45%. But BPF added jelly (T1) resulted in 1.53% of ash content. Compare the BPF extract added jelly (T1) with both BPF and fruit pulp added jelly, ash content is considerably higher in the BPF added jelly (Table 01).

C. Fibre content

The fibre content of the jelly samples ranged from 0.34% to 3% with a significant difference (p<0.05) between the treatments (Table 01). There was no fibre content available in BPF extract, orange, BPF + watermelon, and BPF + orange added jellies, while the highest fibre content was observed for only banana pulp added jelly. Ezzudin and Rabeta (2018) reported the fibre content of *Clitria terntia* L. flower has 2.1%, but the BPF extract incorporated jelly had not been observed for fibre content.

D. *Energy value*

Energy content of jelly samples ranged from 357.03 to 428.66 J/100g with significant differences (p<0.05) between the treatments. BPF extract + banana pulp incorporated jelly had the lowest content of energy (357.03±13.76 J/100g), while the high energy content (428.66±1.07 J/100g) was observed for BPF extract + banana pulp incorporated jelly (Table 01). Zitha *et al.* (2020) reported that total energy value of jelly developed from mangaba (*Hancornia speciosa* Gomes) had around 277 Kcal/100g.

Table 1: Proximate values of different formulation of jelly

Treatments	Moisture (%)	Ash (%)	Fibre (%)	Energy (J/100g)
T1	19.5±1.14 ^{b}	1.53±0.04 ^{c}	0.00 ^{a}	407.10±1.72^{b}
T2	13.1±0.82 ^{a}	0.95±0.02 ^{ab}	0.00 ^{a}	406.38±1.86 ^{b}
T3	19.53±1.24 ^{b}	2.29±0.19 ^{d}	3.00±0.06 ^{d}	420.60±4.16 ^{b}
T4	16.63±0.41 ^{ab}	2.18±0.03 ^{d}	0.34±0.01 ^{b}	415.55±1.64 ^{b}
T5	19.37±1.13 ^{b}	1.19±0.01 ^{bc}	0.00 ^{a}	413.12±1.16 ^{b}
T6	20.00±1.66 ^{b}	0.67±0.06 ^{a}	0.00 ^{a}	428.66±1.07 ^{b}
T7	18.23±0.95 ^{ab}	1.23±0.04 ^{bc}	2.70±0.12 ^{c}	357.03±13.76 ^{a}

Different letters superscripted in the mean values within the column indicate the significant difference at 0.05.

T1; BPF extraction 200ml, T2; Orange 200ml, T3; Banana 200ml, T4; Watermelon 200ml, T5; BPF and orange pulp; 100 ml: 100ml, T6; BPF and watermelon pulp; 100 ml: 100ml, T7; BPF and banana pulp; 100ml: 100ml

E. *Titratable acidity*

The titratable acidity of the jelly ranged from 0.02% to 1.02% with a significant difference (p<0.05) between the treatments. The lowest titratable acidity (0.02%) was seen in jelly with BPF extract alone, while the higher titratable acidity (1.02%) was observed for orange pulp incorporated jelly (Figure 01). According to Lakshan *et al.* (2019), the titratable acidity of beverage developed with BPF extract was around 0.13%.

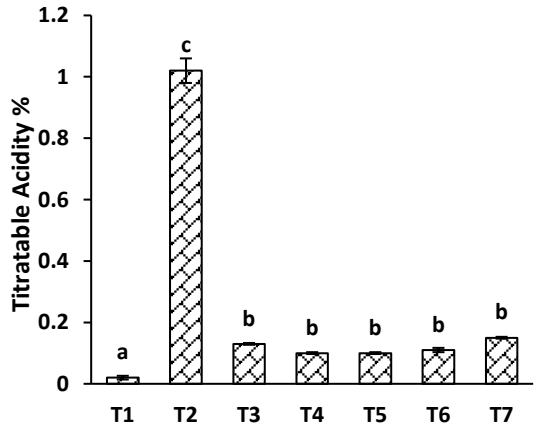


Figure 01: Titratable acidity of different jelly formulations

F. pH

The lowest pH value among the treatments was recorded for orange pulp incorporated jelly and BPF extract incorporated jelly recorded as a higher pH level. There was a significant difference (p<0.05) observed between the pH of jellies formulated using different extract and fruit pulps (Figure 02).

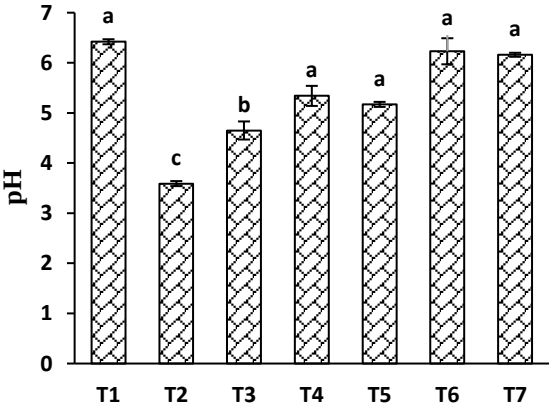


Figure 02: pH values of different jelly formulations

G. Colour

The L* value reflects the sample's lightness, with 100 denoting white and zero denoting black. When the a* value is positive, it indicates redness; when it is negative, it indicates greenness. When the b* value is

positive, it means yellowness, and when it is negative, it means blueness. (Pathare *et al*., 2013). When comparing the color of only BPF extract added jelly with BPF and fruit pulp mixture added jellies, L* value of T5, T6 and T8 are reducing while mixing fruit pulps with BPF extract, which explains that darkness increases with the mixing of fruit pulps. Likewise, redness reduces with the mixing of fruit pulps compare to T1. However, the blueness of the jelly increases with the mixing of fruit pulps with BPF extract (Table 02).

Table 2: L*, a* and b* Color coordinates of jelly formulation

	Classic colour ranges of L*a*b* value		
Treatments	L*	a*	b*
T1	38.86±2.37	16.45±3.10	-25.30±0.90
T2	66.50±3.70	27.31±1.10	80.40±4.50
T3	57.34±2.20	12.52±1.65	33.35±2.80
T4	44.44±1.30	52.8±4.14	43.77±1.98
T5	38.86±1.65	16.45±2.60	-25.3±1.65
T6	34.55±1.93	11.86±0.89	-27.91±2.10
T7	32.91±2.20	5.82±0.62	-31.87±3.21

Mean ± SEM values of different color coordinates

H. Sensory properties of the jelly

The mean scores for consumer preference in terms of taste, texture, colour, smell, appearance, and overall acceptability are presented in Table 03 showed a significant difference ($p<0.05$) among the jelly samples. The mean ranks for the colour range between 5.9 and 7.75. The lowest colour preference was given to the T2 while the highest colour preference was given to T1. Among the treatments, the flavour of T4 was predominantly preferred by the panelists while the panelists less preferred T7.

When considering the texture of the treatment, T4 was mostly preferred and T7 obtained a lower rank for the texture. The T4 obtained a higher score for the taste and a lower score for the T2. Among the treatments, the odour was mostly preferred for T4. The overall acceptability showed that T4 was mostly preferred in terms of all sensory parameters while T7 obtained the lowest score out of all treatments. Generally, overall acceptability may slightly differ from preference because a given product for instance could still be preferred over another when both products may be unacceptable (Kilcast and Angus, 2007; Risvik *et al*., 1994).

IV. CONCLUSION

The *Clitoria ternatea* L. is an under-utilized plant with several health benefits. The BPF extract can be used as an alternative for synthetic colourants mostly in confectioneries food items. The jelly formulations produced with BPF extract obtained a higher mean score for sensory analysis and had a good proximate figure for nutritional values. Therefore, BPF extract can be used as an alternative for blue synthetic colours for jelly confectioneries with market potential.

Table 3: Mean scores for sensory evaluation of different jelly formulations

Treatments	Color	Flavor	Texture	Taste	Smell	Overall acceptability
T1	7.75±0.28 [b]	6.35±0.31 [ab]	6.60±0.31 [ab]	5.65±0.43 [ab]	5.80±0.35 [bc]	6.45±0.36 [b]
T2	5.90±0.51 [a]	4.85±0.44 [a]	5.95±0.40 [a]	4.45±0.39 [a]	3.85±0.41 [a]	4.45±0.46 [a]
T3	6.95±0.35 [ab]	6.26±0.49 [ab]	6.37±0.37 [ab]	5.947±0.47 [abc]	5.26±0.47 [abc]	6.11±0.46 [a]
T4	7.57±0.21 [b]	7.24±0.25 [b]	7.52±0.16 [b]	7.48±0.18 [c]	6.48±0.36 [c]	7.29±0.24 [b]
T5	7.20±0.37 [ab]	6.10±0.37 [ab]	6.70±0.32[ab]	6.70±0.33 [bc]	5.45±0.42 [abc]	6.55±0.39 [b]
T6	6.80±0.43 [ab]	6.15±0.50 [ab]	7.05±0.52 [ab]	6.05±0.56 [abc]	5.20±0.57 [abc]	6.30±0.52 [b]
T7	6.15±0.46 [ab]	4.80±0.46 [a]	5.85±0.39 [a]	4.50±0.50 [a]	3.90±0.53 [ab]	4.40±0.47 [a]

Different letters superscripted in the mean values within the column indicate the significant difference,
*= significant at 0.05

REFERENCES

Aggarwal, D., Sabikhi, L. and Kumar, M.S., 2016. Formulation of reduced-calorie biscuits using artificial sweeteners and fat replacer with dairy–multigrain approach. *NFS journal*, *2*, pp.1-7.

AOAC, 2002. *Official methods of analysis* of analysis. Gaithersburg, MD, USA, Association of Analytical Communities. 17th edition current through 1st revision.

AOAC, 2020. *Official methods of analysis* Washington, DC: Association of Official Analytical Chemists. Vol. 222.

Delgado, P. and Bañón, S., 2015. Determining the minimum drying time of gummy confections based on their mechanical properties. *CyTA-Journal of Food*, *13*(3), pp.329-335.

Dewi EN, Kurniasih RA and Purnamayati L. 2018. Application of microencapsulation phycocyanin as a blue natural colorant to the quality of jelly candy. IOP Conference Series Earth and Enviromental Science. 116(1), pp.1-7.

Gollen, B., Mehla, J. and Gupta, P., 2018. *Clitoria ternatea* Linn: A Herb with potential pharmacological activities: Future prospects as therapeutic Herbal Medicine. *Journal of Pharmacological Reports*, *3*(1), pp.1-8.

Kilcast, D. and Angus, F. eds., 2007. *Reducing salt in foods: Practical strategies*. Elsevier.

Lakshan, S.A.T., Jayanath, N.Y., Abeysekera, W.P.K.M. and Abeysekera, W.K.S.M., 2019. A commercial potential blue pea *(Clitoria ternatea* L.) flower extract incorporated beverage having functional properties. *Evidence-Based Complementary and Alternative Medicine*.

Loñez, H.E. and Banwa, T.P., 2021. Butterfly Pea (*Clitoria ternatea*): A natural colorant for soft candy (Gummy Candy). *Indian Journal of Science and Technology*, *14*(3), pp.239-244.

Morris, J.B., 2009. Characterization of butterfly pea (*Clitoria ternatea* L.) accessions for morphology, phenology, reproduction and potential nutraceutical, pharmaceutical trait utilization. *Genetic Resources and Crop Evolution*, *56*(3), pp.421-427.

Muhammad Ezzudin, R. and Rabeta, M.S., 2018. A potential of Telang tree (*Clitoria ternatea*) in human health. *Food Research*, *2*(5), pp.415-420.

Nair, D.S. and Reghunath, B.R., 2008. Effective use of encapsulation-dehydration technique in cryopreserving somatic embryos of butterfly pea (*Clitoria ternatea* L.). *Journal of herbs, spices & medicinal plants*, *13*(3), pp.83-95.

Pathare, P.B., Opara, U.L. and Al-Said, F.A.J., 2013. Colour measurement and analysis in fresh and processed foods: a review. *Food and bioprocess technology*, *6*(1), pp.36-60.

Risvik, E., McEwan, J.A., Colwill, J.S., Rogers, R. and Lyon, D.H., 1994. Projective mapping: A tool for sensory analysis and consumer research. *Food quality and preference*, *5*(4), pp.263-269.

Zitha, E.Z.M., Machado, P.D.S., Junqueira, L.A., João, E.C.B., de Resende, J.V., Carvalho, E.E.N. and Vilas Boas, E.V.D.B., 2020. Impact of processing, packages, and storage on quality of mangaba (*Hancornia speciosa* Gomes) jelly. *Journal of Food Processing and Preservation*, *44*(10), p.e14814.

Gap Analysis in Implementation Of ISO/IEC 17025:2017 Accreditation Programme in Selected Microbiological Laboratory

B.G.M. Batepola[1*], M.B.F. Jemziya[2], A.M. Rikasa[3] & K.A.N.P. Kanugala[4]

[1,2,3]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*
[4]*Silvermill Groups of Companies, Sri Lanka*

[1*]ganesha1madhushani@gmail.com, [2]jemziya@seu.ac.lk, [3]rikasaseusl@seu.ac.lk, [4]nandana@silvermillgroup.com

Abstract- *ISO/IEC Guide 17025 is a universal guideline that comprises benchmarks for product testing service laboratories. This instruction will assure the testing laboratory to carry out testing services consistently and reliably. Implementation and improvement of the quality management system is an objective of many companies. Having a quality management system is part of strategic business development. A company with good quality practices simply increases faith and interest from existing customers and also from potential customers. Quality is a comprehensive topic, and it indeed cannot be covered thoroughly within this project, therefore focused on three significant angles that could help the process of implementing quality systems become easier. Those are the requirements of ISO/IEC 17025:2017 standard, the construction of a quality manual, and also the company's readiness for accreditation. The main objectives of this study are to identify and analyze the gaps and also implement the ISO/IEC 17025:2017 quality management system in conformance with the standard. The key data was collected through questionnaires, interviews, observations and study of internal documents. The secondary data was collected from reliable sources of information, including guidebooks and standards linked to the study. As well as this study use gap analysis techniques compare to the existing situations with the expected conditions. It gives a quantitative approach to the research. According to the outcomes, the company was mostly compliant with the standard, and there was a need for slight modifications or updates in the system to be fully conformed.*

Keywords: ISO/IEC 17025, Accreditation, Gap analysis, Readiness

I. INTRODUCTION

A quality system is a unified global system of quality standards universally agreed to be a global document to guarantee the quality of management and also it is a system of checking on what their works conform to procedures and rules that have been written and adopted (Sadikoglu and Temur, 2012).

International Organization for Standardization (ISO) is a non-governmental, international, independent organization and it has 162 national standard bodies' members and it was officially established in 1947. Today ISO has 785 technical committees and subcommittees for standard development, Including, ISO 9001 (Quality Management System), ISO 14001 (Environment and Management System), OHSAS 18001 (Occupational Health and Safety Management System), ISO 22000 (Food Safety Management System), ISO/IEC 17025 (General Requirements for the Competence of Testing and Calibration Laboratories) Among them, ISO/IEC 17025 is a family of international standards which addresses the general requirement for the competence and calibration laboratories and assists laboratories to produce precise and accurate tests results and calibration data.

Laboratory accreditation can help laboratories to produce reliable results through implementing the framework of a documented quality system (Beckett and Slay, 2007). Accreditation of the testing and calibration laboratories as per ISO/IEC 17025 standard is the only means to guarantee the reliability of testing laboratories, laboratory management system as per international standard is that the way to give assurance to their customers and also comprising exporters and the business community by providing quality testing and calibrating activities (Okezue, et al, 2020). Through a laboratory management system, a customer understands that laboratories are showing technical competency for the issuance of authentic, reliable and precise results. Laboratory accreditation enhances the trust and confidence of the customer and they offer the best analytical services to its customers (Memon *et al*., 2020).

After the implementation of the revised international standard, the laboratory will be able to demonstrate that it works with a new framework using modern technology and information technology techniques. Furthermore, the format of this standard has been significantly changed to be more in line with modern ISO formatting guidelines. The standard takes into consideration the newest version of the ISO 9001 standard, to help the implementation of ISO/IEC 17025 in laboratories that have already met the requirements of ISO 9001 (Grochau and Caten, 2012)

Laboratories practice ISO/IEC 17025 to implement a high-quality system expected at improving their ability to consistently produce valid results and it's also the premise for accreditation from an accreditation body (Honsa and Mclntye, 2003). Since quality is about competence, accreditation is the official recognition which is an indication of competence. A prerequisite for a laboratory to become accredited is to own a documented quality management system and also the typical contents of the standard operational manuals (SOPs) follow the outline of the ISO/IEC 17025 standard. National accreditation bodies are liable for accrediting laboratories to ISO/IEC 17025. Laboratories can use either an area organization or another universally recognized body in cases where the local organization ‘’has either no international recognition or where it lacks recognition in parts of the planet appropriate to the laboratory’s operations’’ Laboratories usually select a variety of common and sometimes used methodologies that might readily advantage and demonstrate a comprehensive quality system that those methodologies run under.

The question on what were the key causes for implementing ISO 17025 solicited the following answer categories; improving the quality of the goods and services, to streamline procedures and simplify work processes, decreasing client complaints and getting access to more work contracts (Shaltout and Gad, 2019). Respondents acknowledged the fact that there is pressure to get ISO 17025 accreditation because it provides the access to more contracts as some holding organizations prefer using accredited laboratories but improving the quality of the products and services was the key cause stated by respondents. The conclusion from the responses was most of the reasons furnished are somehow interconnected. Better services would lead to fewer client complaints (Cebekhulu and Mugova, 2017).

Reduced client complaints, enhanced testing productivity, enhanced quality of services and increased efficiency of projects are the key benefits of the implementation of ISO 17025 (Wierzowiecka, 2013). The benefits of applying ISO 17025 stated by interviewees, survey respondents and what is normally found in literature was more or less the same (Zapata-García *et al*., 2007). The significance of each of those benefits varied from one organization to another. One organization might have product enhancement as their key benefit were another organization might have reduced client complaints as theirs. The possibility of achieving other benefits is an added incentive (Cebekhulu, 2012).

II. RESEARCH METHODOLOGY

This research was conducted using a quantitative method supported by qualitative data. The quantitative method in this study objectives to measure how far the laboratory readiness in applying ISO / IEC Guide 17025. Though the qualitative data method generating a broad picture of the readiness of the laboratory in implementing ISO / IEC Guide 17025 (Aqidawathi *et al.*, 2019)

A. Gap analysis

This study uses the gap analysis method (Gap Analysis) for assessing the readiness of microbiology laboratory in Silvermill Group of Companies to applying ISO / IEC 17025.

B. Data Collection

For the gap analysis process data collection was done by conducting an internal audit by distributing questionnaires and in-depth interviews to main informants (General Manager, Assistant General Manager, Quality Assurance Manager, Quality Assurance Executive,) at the microbiology laboratory of Silvermill Groups of Companies. Figure 1 shows the framework questionnaires,

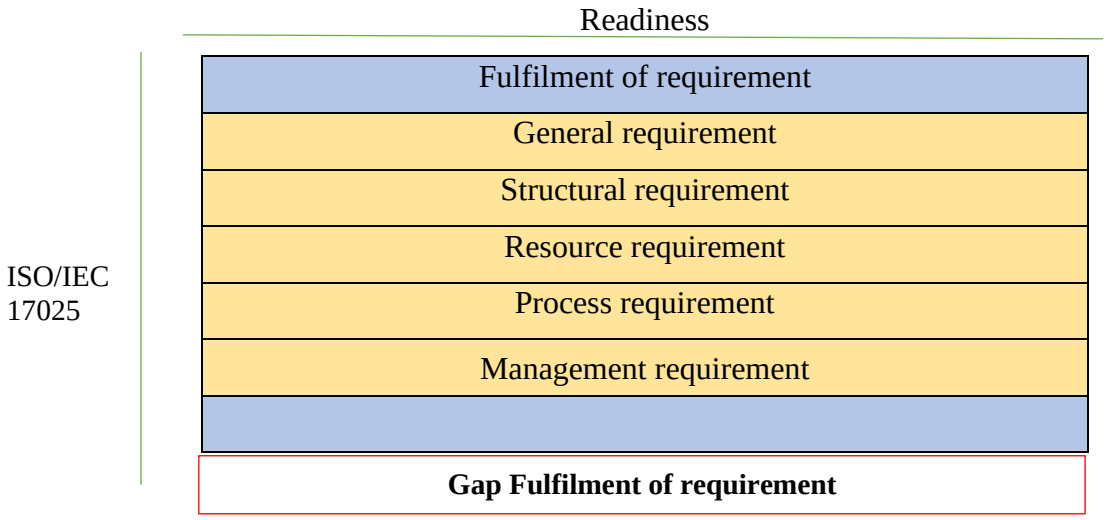


Figure 01: Framework questionnaires

Table 01: Scoring Benchmarks

Score	Criteria
0	The requirement is implemented consistently and having the essential document and resource
1	The requirement is implemented inconsistently and having the essential document and resource
2	The requirement is not implemented, but having the essential document and resource
3	The requirement is implemented, but don't have the all essential document and resource
4	Comprehend with the requirement, but not implementing the requirement and don't have the essential document and resource
5	Don't comprehend the requirement, not implementing the requirement and don't have the essential document and resource

The primary step of this tool is developing a gap analysis checklist that purposes to recognize gaps among written requirements, resources, and the actual process carried out (Putri *et al.*, 2019). This checklist was made based on the requirements of ISO17025. To facilitate the analysis of each clause, scoring for assessment was given in Table 01

C. Questionnaire Design

The designing of the questionnaire was carried out by determining the variables that are influencing the readiness of the microbiology laboratory. Determining the variables was done by deriving the clause contained in ISO / IEC 17025 and identifying the documents and resources required in ISO / IEC 17025. Furthermore, the level of fulfillment was measured.

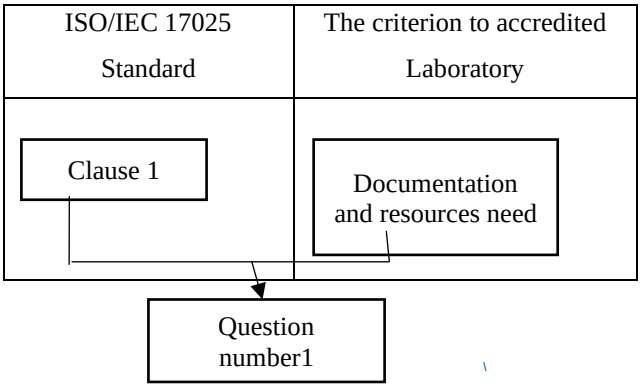


Figure 02: Questionnaire Design

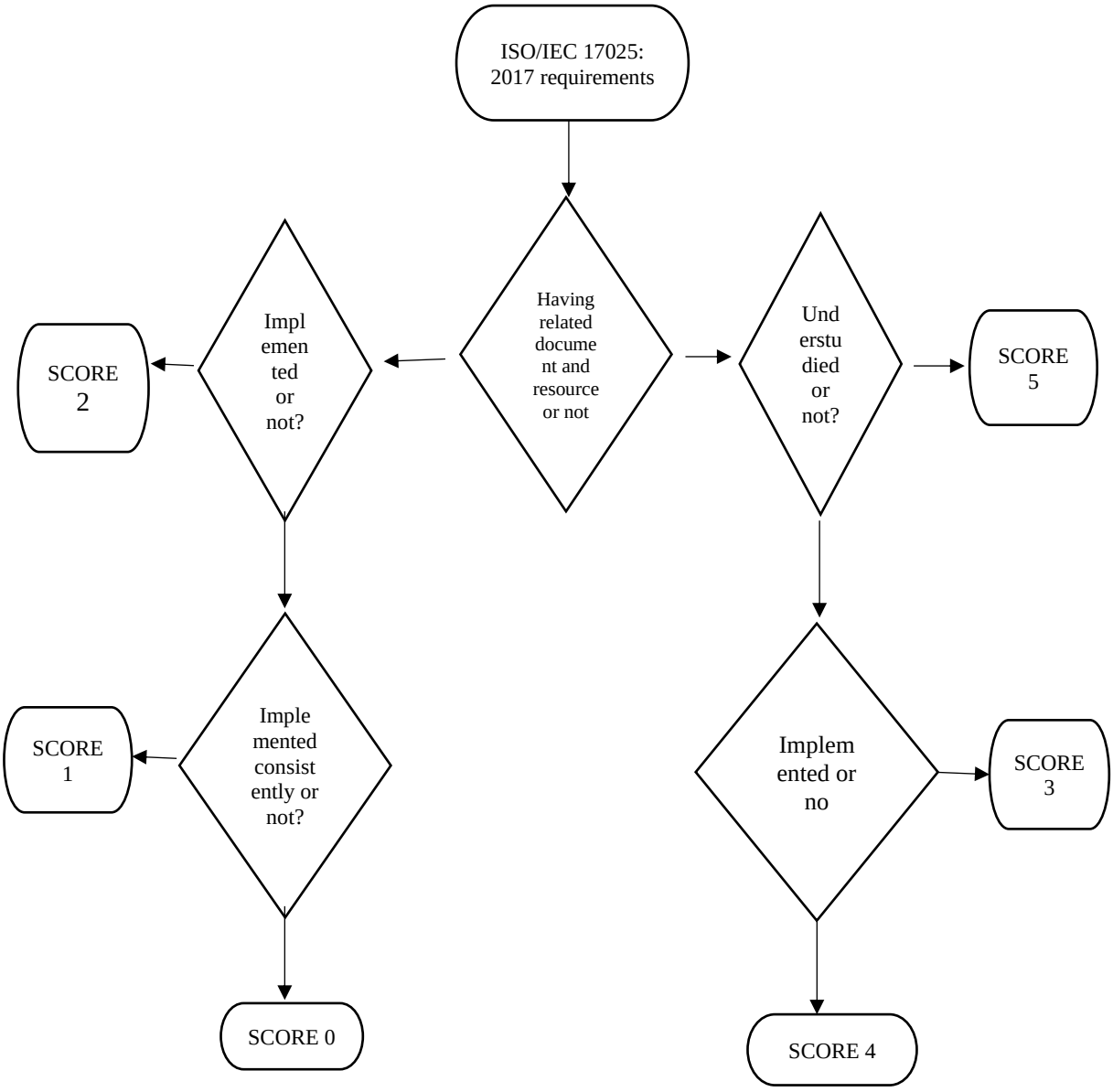


Figure 03: Flow Chart for scoring

Implementation process

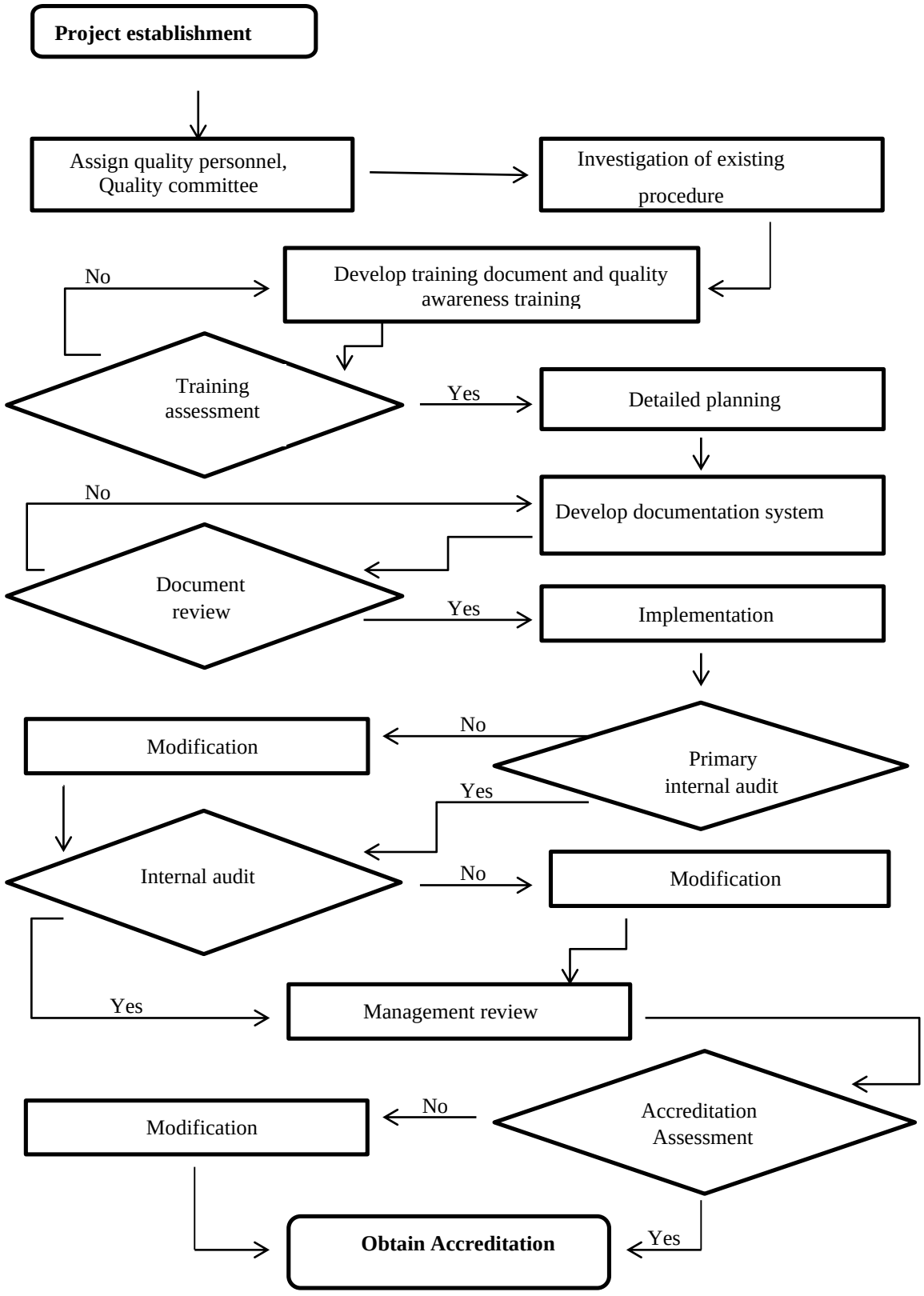


Figure 04: Flow chart for the Implementation process

III. RESULTS AND DISCUSSION

Results of the first audit

The score value was gained from the outcomes of the questionnaire assessment. The maximum score is the maximum gap value where if it reaches that value, it means that the laboratory has not comprehended yet and the laboratory system does not potentially apply ISO / IEC 17025 (Khodabocus and Balgobin, 2011). Then the calculation of the score divided by a maximum score will show the gap value. From the results of the gap, it can be seen the percentage of fulfillment of requirements from ISO / IEC 17025. The first internal audit was conducted to measure the existing situation of the laboratory. Table 2 shows the results of the first internal audit, Question code 1-9 for general requirements comprising of impartiality and confidentiality. In this laboratory, a total score of 0 was created. This shows that a gap value of 0% was created because the laboratory system fulfilled the document, resource requirements and the level of accomplishment of 100% was created because the laboratory has been understood and implementing impartiality and also confidentiality requirements as well as already documented the requirements.

Table 02: Results of first internal audit

Requirement	Question Code	Max Score	Total Score	Gap%	Compliance Level%
General requirement	1-9	45	0	0%	100%
Structural requirement	10-16	35	15	43%	57%
Resource requirement	17-47	155	83	37%	63%
Process requirement	48-114	335	112	33%	67%
Management requirement	115-137	115	71	62%	38%

Question code 10-16 for structural requirements. In this laboratory, a total score of 15 was created. This shows that a gap value of 43% was created because the laboratory does not have a technical manager accountable for the testing process and also there was no documented organizational structure. Then a fulfillment percentage of 57% was created because the laboratory has already defined the laboratory as a legal entity and it was legally responsible for its laboratory activities and also, they identified and documented the overall responsibility of the laboratory.

Question code 17-47 for resource requirements. In this laboratory, a total score of 83 was created. This displays that 37% is created because the laboratory doesn't have complete documentation and resources even though has been understood the requirements. The reasons for the gaps were, Laboratory did not possess all personnel, facilities, equipment, systems and support services. As well as they had not documented monitoring records of facilities and environmental conditions. The duties and responsibilities of laboratory employees are properly communicated, the laboratory was established and maintained metrological traceability of its measurement results, and also it has ensured measurement results are traceable to the international system of the unit. Therefore, with these requirements, the laboratory creates 63% compliance.

Question code 48-114 for process requirements. In this laboratory, a total score of 112 was created. This displays that the gap value is 33%. The main reason for this gap value is the laboratory does not have complete documentation, as well as laboratory does not keep all methods, procedures and supporting documentation. There are, instructions, standards, manuals, and reference data related to the laboratory activities, laboratory have implemented a proper sampling plan and methods but it hasn't documented well, the laboratory doesn't have a written procedure for transportation, receiving, handling, protection, storage, retention and calibration or disposal item. Most of the requirements were implemented but without any proper documentation. Hence the fulfillment rate was 67% achieved because the laboratory has understood the requirements of ISO / IEC 17025 and carried out some of these requirements. Therefore, the laboratory has a procedure for the review of the request, tenders, and contracts, laboratory use appropriate test methods, laboratory properly validates test methods and also retain a document of validation. The laboratory has documented procedures to

receive, evaluate and make decisions on complaints.

Question code 115-137 for management requirements. In this lab, the total score was 71 created. This displays that the resulting gap value is 62% and the fulfillment percentage is 38% because the laboratory staff understood the requirements of the management system but have not compiled yet the document recording procedure. Figure 5 shows the readiness level of implementing ISO 17025,

The general requirements were fully completed there were no gaps and also have proper documentation.

The structural requirement, before implementation the gap value was 43% but after the implementation process, the gap value decreases to 26%. The compliance level increases 57% to 74%. Because the laboratory was documented the organizational structure of the laboratory and the management of the laboratory were identified and documented overall

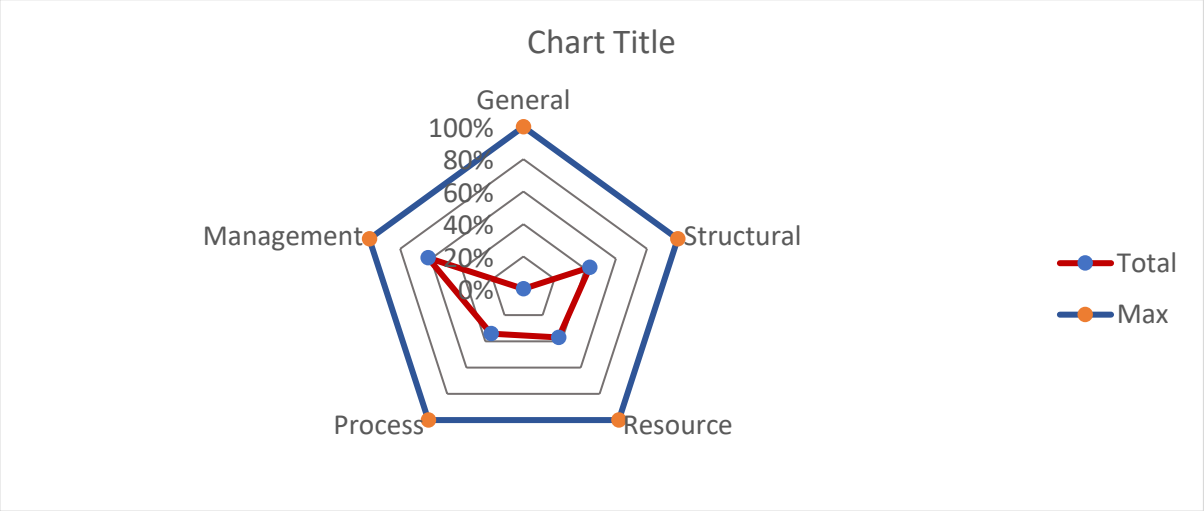


Figure 05: Radar diagram readiness Level of implementing ISO17025

Based on the first internal audit results laboratory have more gaps to fulfill to achieve ISO 17025:2017. The main reason did not have proper documentation. Most of the requirements were already comprehended and implemented but the problem is they were not documented well.

Results of the second audit

After the implementation process, the quality committee was conducted a second internal audit to measure the readiness of the laboratory to achieve ISO 17025:2017. Table 3 shows the results of the second internal audit,

responsibility of the laboratory. But there was a remaining 26% of gaps to fill. The reason was some of the documents were not documented yet. In the resource requirement before implementation, the gap value was 37% but after the implementation process, the gap value decreases to 16%. The compliance level increase to 63%-84%. Because the laboratory fulfills the necessary equipment, personnel, systems, and support services. Before the implementation process, the laboratory there is a shortage of laboratory equipment. Such as a Biosafety cabinet, double door autoclave, digital manometer, automatic pipette washer, loop sterilizer,

Table 03: Results of Second internal audit

Requirement	Question Code	Max Score	Total Score	Gap%	Compliance Level%
General requirement	1-9	45	0	0	100%
Structural requirement	10-16	35	9	26%	74%
Resource requirement	17-47	155	26	16%	84%
Process requirement	48-114	335	30	9%	91%
Management requirement	115-137	115	15	13%	87%

glassware washer, conductivity meter and vortex mixture, etc. the environmental monitoring records are properly documented after the implementation process. Hence increase in the compliance level but there was still a 16% gap is remaining because of some documentation problems of facilities and environmental procedures.

In the process requirement, before implementation, the gap value was 33% but after the implementation process, the gap value has decreased to 9%. The reason for that was the laboratory was kept all methods, procedures and supporting documentation relevant to the laboratory activities. As well as they were prepared a quality manual and standard operating procedures for all equipment and laboratory tests. Because of that, the compliance level was increased to 67-91%.

In the management requirement, the first audit gap value was 38% but after the implementation process, it was decreased to 13%. The compliance level was increased from 62% to 87%.

Based on the above results most of the requirements of ISO 17025: 2017 standard were reached a 75 %compliance level because of that the laboratory is suitable for applying to get ISO 17025:2017 to the laboratory. This analysis was done by the quality department internal audit team but needs to confirm exactly by Industrial Technology Institute (ITI) audit results to verify the company has succeeded in meeting these standard's requirements

As the key objective of this project was to support the company to implement the ISO/IEC 17025:2017 into a quality management system. The company reached a better point of view of its stance in quality management. Now it has a clear framework of steps to walk up the accreditation process. As well as the readiness analysis supports the top management and also staff to comprehend the requirements from the standard. The establishment of a quality manual achieves the main requirement from the manager. A set of Standard Operation procedures (SOP) works as guidance documents for staff to follow. The learning of standard requirement clauses can also serve as a tool and reference for staff in case they want additional explanation or guidelines from the requirements. At the end of the project, the top management team and staff have a clear sight about what are the requirements of the quality management system and how to obtain accreditation. The company has reached quite a satisfactory level of implementing the standard, but the research, also proves that there is still have for enhancement. A few of the greatest significant parts that the company misses from the quality management system are the work and records of annual reviews and audits, management reviews, and staff training. Even though it is adequate to prove that the company has started those activities from the date the accreditation application being sent, earlier records during the whole business time will increase the image of the company in compliant standard and quality. Besides, the documentation system might want preparation and rearrangement. Because of the nature of business, a large quantity of documents stored in the internal electronic documentation system is in not proper

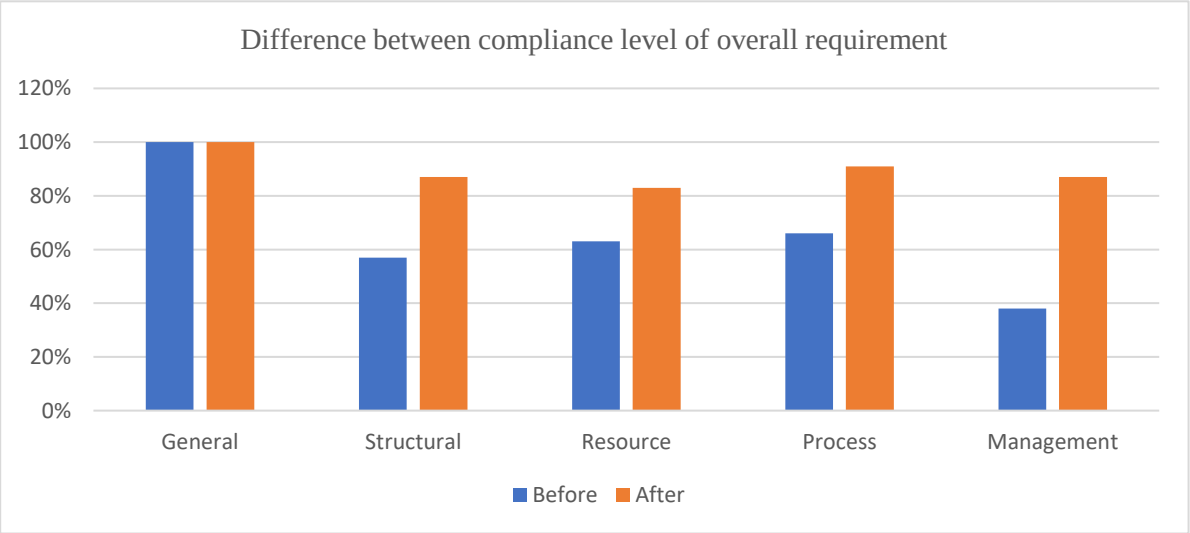


Figure 06: Difference between compliance level of overall requirements in first internal audit and second internal audit results

state. Those can still be improved with the implementation of other document management systems. This restriction can seriously affect the audit result as well as the accreditation outcome. But, one of the simple methods to fix the problem is to attach an appendix to each document and the other method is manually note down what has been changed as proof of record. Each single quality management system needs a different set of documentation, organization and also work procedures.

IV. CONCLUSION

Quality management is always a challenging topic in terms of planning, implementing and evaluating. The perception of quality differs between each individual is one of the reasons for challenges. Each individual in an organization will have a diverse method and action towards the quality objective. Therefore, it is generally tough to have a compromise between all staff. Awareness of variances in quality perception will support the management team to have more effective concentration and effort on quality training and quality management system. The readiness analysis of ISO 17025.2017 in the case company was broad and covered the processes. Some of the teams were resistant to the transformation during the readiness analysis, which might have affected the outcomes. If the person would have been more committed to the alteration from the beginning, the readiness analysis might have been more precise and the ultimate outcomes in the internal audit would have been better. Implements the gaps of requirements to achieve ISO 17025:2017 is the main goal of the study. Overall, the project reached its goals in the restricted schedule and the theory covered each important area.

REFERENCES

Aqidawati, E. F., Sutopo, W. and Zakaria, R. (2019) 'Model to measure the readiness of university testing laboratories to fulfill ISO/IEC 17025 requirements (a case study)', *Journal of Open Innovation: Technology, Market, and Complexity*, 5(1). doi: 10.3390/joitmc5010002.

Beckett, J. and Slay, J. (2007) 'Digital forensics: Validation and verification in a dynamic work environment', *Proceedings of the Annual Hawaii International Conference on System Sciences*, (February 2014). doi: 10.1109/HICSS.2007.175.

Cebekhulu, B. (2012) 'Quality Control in a University Laboratory : a Study of Iso / Iec-17025 Implementation in the Thin Section'.

Cebekhulu, B. M. B. and Mugova, C. (2017) 'Quality control in a university laboratory: Evaluating the gap between ISO/IEC-17025 requirements and the thin section laboratory's processes', *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 2017(JUL), pp. 614–625.

Grochau, I. H. and ten Caten, C. S. (2012) 'A process approach to ISO/IEC 17025 in the implementation of a quality management system in testing laboratories', *Accreditation and Quality Assurance*, 17(5), pp. 519–527. doi: 10.1007/s00769-012-0905-3.

Honsa, J. D. and McIntyre, D. A. (2003) 'ISO 17025: Practical benefits of implementing a quality system', *Journal of AOAC International*, 86(5), pp. 1038–1044. doi: 10.1093/jaoac/86.5.1038.

Khodabocus, F. and Balgobin, K. (2011) 'Implementation and Practical Benefits of ISO/IEC 17025:2005 in a Testing Laboratory', *University of Mauritius Research Journal*, 17(1), pp. 27–60. doi: 10.4314/umrj.v17i1.70730.

Memon, A. R. *et al.* (2020) 'Responsibilities and qualities of an assessor / auditor as per ISO / IEC standards research article responsibilities and qualities of an assessor / auditor as per ISO / IEC standards', (April).

Okezue, M. A. *et al.* (2020) 'Impact of ISO/IEC 17025 laboratory accreditation in sub-Saharan Africa: a case study', *BMC Health Services Research*, 20(1), pp. 1–9. doi: 10.1186/s12913-020-05934-8.

Putri, Z. T. *et al.* (2019) 'A Framework to Measure Readiness Level of Laboratory for Implementing ISO/IEC 17025: A Case Study', *IOP Conference Series: Materials Science and Engineering*, 495(1). doi: 10.1088/1757-899X/495/1/012011.

Sadikoglu, E. and Temur, T. (2012) 'The Relationship Between ISO 17025 Quality Management System Accreditation and Laboratory Performance', *Quality Management and Practices*. doi: 10.5772/37294.

Determination of Quality of Coconut Oil Manufactured in Ampara District with Selected Quality Parameters

M.C. Fathima Sajeetha[1], U.L. Abdul Majeed[2*] & A.M. Mohamed Asmath[3]

[1,2,3]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1]fathimasajeetha.mc@gmail.com, [2*]ulmajeed@seu.ac.lk, [3]mohamedasmath@seu.ac.lk

Abstract- *Coconut oil, commonly used edible oil in Sri Lanka, has number of health benefits such as cholesterol-lowering effects, reduced risk of cardiovascular diseases, weight loss, improved cognitive functions, and antimicrobial activity. Demand for coconut oil rapidly increases. Coconut oil is produced on small to large scale. In Ampara district, there are numerous small-scale traditional coconut oil producers that produce oils that lack of proper knowledge and scientific practices. This study is designed to compare selected quality parameters of coconut oil produced locally with SLS standards (SLS 32:2017). Oil samples were collected from Addalaichenai, Akkaraipattu and Pottuvil. The free fatty acid (FFA), moisture, and peroxide value (PV) were determined using standard methods. The results obtained were the mean values for free fatty acid, moisture, and peroxide value ranged from 1.069±0.15 to 1.1402±0.38 mg NaOH/g oil, 0.3486±0.00 to 1.7920±1.49 % and 1.0913±0.47 to 1.8836±0.55 meq /kg respectively. All three samples had higher moisture and free fatty acid content than the standard value (0.4 and 0.8) respectively, and lower peroxide value (>3). A significant difference was observed in peroxide value, which was lower than the SLS value, whereas the moisture content and free fatty acid value were not found to be significantly differ across all areas. The local manufacturers must improve their oil processing scientifically and hygienically, so as to improve the quality on par with the SLS standards and to provide quality oil to the consumers. However, modern scientific manufacturing methods should be introduced by the local manufacturer.*

Keywords: Coconut oil, quality parameters, SLS standard, Ampara district

I. INTRODUCTION

Coconut oil is obtained by crushing copra, the dried kernel of the coconut fruit (*Cocos nucifera L.*). It is one of the most important coconut base products. Freshly harvested coconut flesh contains 34 % oil, 50 % moisture, 7.3 % carbohydrate, 2.2 % ash and 3.5 % protein (Kumar *et al*, 2019), and dried kernel has 60-65 % oil, has a natural sweet coconut taste, and contains 92 % saturated fatty acids (Krishna *et al*, 2010). The world produced nearly 62.45 million metric tons (MMT) of coconuts in 2018 (FOA, 2018). In 2019, Sri Lanka's coconut production was estimated to be 3,085.6 million nuts. Coconut oil production increased by 309.2 % to 44,648 MT (Annual report of Central bank of Sri Lanka, 2019). Coconut oil has a lot of health benefits, including lowering cholesterol, weight loss, reducing the risk of cardiovascular disease, improved cognitive functions, antimicrobial activity, and others (Lima & block, 2019). Demand for coconut oil rapidly increases among peoples due to its health benefits, growing commercial value and widespread use in cooking (Lima & block 2019). As a result, it is manufactured in Sri Lanka as cottage, micro, small and mid-size enterprises (SMEs) and large industries, as well as it provides a good income to households. Therefore, numerous cottage level traditional coconut industries, manufacture oils lack of proper knowledge and understanding on the quality parameters of coconuts oils for unscriptural financial benefits in Ampara districts, which may pave the way for causing health hazards for the consumers. Hence, the evaluation on the quality parameters of locally manufactured coconut oils has become indispensable due to the negative health concern faced by the general public. Therefore, the present study is designed to determine the quality parameters of locally manufactured coconut oil and compared with the requirements of the SLS 32:2017 to measure the gap between the degree of quality of locally manufactured coconut oil and the requirements prescribed in the SLS 32:2017 standards.

II. LITERATURE REVIEW

In 2020, the total global production of edible-grade coconut oil was 3.57 MMT (Statista, 2021). Philippines, Indonesia, and India were the top three producers (FAO, 2012). Around the world,

54 % of the coconut oil sold is used for cooking, while the remaining 46 % is used for other purposes (Krishna, 2012). In Sri Lanka, coconut production was estimated to be 3,085.6 million nuts in 2019, representing a 17.6 % increase over 2018. Coconut oil production increased by 309.2 % to 44,648 MT in 2019, while virgin coconut oil production climbed by 2.8% to 12,725 MT. As a result, oil imports dropped from 217,730 MT in 2018 to 155,997 MT in 2019 (Annual report of Central bank of Sri Lanka, 2019). Coconut oil is the fat obtained from the kernel of coconut palm. Refined coconut oil (RCO) is made from dried coconut, while the future unrefined oil is made by washing, bleaching, and deodorizing mature fresh coconut in industrial scale production (Gunston, 2002). Coconut oil contains fatty acids, which has been shown to protect against not only cardiovascular disease, but also a variety of chronic health issues such as diabetes and cancer, as well as to prevent and even treat infectious diseases. However, due to a general prejudice against saturated fats, data on coconut oil has been buried in medical journals without interruption (Boateng *et al*, 2016).

III. PROBLEM STATEMENT

Coconut oil has high demand among consumers as it is commonly used for cooking purpose. It is manufactured in Sri Lanka by micro, SMEs, and large industries. It is also produced by cottage industry, which provides a good source of income for households. There are numerous small-scale traditional coconut oil manufacturing industries in Ampara districts which produce oils lack of scientific knowledge and understanding on the overall quality parameters of coconut oils. However, unless coconut oil is processed based on the scientific and good sanitary practice, the quality parameters of oils produced may not meet the required degree of quality and safety standards and may be unsafe for human consumption. Therefore, the present study aims to determine the quality parameters of locally manufactured coconut oil and compare them to the requirements prescribed in SLS 32:2017 requirements.

IV. MATERIALS AND METHODS

A. Sample collection

Three different samples of coconut oil ($1m^3$) produced from copra were collected in a clean container from three—different coconut oil manufacturers in Ampara district namely Akkaraipattu,Addalaichechenai, and Pottuvil. The collected samples were kept at room temperature in the laboratory without direct exposure to sunlight for further analysis. Then five replicates were performed from each sample.

B. Analysis of quality parameters

The peroxide value, moisture content and free fatty acid content were determined among the quality parameters. The oven drying method was applied to determine the moisture contents as described in AOAC 925.10 (1990). The free fatty acid contents were determined according to the method prescribed in AOAC (940.28) while the peroxide value was determined according to the method prescribed in the AOAC 965.33 (2000).

C. Statistical analysis

The data were analysed using t-tests with 95% confidence level. All the tests were done by using SPSS (SPSS.25 windows, 2017)

V. RESULTS AND DISCUSSION

The results obtained from the analyses on moisture content, free fatty acid value and peroxide value are shown in Tables 1.

Table 1: Results of quality parameters of coconut oil

Oil samples	Quality parameters		
	Moisture content (%)	Free fatty acid value (mg NaOH/g oil)	Peroxide Value (meq /kg)
Akkaraipattu	1.39288 ± 0.95^{a}	1.1402 ± 0.38^{a}	1.5768 ± 0.38^{ab}
Addalaichchenai	1.7920 ± 1.49^{a}	1.1382 ± 0.38^{a}	1.8836 ± 0.55^{b}
Pottuvil	0.3486 ± 0.00^{a}	1.069 ± 0.15^{a}	1.0913 ± 0.47^{a}
SLS Standard for coconut oil	Maximum 0.4^{a}	Maximum 0.8^{a}	Maximum 3.00^{c}

Means ± Standard Deviation (SD) within the same column with different superscripts are significantly different at $p<0.05$

D. Determination of Moisture content

The moisture and volatile matters are the most important determinants of oil quality (Choe and Min, 2006). Keeping the moisture content low is preferable which extends the shelf life by preventing oxidation and rancidity processes. When fats and oils are exposed to high moisture levels, they deteriorate due to hydrolytic rancidity (Raghavendra and Raghavarao, 2011; Oseni, 2017). The moisture contents of the oils collected from Akkaraipattu, Addalaichenai and Pottuvil were found to be non-significant ($p > 0.05$) with the comparison to the requirements prescribed in SLS (32:2017) standard. The moisture contents of oil from Akkaraipattu and Addalaichenai were higher than 50 % within the recommended range of 0.4 % in SLS standard. The high moisture content shown in Addalaichenai sample was due to a limited drying periods/process. However, the improper drying process will cause water residual in oil. The moisture content of the sample collected from Pottuvil was found to be less than 0.4 % of the SLS standard value. A low moisture content is essential for a long storage life (Kumar, 2018).

E. Determination of Free fatty acid value

The free fatty acid content of coconut oils is an indicator of hydrolytic rancidity, which causes an unpleasant flavour and aroma to the oil. The action of lipase or moisture is the primary cause of hydrolytic rancidity (Osawa *et al*, 2007). Free fatty acids are present in oil or fat, and their concentration will increase during processing and storage (Darko, 2014). The presence of free fat is commonly used as an initial indicator of oil damage (Darko, 2014). The mean free fatty acids (FFA) contents of all three samples were found to be almost same, indicating free fatty acids values that were higher than the standard value and found to be non-insignificant ($p > 0.05$) in all three locations, indicating moderate quality. It has been shown that the free fatty acid content of coconut oil varies with copra processing and storage time (Darko, 2014).

F. Determination of Peroxide value

Peroxide value is the most important to determine the degree of spoilage of oil or fat. When unsaturated fatty acids bind oxygen to their double bonds, peroxide is formed. Oxygen can oxidize unsaturated fatty acid oils, resulting in the formation of peroxide (Natalia *et al*, 2019). The high peroxide level indicates that the oil has been oxidized and is on the

verge of becoming rancid (Natalia *et al*, 2019). Oxidation of some fatty acids, especially unsaturated fatty acids, may lead to high peroxide numbers (Natalia *et al*, 2019). Low oxidation is defined as a peroxide value between 1 and 5 meq/kg, moderate oxidation is defined as a value between 5 and 10 meq/kg, and high oxidation is defined as a value greater than 10 meq/kg (Moigradean *et al*, 2012). However, SLSI standard limits the peroxide value of coconut oils in general to a maximum of 3 meq/kg (Moigradean *et al*, 2012). The peroxide values of coconut oil, as well as the number of unsaturated fatty acids, were taken into account in this present study. If low amount of peroxide produced during the process, cause the higher quality oil production, as the amount of peroxide in the oil would quickly become rancid if the amount of peroxide increased (Natalia *et al*, 2019). The results in this study shows that all three samples vary significantly to SLS (32:2017) limit and show adequate peroxide levels that are lower than the SLS standard maximum level of 3 meq/kg, indicating that they safe to human consumption.

VI. CONCLUSION

According to the findings of this present study, all three samples were found to be of satisfies the Sri Lanka Standards (SLS) requirement in terms of peroxide value; however, due to the moisture content and free fatty acid value, they failed to meet the requirement of SLS standard. The oil sample collected from Pottuvil is moderately higher in quality in terms of all three quality parameters. Therefore, local manufacturers have to improve their coconut oil processing so as to improve the quality of coconut oil and to provide quality oil to consumers to prevent any possible health hazards.

REFERENCES

CBSL, 2019. ANNUAL REPORT. Central Bank of Sri Lanka, Sri Lanka.

Statista, 2021. *Global oil consumption* [Online]. Available from: https://www.statista.com/statistics/263937/vegetable-oils-global-consumption.

FAO, 2012. FAOSTAT Website for Statistics. Available online: http://www.fao.org/faostat/en/#data (accessed on 20 January 2021).

Association of Official Analytical Chemists (AOAC), 1990. *Official Methods of analysis*, 15th ed.

Association of Official Analytical Chemists, AOAC Pub., Virginia, U.S.A. 69-84, 951-979.

American Oil Chemists' Society (AOCS), 1999. *Official Methods and Recommended Practices*. 5th Edition, The American Oil Chemists' Society, Champaign, IL, Method CD 14d–99.

Boateng, L., Ansong, R., Owusu, W. and Steiner-Asiedu, M., 2016. Coconut oil and palm oil's role in nutrition, health and national development: A review. *Ghana medical journal*, *50*(3), pp.189-196.

Choe, E. and Min, D.B., 2006. Mechanisms and factors for edible oil oxidation. *Comprehensive reviews in food science and food safety*, *5*(4), pp.169-186.

Darko, J.O., 2014. Quality assessment of moisture content, free fatty acids and acid value of coconut oil produced in the Jomoro District of the Western Region of Ghana.

Shahbandeh, M., 2021.*Global coconut production 2000-2019*. Available from: https://www.statista.com/statistics/577497/world-coconut-production/accessed on 25 April 2021

Gunstone, F. ed., 2002. *Vegetable oils in food technology: composition, properties and uses*. (Blackwell, oxfort).

Hamid, M.A., Sarmidi, M.R., Mokhtar, T.H., Sulaiman, W.R.W. and Aziz, R.A., 2011. Innovative integrated wet process for virgin coconut oil production. *Journal of Applied Sciences*, *11*(13), pp.2467-2469.

Krishna, A.G., 2012. Coconut oil: science, technology, and applications. *inform*, *23*(6).

Krishna, A.G., Gaurav, R., Singh, B.A., Kumar, P.P. and Preeti, C., 2010. Coconut oil: chemistry, production and its applications-a review. *Indian Coconut Journal*, *53*(3), pp.15-27.

Kumar, G.P., Lakshmi, N.V.V.S.S., Deena, C., Sekhar, V.C., Nikhitha, N.M., Begum, M.M.H., Bhavani, V.B. and Kumar, P.R., 2018. Determination of the quality of coconut oils (unrefined grade) and (refined grade) produced from three survey regions of East Godavari District, India. *Asian Journal of Applied Chemistry Research*, pp.1-8.

Lima, R.D.S. and Block, J.M., 2019. Coconut oil: what do we really know about it so far? *Food Quality and Safety*, *3*(2), pp.61-72.

Mansor, T. S. T., Man, Y. C., Shuhaimi, M., Afiq, M. A., & Nurul, F. K., 2012. Physicochemical properties of virgin coconut oil extracted from different processing methods. *International Food Research Journal*, *19*(3), 837.

Marina, A.M., Man, Y.C. and Amin, I., 2009. Virgin coconut oil: emerging functional food oil. *Trends in Food Science & Technology*, *20*(10), pp.481-487.

Meedenya, M. and Coorey, R., 2012. Quality assessment of commercially available coconut oils in Sri Lanka using refractometry. In *Proc. Tech. Sess.* (Vol. 28, pp. 37-44).

Moigradean, D., Poiana, M.A. and Gogoasa, I., 2012. Quality characteristics and oxidative stability of coconut oil during storage. *Journal of Agroalimentary Processes and Technologies*, *18*(4), pp.272-276.

Natalia, A., Lukmanto, F., Ani, I. and Tarigan, I.L., 2019. Analysis quality characteristics of virgin coconut oil (VCO): comparisons with cooking coconut oil (CCO). *Medical Laboratory Analysis and Sciences Journal*, *1*(1), pp.30-36.

Osawa, C.C., Gonçalves, L.A.G. and Ragazzi, S., 2007. Correlation between free fatty acids of vegetable oils evaluated by rapid tests and by the official method. *Journal of Food Composition and Analysis*, *20*(6), pp.523-528.

Oseni, N.T., Fernando, W.M., Coorey, R., Gold, I. and Jayasena, V., 2017. Effect of extraction techniques on the quality of coconut oil. *African Journal of Food Science*, pp.58-66.

Raghavendra, S.N. and Raghavarao, K.S.M.S., 2011. Aqueous extraction and enzymatic destabilization of coconut milk emulsions. *Journal of the American Oil Chemists' Society*, *88*(4), pp.481-487

Impact of Different Processing Methods on Proximate Chemical Compositions and Nutritional Contents of Skipjack Tuna (*Katsuwonus pelamis* Linnaeus, 1758)-Balaya Fish

M.R.F. Rukshana[1], U.L. Abdul Majeed[2*] & A.M. Mohamed Asmath[3]

[1,2,3]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1]shanarafaideen@gmail.com, [2*]ulmajeed@seu.ac.lk, [3]mohamedasmath@seu.ac.lk

Abstract- *Millions of people eat fish around the globe, which is high in omega -3 fatty acids and a rich source of protein. Fish is typically processed with a variety of processing techniques. Processing can have an impact on the nutritional value of fish. The effects of processing on proximate composition and sensory quality parameters were investigated. According to the results obtained, the mean moisture, fat, and ash contents of raw fish were found to be 71.36±0.30 %, 0.96±0.02 %, and 1.95±0.05 % respectively. The moisture, ash, and fat contents were found to differ significantly ($p<0.05$) depending on the processing. The highest and the lowest moisture contents were found to be recorded in raw (71.36±0.30 %) and fried samples (41.01±1.77 %). The highest (4.79±0.24 %) and the lowest (1.77±0.06 %) ash contents were found to be recorded in fried and grilled samples. The highest (8.78±0.96 %) and the lowest (0.96±0.02 %) fat contents were found to be recorded in fried and raw samples. Evaluation of sensory quality parameters was performed with nine hedonic scales on both samples. It showed that frying and boiling achieved the highest ratings, while steaming was the least. For nutritional value, boiling was found to be the best. Frying obtained the highest while steaming obtained the least score. Out of the total population, a greater portion consumes tuna fish without the knowledge of the impact of processing on nutritional composition. The findings of this present study will help to explore the best processing method with minimal nutrient loss and to secure maximum palatability.*

Keywords: Katsuwonus pelamis, cooking methods, nutritional value, sensory qualities

I. INTRODUCTION

Fish are one of the most important vertebrate groups, and are a major source of food for humans (Mahaliyana *et al.*, 2015), which is a good source chemical components (Abraha *et al.*, 2018), where moisture, protein, and fat are the primary components of fish, with trace amounts of vitamins and minerals (Aberoumand, 2014). Many people like fish since it is the cheapest source of animal protein and other key elements for human health (Mahaliyana *et al.*, 2015). In 2018, the world fisheries and aquaculture production were 178.5 million tons (FAO, 2020). Meanwhile the total fish production of Sri Lanka in 2019 was 505,830 MT. Furthermore, marine fish production totaled 415,49 MT, while freshwater fish production totaled 90,340 MT. Out of 439,370 MT of marine fish harvested, the production of *Katsuwonus pelamis* only in 2018 was 47,230 MT (Fisheries Statistics, 2020). In 2016, the average per capita consumption of fish in Sri Lanka was 11.8 Kg (Fisheries Statistics, 2020).

Katsuwonus pelamis is a member of the Scombridae family and belongs to the genus *Thunnus* as per the authors Karunarathna and Attygalle, (2009), and it is a popular food and a good source of protein. It is low in fat, with omega-3 fatty acids making up the majority of its fatty acid composition, which have higher health benefits (Mahaliyana *et al*., 2015). Furthermore, it contains a high concentration of Fe, Cu, and Zn, all of which are essential minerals in the human body (Mahaliyana *et al*., 2015). Fresh *Katsuwonus pelamis* had a chemical composition of 71.76 % moisture, 25.29 % protein, 0.60 % fat, 1.49 % ash, and 0.87 % carbohydrates (Nurjanah *et al.*, 2015). Fish is normally not consumed raw; instead, it is prepared using a variety of cooking methods (Aberoumand, 2014). These methods include frying, grilling, baking, steaming and boiling. These cooking methods have a wide range of uses, techniques, and effects on the nutritional and proximate composition of processed fish (Abraha *et al.*, 2018). Proper cooking methods are essential for retaining maximum nutritional value, including proximate composition, vitamins, minerals, and fatty acid composition (Golgolipour *et al*., 2019).

II. LITERATURE REVIEW

A fish is an aquatic vertebrate with a scaled body that moves with fins and tails and breathes through its gills. (Gonzales, 2016). Fish lipids are high in Poly Unsaturated Fatty Acids (PUFAs), which are divided into two groups: omega-3-fatty acids and omega-6-fatty acids (Abraha *et al*., 2018). Both are categorized as essential fatty acids since humans cannot synthesis them and must get them through food or supplements (Chandravanshi *et al*., 2019). Skipjack tuna also have little fat and the majority of its fatty acid composition is made up of omega-3 fatty acids, as well as it contains a high protein content and high concentration of Iron, Copper, and Zinc (24.05, 5.04, and 6.89 mg kg^{-1}), which have more health benefits for human (Mahaliyana *et al*., 2015). ASkipjack tuna's body is fusiform, elongate, and rounded. Gill rakers are abundant, with 53 to 63 on the first-gill arch. Teeth are small and conical, with a single series; gill rakers are small and conical, with a single series. It's a dark purplish-blue with silvery lower sides and belly, as well as four to six prominent longitudinal dark bands (Florida Museum of Natural History, 2017).

Fish processing improves flavor and taste while inactivating pathogenic microorganisms. Furthermore, because of their sensitivity to heat, oxygen, light, pH, or a combination of these, it causes macro and micronutrient distortion (Karimian-Khosroshahi *et al.*, 2016). By generating fragrance compounds, appealing color, crust, and texture, increases the sensory quality of food. In addition, food processing improves hygienic quality by inactivating harmful bacteria and increasing nutrient digestion and bioavailability in the digestive tract (Bognár, 1998). Cooking with steam heat generated by boiling water is the basis of steaming (Sobral *et al*., 2018). According to the same author, boiling is a simple meat and fish cooking method that involves heating the meat or fish in 100 °C water. The heat used during baking can be dry heat, which helps to sterilize the food by killing harmful bacteria, control unwanted enzymatic reactions, and improve nutrient availability (Munir, 2009). Grilling, as opposed to broiling, is a form of cooking that uses radiant heat from below rather than above (El-lahamy *et al.*, 2019).

III. PROBLEM STATEMENT

Fish is one of the invaluable and healthiest food on the planet due to its excellent nutritional value. Fish is rarely consumed as raw and different cooking processes are used to prepare it for eating. Skipjack tuna can be cooked in many ways for consumption such as frying, grilling, baking, steaming and boiling. These cooking methods can impact the nutritional and proximate compositions and sensory qualities of Skipjack tuna fish.

IV. MATERIALS AND METHODS

Four fresh, individual *Katsuwonus pelamis* fish were collected from the fish landing site, Oluvil. They were kept in polystyrene box with ice cubes and taken to laboratory immediately. Upon the arrival at the laboratory, the biometric data of each fish (length, weight, perimeter, etc.) were recorded and the morphological characters of each fish were studied then finally the species was confirmed. Then, the fish were thoroughly washed with water, descaled, de-headed, gutted, and filleted. The fillets were then wrapped with aluminum foil sheet and immediately transferred to frozen storage at -21 ºC until further use. The samples were then removed from the frozen storage and thawed for about 20 minutes at 10 ºC before processing. The thawed fishes were cut into ideal size range from 2.5 cm to 4.5 cm in length, 60-80g weight, 2-4 cm height and immersed in pure coconut oil in a frying pan and deep-fried for 5 minutes at 180 ºC. During the frying process, the fillets were turned upside down occasionally to ensure the evenness of frying of fillets. The steaming of fish fillets was performed by way of placing the fillets in a steamer above steel pot containing 500 ml of boiling water at (100 ºC) and cooked for 15 minutes with the lid on. Baking of fish fillets was performed in a preheating electric oven for 20 minutes with the temperature set at 200 °C. The boiling of fish fillets was performed by way of placing in a stainless-steel cooking pot containing 500 ml of boiling water at (100 ºC) and cooked with the lid off for 15 minutes. The grilling of fish samples was performed by way of being wrapped in a foil sheet and grilled by wood charcoal grilling for 20 minutes.

A. Determination of Proximate Chemical Compositions

Determination of the proximate chemical composition of cooked and raw fish fillets were performed in triplicate for moisture, ash and fat contents. Moisture content was determined by oven drying using oven (Memmert UF110, Germany) at 105 °C to constant weight as described by (AOAC, 2000). The fat content was extracted by using the Soxhlet system (FAT-06A) as described by (AOAC, 2000). Ash content was

determined with muffle furnace (MF 1400-30) by maintaining the temperature at 550 °C to constant weight as described by (AOAC, 2000).

B. Determination of Sensory qualities

25 Panelists indicated their degree of liking for each sample by choosing the appropriate category. The sensory evaluation was carried out based on texture, color, flavor, mouth-feel, and overall acceptability of fried, steamed, boiled, baked and grilled samples.

C. Statistical analysis

The results obtained by proximate analysis and sensory evaluation were submitted to analysis of variance (ANOVA) and means were compared by the test of Tukey's HSD at p= 0.05 using SPSS.25 windows, 2017.

V. RESULTS AND DISCUSSION

A. Determination of proximate chemical composition

The mean weight and length of Skipjack tuna fillets were 2.31±0.03 kg and 54.25±0.47 cm respectively and thickness of the fillets ranged from 2.5 to 4.5 cm on average. The Skipjack tuna fillets were processed as fried, baked, grilled, boiled, and steamed as shown in Figure _1 and compared with raw fillets. The average proximate values were determined by analyzing three samples each.

1) Moisture Content:

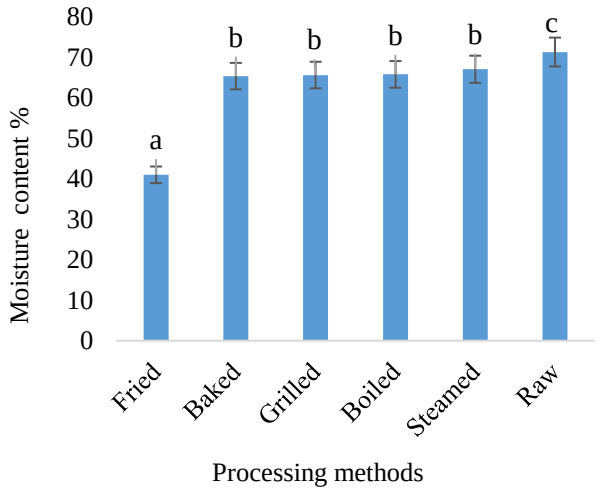


Figure 1: The moisture content of the raw and cooked samples. The bar with different superscripts varies significantly (p<0.05)

When fish filets were subjected to various processing methods, the moisture contents of the samples varied significantly (Oluwaniyi *et al.*, 2010). There was significant difference in moisture content between raw and fried samples, as shown in Figure 1. The moisture content of the raw fish fillets was found to be the highest (71.36 %), while the moisture content of the fried samples was found to be the lowest 41.01 % (Figure 1). Since the water in the fish forms an aqueous/oil mixture during frying and is expelled before the frying is completed since the boiling point of the oil is much higher than that of water, the moisture content of the fried fish samples is the lowest (Oluwaniyi and Dosumu, 2009). According to the results of the present study, there was no significant difference (p>0.05) observed in moisture content among the baked, grilled, boiled and steamed fish sample as shown in Figure 1. According to Aberoumand and Ziaei-Nejad, (2015) due to decreased moisture loss, baked and boiled fish fillets exhibited higher nutritional values than fried fish fillets. The high humidity maintained during boiling and steaming may cause minor water loss during cooking (Sobral *et al.*, 2018).

2) Ash Content:

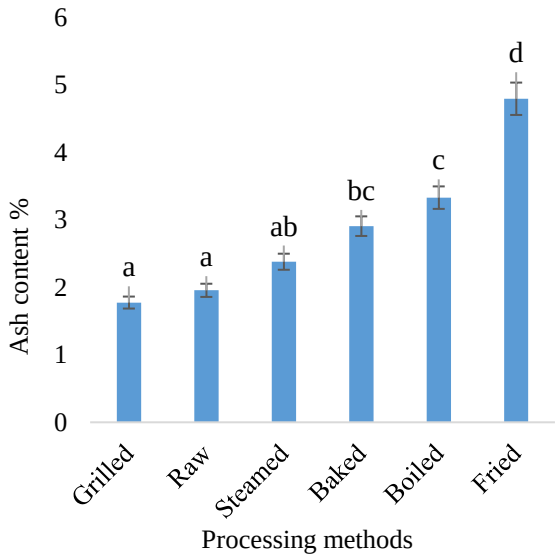


Figure 2: The Ash content of the raw and processed fillets samples. The bar with different superscripts varies significantly (p<0.05)

The ash content of raw and processed fillets is shown in Figure 2. The mineral content of a food sample is defined as ash content of food (Ismail, 2017). In this study, the ash content of processed *Katsuwonus pelamis* fillets ranged from 1.77 % (grilled) to 4.79 % (fried) as shown in Figure 2 above but the authors Nurjanah *et al.*, (2015) report that the ash content was found to be 1.49 % in their study. The highest ash content as per the

present study was found to be in fish samples processed by frying (4.79 %) whereas the lowest (1.77 %) was found to be in fish samples processed by grilling, and significant differences (p<0.05) were observed between the cooking methods in this present study. The ash content of fried sample (4.79 %) was found to be increased significantly (p<0.05) owing to water loss during the frying process (Kocatepe *et al.*, 2011). The ash content of fresh *K. pelamis* fillets was found to be (1.95 %) in wet weight basis, which could increase after cooking, while others have suggested that it could decrease due to lixiviation losses of these components, which are lost with water and diffused when the muscle comes into contact with steam (Bastías *et al.*, 2017). Increased ash content was noticed in steamed, baked, boiled and fried samples when compared to raw fish fillets. No significant differences were observed between the raw sample and processed samples by grilling, steaming and baking. But significant difference was observed in boiled and fried sample as shown in Figure 2. Similar to the present study, the authors Hoffman *et al*. (1994) reported that the ash content was the highest in deep-fried samples (1.42 %) in African sharp tooth catfish (*Clarias gariepinus*) which is in agreement with the present study.

3) Fat Content

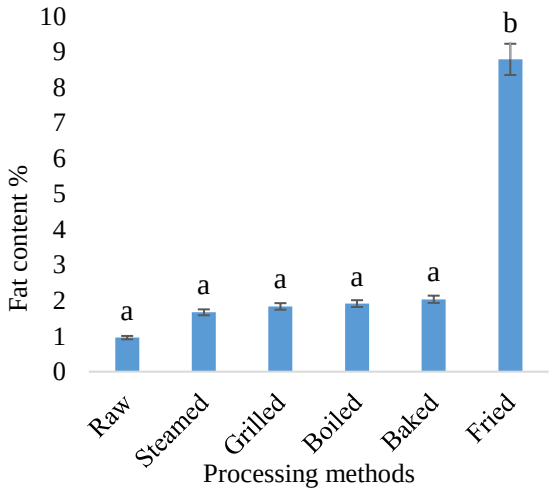


Figure 3: The fat content of the raw and processed fillets. The bar with different superscripts varies significantly (p<0.05)

According to the present study as given in Figure 3, significantly higher fat content (8.78 %) was found to be observed in fried sample whereas the lowest fat content (0.96 %) was observed in raw sample. Similar results were reported for Black sea anchovy (*Engraulis encrasicolus*, Linnaeus 1758) which was cooked by frying (Kocatepe *et al.*, 2011). Further no significant differences in fat at content found between raw, steamed, grilled, boiled and baked samples as shown in Figure 3, but there was a highly significant difference was found in the fried sample when compared with raw and other processed samples as shown in Figure 3. Mature fish has more fat content because it requires substantial energy savings from fat to breed (Nurjanah *et al.*, 2015). Oil absorption during the cooking process is linked to the rise in fat content of fried fish fillets. Furthermore, the increase in fat content can be due to oil penetration on the food after evaporation has lost some of the water (Aberoumand and Ziaei-Nejad, 2015). Apart from that, the fat content of raw fish can affect fat exchanges and interactions between culinary fat and fish fat during processing (Oluwaniyi and Dosumu, 2009). Furthermore, according to the author Bognár, (1998), the act of frying is linked to fat absorption (2 – 14 g per 100 g of raw food)

B. Determination of Sensory qualities

Table 1 shows the results of the sensory evaluation of the processed Skipjack tuna. Since fish is rarely eaten fresh, various processing methods are used to prepare it for consumption. Some of these processes, which may have varying effects on color, texture, and flavor and other sensory parameters (Aberoumand and Ziaei-Nejad, 2015). Texture is essential in the acceptance of many foods, like meat tenderness and bread softness. (Sharif *et al.*, 2017). Due to denaturation and aggregation during cooking, both filament lattice and collagen of proteins shrink, resulting in a loss of water-holding ability and, as a result, a shift in texture of the fish to become hard or firm (Abraha *et al.*, 2018). Color is one of the first features that the human senses pick up on, and it plays an important role in food recognition and final selection (Sharif *et al.*, 2017). Aromatic compounds that are conceived by a mixture of taste and odor and perceived by the mouth and nose are known as flavoring substances (Sharif *et al.*, 2017). The tactile sensations sensed at the lining of the mouth, including the tongue, gums, and teeth, are referred to as mouthfeel (Caracciolo *et al.*, 2020).

Based on this study, the highest scores of the texture, color, flavor and mouthfeel were obtained

Table 1: Evaluation of Sensory qualities of processed *Katsuwonus pelamis* fillets

Processing methods	Texture	Color	Flavor	Mouth-feel	Overall acceptability
Frying	7.40±0.27[b]	7.20±0.36[b]	6.88±0.33	6.92±0.30	7.44±0.23[b]
Steaming	6.44±0.20[a]	5.96±0.35[a]	5.64±0.31	6.52±0.25	6.04±0.30[a]
Boiling	6.36±0.19[a]	6.00±0.27[a]	6.52±0.30	6.92±0.30	6.60±0.24[ab]
Baking	6.40±0.27[a]	6.72±0.26[ab]	6.00±0.31	5.76±0.42	6.64±0.25[a]
Grilling	6.04±0.25[a]	6.16±0.21[ab]	6.08±0.38	5.96±0.26	6.35±0.12[a]

The values are means of the triplicates ± standard error mean (SEM); within a column, means followed by the same letter are not significantly different by the Tukey's HSD at p=0.05

by the frying method. In contrast, the sensory features of color and flavor obtained least scores by steaming method whereas texture obtained by grilling and mouth feel obtained by baking. Eventually, frying and baking methods obtained the highest rate of overall acceptability. However, there were significant differences observed between texture, color and mouth-feel except for the flavor of processed fish by different processing methods.

VI. CONCLUSION

The present study consisted of an evaluation of the impact of different processing methods on proximate chemical compositions and nutritional contents of *Katsuwonus pelamis* fish. It is concluded that all the processing methods analyzed have an impact on the nutritional value of *Katsuwonus pelamis.* Based on the results of nutritional value, the boiling processing method of fish sample was found to be the best among all processing methods. Finally, based on the sensory quality parameters, frying processing of *Katsuwonus pelamis* fish fillets was the best among all processing methods because it turned light brown and had denser texture and had delicious smell.

REFERENCES

Aberoumand, A. (2014) 'Preliminary studies on nutritive and organoleptic properties in processed fish fillets obtained from Iran', *Food Science and Technology*, 34(2), pp. 287–291. doi: 10.1590/fst.2014.0042.

Aberoumand, A. and Ziaei-Nejad, S. (2015) 'Effect of Cooking on Quality Commonly Consumed Marine Fish Platycephalidae (Platycephalus indicus) in Iran', *Turkish Journal of Agriculture - Food Science and Technology*, 3(11), p. 891. doi: 10.24925/turjaf.v3i11.891-893.385.

Abraha, B. *et al.* (2018) 'Effect of processing methods on nutritional and physico-chemical composition of fish: a review', *MOJ Food Processing & Technology*, 6(4), pp. 376–382. doi: 10.15406/mojfpt.2018.06.00191.

Association of Official Analytical Chemists (AOAC), 2000. *Official Methods of Analysis.* 17th Edition, The

Association of Official Analytical Chemists, Gaithersburg, MD, USA. Methods 925.10, 65.17, 974.24, 992.16.

Bastías, J. M. *et al.* (2017) 'Determining the effect of different cooking methods on the nutritional composition of salmon (Salmo salar) and chilean jack mackerel (Trachurus murphyi) fillets', *PLoS ONE*, 12(7), pp. 1–10. doi: 10.1371/journal.pone.0180993.

Bognár, A. (1998) 'Comparative study of frying to other cooking techniques influence on the nutritive value', *Grasas y Aceites*, 49(4–5), pp. 250–260. doi: 10.3989/gya.1998.v49.i3-4.746.

Caracciolo, F. *et al.* (2020) 'Sensory attributes and consumer acceptability of 12 microgreens species', *Agronomy*, 10(7). doi: 10.3390/agronomy10071043.

Chandravanshi, N. K., Dhruw, P. and Bharti, R. K. (2019) 'Nutritional quality of fish food', 6(2), pp. 82–86.

Collette, B. B. and Nauen, C. E. (1983) *FAO Species Catalogue: Vol. 2 Scombrids of the World*, *FAO Fisheries Synopsis*. Available at: http://www.fao.org/docrep/009/ac478e/ac478e00.htm.

El-lahamy, A. A. *et al.* (2019) 'Changes in fish during cooking methods (frying and grilling): A review .', 2(2), pp. 31–34.

Food and Agricultural Organization (FAO), 2020. The State of World Fisheries and Aquaculture.

Sustainability in action. Rome. https://doi.org/10.4060/ca9229e

Florida Museum of Natural History, 2017. Available at: https://www.floridamuseum.ufl.edu/discover-fish/species-profiles/katsuwonus-pelamis/

Department of census and statistics, 2020. Fisheries and Aquatic Resources, Agriculture and

Environment Statistics Division, [ONLINE] Available at: www.fisheriesdept.gov.lk

Golgolipour, S., Khodanazary, A. and Ghanemi, K. (2019) 'Effects of different cooking methods on minerals, vitamins and nutritional quality indices of grass carp (Ctenopharyngodon idella)', *Iranian Journal of Fisheries Sciences*, 18(1), pp. 110–123. doi: 10.22092/ijfs.2018.117675.

Gonzales, B. J. (2016) 'Basic taxonomy and biology of fishes', (April).

Hoffman, L.C., Prinsloo, J.F., Casey, N.H. and Theron, J., 1994. Effects of five cooking methods on the proximate, fatty acid and mineral composition of fillets of the African sharptooth catfish, Clarias gariepinus. *Die SA Tydskrif vir Voedselwetenskap en Voeding*, *6*(4), pp.146-152.

Ismail, B.P., 2017. Ash content determination. In *Food Analysis Laboratory Manual* (pp. 117-119). Springer, Cham.

Karimian-Khosroshahi, N. *et al.* (2016) 'Effect of Different Cooking Methods on Minerals, Vitamins, and Nutritional Quality Indices of Rainbow Trout (Oncorhynchus mykiss)', *International Journal of Food Properties*, 19(11), pp. 2471–2480. doi: 10.1080/10942912.2015.1039028.

Karunarathna, K.A.A.U. and Attygalle, M.V.E., 2010. Nutritional evaluation in five species of tuna.

Kocatepe, D. *et al.* (2011) 'Effects of Cooking Methods on the Proximate Composition of Black Sea Anchovy (Engraulis Encrasicolus, Linnaeus 1758) (in English)', *Gıda*, 36(2), pp. 71–75.

Mahaliyana, A. S. *et al.* (2015) 'Nutritional Composition of Skipjack Tuna (Katsuwonus pelamis) Caught from the Oceanic Waters around Sri Lankae', *American Journal of Food and Nutrition*, 3(4), pp. 106–111. doi: 10.12691/ajfn-3-4-3.

Munir Abba Dandago (2009) 'Changes in Nutrients During Storage and Processing of Foods - a Review', *Techno ScienceAfricanJournal*,3(1),pp.24–27.Availableat: https://www.researchgate.net/publication/294736406%0AChanges.

Nurjanah *et al.* (2015) 'Changes in nutritional composition of skipjack (Katsuwonus pelamis) due to frying process', *International Food Research Journal*, 22(5), pp. 2093–2102.

Oluwaniyi, O.O. and Dosumu, O.O., 2009. Preliminary Studies on the effect of processing methods on the quality of three commonly consumed marine fishes in Nigeria. *Biokemistri*, *21*(1).

Oluwaniyi, O. O., Dosumu, O. O. and Awolola, G. V. (2010) 'Effect of local processing methods (boiling, frying and roasting) on the amino acid composition of four marine fishes commonly consumed in Nigeria', *Food Chemistry*, 123(4), pp. 1000–1006. doi: 10.1016/j.foodchem.2010.05.051.

Sharif, M. K. *et al.* (2017) 'Sensory Evaluation and Consumer Acceptability', *Handbook of Food Science and Technology*, (October), pp. 362–386. Available at: https://www.researchgate.net/publication/320466080.

Sobral, M. M. C. *et al.* (2018) 'Domestic Cooking of Muscle Foods: Impact on Composition of Nutrients and Contaminants', *Comprehensive Reviews in Food Science and Food Safety*, 17(2), pp. 309–333. doi: 10.1111/1541-4337.12327

.

Anthropometric Evaluations of Body Fat Content of Undergraduate Male Students

A. Asmiya[1*], M.A.A. Aqeel[2] & M.N.F. Nashath[3]

[1,3]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*
[2]*Department of Food Science and Technology, Faculty of Agriculture, University of Peradeniya, Sri Lanka*

[1*]asmiya93@seu.ac.lk, [2]aqeel.ansar2@gmail.com, [3]nasath17.mn@seu.ac.lk

Abstract- *Anthropometric measurements are quick and handy methods, predicting the risk of non-communicable diseases (NCDs). Changes in diet, lifestyle and experiencing mental stresses are some of the rapid changes, exhibited in students entering into the residential universities in Sri Lanka. The interest of this study was to identify and compare changes in their body fat and NCD-related risk factors during university life. A cross-sectional study was conducted using 107 male undergraduates with the proportion of Sinhalese: Tamils: Muslims, Catholics as 17.5:5:2:0.5, who were from all batches in the University of Peradeniya. After administrating a pre-tested questionnaire, age, diet pattern, ethnicity and having food or physical activities within 2 hours were questioned, excluding other conditions affecting the body water content. Body weight, body fat percentage and Body Mass Index (BMI) together with muscle mass, bone mass and body water content were reported by the Body Fat Analyzer. All the data drawn were entered and analyzed using SPSS software. Among anthropometric indicators measured, waist circumference (WC) had a slightly better correlation while BMI and waist circumference to height ratio (WHtR) had similar amount of correlations and waist-to-hip circumference ratio (WHR) showed a lower correlation with body fat compared to other indicators. All the mean values of the four batches were below the risk levels of each indicator but it showed a significant increment of body fat from the 1st year to final year and a higher variation in body fat was observed among 1st year students compared to final year students.*

Keywords: Anthropometric measurements, Body fat content, Lifestyle, Non-communicable diseases, Undergraduates.

I. INTRODUCTION

The deposition of excess fat in the human body (obesity) seems to be a leading talk, especially from the last century. It is a natural body maintenance procedure when the body balances required positive energy itself. Unfortunately, it is estimated that globally nearly 700 million people, are suffering from excess body fat condition (Scully, 2012). It has been proven that excess body fat contributes to non-communicable diseases such as dyslipidemia, hypertension, cardiovascular diseases, type-2 diabetes, sleep apnea, etc. Type-2 diabetes has become a major threat to this generation, with about 346 million diabetics across the planet in 2011 and these figures may be doubled by 2030 (Scully, 2012). The effect of social and economic factors in obesity is widespread and has a high impact on healthcare provision in many economic theories. There are various types of fat. The fat that is stored within the abdominal cavity is called Visceral fat (VAT). It can be seen near several organs of the body like the liver and intestine. It can also build up in arteries. This is the fat identified as having a higher risk for cardio vascular diseases (CVD). Another type of fat is subcutaneous fat (SAT), which is the visible fat stored under the skin. Subcutaneous fat is normally considered harmless and may even protect from some diseases. The lower body fat is commonly defined as all adipose tissue caudated to the inguinal ligament anteriorly and the ileac crest posteriorly. Ectopic fat is yet another type of body fat, which is stored in tissues other than adipose tissue, such as skeletal muscle, heart, liver and pancreas. Ectopic fat accumulation in key insulin-sensitive tissues such as liver and skeletal muscle is a critical determinant of insulin resistance and may also predispose to the development of type-2 diabetes (Yki-Jarvinen, 2002). Ectopic fat, though it is normally contained in small amounts, can interfere with a cellular function such as neurotransmission (Thomas et al., 2013). Factors affecting the body fat distribution in the human body among different group of people can be divided into two groups as environmental factors and genetic factors. Diet quality, consumption of alcohol and cigarette and childhood obesity are some of the environmental factors and strong genetic factors are also

considered to play a role in regional fat gain and loss. Predominant upper body fat distribution is generally related to increased visceral fat and with an abnormal metabolic profile over a range of body mass indices (Jensen, 2008). Hence morbidity rate of adults and also children are being increased daily due to metabolic derangements (Wickramasinghe et al., 2017). The proposed study has designed since anthropometric measurements are quick and handy methods to predict the body fat content and there is a need to make aware of students that their physical and mental health is changing due to their displacement from home to hostel in the process of adopting to new environment.

II. LITERATURE REVIEW

A. Fat deposition in the human body

All the energy produced in our body through food will not be utilized as a whole. Thus, excess energy is turned into a tissue called adipose tissue, which is a specialized tissue for fat storage. This process is called adiposity (Thomas et al., 2013). Preferential fat deposition in the abdomen between and within viscera and retroperitoneal has been linked with risk on health. There is a special tissue named abdominal visceral adipose tissue (VAT) that may have relevance to its biological importance. Apart from that, there is another type of adipose tissue called Subcutaneous Adipose Tissue (SAT) that has depots under skins which lower the metabolic risks. Ectopic fat is another type of fat rather than adipose tissues, needed in small quantities in the normal body functions (Thomas et al., 2013). Studies show that free fatty acids (FFA) which are released by adipose tissues cause main abnormalities in the body (Yki-Jarvinen, 2002). VAT is considered as another ectopic fat that does not release free fatty acids to much extend rather it is enough for influencing metabolic derangement in muscles, β cells in the pancreas and vascular endothelium. Upper body subcutaneous adipose tissue releases systemic FFA to the blood circulation, resulting in enhancement of metabolic risk by upper body fat than lower body fat (Yki-Jarvinen, 2002).

B. Measuring body fatness

Thomas et al. (2013) revealed that because of health care, people showed interest in body shape and fatness based on their ages, but changing of behaviors and traditions limited their effort in considering health improvement. Different methods have been developed to measure body fatness for epidemiological field studies or clinical use. Body fat can be measured directly and indirectly.

i. Direct methods: As mentioned earlier, many of body fat can't be measured, having the sub-phenotype including 'thin on the outside, fat on the inside' (TOFI) and 'fat-fit' subjects, which specify the importance of having accurate and reproducible measurements of both the total body-fat and its distribution. Thomas et al. (2013) state that chemical analysis done by macroscopic dissection or lipid extraction under direct measurement has some limitations value as it cannot be related to measurements in vivo**.**

ii. Indirect methods: Body-mass-index (BMI), skinfold anthropometry, bioelectrical impedance, underwater weighing, and body water dilution are some of the indirect methods. All these methods are having their pros and cons. Sometimes, they will give little or no information on adipose tissue distribution. Moreover, most of these methods depend on indirect measurements of either body water or body volume and need equations to convert these into total fat measurements (Thomas et al., 2013).

iii. Anthropometric measures and body fat depots: Body mass index (BMI), waist circumference (WC), waist to hip ratio (WHR) and waist to height ratio (WHtR) provide evidence of body fat with lesser reliability. But some controlled condition they may be good evidence for body fat content. Each of them is not similarly weighed rather vary with sex, age and ethnicity (intercountry) (Jayave, 2019; Lear et al., 2010). Nevertheless, the values are the same inactive versus sedentary females, are significantly correlated with all anthropometric measures disregarding WHR, while in active males, WC is higher than in sedentary male, rather body fat percentage is the same, and is followed by the same WHR and WHtR values (Lutoslawska et al., 2014).

C. Factors affecting body fat deposition

There may be deviation that above anthropometric measurements (WC, WHR, WHtR) convey disease outcome with different factors. The main problem is whether there are systematic differences in the extent to which a given waist circumference or waist–hip-ratio or waist-to-

height ratio, convey disease outcomes in different ethnic groups. It could cause overestimation or underestimation for a particular population. In contrast, systematic differences could be related to differences in body composition and differences in disease occurrence for a particular body fat composition. The relative amounts or types of fat in the body is reflected by the body composition. Also, differences between men and women, and with ageing were variations in body fat distribution that can affect all populations (WHO, 2008).

III. METHODOLOGY

A. *Sample selection*

This study was an epidemiological study conducted at the University of Peradeniya. The local undergraduates who study in the university are nearly 12,756 (Annual report, 2018). But this study is focusing on local male undergraduate students who stay in the hostels on university premises. There are 7185 local students are in hostels. Within those 3054 male students are there. The population consisted of male local undergraduate students in each academic year (1st to 4th year). Faculty was not considered as a factor. First of all, data was collected as much as possible in every boys' hostels on university premises. The total number of students in each year is more or less the same. The representative sample size of the larger study was calculated using an estimated 95% confidence interval. The estimated sample size was 342 local undergraduate but the selected sample size (n=107). The sample was categorized into four groups, in which the first year (36), second year (25), third year (13) and the final year (33) were the sampling units. Cluster sampling of each batch (years) was used, with proportional stratification by ethnicity (ratio of Sinhalese: Tamils: Muslims: Catholics was 17.5: 5: 2: 0.5) and the diet pattern of them (vegetarian, non-vegetarian) because it is hard to see lacto-vegetarians, ovo-vegetarians and lacto-ovo vegetarians.

B. *Instruments and procedures*

The data were collected between February 2020 and mid of March 2020. First, students with any illness or on any medication were excluded and they were asked whether they had their meal or physical activities within 2 hours from the body fat measuring time. If any subject had their meal or physical activities within 2 hours, he was informed as ineligible to involve in the study. After informing the eligibility of students, information of the subjects was obtained by self-report, including name, age, contact number, ethnicity, and academic year. So it was easier to get data in at early morning and late at night at the hostel. Dual data were collected from each subject at different times. The hostel canteen was the place where the measurements were taken. Before getting that fat measurement; diet pattern was also asked from the subject whether he was a vegetarian or not. Height was measured with a portable stadiometer (0 to 220 cm) fixed to the wall, to the nearest 0.1 cm. WC and HC were measured with a non-elastic measurement tape to the nearest 0.1 cm according to procedures recommended by the World Health Organization. A bioelectrical impedance analyser using two-point tactile electrodes was used. This device uses a small direct current (DC). Since two tactile electrodes are built into each footplate, the impedance can be measured by standing on the footplates with bare feet, when the subject's arms were stretched alongside their trunk during measurements. This device measures the leg-to-leg impedance and weight, and can automatically display the % TBF using an inherent prediction equation, age and height. The fat-free mass (FFM) is estimated and then total body fat per cent was shown in the display. BMI was also shown. All the data was written down in paper. The average of body fat content was recorded.

C. *Statistical analysis*

IBM SPSS V19 was used as analytical software for the analysis. All the recorded data were analysed between the sampling units and within the sampling units. Median, mean and, minimum and maximum were obtained from descriptive analysis for comparison of anthropometric measures and other related factors. Graphs for anthropometric measures and body fat were plotted down for the easiness of understanding the relationship. Correlation coefficient (R^2) values, which are the best fit with ordinates, are emphasizing the relationship. Pearson's correlation was used to determine the relationship of hypothesized factors with body fat. A descriptive test was used for getting the mean and standard deviation with $P>0.05$. Graphs were illustrated on showing the relationship with correlation coefficient (R^2). The range of the samples and, the minimum and maximum values were indicated showing boxplots. The frequency of all the clustered samples was shown using a pie chart.

IV. RESULTS

Table 1 shows the mean value of each anthropometric measurement studied and the percentage of the students under healthy range as well as under risky condition for non-communicable diseases. Since the Asian cut off value for BMI is less than 22.9 kg/m2, among the students studied, 30% of them show risky BMI levels that can lead to NCDs. Al though none of undergraduates' the waist circumference did not go beyond the normal level (102 cm) for males, WHR and WHtR exceeds the critical value in 12% and 8% of students respectively. But, all the mean values of anthropometric measurements are under the normal range. Among the samples, a higher percentage of risk for NCD is caused by higher BMI levels.

Table 1: Sample characteristics by anthropometric measurements based on mean values and cut off values

Indicators	Mean	SD	Normal	Risk for NCDs
BMI	21.55	3.53	74 (70%) {≤22.9 Kg/m2}	33 (30%) {>23 Kg/m2}
WC	73.80	8.58	107 (100%) {<102cm}	0 {≥ 102cm}
WHR	0.83	0.06	94 (88%) {<0.9)	13 (12%) {≥0.9}
WHtR	0.43	0.05	98 (92%) {<0.5}	9(8%) {≥0.5}

Table 2 illustrates the relationships between anthropometric measures and body fat content. WC shows a higher correlation (0.706) with body fat content while the lowest (0.358) was observed by the WHR. The WHtR and BMI indicators showed approximately equal values (0.672, 0.626) of correlation with body fat percentage. When considering correlation coefficient (R^2) values, all the indicators showed lower mean values ($p<0.05$).

Table 2: Correlation between anthropometric measurements and sample body fat content

Indicators	Pearson's correlation	R^2 value	*P* value
BMI	0.626	0.445	$P<0.01$
WC	0.706	0.498	$P<0.01$
WHR	0.358	0.127	$P<0.01$
WHtR	0.672	0.445	$P<0.01$

Table 3 point outs the mean and standard deviation of average body fat content of all batches. Final year students show higher average fat content than rest of the batches. However, the difference of average fat content among last three batches are very less; approximately similar. Lowest mean fat percentage was observed in first year students and the minimum amount was recorded as 8.10%. At the same time, the deviation among their fat content also higher than other three batches. The median fat content value out of all batches was high among 2nd year students (Figure 1). As the ideal body fat percentage of male ranges between 18-24% (WHO), the mean body fat of all batches exceeds the risky level and can be predicted that they are under obese condition.

Table 3: Body fat percentage by students' academic year

Academic year (n)	Minimum	Maximum	Mean	SD
1st year (36)	8.10	51.20	24.65	10.27
2nd year (25)	11.55	40.65	28.87	7.07
3rd year (13)	16.55	38.05	28.44	6.30
4th year (33)	11.55	48.10	28.96	8.97

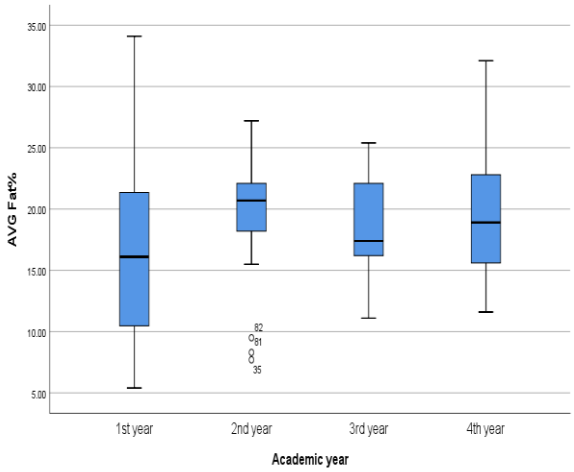


Figure 1: Distribution of body fat content by each academic year

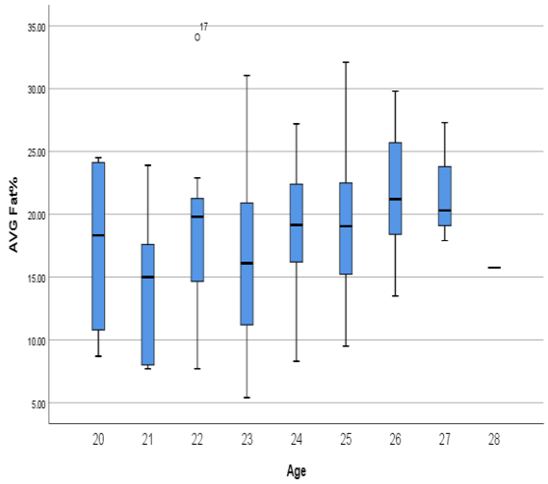


Figure 2: Distribution of body fat content by age of participants

Figure 2 illustrates the fat content of students based on their age. At the age of 21, students' fat content highly deviated and at the age of 26, highest median value has recorded (Figure 2). Results of ethnicity variation in students show that there is no significant variation in body fat content among ethnicity (Table 5). Vegetarians are lower (9.35%) in percentage than non-vegetarian (90.65%) in the study sample and the body fat content of non-vegetarian is highly deviated (Figure 3). The mean body fat of non-vegetarian showed a higher value compared to vegetarians and there are no significant differences in their fat content based on their food consumption behaviours (Table 6).

Table 04: Body fat percentage by ethnicity

Table 4: Body fat percentage by ethnicity

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	5.628	3	1.88	.052	.984
Within Groups	3714.173	103	36.06		
Total	3719.801	106			

Table 5: ANOVA table for different ethnicity groups

Ethnicity	Frequency	Mean	SD
Sinhalese	75	27.41	8.277
Tamils	9	28.11	14.37
Muslim	21	27.36	9.012
Catholics	2	25.35	2.970

Table 6: Body fat percentage by diet pattern

	Maximum fat%	Minimum fat %	Mean fat%	SD	P-value
Vegetarians (10)	33.75	18.75	27.28	5.16	0.865 $P>0.05$
Non-vegetarians (97)	51.20	8.10	27.43	9.20	

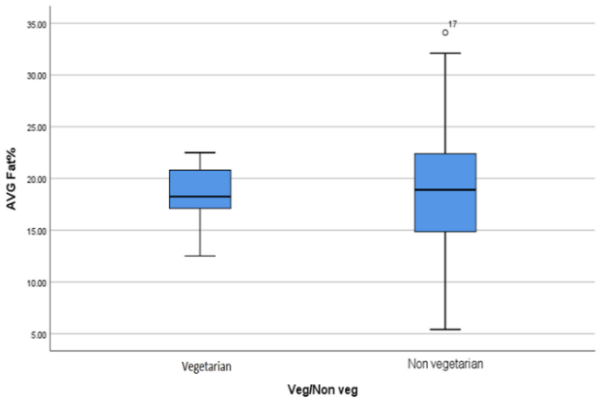


Figure 3: Distribution of vegetarian and non-vegetarian with body fat content

V. DISCUSSION

According to the Asian cut off value of male BMI, it consists of four categories such as underweight (<18.5 Kg/m2), normal (18.5-22.9 kg/m2), overweight (23-27.5 kg/m2) and obese (>27.5 kg/m2) (Liabsuetrakul, 2011). In this study, overweight and obese are considered as a higher risk for non-communicable diseases and, underweight and normal are opposed. The mean of BMI is approximately at the boarder (21.55kg/m2) of critical point of risk. BMI can correlate with body fat to some extent, here it has positive correlation with body fat and correlation

coefficient is 0.626. While describing, below half of the sample can be used for interpreting the body fat content using BMI values (R2 value = 0.445). Table 1 emphasizes that all the anthropometric measures other than WC contrasts the presence of risk individuals for NCDs. According to Sharpe and Bradburuy (2015), WC is much effective for female than male. In this study also WC measurement was the indicator detecting lower risk for NCDs. Population mean of WC was below the critical value (<102 cm). It says that the whole population are not at-risk regarding WC while a better indicator related to the correlation coefficient. But this can't be the best measures for detecting body fat because this model fits less than 50%. WHtR is another measure, revealed as a good indicator for the risk of CVD and diabetes (Wikramasinghe et al., 2017; Sharpe and Bradburuy, 2015). Mean of WHtR in the sample population contrasting lower than the risk level (<0.5) and eight per cent was the risk. It correlates better than BMI with body fat content but lesser than WC and closer to it. WHR is encountered as a lower correlating indicator (correlation co-efficient = 0.358) and has a lower mean (0.83) value than risk level (> 0.9) for NCDs. Singh (1993) has pointed out that WHR is expressed as youthfulness and reproductive status of endocrinology and caused to long term health risk. Other than that, WHR is a strategy while choosing the partner, and hence attractiveness judgment (Tovée et al., 1999; 2002). Thomas et al. (2013) has illustrated that there are some undiagnosed conditions" Thin in outside fat in inside" and "fat fit" conditions caused to an inverse relationship with body fat content. MRS (Magnetic Resonance Spectroscopy, MRI (Magnetic Resonance Imaging) and DEXA (Dual Energy X-ray absorptiometry) are the appropriate methods for body fat analysis. Despite the anthropometric measures having little correlation with body fat, most of the cases are underestimated. Visceral adipose tissue is not only the fat that directs to health risks but also ectopic fat can be caused to metabolic risks like diabetes and heart disease (Neeland et al., 2019). MRI and MRS can estimate the ectopic fat in the liver, heart and pancreas which the anthropometric measures cannot detect. At the entrance to the university, the student shifts from home to hostel life. During that displacement, they may attempt to adapt accordingly. The body fat content of university students may change from 1st year to 4th year due to the change in dietary pattern in hostel life, lower physical activity or lower VO2 max and stress of academic life of the university (Gropper et al., 2012). According to the data, there was a change in the mean of body fat of 1st-year students which increased towards the final year. Body fat content at the beginning of the university is diversified despite the final year is somewhat unique. Hence some other factors may be responsible for the change in the body fat content of undergraduate. Based on the analysed data, students' mean body fat content from all batches exceeds the risk level of fat content for male, declared by WHO (18-24%), can be taken as they are under risk of obesity. The age of participants varied from 20 to 28 years during undergraduate life while data at 20th age is highly diversified. Because most of the first years are at the age of 20. They are fresh to university life. There is not enough data to discuss with the final year. Age is correlated well with VAT as mentioned by Ferrannini et al. (2008). BMI and WC are increased with age increases. But it cannot be studied using this sets of data. Ethnicity cannot be elaborated as having any significant effect on the body fat content as shown by different ethnicities. Tamils showed deviated body fat content rather than others because of their diet pattern differs much based on their cast variations and some restrictions on their religion based on their cultural behaviours. There are seven different types of vegetarianism. They are vegan, semi-vegetarian, lacto vegetarian, ovo vegetarian, lacto-ovo vegetarian, pollotarian and pescotarian. But these all pattern cannot be seen enough data for analysis. So these categories were split into two main groups as vegetarian and non-vegetarian. A non-vegetarian had diversified body fat content than vegetarian (Janelle and Barr, 1995). But some studies showed that the vegetarian has higher body fat than non-vegetarian (Leelakumari, 2017). The mean fat of non-vegetarian was slightly higher than vegetarian (but not significant at 5% significant level, Table 6), according to these data.

VI. CONCLUSION

Anthropometric measurements are quick and handy methods, predicting the risk of non-communicable diseases (NCDs) while none of methods available is perfect to determine the body fat and health risk for NCDs. But, modern techniques of body fat analysis can be used to determine body fat content precisely. Among the anthropometric indicators used, WC is found to be a good indicator than BMI, WHtR, and WHR, having the best correlation with body fat and risks for NCDs can be diagnosed easily at a lower cost. Changes in lifestyle, food consumption behavior

and residence affect the body fat content of male undergraduates in a considerable amount and sudden changes affect little more till they get into an adoption to the environment. Changes in body fat content significantly depends on the age, body structure and the lifestyle. Body fat content of male undergraduates differs much during their residency within university premises and awareness should be addressed in concerning their health.

REFERENCES

Ferrannini, E., Sironi, A.M., Iozzo, P. and Gastaldelli, A., 2008. Intra-abdominal adiposity, abdominal obesity, and cardiometabolic risk. *European Heart Journal Supplements*, 10, pp.B4-B10.

Gropper, S. S., 2012. Changes in body weight, composition, and shape: a 4-year study of college students. *Applied Physiology, Nutrition, and Metabolism* 37(6), pp. 1118-1123.

Janelle, K. C. and S. I. Barr., 1995. Nutrient intakes and eating behaviour see of vegetarian and non-vegetarian women. *Journal of the American Dietetic Association* 95(2), pp. 180-189.

Jayave, K., 2019. Relationship between body mass index, waist hip ratio and chronic periodontitis - a case control

Jensen, M.D., 2008. Role of body fat distribution and the metabolic complications of obesity. *The Journal of Clinical Endocrinology & Metabolism*, 93, pp.s57-s63.

Lear, S.A., James, P.T., Ko, G.T. and Kumanyika, S., 2010. Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. *European journal of clinical nutrition*, 64(1), pp.42-61.

Liabsuetrakul,T. 2011. Is International or Asian Criteria-based Body Mass Index Associated with Maternal Anaemia, Low Birthweight, and Preterm Births among Thai Population? - An Observational Study. *Journal of Health, Population and Nutrition*, 29(3), pp.219.

Lutoslawska, G., Malara, M., Tomaszewski, P., Mazurek, K., Czajkowska, A., Kęska, A. and Tkaczyk, J., 2014. Relationship between the percentage of body fat and surrogate indices of fatness in male and female Polish active and sedentary students. *Journal of Physiological Anthropology*, 33(1), pp.1-6.

Neeland, I.J., Ross, R., Despres, J.P., Matsuzawa, Y., Yamashita, S., Shai, I., Seidell, J., Magni, P., Santos, R.D., Arsenault, B., 2019. Visceral and ectopic fat, atherosclerosis, and cardio metabolic disease: a position statement. *The lancet Diabetes & endocrinology*, 7(9), pp. 715-725.

P. Leelakumari, P., 2017. Body Fat Percentage in a Vegetarian and Non-Vegetarian Population and Prevalence of Essential Hypertension and Type-2 Diabetes Mellitus: A Comparative Investigation in Indian Population. *International Journal of Medical Research Professionals*,3(6),pp.9-12.

Scully, T., 2012. Diabates in some of the implications for national governments. *Nature*, 2011, 0–1.

Sharpe, H., Bradburuy, S., 2015. *Understanding Excess Body Weight.* New Zealand Health Survey. Ministry of Health.

Singh, D., 1993. Waist-to-hip ratio (WHR): A defining morphological feature of health and female attractiveness. *Journal of Personality and Social Psychology*, 65(2), pp.293-307.

Thomas, E.L., Fitzpatrick, J.A., Malik, S.J., Taylor-Robinson, S.D. and Bell, J.D., 2013. Whole body fat: content and distribution. *Progress in nuclear magnetic resonance spectroscopy*, 73, pp.56-80.

Tovée, M.J., Hancock, P.J., Mahmoodi, S., Singleton, B.R. and Cornelissen, P.L., 2002. Human female attractiveness: Waveform analysis of body shape. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 269(1506), pp.2205-221

Establishment of Sensory Evaluation Panel for A Biscuits Manufacturing Industry

V.P.N. Sachinthani[1], U.L. Abdul Majeed[2*], S. Rajapaksha[3] & M.N.F. Nashath[4]

[1, 2, 4]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*
[3]*Ceylon Biscuits Limited, Pannipitiya, Sri Lanka*

[1]navodyavidanapathirana@gmail.com, [2*]ulmajeed@seu.ac.lk, [3]shyamar.cbl@cbllk.com, [4]nasath17.mn@seu.ac.lk

Abstract- *The food sector is highly reliant on quality and price of the product. Sensory evaluation is a scientific approach to assess food sensorial quality criteria while eating. The purpose of this study was to establish a new sensory panel and train the members to evaluate their performances on product-oriented sensory panel in the Ceylon Biscuits Limited, a conglomerate and well grown and popular food industry in Sri Lanka. Therefore, the necessity has arisen to possess a properly structured framework of sensory analysis for obtaining reliable, accurate and repeatable results which may be important in the critical business decisions that are heavily depended on assessment of the quality of product. Initially interested 52 staff members, with good health, were selected from the questionnaire distributed among them from the same organization. Then they were defined by a set of screening tests, including basic taste identification test, odor identification test, ranking test for basic taste. Results of the sensory evaluation data were statistically analyzed using Friedman test and chi-square tests with SPSS software. In each test, the samples showed to be significantly different from one another ($p<0.05$). The performance of the panelists was not found to be significantly different for basic taste and odor ($p>0.05$). Hence, they can be considered as a homogenous trained sensory panel. Finally, 13 members who were able to identify all the tastes and more than 80% of the odors of the samples were selected as sensory panel members for the company.*

Keywords: Ceylon Biscuits Limited, Screening test, Sensory evaluation, Sensory panel

I. INTRODUCTION

Sensory evaluation is the process of identifying, measuring, analyzing and interpreting a product's features (attributes) as determined by the five senses of sight, smell, taste and hearing (Jayashantha, 2006). Sensory characteristics are more important than most of the other factors. Foods are complex mixtures of organic and inorganic compounds (Nunez *et al*., 2005). During consumption various physio-chemical characteristics of the food stimulate all of human senses to some extent. These stimulations are saltiness, sweetness, redness, toughness, acidity, iciness, viscosity, size, shape, opacity, gloss, lightness, blueness, greenness and earthiness (Jayashantha, 2006).

Sensory professionals are invited to make decisions during the different stages of a product development, from the conception to post – launch monitoring. Sensory evaluation and consumer testing can provide precise information related to human behavior and perception at a deeper level (Kemp *et al*., 2011). Identifying the key sensory features is important for determining acceptability across a product categories and sensory – based target consumer segments, as well as analyzing competitor products and evaluating novel concepts. Sensory testing is done for several purposes such as ensuring the standard products do not enter onto the market and determining shelf life and product variability through the supply chain. It is also performed to identify new technologies to improve product development and understanding consumer behavior (Kemp *et al*., 2009).

Both trained personals and consumers can make a sensory panel where trained personals are used to evaluate treatment variations in the product being evaluated. A range of factors need to be considered when forming a consumer panel such as the target populations, demographics, the number of the markets to test, and product consumption trends. A trained panel may have fewer members because they are highly trained and selected. Utilizing a sensory panel when available is beneficial because it concerns from people's impressions (Ramanthan, 2020).

A sensory analysis panel consists of actual "measuring instruments" and due to that the results are depended on the panel members. Therefore, the process of recruiting people who are interested in participating in a panel should be handled with care and treated as a real tool, both in terms of time and money (Murray *et al*., 2001). It is essential to undertaken a preliminary screening of the candidates during the hiring process, in order to identify those who are unsuitable for sensory analysis (Carpenter *et al*., 2000). However, the final selection and training are important. The panel leader is in charge of overseeing the group of expert assessors and ensuring that they are properly trained. Since having a well-trained sensory evaluation panel is very important to a company related to food sector, the present study is aimed to establish a sensory panel and train new members to evaluate their performances on product-oriented sensory panel in the Ceylon Biscuits Limited, a conglomerate and well grown and popular food industry in Sri Lanka.

II. METHODOLOGY

A. Recruiting panelist

The panelist for the trained panel was chosen among the staff members of the organization. All prospective panelists were instructed to fill out a google sheet including the details being furnished such as their food likes/ dislike, level of interest in the project to be carried out, any food restriction, allergic reactions, age, medical treatments (for diabetes and hypertension), involvement in product testing and decision making activities regarding product quality, their habits (Consuming alcohol, smoking cigarettes and consumption of spicy foods regularly) and presence at a given time period. After obtaining responses from adequate numbers of personals, all the details were arranged and 66 personals were finally selected for the whole organization.

B. Screening the panelist for the training

01) Ranking test for selecting the threshold level: Ranking test for basic test samples, each sample was prepared with different concentration of the stock solutions as given in Table 01 and diluted to a certain concentration and presented to the randomly selected persons. They were then requested to rank each sample and mention the taste of each series. The instructions for the members were given on top of the ballot paper to rinse their mouth with water between the samples. All the sample containers were with three digits which coded with random patterns before presenting to the participants who recorded their results in their own ballot paper which were in ascending order for each basic taste of sample and in an identical level according to the sample concentration (Table 02). Considered all the ballot paper results were selected average of the threshold level for basic taste samples.

Table 01: Stock solutions

Basic Taste	**Stock Solution**		**Percentage (%)**
	Sample weight (g)	**Water amount (ml)**	
Sweet (sucrose solution)	25	250	10%
Salt (Nacl)	25	250	10%
Sour (citric acid)	2.5	250	1%
Bitter (caffeine)	0.25	250	0.1%

Table 02: Concentration of each basic taste for ranking test

Basic Taste	**Stock Solutions**	**Concentration**
Sweet (Sucrose solution)	A– 25g/250ml	A1- 5ml of A/500ml A2- 10ml of A/500ml A3- 15ml of A/500ml A4- 20ml of A/500ml A5- 25ml of A/500ml A6- 30ml of A/500ml A7- 35ml of A/500ml A8- 40ml of A/500ml
Salty (NaCl Solution)	B– 25/250ml	B1- 2ml of B/500ml B2- 4ml of B/500ml B3- 7.5ml of B/500ml B4- 10ml of B/500ml B5- 12.5ml of B/500ml B6- 15ml of B/500ml B7- 17.5ml of B/500ml B8- 20ml of B/500ml
Salty (NaCl Solution)	C– 2.5g/250ml	C1- 5ml of C/500ml C2- 10ml of C/500ml C3- 15ml of C/500ml C4 - 20ml of C/500ml C5- 25ml of C/500ml C6 -30ml of C/500ml C7- 35ml of C/500ml C8- 40ml of C/500ml
Bitter (Caffeine)	D- 0.25g/250ml	D1- 4 ml of D/500ml D2- 5 ml of D/500ml D3- 6 ml of D/500ml D4- 7.5 ml of D/500ml D5- 10 ml of D/500ml D6- 15 ml of D/500ml D7- 20 ml of D/500ml D8- 30 ml of D/500ml D9- 40 ml of D/500ml

02) Basic taste identification: The basic selection for the sensory panel was done using questionnaires considering the candidate's age, health status, availability, interest, and motivation. The selected individuals were subjected to a series of screening tests outlined in ISO standards (ISO 8586:2012). The Basic Taste Identification Test used four basic tastes (sweet, sour, bitter, and salt) that were made with food-grade reference substances (Table 03) and presented to each assessor at random, with the task of identifying the taste of the samples.

Table 03: Basic Taste Recognition Test

Taste Basic	Stock solutions	Concentration
Sweet (sucrose solution)	A – 25g/250ml	A – 40ml of A/500ml
Salty (Nacl solution)	B – 25g/250ml	B – 3ml of B/500ml
Sour (Citric acid solution)	C – 2.5g/250ml	C – 30ml of C/500ml
Bitter (Caffeine)	D – 0.27g/250ml	D-30ml of D/500ml

03) Basic odor recognition test: This testing was carried out by a common house hold odors as given in Table 04. One liter of water was measured with measuring cylinder and poured into six of blank plastic jugs as one liter for each jug. Then 1g/1ml of each sample (vinegar, vanillin, cinnamon, clove, lemon and mustard) as powder or liquid was measured and mixed well with spoon with water separately. Assessors were provided with reference samples randomly (Silva *et al*., 2014).

Table 04: Basic Odor test

Substance	Odor
Vinegar	Sour/ Acetic
Vanillin	Vanillin
Cinnamon	Cinnamon
Cloves	Clove
Lemon	Lemon
Mustard	Mustard

C. Training of the Selected Panelists

Finally, 10-15 number of persons having high sensory sensitivity were selected. Then they were moved to the basic sensory training which was conducted by qualified professionals. Since the Ceylon Biscuits Limited is mainly manufacture biscuit, the selected candidates were specifically trained for biscuit production.

III. RESULTS AND DISCUSSION

Out of 52 candidates who filled and submitted their questionnaire, only 13 candidates were screened out being considered their health conditions, whether they were taking long term medicine that could damage their senses and suffer from any food allergies.

Table 05: Summary of the basic taste recognition test

		Partic ipant	TI (Sweet)	DI (Sweet)	TI (Salt)	DI (Salt)	TI (Sour)	DI (Sour)	TI (Bitter)	DI (Bitter)
N	Valid	52	52	52	52	52	52	52	52	52
	Missing	0	0	0	0	0	0	0	0	0
Mean		26.50	.96	.96	.81	.67	.92	.92	.63	.44
Median		26.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.00
Mode		1[a]	1	1	1	1	1	1	1	0
Std. Deviation		15.155	.194	.194	.398	.474	.269	.269	.486	.502
Sum		1378	50	50	42	35	48	48	33	23

Taste Identification – TI, Difference Identification – DI, Taste identification (Sweet) was most frequency 50 out of 52 which was 96.2 %.

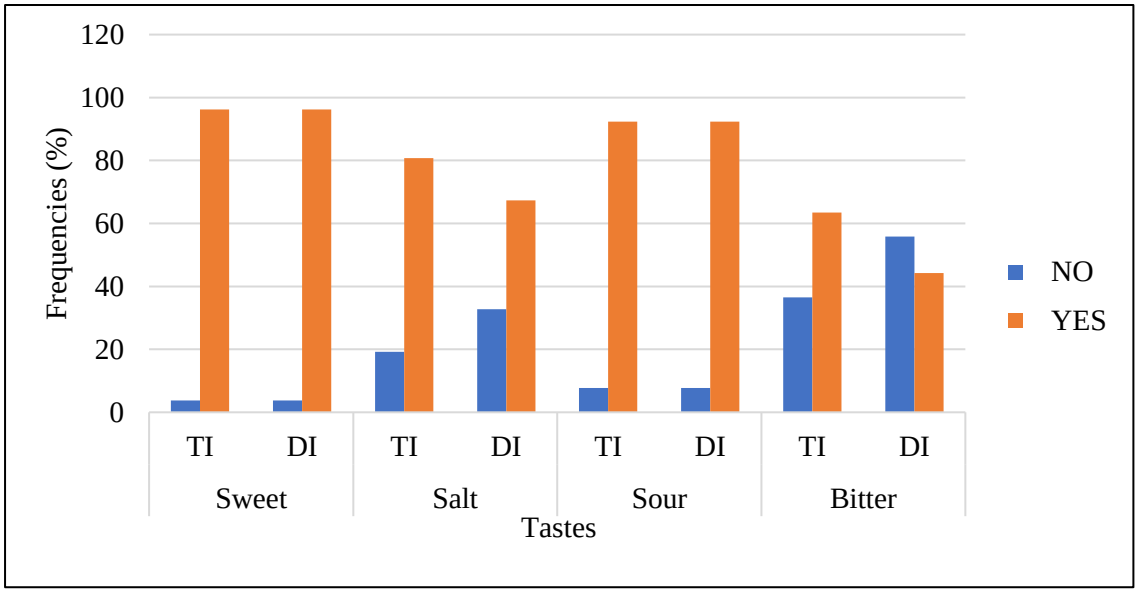


Figure 1: Frequencies of scores obtained for different tastes

Table 06: Summary of the basic odor recognition test

		Participant	Vinegar (A)	Vanilla (B)	Cinnamon (C)	Cloves (D)	Lemon (E)
N	Valid	52	52	52	52	52	52
	Missing	0	0	0	0	0	0
Mean		26.00	.57	.53	.76	.63	1.00
Median		26.00	1.00	1.00	1.00	1.00	1.00
Mode		1[a]	1	1	1	1	1
Std. Deviation		14.866	.500	.504	.428	.488	.000
Sum		1326	29	27	39	32	51
a. Multiple modes exist. The smallest value is shown							

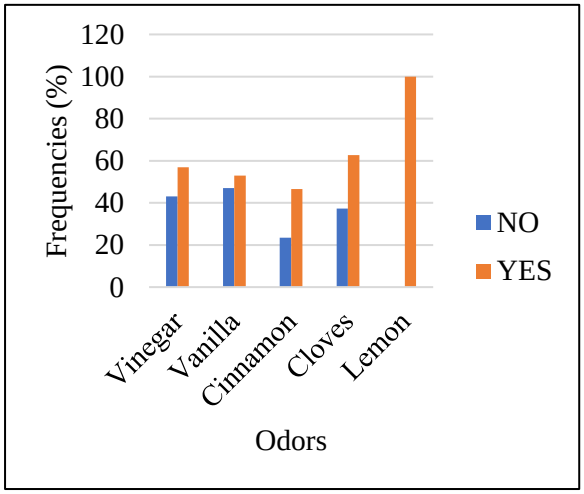


Figure 2: Frequencies of scores obtained for different odors

Figure 1 shows the frequencies of scores obtained for different tastes and figure 2 shows the frequencies of scores obtained for different odors tested in this study. The tastes of all the samples were identified by 13 candidates out of 52 correctly in the basic taste identification test and they were also able to describe the odors of more than 80% of the samples correctly in basic odor recognition test. Some people found difficulties in describing certain odors, even though they felt that they were familiar with these odors. Hence, these 13 candidates were selected as the panelists for the sensory panel. The selected panel was trained in the detection and recognition of different tastes and odors. In a previous study done by Silva *et al.* (2014) to recruit and train the product oriented sensory panel, 19 out of 29 members were able to identify all the tastes (sweet, salt, sour and bitter) in the basic taste identification test and a total of 17 participants were able to describe the odors of

more than 65% of the samples correctly in the odor recognition test.

According to the output of the non-parametric Friedman test, sample, taste and odor were significantly different among the tested samples (p<0.05) (Table 07).The members of the panel were taught how to identify and recognize tastes and odors using paired comparison test for both taste and odors. The acquired results were statistically analyzed at significance level of 0.05. The analysis was performed by chi-square test. Performance of the existing panel was confirmed to meet the requirements. Then 13 new members were recruited for the sensory panel. The performance of the panelists was found to be not significantly different in for basic taste and odor (Table 08). Hence, they can be considered as a homogenous trained sensory panel.

Table 07: Results of Friedman test for sensory evaluation performance of candidates

	N	Mean	Std. Deviation	Min	Max	Rank
Sample	52	3.00	.863	1	4	1.71
Taste	52	3.33	.944	1	4	2.01
Odor	52	3.50	1.213	1	5	2.28

Test Statistics[a]	
N	52
Chi-Square	11.386
df	2
Asymp. Sig.	.003
a. Friedman Test	

Significant level of p<0.05

Table 08: chi-square test for the performances of the panelists

	Pearson chi Square	Asymptotic Significance (2-sided)
Taste	52.000[a]	0.435
Odor	51.000[a]	0.434

Significant level of p<0.05

IV. CONCLUSION

A sensory evaluation panel having thirteen new members was formed for Ceylon Biscuits Limited, Sri Lanka. These 13 members were able to identify all the tastes and more than 80% of the odors of the samples. The performance of the panelists was found to be not significantly different in for basic taste and odor test. Therefore, this panel can be considered as a homogenous trained panel and can be used for the sensory evaluation of biscuit products of the company in future.

REFERENCES

Carpenter, R.P., Lyon, D.H. and Hasdell, T.A., 2000. Who are the right people for sensory analysis. In Guidelines for sensory analysis in food product development and quality control *Springer*, pp. 71-93.

Jayashantha, D. H. V., 2006. Establishing a sensory testing laboratory panel and procedure for biscuit industry. University of Sri Jayawardhanapura. pp 1-80.

Kemp, S. E., Hollowood, T. and Hort, J., 2009. *Sensory evaluation practical hand book*, John wiley and sons, 2-4

Kemp, S.E., Hollowood, T. and Hort, J., 2011. *Sensory evaluation: a practical handbook*. John Wiley & Sons

Murray, J.M., Delahunty, C.M. and Baxter, I.A., 2001. Descriptive sensory analysis: past, present and future. *Food research international*, *34*(6), pp.461-471.

Nunez, O., Moyano, E. and Galceran, M.T., 2005. LC–MS/MS analysis of organic toxics in food. *TrAC Trends in Analytical Chemistry*, *24*(7), pp.683-703.

Ramanathan, R., Mafi, G.G., Yoder, L., Perry, M., Pfeiffer, M., VanOverbeke, D.L. and Mheswarappa, N.B., 2020. Biochemical changes of postmortem meat during the aging process and strategies to improve the meat quality. *In Meat quality analysis Academic press*, pp. 67-80.

Sharif, M. K., Sadiq, M. B., Hafiz, R. S. and Muhammad, N., 2017. Sensory Evaluation and Consumer Acceptability. National Institute of Food Science and Technology, University of Agriculture. 6 (1), pp 362- 386.

Silva, A.Y.S.L., Binduhewa, A.M.C.U. and Subodinee, A.A.M., 2014. A study to recruit and train the product oriented sensory panel. *International Journal of Multidisciplinary Studies*. 1(2), pp. 247-250.

Assessment of Quality Parameters of Locally Manufactured Yogurts in the Coastal Area of Ampara District

A.M. Fathima Jahan[1], U.L. Abdul Majeed[2*] & A.M. Mohamed Asmath[3]

[1,2,3]*Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1]fattimajahan@gmail.com, [2*]ulmajeed@seu.ac.lk, [3]mohamedasmath@seu.ac.lk

Abstract- *Yogurt is a highly nutritious fermented dairy product that is widely popular among Sri Lankans due to its numerous health benefits, including the prevention of high blood pressure, easing the gastrointestinal problems, and weight control. As a result, there has been a rise in the number of yogurt consumers. No any updated and significant research on the quality parameters has been carried out. Hence, the current study is aimed to determine the compatibility of some quality parameters with specification for yogurt as per (SLS 824:2018) and to educate and promote the local manufacturers to comply with it. Samples of three different local manufacturers were collected from markets. Quality parameters such as, pH, fat, solid-non-fat (SNF), moisture and titratable acidity (TA) were determined with standard methods. The mean pH, fat, SNF, moisture and TA contents were found to be ranged from 4.49±0.016 - 4.63 ± 0.010, 0.10±0.00 - 0.36±0.20%, 21.6±0.530 - 25.81±0.08%, 73.73±0.15 - 78.13±0.35% and 0.11±0.00 - 0.426±0.08% respectively. All samples were found with lower moisture, TA and fat contents (81%, 0.6% and 3.0%) respectively, and higher SNF (8.0) while similar pH (4.5) to (SLS 824:2018). SNF, TA, fat and moisture contents were significantly varied ($p<0.05$) whereas no significant variation ($p<0.05$) was observed in pH value with (SLS 824:2018). There is room for local manufacturers to improve their whole production processes scientifically and provide quality products on par with (SLS 824:2018) to the local consumers.*

Keywords: SLS standard, solid non- fat, titratable acidity, yogurt

I. INTRODUCTION

Yogurt, on the other hand, has a composition that is very similar to milk. It is high in milk proteins and other nutrition (Weerathilake et al, 2014). It is a healthy and delicious food, which consumption has increased over the last decade in Sri Lanka, due to its high nutritive and therapeutic value (Perdigon *et al*, 2002 and Hemamali *et al*, 2016). It can also be prescribed to those with lactose intolerances, gastrointestinal illnesses (bowel illnesses), and weight loss due to its excellent digestion and bioavailability of nutrients (Lourens and Viljoen, 2001; Mckinley, 2005). Yogurt consumption is expanding due to the health benefits associated with it, and it is the fastest growing dairy category in the market specially, set yogurt and yogurt drinks (National Yogurt Association, 2013). Yogurts are probiotic carriers and they have a mildly sour taste with smooth texture, aroma and pleasant flavor (Mckinley, 2005). Yogurt improves the overall quality of the diet while also boosting the possibilities of meeting nutritional recommendations such as Recommended Dietary Allowances (RDA) for each nutrient daily (Weerathilake *et al*., 2014). According to World Health Organization (WHO), per capita milk consumption should be 200 ml per day per person and in 2020, the total annual milk production was estimated to be 491,538,618 liters (Department of Census and Statistics, 2020). However, the milk consumption in Sri Lanka is just more than 50% of what is required. Dairy market growth has been steady in recent years, indicating an upward trend. Yogurt is one of the most popular dairy products in Sri Lanka, accounting for more than 80% of the overall dairy market (Institute of Certified Management Accountants of Sri Lanka, 2017). As variety, just a few flavored products such as vanilla, strawberry, treacle, chocolate, fresh fruits and jelly yogurts are available in the markets. Furthermore, when compared to stirred yogurt, set yogurt is highly demanded in Sri Lanka (Institute of Certified Management Accountants of Sri Lanka, 2017). Adjusting the initial milk composition, pasteurizing the yogurt mix, fermenting at thermophilic temperatures (40-45^{0}C), cooling, and adding fruits and tastes are all part of the overall yogurt production process flow (Weerathilake *et al*., 2014).

According to earlier studies, yogurt was consumed by 96 % of households in various districts of Sri Lankan. (Diwuldeniya and Weligamage, 2015).

Hence, yogurt shall be prepared in accordance with the requirements laid down in the Sri Lanka Standards for yogurts (SLS 824:2018) to assure its health benefits and microbial safety, as well as consumer acceptability and preference (Hemamali et al., 2016). The Sri Lanka Standard Institution also explain legally recognized standards of quality, safety, composition, packaging, and labeling for food goods suitable for the Sri Lankan market (Weerasekara et al., 2010). Lack of information on the quality parameters of yogurts manufactured in Ampara district put the consumers on peril of health issues and the question arises whether the products meet the value for the money consumers paid for it. Therefore, it is necessary to evaluate the quality characteristics of locally manufactured yogurts.

II. LITERATURE REVIEW

The word "yogurt" comes from Turkish and refers to a fermented milk product produced by bacterial fermentation of milk (Ranasinghe and Perera, 2016). The general process flow of yogurt production includes adjusting the original milk composition, pasteurizing the yogurt mix, fermenting at thermophilic temperatures (40-45^{0}C), cooling, and adding fruits and flavors (Weerathilake *et al.*, 2014). Among the many dairy products on the market, yogurt is the most common product. It has the potential to be a low-cost and high-impact tool for helping individuals in underdeveloped nations to improve their nutritional status and health (Hattingh, 2001 and Al-Otaibi, 2009). Traditional culture yogurt and bio or probiotic yogurt are the two varieties of yogurt. *L. bulgaricus* and *S. thermophilus* are used to make standard yogurts. Although these bacteria are not said to live in the gut, they are capable of encouraging the friendly micro flora already present in the gut, assisting in the preservation of overall intestinal health (Dowden, 2013).

In addition to the traditional yogurt organisms; *S. thermophilus* and *L. bulgaricus*, some yogurt products have recently been reformulated to incorporate live *Lactobacillus* strains, such as *L. acidophilus*, and *Bifidobacterium* species (Nwamaka and Chike, 2010). Consumption of probiotics, which are live microbial supplements with presumed health benefits on human physiology, has become widespread. Probiotic bacteria increase the makeup and function of the gut microbiota while also boosting the immune system. Furthermore, vitamin synthesis has been recognized as one of the causal linkages of probiotic health effects (Hemarajata, and Versalovic, 2013).

Yogurt is rich in protein that contains all of the essential amino acids required for good health, a rich source of carbohydrate and contains a highly bioavailable source of calcium and also it contains source of phosphorus and potassium, riboflavin (B2), niacin (B3), as well as vitamin A and vitamin B12 (Weerathilake *et al.*, 2014). Observational studies and meta-analyses have found favorable relationships between yogurt consumption and risk factors for cardiovascular disease. Regular consumers of low-fat yogurt were 31% less likely to develop high blood pressure than those who consume it infrequently, according to research from the US Framingham cohort. It was once considered that eating a lot of yogurt could help with blood pressure regulation and may potentially help avoid hypertension (Wang *et al*., 2013).

III. PROBLEM STATEMENT

Many researchers in different districts of Sri Lanka have reported on the evaluation of yogurt quality parameters (Hemamali *et al*., 2016 and Weerasekara *et al*., 2010). However, no recent research has been conducted significantly on the quality parameters of yogurts manufactured in the coastal area of Ampara district; Kalmunai, Akkaraippattu and Pottuvil. Therefore, the present study aims to measure the gap between the values of some selected quality parameters of yogurts with the specification laid down in SLS 824:2018 so as to educate the manufacturers to comply with it and the consumers to select quality products as well.

IV. METHODOLOGY

A. Sample collection

Yogurts manufactured from three different local manufacturers were purchased as samples from markets representing the coastal area of Ampara district. The storage conditions, physical appearance and the shelf life of samples were considered as pre-requisite and get confirmed at the time of purchasing. All the samples were kept in a polystyrene ice box at 4 ^{0}C immediately after purchasing and brought to the laboratory for further analysis. Five individual number of yogurts cups from a manufacturer were purchased

and tested for all five cups individually as replicates. Then five replicates of testing were performed for each sample.

B. Analysis of quality parameters

The pH values were determined at 27°C with a benchtop pH meter (Starter 3100, OHAUS, USA) and moisture contents were determined with oven drying method to a constant weight using a dry oven (Memmert UF110, Germany). The fat contents were determined with Soxhlet system (FAT-06A) and the titratable acidity was determined with titrimetric method. The difference between the percentage of total solids and the percentage of fat contents were used to calculate the total solids-non-fat (SNF). All of the above determinations were carried out as per described in Association of Official Analytical Chemists (AOAC, 2005).

C. Statistical analysis

The data were analyzed with ANOVA at 95% confidence level. All the analyses were performed using SPSS 25 version.

V. RESULTS AND DISCUSSION

Three different brands of locally manufactured samples were analyzed. The results obtained from the analyses on moisture content, pH, titratable acidity, fat and solid non-fat are shown in Table 1.

Table 1: Results of quality parameters of local samples

Yogurt samples	pH	Fat (%)	Solid non-fat (%)	Moisture (%)	Titratable acidity (%)
Brand 1	4.63 ± 0.010	0.29 ± 0.137^{a}	25.82 ± 0.083^{d}	73.73 ± 0.151^{a}	0.43 ± 0.08^{b}
Brand 2	4.50±0.016	0.10 ± 0.002^{a}	21.60 ± 0.530^{b}	78.13 ± 0.353^{c}	0.12 ± 0.008^{a}
Brand 3	4.57±0.015	0.36 ± 0.205^{a}	23.04 ± 0.241^{c}	76.50 ± 0.153^{b}	0.19 ± 0.053^{a}
SLS Standard	4.50	3.00^{b}	8.00^{a}	81^{d}	0.6^{d}

Means ± SD within the same column with different superscripts are significantly different at $p<0.05$

A. Determination of fat content

The fat content in milk can be influenced by genetics, breed, diet used to feed the animal, and disease circumstances. Fat content of yogurt samples was found to be ranged from 0.10 - 0.36%, which were found to be lower than what is pacified in SLS 824:2018 and it could be one or many reasons such as genetic breed, diet used to feed the animal, and diseases (Weerasekara *et al*., 2010). Generally, low-quality milk contains low fat content (Weerasekara *et al*., 2010) and therefore great concern should be taken when the raw materials being purchased especially raw milk. According to USDA (2001), yogurt with less than 0.5% fat content should be labeled as "non-fat yogurt," those with fat levels between 0.5 - 2.5% should be called as "low fat yogurt," and those with fat content greater than 3.25% should be labeled "yogurt" (USDA, 2001). According to the results obtained in this present study, all yogurts samples could be termed as “non-fat yogurt” due to less fat content (below 0.5%). A significant difference ($p<0.05$) in fat contents was found to be observed between the local samples and that of the requirements prescribed in SLS 824:2018. Meanwhile, no significant variation was observed within the local samples. A study conducted in the North Central regions revealed that the fat content of yogurt was not up to the specification prescribed in SLS 824:2018 and that the fat percent by mass in most of the samples was below the required amount (Weerasekara *et al*., 2010).

B. Determination of pH Content

The pH values of all local samples were found to be more and less similar when compared to the requirements of pH value (4.5) specified in SLS 824:2018. Improper fermentation and time interval of storage that occurred further microbial fermentation causes higher pH value (Ali *et al*., 2002; Rashid and Miyamoto, 2005). The pH values of all the samples were found to be non-significant ($p>0.05$) when compared to the requirement prescribed in the respective SLS

standard. According to research conducted in Sabaragamuwa province of Sri Lanka, the pH of locally manufactured yogurts ranged from 3.97 - 4.10, and it was not higher than the SLS standard (De Silva and Rathnayaka, 2014).

C. Determination of Solid-Non-Fat (SNF)

SNF contents in milk can also be influenced by the genetics, breed, feed that used to feed animal and disease conditions (Weerasekara *et al*., 2010). As far as the yogurt production is concerned, in addition to fat content, determination of SNF content also one of the important parameters. According to the results of this present study, SNF was nearly three times higher than that of the requirements of SLS standard (8.0%) and it was found to be significantly varied (p<0.05) between the local samples and the SLS standard. Maximum SNF percentage was found to be observed in a local sample (25.81%). It is obvious that the drastic increase in SNF content was due to the reason of adulterating the milk to increase the consistency of the milk so that to increase the thickness of the yogurts. According to a study conducted in Sabaragamuwa province, SNF of locally manufactured yogurts ranged from 13.5 - 26.54, which was greater than the SLS standard and there was no any significant variation was observed among collected sample (De Silva and Rathnayaka, 2014).

D. *Determination of moisture content*

Moisture content of yogurt samples was found to be varied between 73.73 - 78.13%, which were found to be less than that of the requirements prescribed in SLS 824:2018 (81%) and a further significant difference was observed (p<0.05) within the local samples and between the requirements prescribed in SLS standards 824:2018. According to the study of Laxminarayana *et al.* (1952) the moisture content should be 85-88% for whole milk yogurt, but during the production of yogurt, producers used to add milk powder to increase the concentration of yogurt which gives more firmness to the yogurt. The variation in moisture contents between different local samples could be caused by over ripening and also being used more cultures than required (Saiful Bari *et al*, 2015).

E. Determination of Titratable Acidity (TA)

The maximum TA value was found to be observed in a local sample (0.42%) and minimum was found to be in another sample (0.116%). The Highest acidity value of yogurt might be due to improper incubation and prolonged storage while the lowest value of yogurt samples might be produced under controlled incubation and temperature (Saiful Bari *et al*, 2015). Titratable acidity values were found to be lower than that of the standard value and found to be observed significant (p<0.05) variation with the requirement of SLS standard value of 0.6%.

VI. CONCLUSION

According to the findings of this present study, all three local varieties were found to be of high quality in terms of SNF content; however, in terms of moisture, titratable acidity and fat contents, all three samples were found to deviating from the requirement of SLS standard. So, those parameters could be maintained by way of practicing proper yogurt manufacturing standards procedures and adapting suitable quality control activities of the local manufacturers. Due to a lack of information on the quality parameters of yogurts manufactured in Ampara district, the consumers are clueless over the quality and consistency of locally manufactured products and also the consumers are at a peril of health risks and the question arises whether the product meets the value for the money paid for it. Therefore, it is highly recommended to the local manufacturers to comply with the relevant standards so as to supply products on par with the standards.

REFERENCES

Ali, M.Y., Islam, M.A., Alam, M.J. and Islam, M.N., 2002. Quality of yogurt (Dahi) made in laboratory and available in the market of Mymensingh Town in Bangladesh. *Pak. J. Biol. Sci*, *5*, pp.343-345.

Al-Otaibi, M.M., 2009. Evaluation of some probiotic fermented milk products from Al-Ahsa markets, Saudi Arabia. *American journal of food technology*, *4*(1), pp.1-8.

AOAC, 2005. Official Methods of Analysis of AOAC International, 18th ed.

Bari, M.S., Shariful, I., Mahmud, M.H., Ali, M.S. and Khan, M.S.I., 2015. Chemical and microbiological evaluation of yoghurt available in the market of Bangladesh. *Wayamba Journal of Animal Science*, *7*, pp.1119-1123.

De Silva, K.L.S.R. and Rathnayaka, R.M.U.S.K., 2014. Physico-chemical sensory and microbiological evaluation of set and fruit yoghurt in Sabaragamuwa Province, Sri Lanka. *Journal of Scientific Research and Reports*, pp.284-293.

Department of Census and Statistics, Sri Lanka (2020). Cow and buffalo milk production 2015-2020,

Agriculture and Environment Statistics Division, Department of Census and Statistics, Sri Lanka.

Diwuldeniya, D.W.K.S. and Weligamage, P., 2015. Consumption Patterns and Preferences of Households for National and Local Brands of Yoghurt and Curd: A Study in Anuradhapura District. *Volume IV*, p.82.

Dowden, A., 2013. The good yoghurt guides. Daily Mail, [online] 4 December.

Food and Drug Administration, 1996. Yogurt. 21 CFR 131.200, code of federal regulations. *United States Department of Health and Human Services, Washington, DC*.

Hemamali, K.K.G.U., Jayamanne, V.S. and Amarathunge, S.M., 2016. Physico-Chemical and Microbiological Quality Of Some Consumer Preferred Plain Set Yoghurts Sold In Matara Municipal Area Of Sri Lanka. *International Journal of Scientific Research*, *5*(1), pp.62-65.

Hemarajata, P. and Versalovic, J., 2013. Effects of probiotics on gut microbiota: mechanisms of intestinal immunomodulation and neuromodulation. *Therapeutic advances in gastroenterology*, *6*(1), pp.39-51.

Laxminarayana, H., Nambadripad, V.K.N., Lakshmi, N.V., Nantaramiah, S.N. and Sreenivasamurthy, V.,1952. General Survey of the quality of market Yoghurt. Studies on Yoghurt II. Ind J Vet Sci, 22(1), 13- 17.

Lourens-Hattingh, A. and Viljoen, B.C., 2001. Growth and survival of a probiotic yeast in dairy products. *Food Research International*, *34*(9), pp.791-796.

Lourens-Hattingh, A. and Viljoen, B.C., 2001. Yogurt as probiotic carrier food. *International dairy journal*, *11*(1-2), pp.1-17.

Mckinley, M.C., 2005. The nutrition and health benefits of yoghurt. *International journal of dairy technology*, *58*(1), pp.1-12.

National Yogurt Association, 2013. Yogurt: Wholesome Food for Every Body. [online] Available at: <http://aboutyogurt.com/index.asp?bid=31.

Nwamaka, N.T. and Chike, A.E., 2010. Bacteria population of some commercially prepared yoghurt sold in Enugu State, Eastern Nigeria. *African Journal of Microbiology Research*, *4*(10), pp.984-988.

Perdigon, G., de LeBlanc, A.D.M., Valdez, J. and Rachid, M., 2002. Role of yoghurt in the prevention of colon cancer. *European Journal of Clinical Nutrition*, *56*(3), pp. S65-S68.

Puhan, Z., Flueler, O. and Banhegyi, M., 1973. Mikrobiologischer Zustand, sowie Menge und Konfiguration der Milchsaure des industriell hergestellten Joghurts in der Schweiz. *Schweizerische milchwirtschaftliche Forschung*.

Ranasinghe, J.G.S. and Perera, W.T.R., 2016. Prevalence of Lactobacillus bulgaricus and Streptococcus thermophilus stability in commercially available yogurts in Sri lanka. *Asian Journal of Medical Sciences*, *7*(5), pp.97-101.

Rashid, M.H. and Miyamoto, T.,2005. Quality evaluation of traditional fermented milk "Yoghurt" in Bangladesh. Milk Sci,54(1), 29-36.

Sri Lanka Standarts specifications for fermented milk products. yoghurts SLS:824: Part 2: 2018. Colombo 08, Colombo 00800, Sri Lanka.

The integrative case study (2017). Healthy Dairy Entrance to the Market :Institute of certified management accountants of Sri Lanka-may 2017 examination. Availabe at: http://www.cma-srilanka.org/sites/default/files/pub/ICS-%20501%20May'17.pdf.

USDA, 2001. USDA Specifications for Yogurt, Nonfat Yogurt and Lowfat Yogurt. Dairy Programs. Agricultural Marketing Services. United States Department of Agriculture: Washington, DC.

Wang, H., Livingston, K.A., Fox, C.S., Meigs, J.B. and Jacques, P.F., 2013. Yogurt consumption is associated with better diet quality and metabolic profile in American men and women. *Nutrition Research*, *33*(1), pp.18-26.

Weerasekara, W.M.S.I.M., Karunarathne, G.M.C.R. and Prathapsinghe, G.A., 2010. Assessment of quality parameters in curd and yoghurt of small-scale processors in North Central Province. *Wayamba Journal of Animal Science*.

Weerathilake, W.A.D.V., Rasika, D.M.D., Ruwanmali, J.K.U. and Munasinghe, M.A.D.D., 2014. The evolution, processing, varieties and health benefits of yogurt. *International Journal of Scientific and Research Publications*, *4*(4), pp.1-10

TRACK - NETWORK AND SECURITY TECHNOLOGIES

A Prototypical Adoption Security Model for Major Vulnerabilities in Cloud Computing

S.G.M.U. Kumarasinghe[1*], M.S. Shafana[2] & M.J. Ahamed Sabani[3]

[1,2,3]*Department of Information and Communication Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*]uddhika5004@gmail.com, [2]zainashareef@seu.ac.lk, [3]mjasabani@seu.ac.lk

Abstract- *Companies around the world are speedy in using the cloud to revolutionize their digital transformation initiatives. Cloud Computing enables companies to outsource the entire Information Technology process to stay focused on their core business to improve their productivity and creativity in providing clients with services. It allows companies to reduce the high cost of IT infrastructure without losing attention to customer needs. Although the cloud provides a lot of benefits that attract organizations, data security is one of few things which hold back companies from adopting cloud computing solutions. Cloud infrastructure could be complicated, and where complexity and security issues definitely exist. There exist unique cloud computing security issues in a cloud computing infrastructure. Data are stored in the cloud and accessed through the internet via a third-party provider. This means that there is limited visibility and control over the data, which is not a thing to be ignored. There are many other security threats to cloud computing vulnerabilities that cannot be ignored. This paper is going to describe some of the security threats on cloud computing vulnerabilities and will provide a prototypical model to adopt as a solution to overcome the major vulnerabilities. The goal is to convey the proper information to the users (organizations) who are thinking of deploying clouds for their organizations. This paper will help them to be conscious about opting for a proper cloud service provider and will help them in taking precautions to avoid the security issues.*

Keywords: Cloud computing, Threats, Security model, Vulnerabilities, CSP, cloud service provider

I. INTRODUCTION

The global market for public cloud services is steadily growing. According to Gartner, "The global market for public cloud services will expand by 17% in 2020 to $266.4 billion from $227.8 billion in 2019"(Worldwide Public Cloud Revenue to Grow 17% in 2020, 2019). Organizations are trying to migrate to existing cloud or developing new applications using cloud-based platforms. Analyzing cloud computing service provider is very crucial before deploying cloud computing infrastructure in organization. A company which adopts cloud computing or opt cloud service provider by ignoring all the risks associated with them is basically invites all the financial, technical and compliance risk to its organizations.

Cloud providers are a diverse, distributed and completely virtualized which makes cloud unique. Cloud has large pool of resources and has many specific characteristics if we compare it to traditional technologies. That's why traditional security precautions such as identification, authentication and authorization are not sufficient in case of cloud computing. Due to its method of service deployment, operations, and enabling technologies, cloud computing presents organizational risks different from traditional IT. The integration of security into the cloud services often makes it harder to solve the problem. Many companies concern moving the critical applications of the organization and its legacy database with sensitive information to the Cloud Service Provider. To reduce this concern, cloud service providers must ensure that its applications and sensitive data continue to be provided to customers with the same security and control as upstream systems. To achieve this, the cloud service providers must provide a customer with evidence that all service level contracts have been met and that auditors can ensure compliance. High data volume on the cloud is stored, and this data requires an internet connection. This means that anyone who uses cloud services may face cyber-attacks such as Distributed Denial of Service (DDoS) attacks, which are increasingly a common threat in cloud computing. Hackers send unprecedented traffic volumes to an application on the Web, thus further crashing the cloud servers. Companies should have steady regulations governing who can access the data. It can be challenging to track who really can access these

details with cloud computing easily access large-scale data(Khan and Al-Yasiri, 2016).

This study aimed to determine cloud computing vulnerabilities and threats that lead to those security issues. Vulnerabilities relate to system gaps that allow attacks to succeed, and threats are an assault that attempts to exploitations resources or information on system gaps. By dealing with these issues, we strive to strengthen the organizational preparedness of the cloud computing by providing a prototype for adoption. Since security is the most viable thing to cloud adoption, adding enough security is very important for cloud service providers.

II. LITERATURE REVIEW

Recently, the Cloud computing has emerged as a new paradigm which is enabling organizations to migrate all of their infrastructure from physical to virtual (cloud). Cloud Service Providers (CSP) around the globe are attracting organizations to adopt cloud and use their services. These providers attract them by mentioning bunch of advantages (High storage, high performance computing scalability etc.) moving towards cloud (Ramamurthy et al., 2020). They actually provide these benefits but there are a lot of security threats on cloud computing vulnerabilities which are ignored. Users does not give much importance to those issues and in the end, they find problems after moving towards cloud. Cloud security threats are multifaceted, and hackers continue to exploit those security vulnerabilities in clouds (Girma, Garuba and Li, 2015). Security defects must be detected to provide better quality of service for cloud users, so that an effective defense mechanism must be established (Chandra, Challa and Pasupuleti, 2016). Cloud service providers must check the cloud at regular intervals to prevent external threats from occurring. Furthermore, cloud providers must ensure that all Service Level Agreements (SLAs) are met, and human errors are reduced to make it possible for them to work smoothly (Ibrahim, Varrette and Bouvry, 2018). Keep in mind that cloud service providers are using a shared security responsibility model. Responsibilities for some security aspects are taken by the CSP. The CSP and the consumer share other security aspects. And certain security aspects remain a consumer's sole responsibility. The knowledge and performance of all consumer responsibilities depends on effective cloud security. Consumers' lack of understanding or lack of fulfillment of their responsibilities is a major cause of cloud-based cybersecurity threats. Our studies indicate the importance of data confidentiality in this field and introduction to *cloud computing security threats(Gupta and* Kumar, 2019). Most of the researchers work on the use of encryption techniques in the field of cloud computing, data security and organizational cloud deployment issues. This paper produces a simple and basic security analysis of security threats on cloud computing vulnerabilities and possible solution to those threats. Researchers seldom ignore vulnerabilities regarding cloud computing security. Therefore, this research identified the major and up to date vulnerabilities and also analyzed possible solution to cloud computing deployment threats. These vulnerabilities are major concern in cloud computing security. This study emphasizes strengthening the organizational preparedness of the cloud computing adoption framework. Since security is the most viable thing to cloud adoption, adding enough security is very important for cloud service providers.

III. METHODOLOGY

The methodology that is used to collect the knowledge on finding the facts about Security threats on cloud computing vulnerabilities, is to use the academic journals and the research papers that are interrelated with the topic of this study. By reading several kinds of research papers and academic papers related with this topic on Security threats on cloud computing vulnerabilities, it was able to get a rich knowledge on the respective field. The sources for this study are from various kind of multiple databases, university repositories, digital libraries, and web sites.

The technological information such as details about cloud platforms and related software information are collected from various kind of technology related and technical business official websites. By studying those resources that are published with those websites were gathered to analyze the common approach related with them to conduct the major research on Security threats on cloud computing vulnerabilities.

Those materials that collected to gain the knowledge, and ideas can be categorized as several types such as the related articles from blogs, e-commerce websites, and the research paper related to this study. Most of the information is based with the original works of those authors. Therefore, their originality and the trustworthiness

along with the content included with those papers are within the satisfied levels. Because of that it was able to do this study by consisting more valuable and correct information from that updated set of data. It was chosen the most appropriate research papers from the various type of research papers and the articles that are related with the cloud computing, that are more similar with this topic.

Within the research papers that gathered upon the vulnerabilities and attacks towards the computer systems, it was chosen the set of articles where they are only about the vulnerabilities that are interrelated with the cloud computing platforms.

Further, after the collection that it was gained by reading various kind of research papers, it was able to analyze them in a proper way to get the summarized ideas and the knowledge that are written over them. Furthermore, it was examined the frequently asked questions related with the topic of this study to identify the recent and current issues with them. By having all that information related with this topic, it was able to conduct the research in a better way.

As a deliverable of this study, it provides a prototypical model to overcome these vulnerabilities. This model has been prepared by having a thorough analysis of the collected information from already available various research and technology based sources. This model has three (03) types of actor levels: service provider, administrator, and user to achieve indented protections with specific responsibilities for each. As a lack of this research, it is unable to test this prototype to evaluate the effectiveness of the outcome due to the inability to access all these related resources at a needed actor level to perform their responsibilities. Therefore, this time we provide this as a prototypical model that can be provided as an evaluated model in the future.

IV. DISCUSSION

In this research we have identified almost seven risks and their solutions. In future we will try to describe maximize the number of threats and their solutions. We may focus on precautions which organizations can take to avoid or solve these types of threats.

A. Abusive use of computational resources

In the previous era, hackers were using multiple computers or a botnet to generate a high level of computer power to perform cyber-attacks on computer systems. This has been a complicated process which may take months. Now a powerful computer infrastructure can be easily built in the cloud computing service provider by a simple registration process. The software and hardware components are available in this infrastructure. Due to prevailing computing power of cloud computing, hackers can attack very quickly in short time(Chou, 2013). Brute force attacks and DoS attacks are included in abusive use of computational resources.

B. Brute force attack

A brute force attack is a breaking-password technique. It is basically the easiest way to access a website, a server or anything that is protected by a password. It repeatedly tries different combinations of usernames and passwords until they are included(Brute Force Attacks: Password Protection, no date; Idhom, Wahanani and Fauzi, 2020) The attack's success depends on strong computing ability as thousands of possible passwords must be sent to a target user's account until the correct one to access is found. Cloud computing offers a perfect platform for hackers to start such an attack(Hickey, 2011).

C. Denial of service attack

An attack by DoS is an attempt to prevent authorized users from using their services. In this type of attack, many requests flood the server that provides the service and therefore no authorized user can access the service. When trying to access the site, we sometimes see that we can no longer access the site and observe a mistake because the server is overloaded by requests for access to the site. This occurs if the number of requests that a server can process is higher than its capacity(Patil et al., 2018).

D. Misconfiguration

Cloud security misconfigurations are one of the leading causes of cloud data breaches(Bisson, 2021) Cloud security adaptation strategies of many organizations are not sufficient to protect their cloud infrastructure. The cloud infrastructure is designed to be simple to use and to facilitate data sharing, making it difficult for organizations to make certain that only authorized parties have access to their data. Cloud-based companies also have not completed visibility and infrastructure controls which means that they need security controls from their cloud service provider (CSP) to configure and secure their cloud

deployments(Top Cloud Security Issues, Threats and Concerns, no date). As many organizations have no familiarity with a cloud infrastructure and often have multi-cloud deployments (all with a vendor-based security system)(Ramamurthy et al., 2020), it is easy to leave cloud-based resources of an organization exposed to attackers when it comes to configuration or security monitoring.

One of the most frequent problems is not to diffuse well-known security configuration in baseline settings. This means that the learning from the past can be taken for future instances of an app or part of a cloud infrastructure.

E. Insecure Cryptography

Cryptography algorithm produces random numbers, which are used to generate actual random numbers by uncertain sources of information to gain a larger entropy pool. If only a small entropy pool is provided by the random number generators, the numbers can be brutally forced. The primary source of randomized in client computers is the movement of the user's mouse and key presses, but the servers run without human input(Lukan, 2014). Consequently, virtual machines must rely on the sources available, so that numbers that do not provide much entropy in cryptographic algorithms can easily be guessed.

F. Insecure APIs

The primary tools that allow interactions with cloud storage systems are application user interfaces (APIs). Two different groups of employees normally use APIs such as own staff of organization means the users who would use the API to access cloud data, and staff of cloud service provider.

Unfortunately, several APIs are still vulnerable to security and cloud storage providers usually have unwarranted data access levels(Johnson, 2014). For example, it appeared a few months ago that some popular social network and online platforms stored user passwords in plaintext, which would enable their employees to read them(Chapman, 2019; JOHNNY LIEU, 2019). As dependence upon APIs increases, attackers possess easy methods to use unreliable APIs for malicious purposes.

Developers often develop APIs without properly controlled authentication. As a consequence, these APIs seem to be entirely open to Web and can be used by anyone to access company data and systems. Most of the developers believe that the attackers would not see backend API calls and do not implement adequate authorization control measures. If not, backend data compromise is insignificant.

G. Data Sovereignty

A huge proportion of geographically spread data centers are provided to most cloud providers. This enables the ease of access and performance of Cloud-based resource base to be improved and facilitates CSP's ability to maintain service level contracts in the face of disruptive activities such as natural disasters, power interruption, etc. Organizations that store their data in the cloud mostly do not know in which their information is fully stored in a CSP data center range. This creates important concerns for thirty seven percent (37%) of organizations with respect to data sovereignty, residence and control. Using a cloud platform with data centers outside the authorized area can lead to a regulatory non-compliance for an organization through data protection regulations(Top Cloud Security Issues, Threats and Concerns, no date). Moreover, there are different jurisdictions with different laws on availability to law enforcement data and national defense which can affect customers' security and privacy.

H. Reused IP Addresses

An IP address is provided for every node of the network and therefore a limited amount of an IP address exists. Several cases have been observed recently with regard to the reused IP-address issue. If a specific user leaves the network, a new user is assigned the associated IP-address (former). This sometimes affects the security of the new user because it takes a time to clear the IP address in DNS and in DNS caches(Akinola and Odumosu, 2015). Because of this, sometimes even though the old IP address is given to a new user, it is not insignificant that some other user still has the opportunity to access the data, given that the address remains in the DNS cache and data from a certain user can be available to some other damaged user.

I. Loss of Control over End-User Actions

If companies don't know how their staff use cloud computing services, they can lose control and eventually become vulnerable to violations and threats to security of the insider. Insiders need not to break through private virtual networks (V PNs), proxy servers, or other security defenses to obtain

access to an enterprise's cloud-related internal data. You can access sensitive data directly without too much trouble in the cloud computing. The loss of intellectual property and confidential data can lead to obvious consequences for the company. In order to deal with the loss of supervision over end-user actions, it is important to check, monitor, escalate, analyze incidents, remedy, investigate and respond to incidents. All these measures must be part of the data protection program of the company(Calam et al., 2019).

The following proposed prototypical model (Figure 1) suggests some effective adoptable techniques or solution to overcome these discussed major security threats by cause of vulnerabilities in cloud computing. In deeper by this prototype model, in order to overcome the Brute force attacker, service providers must ensure that system passwords are encrypted at the highest possible encryption rates, such as with 256-bit encoding. The more bits the encryption system contains, the more difficult is

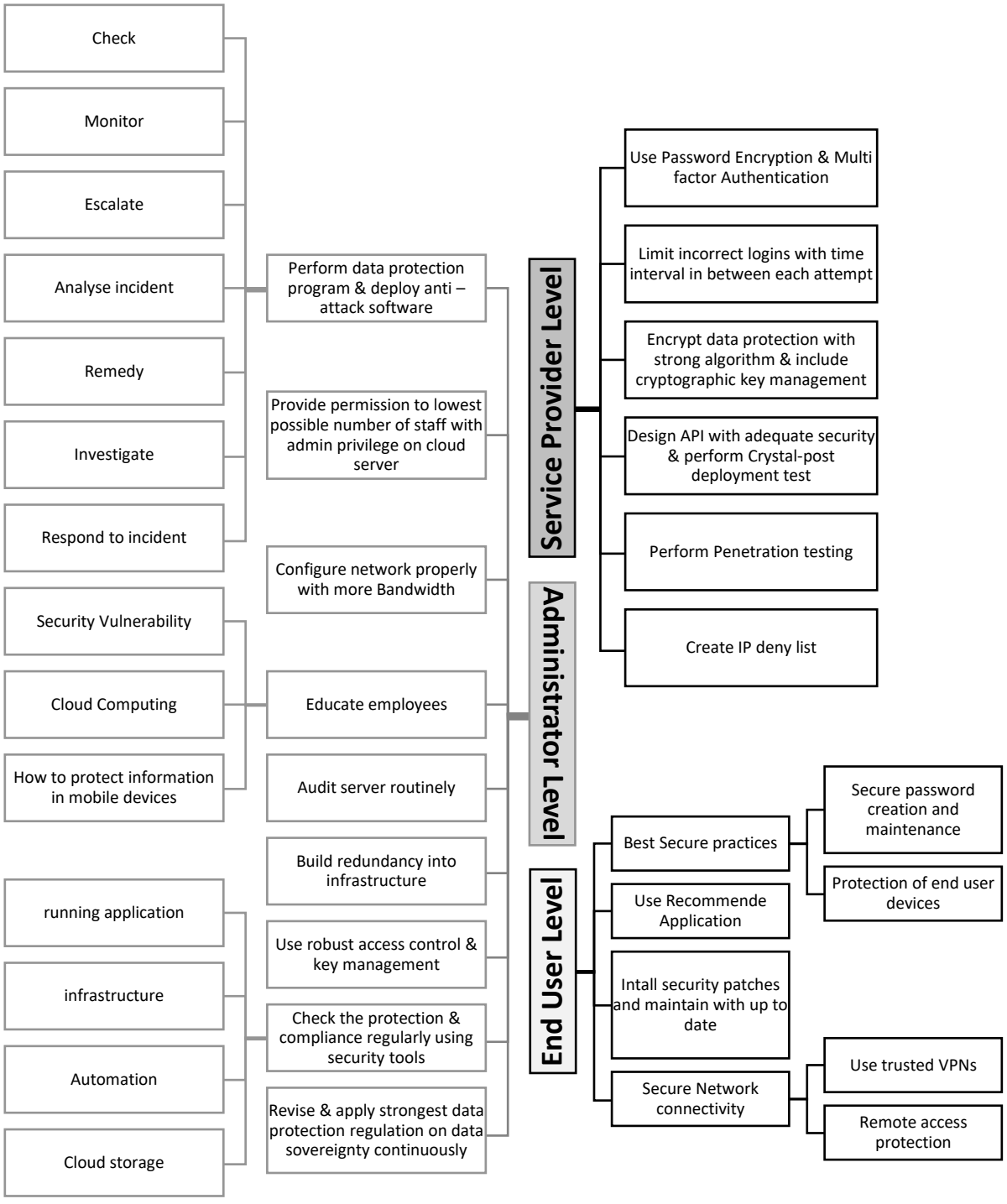


Figure 1: A prototypical model for Security guideline at different levels of cloud interactors

the password to break. also using two factor authentications can minimize brute force service attack. Further we can limit the number of attempts to enter password also reduces the risk of Brute force attacks. If a hacker can continue to try passwords even after a temporary lockout, it can go back to try again. If the account is locked and the user requires IT contact for unlock, this activity will be deterred. If Attacker's efforts for breaking passwords can also be reduced by setting times in between each single login attempt. If a login fails, the timer can stop log in for a short time. Some hackers may stop breaking the passwords if they have to wait. Also, using an IP denylist for the purpose of blocking known hackers (attackers) can also reduce brute force attack(Brute Force Attacks: Password Protection, no date).

In case of Denial-of-Service attack, by buying more bandwidth will help the system to avoid DoS attack. Further security can be achieved over DoS attack by building redundancy into infrastructure, configuring the network properly, and deploying anti-DoS software modules.

The misconfigured base causes problems from the beginning of deployment. Agile development methods(Kalem, Donko and Boskovic, 2013), such as DevSecOps(Zaydi and Bouchaib, 2019), utilize scale developed to assist developers in secure code development and code deployment. But companies do not go far enough sometimes. Protection and compliance should be checked regularly for all running applications and infrastructure and automation can also be helpful(Lemos, no date). Specific tools can also be used to check security configurations for cloud storage. The security tools in the cloud help you to check the security settings in a schedule and identify vulnerabilities before it is too late(ZELLEKE, 2021). During developments and speeding up application deployment, automation should not be restricted to testing code. Critical post-deployment testing should be made as regular cloud services safety testing.

Companies and organizations must take a data-centric approach to preserve their sensitive information from emerging attacks to virtualization, cloud services and mobility in dynamic and complex surroundings. Companies are supposed to deploy data security solutions that consistently protect sensitive data, including cryptographic key management and encryption data protection. An extensive cloud security and encryption platform should also provide robust access controls and key management capabilities that enable companies to use encryption to achieve strategic goals in a useful, cost-effective and exhaustive fashion.

As a mitigation for in secure APIs, developers must be encouraged by cloud service providers to design APIs that provide strong authentication, encryption, intrusion detection and access control. Providers need to secure the APIs. Cloud providers need to perform penetration tests to replicate an external attack to target one's API endpoints and get a safe code review. It is best to make sure secure life cycle of software development through which that reliable applications and APIs are constantly developed. Cloud service providers should consider utilizing data-in-transit SSL/TLS cryptography. Implement multi-factor authentication using schemas such as unique passwords, digital identities, etc.

In order to overcome this issue, the strongest of regulations should be applied uniformly by companies. If an organization has a global presence, it is a continuous challenge to comply with the legislation on data sovereignty of each region. The strongest of these legislations and consistently implement it in every region, irrespective of what other regions require, is one way to reduce complexity. That can be helped by the cloud. Evaluate which cloud services offer these options usually, larger providers and those focusing on certain vertical industries will do their best. Initial and thorough backup discovery and classification must be performed by the cloud service provider. Based on the results, any noncompliance will be identified, and the backups will either be complied with, relocated, or destroyed. It should ensure the establishment of ongoing assessment processes to ensure compliance. Laws and legislation on data sovereignty are continually changing and increasingly compulsory. The tsunami of data continues. And cloud adoption is growing fast(Ashwin Krishnan, 2020).

This study highlights a solution for this issue is that the organizations need to educate their employees about handling security vulnerabilities, for example spoofing and malicious software. Educate them about cloud computing and about how to protect their confidential information on mobile devices or laptops outside the organization. Tell them about the effects of malicious activities. There ought to be Audit

servers routinely within the cloud infrastructure to recognize and timely fix data-security vulnerabilities. Focus on authorized images that are routinely scanned for security vulnerability. Then deploy new image servers to continuously scan for proper setup and vulnerabilities. If the server is vulnerable, do not fix it, replace this with a hardened image, which is approved. Ensure that a lowest possible number of people are limited to privileged central servers and access security systems but that those staff have appropriate training to safely handle their administrator privileges on a cloud server(Cloud Computing Security Vulnerabilities and What to Do About Them, 2020).

V. CONCLUSION

In order to move successfully towards the cloud, a company must be aware of the cloud threats. Instead, we should understand safety threats in our cloud service providers and communicate with our CSP to determine the way in which they deal and from there continue to address security threats. The use of cloud computing has changed the way businesses and hackers act. It brought a wide range of opportunities and a whole new set of risks to cloud security. Companies must continually address the risks and challenges of cloud security while adopting appropriate security tools to simplify operational operations. None of the mentioned security threats are new, but they are more important than ever because staff members are forced to work in this pandemic from home. Encryption is therefore essential to protect against regular audits that have access to your cloud storage and choose a high-quality cloud service provider. In the end, organizations will also protect their data, staff, and customers on a long-term basis by using this opportunity to better their cloud security. The goal of this study is to convey the proper information through a prototypical model to the users (organizations) who are thinking of deploying clouds for their organizations. This paper will help them to be conscious about opting for a proper cloud service provider and will help them in taking precautions to avoid these security issues.

REFERENCES

Akinola, K. E. and Odumosu, A. A. (2015) "Threat Handling and Security Issue in Cloud Computing," *International Journal of Scientific and Engineering Research*, 6(11), pp. 1371–1385.

Ashwin Krishnan (2020) *Steps to ensure data sovereignty in cloud computing*. Available at: https://searchcloudsecurity.techtarget.com/tip/3-steps-to-ensure-data-sovereignty-in-cloud-computing (Accessed: May 11, 2021).

Bisson, D. (2021) *Misconfigurations: A Hidden but Preventable Threat to Cloud Data*. Available at: https://securityintelligence.com/articles/misconfigurations-hidden-threat-to-cloud-data/ (Accessed: May 11, 2021).

Brute Force Attacks: Password Protection (no date) *Kaspersky*. Available at: https://www.kaspersky.com/resource-center/definitions/brute-force-attack (Accessed: May 11, 2021).

Calam, M. *et al.* (2019) "Perspectives on transforming cybersecurity," *McKinsey Global Institute*, (March). Available at: https://www.mckinsey.com/~/media/McKinsey/McKinsey Solutions/Cyber Solutions/Perspectives on transforming cybersecurity/Transforming cybersecurity_March2019.ashx.

Chandra, J. V., Challa, N. and Pasupuleti, S. K. (2016) "Advanced persistent threat defense system using self-destructive mechanism for cloud security," *Proceedings of 2nd IEEE International Conference on Engineering and Technology, ICETECH 2016*, (March), pp. 7–11. doi: 10.1109/ICETECH.2016.7569181.

Chapman, G. (2019) *Facebook admits storing passwords in plain text*. Available at: https://phys.org/news/2019-03-facebook-passwords-plain-text.html (Accessed: May 13, 2021).

Chou, T.-S. (2013) "SECURITY THREATS ON CLOUD COMPUTING VULNERABILITIES," *International Journal of Computer Science & Information Technology (IJCSIT)*, 5(3), pp. 79–88. doi: 10.5121/ijcsit.2013.5306.

Cloud Computing Security Vulnerabilities and What to Do About Them (2020) *Towards Data Science*. Available at: https://towardsdatascience.com/7-cloud-computing-security-vulnerabilities-and-what-to-do-about-them-e061bbe0faee (Accessed: May 11, 2021).

Girma, A., Garuba, M. and Li, J. (2015) "Analysis of Security Vulnerabilities of Cloud Computing Environment Service Models and Its Main Characteristics," *Proceedings - 12th International Conference on Information Technology: New Generations, ITNG 2015*, pp. 206–211. doi: 10.1109/ITNG.2015.39.

Gupta, H. and Kumar, D. (2019) "Security threats in cloud computing," *2019 International Conference on Intelligent Computing and Control Systems, ICCS 2019*, (Iciccs), pp. 1158–1162. doi: 10.1109/ICCS45141.2019.9065542.

Hickey, A. R. (2011) *Amazon Cloud Can Be Used To Crack Wi-Fi Passwords With "Brute Force," CRN*. Available at:

https://www.crn.com/news/cloud/229000447/amazon-cloud-can-be-used-to-crack-wi-fi-passwords-with-brute-force.htm (Accessed: May 11, 2021).

Ibrahim, A. A. Z. A., Varrette, S. and Bouvry, P. (2018) "On Verifying and Assuring the Cloud SLA by Evaluating the Performance of SaaS Web Services Across Multi-cloud Providers," *Proceedings - 48th Annual IEEE/IFIP International Conference on Dependable Systems and Networks Workshops, DSN-W 2018*, pp. 69–70. doi: 10.1109/DSN-W.2018.00034.

Idhom, M., Wahanani, H. E. and Fauzi, A. (2020) "Network security system on multiple servers against brute force attacks," *Proceeding - 6th Information Technology International Seminar, ITIS 2020*, pp. 258–262. doi: 10.1109/ITIS50118.2020.9321108.

JOHNNY LIEU (2019) *Google stored some users' passwords in plain text for years*. Available at: https://mashable.com/article/google-plaintext-password-enterprise/ (Accessed: May 13, 2021).

Johnson, M. C. (2014) "Cloud Insecurity and True Accountability," *Guardtime*, p. 15. Available at: https://guardtime.com/files/Cloud_Insecurity_and_True_Accountability_1403.pdf.

Kalem, S., Donko, D. and Boskovic, D. (2013) "Agile methods for cloud computing," *2013 36th International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO 2013 - Proceedings*, pp. 1079–1083.

Khan, N. and Al-Yasiri, A. (2016) "Identifying Cloud Security Threats to Strengthen Cloud Computing Adoption Framework," *Procedia Computer Science*, 94, pp. 485–490. doi: 10.1016/j.procs.2016.08.075.

Lemos, R. (no date) *Cloud misconfigurations and security: How to avoid your next fail*, *TechBeacon*. Available at: https://techbeacon.com/security/cloud-misconfigurations-security-5-ways-avoid-your-next-fail (Accessed: May 11, 2021).

Lukan, D. (2014) *The top cloud computing threats and vulnerabilities in an enterprise environment*, *CLOUD TECH*. Available at: https://cloudcomputing-news.net/news/2014/nov/21/top-cloud-computing-threats-and-vulnerabilities-enterprise-environment/ (Accessed: May 11, 2021).

Patil, A. *et al.* (2018) "A multilevel system to mitigate DDOS, brute force and SQL injection attack for cloud security," *IEEE International Conference on Information, Communication, Instrumentation and Control, ICICIC 2017*, 2018-Janua, pp. 1–7. doi: 10.1109/ICOMICON.2017.8279028.

Ramamurthy, A. *et al.* (2020) "Selection of cloud service providers for hosting web applications in a multi-cloud environment," *Proceedings - 2020 IEEE 13th International Conference on Services Computing, SCC 2020*, pp. 202–209. doi: 10.1109/SCC49832.2020.00034.

Top Cloud Security Issues, Threats and Concerns (no date) *Check Point Software*. Available at: https://www.checkpoint.com/cyber-hub/cloud-security/what-is-cloud-security/top-cloud-security-issues-threats-and-concerns/ (Accessed: May 11, 2021).

Worldwide Public Cloud Revenue to Grow 17% in 2020 (2019) *Gartner*. Available at: https://www.gartner.com/en/newsroom/press-releases/2019-11-13-gartner-forecasts-worldwide-public-cloud-revenue-to-grow-17-percent-in-2020 (Accessed: May 11, 2021).

Zaydi, M. and Bouchaib, N. (2019) "DevSecOps PRACTICES FOR AN AGILE AND SECURE IT," 22(December), pp. 527–540.

ZELLEKE, L. (2021) *Best Cloud Security Tools for 2021*. Available at: https://www.comparitech.com/net-admin/cloud-security-tools/ (Accessed: May 11, 2021).

TRACK - COMPUTER AND INFORMATION SYSTEM

Impact of Facebook on Students' Academic Activities

S.L. Fathima Ruksana[1*], M.N. Ruhana Banu[2] & M.S. Mohammed Ismath[3]

[1,2]*Department of Information Technology, Faculty of Arts and Culture, South Eastern University of Sri Lanka, Sri Lanka*
[3]*Department of Political science, Faculty of Arts and Culture, South Eastern University of Sri Lanka, Sri Lanka*

[1*]fathimaruksanasl@gmail.com, [2]riznazweety@gmail.com, [3]ismathm95@gmail.com

Abstract- *Facebook is one of the trending social media to spread information all over the world. Facebook is an online platform, where users can create the content and share them to public or particular ones. It is one of the communication tools which used to communicate with friends and society academically and otherwise. Facebook can spread the news very speedily all over the world with the help of the network. Facebook has revolutionized the mode of communication, where university students use it for many reasons such as for study purposes, information sharing purposes, and for the purpose of spreading news, etc. Moreover, Facebook is used by many university students to fulfill their needs in academic activities. This research has mainly assessed the impact of Facebook on students' academic performance especially those who are studying ICT special in faculty of arts and culture in the South Eastern University of Sri Lanka.*

Keywords: Academic, students, performance, Facebook, social media

I. INTRODUCTION

The internet has created a big platform for millions of computers at numerous sites in many countries, it belongs to thousands of businesses, governments, research institution, educational institutions, and other organizations to make the interaction with one another. Really, it provides a very rich medium for information spreading, exchange and collaborative interaction among individuals and computers, and also it does not require the geographical limitation of space. We all heard very deeply about the social networking which has become a general worldwide trend, using this social networking in every corner of the world we can use to spread information. Over the last few decades, Facebook has been used among the young men and women to exchange ideas, feelings, personal information, and videos at an amazing rate. The Facebook has changed the life of people in a fantastic way all over the world. Among the Facebook users most of them are teenagers and young adults who are highly using the Facebook to communicate with all peers around the world and they sharing the information, showing their personalities, and conveying their daily routines through the status. According to these pros the Facebook became very famous in our society. And also a huge platform among the students and mainly we want to consider about the undergraduate students that how this Facebook affects their academic activities.

II. LITERATURE REVIEW

According to Fawsi. Altanny, and A Jassim (2013), There are many social media available in the world, among them, Facebook is the one which connected more people in the world for the communication and in the universities. Facebook is used to make the relationship, friendship, social networking among the students. Mostly the students are involved in the Facebook to do their academic activities effectively. And they pointed out that the Facebook was implemented in 2004_for the students but nowadays it became in other social sites also.

According to Thuseenthan and Kuhanesan (2014), Facebook is the electronic communication and it became very friendly among all the people. Facebook is a social media which became benefit for the advanced level and university students.

According to El Badawy and Hashem, (2015), The technology is growing rapidly the most affected ere the students. They defined that social media are so interacted with the life of people and among the students. And most of the students are spending more time with the Facebook.

According to Siddiqui and Singh, (2016), The social media nowadays are interacting in all the activities of the human's day to day activities such as in business, education, etc... Social media are making easy to interact with more number of people to form the connection through Twitter, Facebook etc. The advantage of the social media on education easily communicates and shares the information quickly through the Facebook and

some of other social media sites. And they indicated not only the positive impact, but also they indicated the negative impact also such as if the people spend more time to use the Facebook they will be addicted to Facebook, by these reasons studies and works will be spoiled. And the social media affect the kids, it means unwanted images and videos will be watched by the students mean, by these they will be affected badly. So, there are positive and negative effects having by using social media.

Akram and Kumar, (2018) reported that, Facebook is the largest social media network on the internet. And this Facebook becomes a very famous and best medium for connecting the people. In addition, Facebook used to build the business and it is providing a good platform for it.

III. STATEMENT OF THE PROBLEM

Students are using digital devices mostly and new technology devices for their studies. So Facebook is one of the social media used in the educational activities. For our study, we identified following problems.

- Students have difficulty in studies when they have no communication with their friends and college groups.
- There i4s a problem to discuss the academic matters and share the ideas among them without using social media.
- There is a problem to solve the doubts in their studies.
- There are some students who are not social or shy to interact with their friends

IV. METHODOLOGY

This study to identify the impact of the Facebook on the student's academic activities.

The sample study was conducted with population 80 students from first, second, third year students from ICT special students attached to the Faculty of Arts and Culture South Eastern University of Sri Lanka. First, we conducted an interview individually and in group. There are around 350 students in faculty of arts and culture, in that 80 are studying ICT as a special study. We have used semi- structured questionnaires and we have used qualitative research techniques for our research. A questionnaire was designed with 25 questions and the data was collected through a questionnaire and analyzed.

The questionnaire consists of 4 parts. The first part of questionnaire consists of different types of social media used by the students. Second part consists questions on of the purpose of using Facebook, third part asks on how the Facebook impact students' performance and academic activities and while fourth part of the questionnaire consists of the misuse of the Facebook for many reasons. Related information was collected from the respondents.

These questionnaires were distributed among the students who are studying ICT special at faculty of arts and culture south eastern university of Sri Lanka. The main reason for selecting ICT special students for this study is that, they are mostly related to Facebook. And highly use to works effectively and efficiently. Analysis of Different types of social media used by the student from questionnaires. Analysis Different types of Social media were used by the students. The data obtained through the questionnaire has been analyzed and given in Table 1.

Table 1: Different types of social media used by the students

Year	No of students Using Facebook	No of students Using Whats App	No of students Using Twitter	No of students Using Linked In	No of students Using nothing
1st year	19	16	10	5	1
2nd year	20	19	1	2	03
3rd year	20	20	0	1	0
4th year	20	17	1	3	0

Table 2: Misuse of Facebook

Ways of Facebook in academic activities	Percentage of students misusing Facebook
Use for chatting	75%
Use fake Facebook ids	65%
Use for watching films	30%
Use as a video conference tool to communicate unwanted ones	20%
Playing games	10%

V. RESULTS AND DISCUSSION

The survey results were analyzed and presented in Table 1, Table 2 and Table 3. We have selected the students who are studying in the Faculty of Arts and culture of South Eastern University of Sri Lanka as ICT special students. Nowadays, most of the students are using social media, among that Facebook is one of the very important and trending one among that. The ratio of Facebook usage among female vs male is 54:6. They can communicate with friends from different geographical areas using network technology through Facebook.

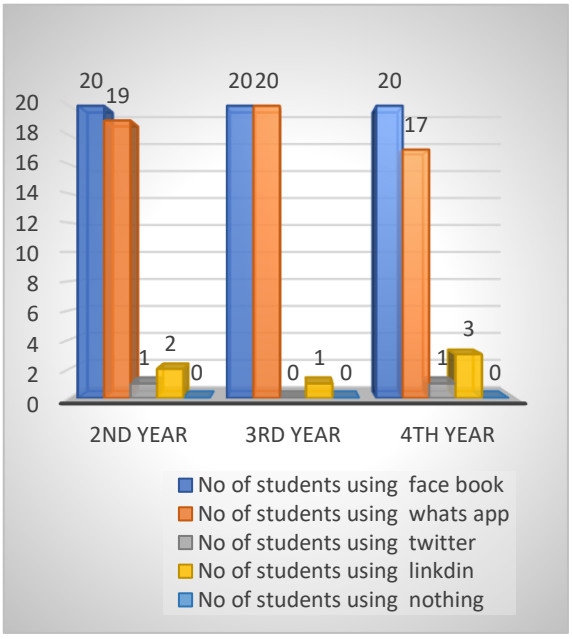


Figure 01: Number of students using Facebook for their academic activities

Table 3: Uses of Facebook for many purposes

Uses of Facebook	Percentage of always use
Prepare for lesson	85%
Collect resources	70%
Online discussion	47%
Communicate purpose	60%
Watch video clips related to the academic activities	60%

According to the analysis, of the impact of Facebook on students' performance is high, more than 95%of the students used social media and to get benefit in their learning activities and Facebook was misused by the students by nearly 45% of the students. Most students use Facebook for many learning purposes. So, the use of Facebook, can increase the progress of the students in studying and not only in studying but also they can become a social students in the world.

Some analyzed charts show the number of students using the social media and percentage of misusing Facebook.

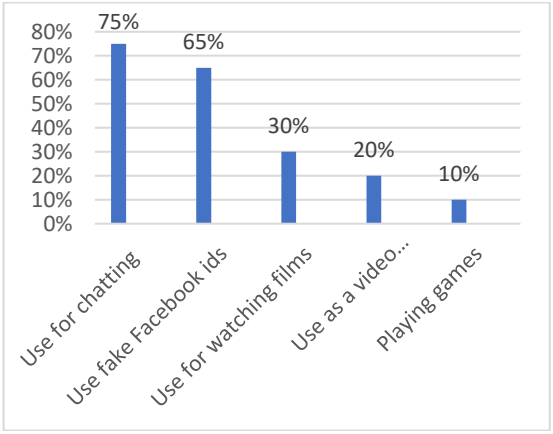


Figure 02: Percentage of students misusing Facebook

At the end of the study, we found the following impact of using Facebook in academic activities.

- Facebook is generally available to most students in their digital devices.
- Most of the students are using mobile phones and digital devices for their academic activities.
- Found that if the students use their mobile and digital devices for their learning and academic activities, they are very eager to engage in studies.

- The knowledge about the Facebook such as how to use that, how to get advantages for academic activities, how we want to spend time with Facebook needs to be given to enhance the knowledge on Facebook among the students.
- According to the analysis most of the students will use the Facebook for their academic activities in future.

Some poor students may not have the digital devices to use the Facebook for their academic activities. This challenges the poor students to get digital equipment.

VI. RECOMMENDATION

There are some recommendations to fulfill the issues related Facebook. So, it's better to provide Facebook related knowledge to the students, which can be used in the positive way for students to get the advantages for learning process. Digital devices, free Wi-Fi facilities for students to use Facebook, and arrange online guidance programs to use the Facebook for the academic purpose to get a good advantage for their academic activities.

VII. CONCLUSION

The use of the Facebook has become very vital and famous around the globe due to the vast and wide development of technology. Facebook is very useful for not only in everyone's life, but also it is very helpful for the academic activities of the students. According to the study, Students use Facebook very effectively for their academic activities. And also Facebook can negatively affect on the students' academic activities. Students are the vital resources. According to that, we suggest that, if they use the Facebook, it can impact in their academic activities at the same time it can give a negative effect for their studies at the same time we need to minimize the time to waste on using Facebook and some students misusing this Facebook. It can be very helpful for their academic purposes too and helps to enhance the performance of the students and also the by the use of the Facebook the students can become a social ones and forwarded ones in the society by communicating with each other and they can also maintain a lifelong relationship with the peer groups and can easily solve the problems among the groups.

REFERENCES

Akram, W. and Kumar, R., (2017) 'A Study on Positive and Negative Effects of Social Media on Society'. International Journal of Computer Sciences and Engineering, vol.5, pp.351-354,Doi:10.26438/ijcse/v5i10.351354

Bryfonski, D. (2012) The global impact of social media. Detroit, MI: Greenhaven Press.

Chan, K., n. d. The Social Impact of Facebook on Tertiary Students.

El-Badawy, T. and Hashem, Y. (2014) 'The Impact of Social Media on the Academic Development of School Students' International Journal of Business Administration, vol.6, Doi:10.5430/ijba.v6n1p46.

Lacida, A. and Murcia, J . (2015) Influence of Facebook Addiction on Study Habits of College Students. SSRN Electronic Journal, Doi:10.2139/ssrn.2617158.

Michikyan, M., Subrahmanyam, K. and Dennis, J. (2015) 'Facebook use and academic performance among college students: A mixed-methods study with a multi-ethnic sample'. Computers in Human Behavior, pp.265-272.

Moghavvemi, S. and Salarzadeh Janatabadi, H.(2017) 'Incremental impact of time on students' use of E-learning via Facebook' British Journal of Educational Technology, vol.49(3), pp.560-573. Doi:10.1111/bjet.12545

Positive Negative Effects(2021) Positive and negative effects of Facebook - Essay and speech. [online] Available at: <https://www.positivenegativeeffects.com/facebook> [Accessed 5 March 2021].

Sehnaz, B., 2015. The impact of Facebook in teaching practicum: Teacher trainees perspectives. Educational Research and Reviews, vol.10(17), pp.2489-2500.

Siddiqui, S. and Singh, T. (2016) 'Social Media its Impact with Positive and Negative Aspects' International Journal of Computer Applications Technology and Research, vol. 5(2), pp.71-75,Doi:10.7753/IJCATR0502.1006

Thuseethan, S. and Kuhanesan, S. (2014) 'Influence of Facebook in Academic Performance of Sri Lankan University Student' SSRN Electronic Journal.

Zimuto, J. (2013) The impact of Facebook on Zimbabwean University students: Culture dilution or Pedagogical. International journal of management & information technology, vol. 3(3), pp.26-31, Doi:10.24297/ijmit.v3i3.174

Identifying Suite Type of Blockchain for Application: Public and Private

H.M.A.D. Herath[1*], M.J. Ahamed Sabani[2] & M.S. Shafana[3]

[1,2,3]*Department of Information and Communication Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*]ayeshandasantha@gmail.com, [2]mjasabani@seu.ac.lk, [3]zainashareef@seu.ac.lk

Abstract- *This study introduced some thoughts in relation to the concept of blockchain, the types of blockchain which include details about the public and the private blockchain and have made a comparison between the public and the private blockchain. Therefore, we first recall what blockchain is and highlights the blockchain as a technology to keep records of the transactions and to make transactions securely. The focus is then moved towards the introduction of public and private blockchain. From which it came to know that in public blockchain the participants' access, read/write into the system whereas, in private blockchain, the participants are restricted, and it is not open for the public. There are number of similarities and differences between the public and the private blockchain, and also this comparison is being a debating topic in both sides of users and developers. This study tried to answer for the question of best type of blockchain can be used, either public or private depend on their specific use. It found that both types of blockchains are better and good in their own ways and provides a variety of benefits depending on the scenarios based.*

Keywords: Blockchain, Public blockchain, Private blockchain, Cryptocurrency, Bitcoin, Blockchain application

I. INTRODUCTION

Blockchain is a technology used to keep a record of transactions; it records the facts and the figures to make it completely impossible for anyone to hack the system or make changes to the system. It was developed in 2009 by grouping. The name of this system also implies its structure. In this system, all the individual records are stored in a block and called blocks and connected in a single chain, called a chain (Christidis and Devetsikiotis, 2016). To keep track of the transactions made through cryptocurrencies (Lee, Guo, and Wang, 2018), such as Bitcoin (Nakamoto, 2008; Conti et al., 2018), we use Blockchain. It is considered as a digital ledger of transactions that is copied, and it is shared with all the systems that are a part of the network.

Many industries are expected to be transformed due to blockchain's ability to provide quick, verifiable transfer and monitoring. (Heath, 2018). The main reason for developing Blockchain technology was to create a new digital money system that could restore the current payment procedures. For many years the project remained under development, and some minor improvements have been made. Later, the potentiality of this project was recognized by the fintech industry. Considering the real Nakamoto's paper (Nakamoto, 2008), many experts started creating their projects. This research is going to make a comparison between two types of blockchain named Public Blockchain and Private Blockchain. It will have a detailed representation of both types of Blockchain technologies (Lepore et al., 2020). Further, we specify the different notations to properly understand the concepts of cryptocurrency and blockchain.

The blockchain can be considered as a kind of database. It can be differentiated from a local database in the aspect of the method it uses to store the facts and the figures or the information; blockchain stores the data into the blocks connected together. When fresh data comes, it is put into the new individual block, and the block is chained with the previous block. The blockchain is capable of storing different types of information, but it is mostly used for storing ledgers of the transactions. Blockchain technology is defined as the decentralized technology that is spread over the network that is used to manage and perform transactions (Royal and Voigt, 2021). The blockchain is used in a decentralized way in bitcoins so that no single person or group can have access or have control; rather, all the users collectively gain control. Blockchain technology apparently seems complicated, but its core concept is based on storing any type of information acting as a database. It is decentralized and can also be a centralized ledger in which the participants can confirm all the transactions in the peer-to-peer network. There is no need for a centralized authority to confirm the transactions. Potential applications include

transferring funds, settling trades, voting, and many other uses (Conway, 2020).

Cryptocurrency (Lee, Guo and Wang, 2018) is a type of digital currency that can be used to make payments, purchase and give goods and services, and be exchanged online. It is a digital or virtual currency secured by using cryptography which makes it impossible to hack. Cryptocurrencies use blockchain technology. Cryptography is a method of protecting messages using keys by ensuring integrity and confidentiality. This is an antique technique for a long time; it was considered an art, and the popularity of this technique started in the 20th century. Several types of cryptography algorithms (Qiu, Lu and Lin, 2019) are used, such as classical cryptography, symmetric cryptography, and asymmetric cryptography. The encryption is done using the local key and decryption using the personal key. The message is encrypted at the sender side, and then decryption is made at the receiver side. In these technologies, the message is encrypted and then sent to the receiver using the secured protocols in case of transferring messages. The computer protocol named TCP-IP (Transmission Control Protocol and Internet Protocol) allows transferring the packet of messages securely from one point to another point (Hagström and Lindblom, 2018).

The hash function is the signature of the message, which cannot exceed the length of 256 bits, and to transform a large number of message signatures, and we use the hash function. In the first half of 2017, there were counted 20,000 blockchain projects which spang out on the GitHub platform. Only eight percent of these projects are still alive, and they last, on average, 15 months; this observation was made by the China Academy of

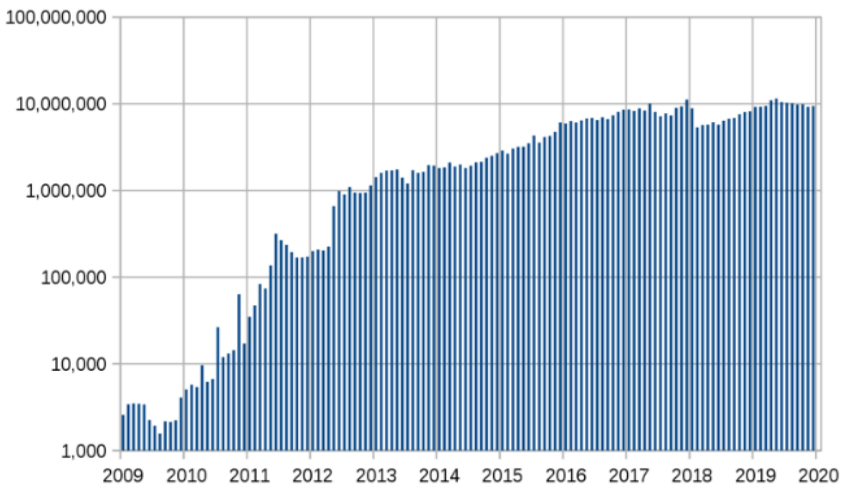


Figure 1: History of Bitcoin

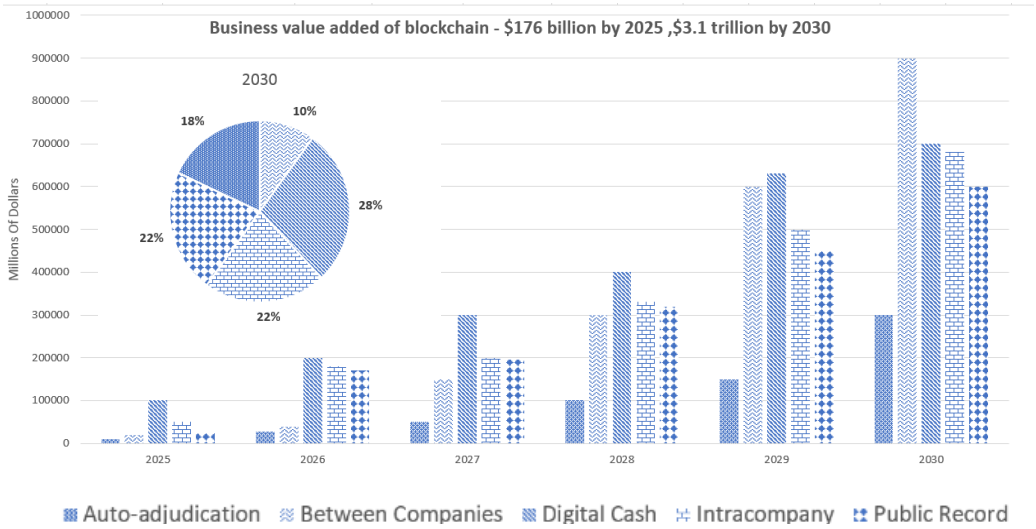


Figure 2: Blockchain Market Value (ConsenSys, 2019)

Information and Communications Technology (CAICT) (James, 2018).

Figure 1 shows the history of bitcoin value changes from 2009 to 2020 and Figure 2 depicts that the business value-add of Blockchain increases to $3.1 trillion by 2030 from $176 billion by 2025. On the other hand, blockchain is a secure and transparent technology used for storage and transmission. It is used to transfer messages from point A to point B, and it works without any central controlling device (Guegan, 2017). The blockchain can be categorized into two main types, namely, public blockchain and private blockchain.

A public blockchain network is the one that allows everyone to join into the system and see the system at any time they want is known as Public blockchain. Every user can read into the system, and every user can also carry out the transaction methods. Participation is not restricted to public blockchain; anyone at any time can participate in it. Hence, anyone can see and make changes to the ledger and can also participate in the transaction methods.

Ethereum is an example of a public blockchain (Anoaica and Levard, 2018; Kfoury and Khoury, 2018; Bousaba and Anderson, 2019; Aleksieva, Valchanov and Huliyan, 2020). It does not comprise any centralized system. And does not have any central network system. It is best used in cases when the requirement is of the decentralized system. It is used by people who do not want a centralized system for blockchain. But it becomes a bit problematic when it comes to comparing the public blockchain system with the enterprise blockchain process. The very first type of blockchain technology revolution is the public blockchain. The foundation of blockchain came into existence because of the bitcoin currency. The best part of the public blockchain technology is that each participant gets the chance to have equal rights no matter who they are or why they are using the system. After seeing the success of the public blockchain, people became keen to create different versions of blockchain technology to solve the current issues. People can join the transactions and can also interact with their peers.

Everyone in this system is able to see the transaction ledger. The companies that offer the public blockchain technology also make sure that the participants also get the highest level of security. Therefore, the public blockchain technology also shares all the flaws among the users equally. Hence, these systems are quite slower than the other systems (Iredale, 2021).

The private blockchain is the second type of blockchain technology. It is a kind of technology in which the authority over the network is given to only one organization. It works on the access control system that restricts the people who can participate in the network. In this type of blockchain, the entities that are the participants of the system can have complete knowledge about the system; on the other hand, others will not be able to access the system. Hyperledger fabric of Linux Foundation (Sharma, no date) is an example of private blockchain.

The private blockchain cannot participate in the system as it is not open to the general public. It is open only for specific people. Hence, all the private blockchain system has some form of authorization technique that helps to identify who is entering the system. Hence, the private blockchain platforms are meant for companies that need an internal networking system. Therefore, to use this system, you need trust. This network model would not work without the trust factor. Thus, the employees of the organization can access the system anytime they want. Hence, we get to know that private blockchain is not fully decentralized. It is said to be a partially decentralized blockchain platform. The private blockchain also comprises some rules and regulations that do not exist on other platforms. Hence, to ensure the company's proper flow, all the users should have to follow the standard rules.

For enterprises that need privacy, a private blockchain is the best fit for them. Without privacy, the competitors of the enterprise can get into the system. They can leak the most valuable information to the press or get information that is confidential to the enterprise. This can then influence the brand's value greatly so, maintaining privacy is the priority. There are also many controversies regarding the private blockchain platforms as people believe that the transactions can be changed by the governing authorities that are not true at all (Iredale, 2021).

The main objective of this research is to lead the users to select the suitable type of blockchain for their needs by understanding public and private blockchain by comparing them. This paper discusses the private and public blockchain in deeper, based on different practical, real-life use

cases in different sectors. Also, it focuses on the importance of private and public blockchain technology, not only in real-life scenarios but also its importance in business and banks, as the Blockchain is being very popular among the general audience now.

The field of Blockchain in the IT area is becoming exceptionally quick. It is assessed that Blockchain innovation has been received by more than 33% of the organizations in the world, and interest for blockchain designers is always expanding. Blockchain innovation gives perhaps the most secure and safe online exchanges, which have shaken every one of the enterprises. Because of its various advantages to the business, numerous organizations and experts have begun to embrace blockchain innovation.

The significance of this study is that the Enterprise Organizations are reliably reluctant with public and private blockchain progresses; thus, we will tunnel further and grasp the features and take a gander at public versus private blockchain. Since the beginning of blockchain advancement, people have talked about open versus private blockchain. In an endeavor environment, it's better to know the huge differences between these two. Basically, public and private blockchain models accept a huge part in the associations looking for the ideal blockchain type for their answers. Regardless, how? For sure, expecting you can't perceive how this differentiation and select some inadmissible stage, your answer won't work. Nevertheless, various people really overwhelm them these days. That is the motivation to deal with you; we will focus on open versus private blockchain today. Ensuing to knowing their resemblances and differences, you can without a doubt pick the one that is proper for your necessities.

II. LITERATURE REVIEW

Fewer authors have carried the work on the comparison between public and private blockchain. Therefore, comparatively, we found less research work on this topic. But this topic is gaining more attention due to its validity in the modern world and the trend to move towards blockchain technology. One of the research papers on the comparison between private and the public blockchain is by Dominique (Guegan, 2017) ; it has been stated in their study that people of the private blockchain are more likely to remain loyal and attached to the private blockchain rather than to move to the public blockchain because of the reason that the private blockchain is centralized. He stated that public blockchain seems to be less attractive for the people if they first started to use the private blockchain because of the reason that the public blockchain is an open blockchain. It is open for everyone to join and participate in the public blockchain, but the private blockchain is secure; it is not open for everyone. Not everyone can join and participate in the private blockchain system. Private Blockchain system only allows the people to participate who are allowed by the organization.

To participate in the private blockchain system, the user has to get registered into the system by the organization. The organization or the company first authenticates the validity of the user before allowing them to participate in the system. That is why once the user starts to use the private blockchain system, they are less likely to move towards the public blockchain. Another research carried out on blockchain is the systematic review of blockchain-based applications across multiple domains (Casino, Dasaklis, and Patsakis, 2019). It focuses on the different applications working on the blockchain, checks the functionality of the different blockchain-based applications, and then does a systematic review about the working and advantages/disadvantages. The author researched the applications that use blockchain technology to make digital transactions. They reviewed different applications and checked the working of each application, the functionality they are providing, and the advantages/disadvantages that are concerned with those blockchain-based applications.

There are a number of applications that are working on blockchain technology and facilitating users in different aspects. One more research paper is of research on the blockchain and applications to secure network control planes. It states about the control planes working on the blockchain technology and states about the complete functionality of the working. It gives a detailed review of the working of the control plane blockchain-based application (ul Hassan et al., 2019), such it works, and what are the functionalities or advantages/disadvantages this control plane based on the blockchain is offering. The main focus of that research paper was to identify how we can make the blockchain-based control-plane system more secure by using neural networks, what are the areas of improvement required for the current working system, How we can improve the system, how we would be able to

make the control-plan system more secure neutrally, and how the control-plane system can be improved and made more flexible for the public users.

III. METHODOLOGY

Blockchain applications are mostly classified into financial and non-financial ones. Our research will use the processes recommended by (Briner and Denyer, 2012) and some features of the PRISMA statement (Moher et al., 2009). The following steps will be included in our methodology:

- Preparation of a review proposal, identifying the need for doing the review, and making a protocol for review.
- Identification of research, select studies, note important points, extract data, and synthesize data.
- Formation of a report based on the results of our research.

Scopus was used as the database to search for all the articles with the keyword "blockchain." This study started with an observation. Observation plays a vital role in the research throughout. In the same way, this research has a straightforward methodology. The methodology adopted for this research is qualitative. Qualitative research is based on what people think and why they think so (Scandura and Williams, 2000). This is for expressing open-ended answers or observations. The topic of this research required a strong back of experts. The expert's opinions can be adopted in two ways (da Silva et al., 2009). It can be adopted through a questionnaire. In contrast, a more appropriate way and the method used in this study is an interview with experts. Moreover, it was obtained through peer review as well.

A depth study for this topic requires analyzing the differences between the type of blockchains. The techniques used to collect the resources for identifying suite type of blockchain for application are the academic journals and the studies from papers that are interrelated with the topic of this study, it became able to get a rich knowledge on the respective subject. The assets for this observation are from a diverse type of more than one database, college repositories, digital libraries, and websites.

And the technological facts consisting of the details about suite type of blockchain statistics are accumulated from various sort of generation associated and technical-commercial enterprise reliable and official web sites. By means of studying the one's sources which can be published with those web sites had been collected to analyze the commonplace approach related with them to conduct the primary research on identifying suite type of blockchain for application. Those materials that were collected to advantage the information, ideas and the associated scope of them can be labeled as several sources along with the articles from blogs, the associated articles from financial and business websites interacted with their merchandise listing for the customers, and the researches in which they've gathered important facts associated with this examine. The maximum of that information is based on the original works of some authors. Consequently, their originality and the trustworthiness at the side of the content material protected with the one's papers are inside the satisfying degrees. Due to that, it was able to try this observation while considering extra precious and correct information from that updated set of information. It turned into choosing the most appropriate research papers from the various type of studies and the articles that are related to the blockchain, that are with greater similarity with this topic. Further, after the gathering of those resources, it became capable of investigating them in a proper manner to get the summarized thoughts and the knowledge that is written over them. And furthermore, it was tested with the frequently asked questions related to the subject of this study to discover the current and cutting-edge problems with them. Having all facts associated with this subject matter, the behavior of the studies was upgraded. It changed into capable of behavior the studies in a better manner.

IV. DISCUSSION

These two types of blockchain also have something in common such; both the blockchain platforms are non-central peer-to-peer network, every user in both maintains a shared local, both provides the guarantee on the stability of the ledger, both provides the guarantee on the permanence of the ledger (Jayachandran, 2017). Yet, there are several differences between these two types of blockchain.

In Public Blockchains, network actors do not know each other, and in private blockchains, network actors know each other. The value of anonymity of each user participating in the blockchain is also a big difference between the public and private blockchains. Anonymity may

be one of the most important things for only certain applications, which certainly applies to cryptocurrencies. Even so, companies cannot connect their network with anonymous users, in which case they will need a privately owned blockchain. The base of public blockchains seems to be anonymity. Anyone involved with individual users will have a high degree of privacy while using the same resources as anybody else on a blockchain. Anonymity and data protection can create an adequate level of confidence in a blockchain for individual users that can boost faith and credibility within the whole environment. In an enterprise, anonymity is not so well functioning because the enterprise's assets must stay safe and confidential in contrast to the privacy and security of the participating users. There is no way to give any user-specific allowances without knowing what they are doing, and because a private blockchain's key factor is that if it is allowed, anonymity won't work. This is why a private blockchain can build a business wonderful. The speed of public blockchain is slower than private blockchain. Because of the higher number of nodes in the network, "bad actors" cannot attack the system to gain control of the network. A private blockchain is more likely to be hacked, risked, and manipulated. Bad actors can easily impede the whole network (Seth, 2021).

The order of magnitude of a public blockchain is lesser than the private blockchain. Availability to a central authority for the whole network must be given in a public blockchain so that it becomes a private blockchain at this point. Anybody who monitors the network can change or change any transactions to suit their needs in a private blockchain (Sharma, no date). A Native Token is required in a public blockchain, and in a private blockchain, a Native Token is not necessary. Transactions per second are fewer transactions that can be carried out in public blockchain than compared to private. Public blockchains are immutable as well as distributed. Nobody can modify an entry after it has been verified, and customers can be sure that they have not modified or deleted its transactions. In such a case, organizations, although they do not publish their data, use the distributed ledger technology. Private blockchains are not equivalently secure to public blockchains, which means their owner may alter the records.

Public blockchains are untrustworthy, and respondents should not trust one another in a private blockchain setup. In a private blockchain, it is impossible to independently verify the validity of records because the credibility of a private network is based on the legitimacy of authorized nodes. Consensus Algorithms in public blockchain are proof of stake (Nguyen et al., 2019; P. Rajitha Nair and Dorai, 2021), proof of work (Wüst et al., 2016; P. Rajitha Nair and Dorai, 2021), proof of space (Dziembowski et al., 2015), etc. It is more likely to get attacked because, in this network, no one knows each other. And there is no validation of the participants. The participants in this do not require any permission to get into the system. Consensus Algorithms in private blockchain are Proof of Elapsed Time (PoET), raft, and Istanbul BFT. It is less likely to get attacked as every participant of the network is known, and their authentication is check before allowing them to enter the network (Ashi Srivastava, 2020). The participants in this require permission to get into the system.

There is no chance of a tiny collision in a private blockchain. They are known to each validator and have the appropriate credentials in the network. But no one knows who each validator is in a public blockchain, increasing the chance of potential collision or an attack by 51% (Sabani, Shafana, and Kariapper, 2020). A public blockchain uses more energy than a private blockchain because many electric power resources are necessary for network consensus and operation. Private Blockchains consume less power as well as less energy. Some blockchains are more scalable than other blockchains depending on the number of nodes, the number of transactions, how transactions are stored, and the consensus method used. Public blockchains seem to be infamous for scalability problems, particularly of cryptocurrencies. An ever growth of public blockchains means that far more nodes are available to interact with, more transactions occur, a restriction to how often transactions can be saved per block, as well as a possibly complicated consensus method. The factors that keep the scalability of a public-Blockchain squad can be adjusted in private blockchains with a large amount of control. Suppose a private blockchain begins to be sluggish than wanted. In that case, decreasing node counts, allowing more transactions per frame, or adapting the consensus method can bring huge positive advantages for blockchain effectiveness (Bartel, no date).

We ought to change the incentive for good behavior in Public Blockchain a little since we do not really know who the user is. We count on the

incentives of economics and the theory of games to ensure everybody in the system is honest and compliant. We create situations by group consensus, where honest participants are economically rewarded, where dumb ones incur work or costs and are unable to recover their costs. We rely on the fact that we know who a user is in a private permissioned blockchain. In a company scenario, we also presume that they will behave fairly because otherwise, we exactly know who is mistaken, and they know they will suffer the consequences. So, in a Corporate Case, Blockchain for a Business, Blockchain for supply value chain chains. Blockchains, both public and private, have two vastly distinct offerings. Many individuals have the perception they are competing, but they do not really do. They only offer various types of solutions.

Public and private blockchains differ in the method of operation whenever it comes to authority. More like a decentralized system, the public blockchain is that no one is going to monitor its network. Power is distributed throughout all user groups. But power is only partially decentralized in the private blockchain. There is one authority only at the head of the network, and then the whole system is managed. In terms of data management capability, you will find differences. You can read and write on the common ledger with a public blockchain. However, once it has been written and documented, it cannot be remedied or changed. Only the leading entity can write on the booklet in private blockchains, even with a few nodes. There are many considerable differences between public and private blockchains in addition to functional efficiency. Private versions are much more stable because they operate with small nodes as well as transactions. Since all users in the public blockchain can access the entire network, the number of processes can increase and slow down the entire network, thereby affecting system efficiency.

Transaction quality is a very important issue in the private vs. public blockchains debate. For the latter, a transaction can involve only certain nodes. This means that the resources are not tight, and the transaction speed remains unchanged. On the other hand, there really is no limit on the number of nodes if you are working with public blockchains. The process may become slow if users request too many transactions (Ashi Srivastava, 2020). At first, even so, both networks are operating at the very same speed. Many blockchain organizations are launching solutions for connecting private and public blockchains to generate the Internet of blockchains. The cryptocurrencies currently have to pass value exchanges among blockchains. However, even using exchanges, data stored on a blockchain cannot be shared with others.

By interoperability of blockchains, data on personal chains will not be isolated. It would instead flow as flexibly as any data that we currently see on the internet. Within the business world, researchers perceive private blockchains are adopting on a scale as the concerns are indeed the opposite. Anonymity is a bad thing in a business scenario. Let's suppose I am a user, and I have public or private blockchains to choose from. I want to know who all participants are exactly, and I have to know what they are doing because I do not want complete transparency. I do not want to share all my business data with all my business network participants and with the general public. I would like to control who is seeing, what information, and who is able to write this information on the blockchain, according to what circumstances. So, for managing supplier-vendor relations, I could use a Private Blockchain solution, where only I and my suppliers can see how much I pay for a specific item. The specifics of the contract I possess with them and not really the contract details I have with some other providers are only available to a particular provider.

Especially public blockchain addresses few specific features such; Authentic security, Anonymous Nature, Open Environment, No Regulations, and Distributed. A public blockchain is preferred to an environment where it needs to be truly decentralized, full transparency, immutability, and full user environment. Further, public blockchain is used by the cryptocurrencies such as bitcoin, Litecoin, and Ethereum. The government can also use it to handle the voting system or to keep the records of health care. Transparency and anonymity are the main features of these platforms. Public blockchain can be considered as a relationship between the business and the users who use its solution. Table 01 summarizes the comparison results between public and private blockchain.

Meanwhile, private blockchain also does not fail to impress the users with the best features such as high efficiency, full privacy, empowering enterprises, stability, and faster transactions.

Private blockchains can be considered to be deployed for especially the purposes of low fees, saves money, no illegal activity, and regulations (Iredale, 2021). Further, in the private blockchain, each participant is provided with a unique and verified identity that is also used to identify the type of access the participant has. In this enterprise solution, the resources and the actions that everyone carried out can be controlled. This allows to perform faster transactions, and the energy consumption is also reasonable. To maintain the supplier-vendor relationship or create a shared network among all the enterprises, for business-to-business relations, the private blockchain is the best option to go for.

Another major concern in this area is "how secure are the blockchains." In a private blockchain as the user's access to the information is controlled, but it is less secure than the public blockchain. The public blockchain provides a completely invisible ledger. As the public blockchain is non-centralized, facts and figures are encrypted and are stored in different places or locations. The greater number of participants, the more secure the public blockchain is. A public blockchain is sometimes called 'censor-free' and is particularly resistant to the distributed denial-of-service (DDoS) attacks. A private blockchain is more at risk of hacking, and on the other hand, the owner of the organization can make changes to the system such that it is able to alter the system (Heath, 2018).

V. CONCLUSION

From the above comparison, it came up to the conclusion that there is no competition between the public and private blockchains. Both are specified for different purposes and used in different scenarios. Both have some number of advantages and disadvantages, and both are the best fit for numerous numbers of scenarios or solutions. If you want a blockchain system that is open to the public, has a high level of user control that is fully transparent, all the users are treated equally, and that is completely decentralized, then public blockchain is the best choice. Suppose you wanted a blockchain system in which all the users are authenticated by the owner of the organization and know its users, whose admin has the ability to permit or take control of the users and to alter the ledgers., in that case, it has a great transaction rate and is private for the general public then you can choose the private blockchain. The choice for the type of blockchain depends on the scenario or the environment for which you want the blockchain. And as it is concerned that which type of blockchain is the better public or the private? Then the answer to these questions is that both types of blockchains are better and good in their own ways and provides a variety of benefits depending on the scenarios.

REFERENCES

A. (2020) "Smart Contracts based on Private and Public Blockchains for the Purpose of Insurance Services," *2020 International Conference Automatics and Informatics, ICAI 2020 - Proceedings*. doi: 10.1109/ICAI50593.2020.9311371.

Anoaica, A. and Levard, H. (2018) "Quantitative Description of Internal Activity on the Ethereum Public Blockchain," *2018 9th IFIP International Conference on New Technologies, Mobility and Security, NTMS 2018 - Proceedings*, 2018-Janua, pp. 1–5. doi: 10.1109/NTMS.2018.8328741.

Ashi Srivastava (2020) *Difference between Public and Private blockchain, GeeksforGeeks*. Available at: https://www.geeksforgeeks.org/difference-between-public-and-private-blockchain/ (Accessed: May 17, 2021).

Bartel, G. (no date) *8 Differences Between Public and Private Blockchains, Grant Bartel*. Available at: https://www.grantbartel.com/blog/differences-between-public-and-private-blockchains/ (Accessed: May 17, 2021).

Bousaba, C. and Anderson, E. (2019) "Degree Validation Application Using Solidity and Ethereum Blockchain," *Conference Proceedings - IEEE SOUTHEASTCON*, 2019-April. doi: 10.1109/SoutheastCon42311.2019.9020503.

Briner, R. B. and Denyer, D. (2012) "Systematic Review and Evidence Synthesis as a Practice and Scholarship Tool," *The Oxford Handbook of Evidence-Based Management*, (November 2015). doi: 10.1093/oxfordhb/9780199763986.013.0007.

Casino, F., Dasaklis, T. K. and Patsakis, C. (2019) "A systematic literature review of blockchain-based applications: Current status, classification and open issues," *Telematics and Informatics*, 36, pp. 55–81. doi: 10.1016/j.tele.2018.11.006.

Christidis, K. and Devetsikiotis, M. (2016) "Blockchains and Smart Contracts for the Internet of Things," *IEEE Access*. doi: 10.1109/ACCESS.2016.2566339.

ConsenSys (2019) *Blockchain Will Deliver $3.1 Trillion Dollars in Value by 2030, Gartner*. Available at: https://media.consensys.net/gartner-blockchain-will-deliver-3-1-trillion-dollars-in-value-by-2030-d32b79c4c560 (Accessed: May 17, 2021).

Conti, M. *et al.* (2018) "A survey on security and privacy issues of bitcoin," *IEEE Communications*

Surveys and Tutorials. doi: 10.1109/COMST.2018.2842460.

Conway, L. (2020) *Blockchain Definition: What You Need to Know*. Available at: https://www.investopedia.com/terms/b/blockchain.asp (Accessed: May 17, 2021).

Dziembowski, S. *et al.* (2015) "Proofs of space," *Lecture Notes in Computer Science*, 9216(616160), pp. 585–605. doi: 10.1007/978-3-662-48000-7_29.

Guegan, D. (2017) *Public Blockchain versus Private blockhain*. France.

Hagström, J. and Lindblom, L. (2018) "Performance of Network and Transport Protocols in the Implementation of a New Cryptocurrency Performance of Network and Transport Protocols in the Implementation of a New Cryptocurrency."

Heath, N. (2018) *What's the difference between a private and public blockchain?*, *INTHEBLACK*. Available at: https://www.intheblack.com/articles/2018/09/05/difference-between-private-public-blockchain (Accessed: May 17, 2021).

Iredale, G. (2021) *Public Vs Private Blockchain: How Do They Differ?*, *101 Blockchains*. Available at: https://101blockchains.com/public-vs-private-blockchain/ (Accessed: May 17, 2021).

James, A. (2018) *92% of Blockchain Projects Have Already Failed, Average Lifespan of 1.22 Years*, *bitcoinist.com*. Available at: https://bitcoinist.com/92-blockchain-projects-already-failed-average-lifespan-1-22-years/ (Accessed: May 17, 2021).

Jayachandran, P. (2017) *The difference between public and private blockchain*, *Blockchain Pulse: IBM Blockchain Blog*. Available at: https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain/ (Accessed: May 17, 2021).

Kfoury, E. F. and Khoury, D. J. (2018) "Secure End-to-End VoLTE Based on Ethereum Blockchain," *2018 41st International Conference on Telecommunications and Signal Processing, TSP 2018*, pp. 128–132. doi: 10.1109/TSP.2018.8441204.

Lee, D. K. C., Guo, L. and Wang, Y. (2018) "Cryptocurrency: A new investment opportunity?," *Journal of Alternative Investments*. doi: 10.3905/jai.2018.20.3.016.

Lepore, C. *et al.* (2020) "A survey on blockchain consensus with a performance comparison of pow, pos and pure pos," *Mathematics*, 8(10), pp. 1–26. doi: 10.3390/math8101782.

Moher, D. *et al.* (2009) "Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement," *PLoS Medicine*, 6(7). doi: 10.1371/journal.pmed.1000097.

Nakamoto, S. (2008) *Bitcoin: A Peer-to-Peer Electronic Cash System | Satoshi Nakamoto Institute*, *2008-10-31*.

Nguyen, C. T. *et al.* (2019) "Proof-of-Stake Consensus Mechanisms for Future Blockchain Networks: Fundamentals, Applications and Opportunities," *IEEE Access*, 7, pp. 85727–85745. doi: 10.1109/ACCESS.2019.2925010.

P. Rajitha Nair and Dorai, D. R. (2021) "Evaluation of Performance and Security of Proof of Work and Proof of Stake using Blockchain," in *Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks, IEEE Xplore*, pp. 279–283.

Qiu, J., Lu, X. and Lin, J. (2019) "Optimal selection of cryptographic algorithms in blockchain based on fuzzy analytic hierarchy process," *2019 IEEE 4th International Conference on Computer and Communication Systems, ICCCS 2019*, pp. 208–212. doi: 10.1109/CCOMS.2019.8821757.

Royal, J. and Voigt, K. (2021) *What Is Cryptocurrency? Beginners Guide to Digital Cash*, *NerdWallet*. Available at: https://www.nerdwallet.com/article/investing/cryptocurrency-7-things-to-know (Accessed: May 17, 2021).

Sabani, M. J. A., Shafana, M. S. and Kariapper, R. K. A. R. (2020) "Security Issues By Allied Attacks In Blockchain Technology," *International Journal of Advanced Science and Technology*, 29(8), pp. 5371–5376.

Scandura, T. A. and Williams, E. A. (2000) "Research methodology in management: Current practices, trends, and implications for future research," *Academy of Management Journal*, 43(5), pp. 1248–1264. doi: 10.5465/1556348.

Seth, S. (2021) *Public, Private, Permissioned Blockchains Compared*. Available at: https://www.investopedia.com/news/public-private-permissioned-blockchains-compared/ (Accessed: May 17, 2021).

Sharma, T. K. (no date) *Public Vs. Private Blockchain : A Comprehensive Comparison*, *Blockchain Council*. Available at: https://www.blockchain-council.org/blockchain/public-vs-private-blockchain-a-comprehensive-comparison/ (Accessed: May 17, 2021).

da Silva, A. P. *et al.* (2009) "Quality of supply performance benchmarking: Improvements to methodology," *IET Conference Publications*, (550 CP), pp. 8–11. doi: 10.1049/cp.2009.1094.

ul Hassan, F. *et al.* (2019) "Blockchain and the future of the internet: A comprehensive review," arXiv, pp. 1–25.

Wüst, K. et al. (2016) "On the Security and Performance of Proof of Work Blockchains," in. doi: 10.1145/2976749.2978341.

Brain-Computer Interface: Systems and Interacting Devices

M.S. Faathima Fayaza[1*]

[1*]*Department of Information and Communication Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*] fayaza@seu.ac.lk

Abstract- *In the past, mind control was thought to be a fantasy beyond human intelligence. Over the last few decades, significant advances have been made, such as the invention of novel devices for enhancing information flow into computers through multimodel devices. Brain-Computer Interface (BCI) was initially developed to build communication between paralyzed people and the environment. BCI variously improves human life in the field of medicine, entertainment, security and etc. This paper focuses on the technologies and principles behind the BCI. The paper also discusses the various steps in the BCI system: signal acquisition, preprocessing, feature extraction, and classification. The key challenge in BCI signal processing is the curse of dimensionality in the feature vector. Further, the paper focuses on the BCI communication methods, such as invasive, semi-invasive, and non-invasive BCI, advantages, and limitations.*

Keywords: Brain-Computer Interface, BCI Feature, BCI Devices

I. INTRODUCTION

The Brain-Computer Interface (BCI) is a groundbreaking advancement in the field of Human-Computer Interaction (HCI). The aim of BCI is to use directly generated commands and messages to link the human brain to external devices. The same way devices connecting to the BCI can send and receive messages to the brain. The human brain is a complex structure of over 100 neurons and is responsible for performing a variety of complex functions (Papanastasiou et al., 2020). Different parts of the brain are responsible for these various functions. As a consequence, for different functionalities various regions of the brain are activated, emitting a variety of signals. Therefore, BCI system is intended to identify the various signals generated by the brain's various parts. Electromagnetic signals are generated during brain activity. BCI will use the signals produced to process, recognize and measure this brain activity and transmit control signals that reflect the user's decision.

After observing the electrical activity of the human brain, Hans Berger (1931) invented the Brain-Computer Interface. Electroencephalography (EEG) was the first technique used; it can monitor the electrical activity of the human brain. Brain-computer interface system could be used to recognize human brain expressions. BCI techniques are not a cure for any disease; rather, BCI is assisting disabled people in greatly improving their lives by providing an efficient means of expressing their thoughts, emotions and needs. Via neuron silicon interfaces, BCI allows paralyzed people to interact with their community. Brain imaging techniques use detecting brain activity in a variety of ways. Some of the examples for brain imaging techniques are Functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG), Magnetoencephalography (MEG), Electrocorticography (ECoG0, and Near-Infrared Spectroscopy (NIRS). (Ellenbogen and Lucas, 2006)

BCI can be applied in several areas such as medical, system management, security and authentication, entertainment and gaming, education and self-regulation, user monitoring, training, neuromarketing and advertisement etc (Abdulkader, Atia and Mostafa, 2015). Early BCI studies were centered on restoring hearing, vision, and movement defects. BCI is now being used to interact with people who are completely paralyzed by interpreting and analyzing their brain signals. Figure 01 describes the outline of the BCI system.

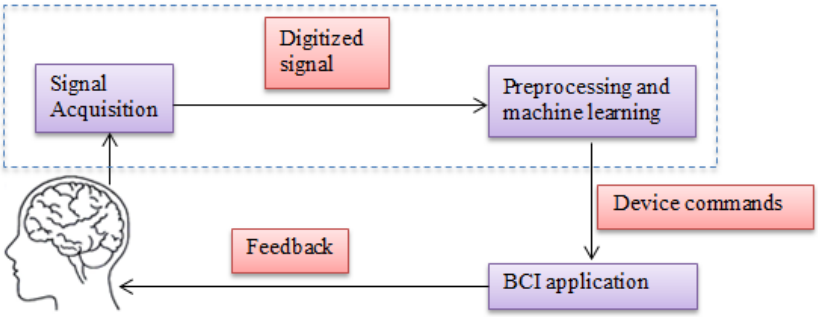


Figure 01: BCI System layout

II. BRAIN AND INTERACTING DEVICES

A. *Human Brain*

Neurons make up the brain. To generate thought and control physical activities, neurons interact with one another. The brain areas divide into the cerebral cortex and subcortical regions. Pattern recognition, reasoning, language comprehension, and other high-level tasks are all handled by the cerebral cortex. Preparing this area of the brain is of particular interest to BCI. The sub-cortical zone handles the heart rate, memory, emotional and instinctive response, temperature regulation, and etc.

Neurons can interact by transmitting electrical signals to other neurons through physical links or by exchanging chemicals (neurotransmitters). Neurons interact with one another for different activities. During this time electrical, chemical and blood flow get change in the brain. Using brain imaging technology, these changes can be detected. This technology can be used to create distinguished images of brain function and structure. Relevant brain tasks established during that period can be analyzed using these images (Vidal, 1977; Birbaumer, 2006).

Brain imaging techniques are divided into three groups; invasive, semi-invasive and non-invasive (Berger, 1931). Invasive technology places sensors inside the brain, while noninvasive technology uses external sensors to monitor neuron activity. In semi-invasive method the electrodes are attached to the brain's exposed surface.

B. *Signals Types*

During brain function, the brain generates a large number of signals. There are two main types of signals that can be distinguished. Spikes and field potentials. Spikes are from individual neurons. Invasive BCI devices use microelectrodes to detect these signals. Field potentials are from a group of neurons. Non-invasive BCI instruments can be used to detect these signals (Lotte et al., 2007)

C. *Brain Imaging Technologies*

1) Electroencephalography (EEG): It makes use of the electrical potential of brain activity. Electrodes mounted on the scalp are used to test EEG (Grünwald and Kamada, 2018). It detects the weak electric potential produced via the neural system. EEG devices are compact and wearable, and they have a great temporal resolution. However, because of the disturbance generated as the signal passes through bone, fluid, and muscles, it has a poor spatial resolution (Novak, 2018).

EEG tracks signals are divided into multiple bands such as 1. Delta 2.Theta, 3.Alpha, 4.Beta, and 5.Gamma. However, BCI systems are primarily concerned with alpha and beta signals (Birbaumer, 2006). Mansoor et al., (2020) introduced deep learning classification for EEG signals and it provided better real time result compare to other algorithms.

2) *Magnetoencephalography (MEG):* It works by detecting the magnetic fields produced by the neurons' electrical activity. MEG is much more capable and receptive than EEG in terms of brain imaging. Despite the fact that the system is outside the skull, it is vulnerable since the skull is entirely apparent to magnetic fields. However, in order to process the superconductivity of magnetic potentials, bulky and costly devices are needed (Guenther et al., 2009).

3) *Functional Magnetic Resonance Imaging (fMRI):* fMRI assesses the reduction in deoxyhemoglobin to active brain areas through testing the magnetic properties of the brain(Guenther et al., 2009).

4) Functional Near Infrared (fNIR): The optical brain monitoring technique determines the change in blood oxygenation and blood volume associated with human brain activity. This technique uses near-infrared spectroscopy for functional neuroimaging (Guenther et al., 2009).

5) Positron Emission Tomography (PET): It measures gamma-ray emissions to detect the chemical activity of injected radioactive tracers. Owing to the need to inject hazardous material, it is not appropriate for long-term use.

6) *Single Photon Emission Computed Tomography (SPECT):* It functions similar to PET, but instead of measuring photons emitted by gamma rays, it uses photomultiplier tubes.

7) *Electrocorticogram (ECoG):* ECoG is an invasive method. ECoG uses electrodes fixed directly on the cortical to monitor brain electrical field potentials. In humans, ECoG is moslty used to detect seizures in patients with medically intractable epilepsy (He, 2020; Sanjanasri et al., 2020). Figure 02 a) shows the X-ray and Electrocorticography data, where b) #1 and #2 show signals from the left frontal cortex, #3 signals from left temporal cortex.

D. *Invasive Brain Computer Interface*

Invasive BCI instruments are attached to the cortex's surface. To position the sensors inside the skull, a craniotomy surgery is needed. The sensors are permanently implanted within the skull.

The signals from the brain would be recorded by the electrodes, and this form of signal recording is known as Electrocorticogram (ECoG). Since the sensors are close to the brain inside the skull, the signals recorded from the brain would have high quality and spatial resolution, as well as less interference from outside sources. The combined brain function of a large number of brain cells is recorded by ECoG. They are unable to record individual neural activities. ECoG will also record the neuronal activity of the brain closest cells. As a result, recording all of the brain's neural activity is difficult, and placing several electrodes within the brain is a dangerous process. The ECoG technology that was used in the brain neurons will not be harmed by intrusive BCI. The electrode is not capable of penetrating the brain. However, there is a drawback to this method: scar tissue grows on the sensors, posing a risk to the brain while also reducing sensor sensitivity. As a result, surgery is needed on a regular basis, which is harmful to the individual's wellbeing.

Intracortical recording is one more technique used in invasive BCI. The electrodes used in this process will penetrate brain tissues, allowing it to record brain activity (Birbaumer, 2006; Ellenbogen and Lucas, 2006)

E. *Non-invasive Brain Computer Interface*

The noninvasive BCI approach is the safest since the sensors are not implanted by surgery, and the devices are compact and simple to use. The system will be fixed in the human head and it will include a variety of electrodes that will collect signals from various parts of the brain. The sensors that are used by BCI instruments are non-invasive and capable of detecting and interpreting signals released throughout brain activity. Interferences from the bone, fluid, and skin of the brain, as well as external radio and electrical operations are mixed with original signal and create noises. In the presence of weak signals, the devices can successfully recognize the necessary signals

Electroencephelography (EEG), Functional Magnetic Resonance Imaging (fMRI), Magnetoencephelography (MEG), Functional Near Infrared Imaging (FNIR), Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) are some examples for non-nvasive BCI. EEG is the most common one among them and measures the electrical activity of the brain. (Guenther *et al.*, 2009; Neuper *et al.*, 2009)

F. *International 10-20 System*

Different functions are regulated by different parts of the brain. Scientists created an international standard scheme to collect all brain activity signals from those particular areas. The electrodes were precisely placed on the head using the International 10-20 Method. The electrodes in the systems are evenly spaced from left to right and front to back. All of the electrodes are symmetrically arranged. The electrodes are named according to their position; T - temporal, O - occipital, C - central, P - parietal, Fp - pre-frontal, F – frontal (Lotte *et al.*, 2007). Figure 03 shows international 10-20 system.

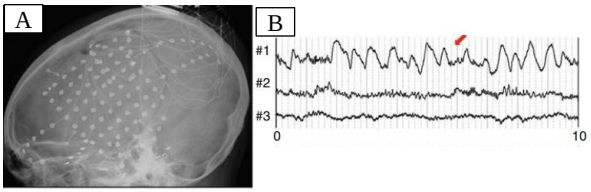


Figure 02: A- X-ray of electr ode placements
B- Electrocorticography (ECoG) data

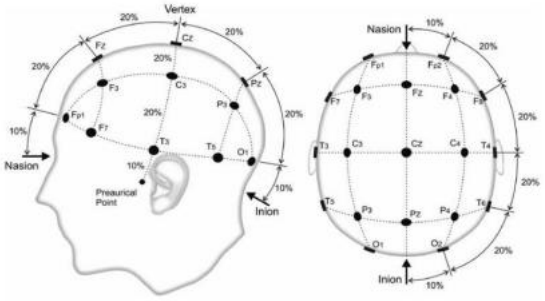


Figure 03: International 10-20 system.

III. SIGNAL PROCESSING, FEATURE EXTRACTION AND CLASSIFICATION

BCI instruments recognize and interpret signals in order to detect brain activity. These are the three steps of signal processing:

1. Preprocessing
2. Feature extraction
3. Feature classification.

The BCI techniques are efficient in capturing and analyzing the electromagnetic signals generated by the human brain (Birbaumer, 2006). The main goal of BCI is to understand brain signals and translate them into computer understandable signals. The two most common approaches used in the literature for this purpose are regression and classification (Lotte *et al.*, 2007). There are few distinct characteristics in the brain signal.

- High dimensionality- the dimensionality of feature vectors is high. The challenge in these data is number of data is smaller than the feature vector.
- Time Information- Neural activity patterns are linked to unique EEG time variations therefore need to have time feature.
- Outliers and noise- Noise and outliers are mixed in with the original signal. Muscle movements are responsible for these noises.
- Non-stationary- Signals change over time and session.
- Small testing set - Training sets are comparatively small.

However, BCI devices are capable to recognize these characteristics and extract them correctly, allowing users to communicate.

A. *Preprocessing*

Preprocessing reduces the amount of time it takes to process data by eliminating noise and other unrelated information from the original signal. Electrodes can detect signals if there is any pattern of neural activity within a time frame. Brain signal processing methods focus the temporal or spatial processing, or a combination of both. EEG is the broadly used technology; however, while recording a neural activity, most of the noises are caused by non-central nervous activities, such as facial muscular movements and eye expression. It is important to reduce the noise in the signal in order to recognize the specific neural activity. The task of identifying and removing these types of noises is critical because they are overpowering and can cause the target signal to be confused when both signals have the same frequency or amplitude causing it hard to separate the noise from the original signal. Independent Component Analysis (ICA) method is used to filer the noise from the such signals(Abdulkader, Atia and Mostafa, 2015).

B. *Feature Extraction*

When designing a BCI system some necessary features are to be considered such as: Band Powers (BP), Auto Regressive (AR) and Adaptive Auto Regressive (AAR) parameters, Time-frequency features, amplitude values of EEG signals, Power Spectral Density (PSD) values and inverse model-based features (Lotte *et al.*, 2007).

1) Characteristics of Feature Extraction Methods: To extract the target signal from the noise, it employs heuristic search techniques. Heuristic search examines a vast volume of data in order to separate the original data from the noise. Heuristic search has a beginning point that will decide the search path, then it will delete irrelevant data and search in a structured manner using a scoring feature. Following that, it will evaluate all possible subsets of the function. It will continue to look for relevant information until it finds it (Birbaumer, 2006).

2) Types of Feature Extraction Methods: For feature extraction, there are three types of methods available.

1. Filter algorithm: These algorithms operate by eliminating unnecessary features from the translation algorithm before it is trained. This can be done by computing entire features correlation along with respect to the target function and selecting higher score features. Next approach, discovers the feature derivation based on features extracted from raw data, sorting these data features based on the amount of variance and selecting a fixed number of top scoring features.

2. Embedded algorithm: Once novel training set is introduced the feature selection process add or eradicate features to counter prediction.

3. Wrapper algorithm: The features will be chosen by evaluating the consistency or uncertainty of a collection of features using the translation algorithm (Birbaumer, 2006).

C. *Feature classification*

Main challenge in the BCI classification is the curse of dimensionality. Usually the feature vectors increase exponentially with the increase in data needed for the classification. Unfortunately BCI training datasets are smaller than the feature vectors *(Lotte et al., 2007)*. Following are the classification algorithms used in the BCI system.

1. Linear Classifiers: Linear classifiers classify various data groups by using linear functions. This technique is the easiest and popular in BCI systems. It uses Support machine Vector (SVM) and Linear Discriminant Alalysis (LDA) techniques (Lotte *et al.*, 2007).

2. *Artificial Neural Networks:* Neural networks along with linear classifiers is the most used classifier in the BCI system. Artificial neural network is a set of artificial neurons. It allows for the development of nonlinear decision boundaries. The Multi-Layer Perceptron (MLP) is a neural network used to classify data in BCI systems(Lotte *et al.*, 2007).

3. *Nonlinear Bayesian Classifiers:* Nonlinear decision-making is performed by this classifier. This is the power of generative algorithms; they can more and reject suspect samples quickly classify. Bayesian classifiers can be divided into two types: Bayesian Quadratic and Hidden Markov Model (HMM)(Lotte *et al.*, 2007)

4. *Nearest Neighbor classifiers:* These are non-linear discriminative classifiers. These classifiers allocate a class based on its nearest class. The neighbor might be a class prototype or feature vector of the training set (Lotte *et al.*, 2007).

5. *Combinations of Classifiers:* This employs a variety of classifiers that are combined in various ways. Some of them are:

Boosting: Boosting entails using a series of classifiers in a cascade. The errors made by the previous classifiers will be the priority of each classifier. This method allows you to construct a strong classifier from a set of weak classifiers. Ordinary Least Square (OLS) and Multi-Layer Perceptron classifiers are used to evaluate boosting (Lotte *et al.*, 2007).

Voting: In the voting system, each of the combined classifiers assigns a class to the input feature vector. As a result, the final class will be the bulk of them. Therefore majority one is selected as final class. It is the most well-known method in BCI because it is both effective and simple.

Stacking: In stacking, the classifiers combine to identify the input function vector. The results of these level 0 classifiers will be fed into meta-classifiers, which are also known as level 1 classifiers.

The final decision will be made by these meta-classifiers. Hidden Markov Models is used as level 0 and Support Vector Machine (SVM) is used as level 1 classifiers in stacking(Lotte *et al.*, 2007).

By combining similar classifiers, one of the classifiers would outperform the others, lowering error and variance.(Lotte *et al.*, 2007)

IV. CONCLUSION

Brain signals represent the brain's controlled activities and actions, as well as the effect of input obtained from body, such as sensing or internal organs. Brain Computer Interfacing allows communication between the brain and external devices. BCI translates brain signals into outputs that convey a user's intent. The research community is interested in BCI applications. Several studies focusing on improving the BCI application fields such as medical, games and entertainment, organizational, transportation and security and authentication. Further, researchers continuously work improving the different instruments that can be used to capture brain signals. Invasive and non-invasive recording

devices are two major groups. Invasive techniques achieve higher accuracy rates either spatially or temporally therefore this is typically required for critically paralyzed situations. Unfortunately invasive techniques involve with implanting surgery. The non-invasive group, on the other hand, has been widely adopted in other application fields due to its advantages over the invasive one. BCI signal processing mainly consists of preprocessing, feature extraction and feature classification. The key challenge in the BCI signal processing is the curse of dimensionality in the feature vector. Possible future directions in the BCI technology will be emotion classification based on brain signals using machine learning techniques. Further studies are needed towards BCI in virtual reality.

REFERENCES

Abdulkader, S. N., Atia, A. and Mostafa, M. S. M. (2015) 'Brain computer interfacing: Applications and challenges', *Egyptian Informatics Journal*, 16(2), pp. 213–230. doi: 10.1016/j.eij.2015.06.002.

Birbaumer, N. (2006) 'Breaking the silence: Brain-computer interfaces (BCI) for communication and motor control', *Psychophysiology*, 43(6), pp. 517–532. doi: 10.1111/j.1469-8986.2006.00456.x.

Ellenbogen, R. G. and Lucas, T. H. (2006) 'Brain Computer Interface', *Neurosurgery*, 58(6), pp. N6–N6. doi: 10.1227/00006123-200606000-00031.

Grünwald, J. and Kamada, K. (2018) *Chapter 9 - Electrocorticogram based brain–computer interfaces*. Second Edi, *Chiral Analysis*. Second Edi. Elsevier B.V. doi: 10.1016/B978-0-12-812892-3/00009-1.

Guenther, F. H., Brumberg, J. S., Wright, E. J., Nieto-Castanon, A., Tourville, J. A., Panko, M., Law, R., Siebert, S. A., Bartels, J. L., Andreasen, D. S., Ehirim P, Mao H., Kennedy P. R., (2009) 'A wireless brain-machine interface for real-time speech synthesis', *PLoS ONE*, 4(12). doi: 10.1371/journal.pone.0008218.

He, B. J. (2020) 'Encyclopedia of Computational Neuroscience', *Encyclopedia of Computational Neuroscience*, pp. 1–5. doi: 10.1007/978-1-4614-7320-6.

Lotte, F., Congedo, M., Lecuyer, A., Lamarche, F., Arnaldi, B., (2007) 'A review of classification algorithms for EEG-based brain-computer interfaces', *Journal of Neural Engineering*, 4(2). doi: 10.1088/1741-2560/4/2/R01.

Mansoor, A., Usman M.W, Jamil, N., Naeem, M .A, (2020) 'Deep Learning Algorithm for Brain-Computer Interface'. doi: 10.1155/2020/5762149.

Novak, D. (2018) *Biomechatronic applications of brain-computer interfaces, Handbook of Biomechatronics*. Elsevier Inc. doi: 10.1016/B978-0-12-812539-7.00008-8.

Neuper C., Pfurtscheller G. (2009) Neurofeedback Training for BCI Control. In: Graimann B., Pfurtscheller G., Allison B. (eds) Brain-Computer Interfaces. The Frontiers Collection. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-02091-9_4

Papanastasiou, G., Drigas, A., Skianis, C., Lytras, M., (2020) 'Brain computer interface based applications for training and rehabilitation of students with neurodevelopmental disorders. A literature review', *Heliyon*, 6(9), p. e04250. doi: 10.1016/j.heliyon.2020.e04250.

Teo, W. P., White, D. and Macpherson, H. (2018) *Using noninvasive methods to drive brain-computer interface (BCI): The role of electroencephalography and functional near-infrared spectroscopy in BCI*. Second Edi, *Smart Wheelchairs and Brain-computer Interfaces: Mobile Assistive Technologies*. Second Edi. Elsevier B.V. doi: 10.1016/B978-0-12-812892-3.00003-0.

Vidal, J. J. (1977) 'Realtime Detection of Brain Events in EEG', *Proceedings of the IEEE*, 65(5), pp. 633–641. doi: 10.1109/PROC.1977.10542.

TRACK - SOFTWARE TECHNOLOGIES

Smartphone, Voice, and Infra-Red Remote Controlled Learning kit with Feedback Voice

Sirajudeen Safdhan[1*], Muhammad Shamsuzzaman Kabir[2], Mohammed Abdul Kader Muhammad[3] & Ibralebbe Mohamed Kalith[4]

[1,4]*Department of Information and Communication Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*
[2,3]*Department of EEE, International Islamic University Chittagong, Bangladesh*

[1*]safdhan.edu@gmail.com, [2]shamsuzzaman06@gmail.com, [3]kader05cuet@gmail.com, [4]imkalith@seu.ac.lk

Abstract- *This paper presents a new tool for teaching the alphabets and numbers of different languages to children. This device is made with a large 32X32 Matrix Display, with the ability to show alphabets of different languages and numbers with feedback sounds, it can be controlled using voice commands, TV remote control, and an android application in a smartphone. Moreover, the device is designed in such a manner, to display a real-time clock at the first run. To obtain data such as time and calendar, an RTC (Real-Time Clock) module is interfaced with Arduino Mega 2560. To display each character on 32X32 Matrix display, the monochrome bitmap format of each character was taken and converted into the required format using the software called "LED Matrix Studio". Based on the UART communication protocol, mobile and voice command controls are executed through HC 05 Bluetooth Module. Further, the TV remote sends a code to the IR receiver in NEC format for each button that is pressed. Since the power consumption of the device is quite low, it can be used in places where the famine of electricity has empowered. The device can be added with some additional features, such as music, animation, mathematical search. A noisy environment will affect the operation of the device for voice commands. Although, the device will make learning procedures easy for children and teaching procedures easy for teachers.*

Keywords: Arduino Mega 2560, UART, NEC, Matrix Display, Voice Command, HC-05 Bluetooth, Android Application, Feedback sounds, Real-Time Clock, monochrome bitmap, LED Matrix Studio

I. INTRODUCTION

Nowadays, kids are highly attracted by technological advancement and engaged themselves more often with entertainment, social media, games, etc and hence they have driven away from education. Hence, it is crucial to make a technological device that will attract kids for the studies i.e., which will teach them. Moreover, the prices of the product need to be in the range of the poor and may also use this technology.

This paper presents a device of 32X32 matrix display by cascading four16X8 LED matrix displays and each display is driven by the driver chip MAX7219 that displays the alphabets of three different languages, such as English, Tamil, and Bangla, and numbers from 0 to 9. Furthermore, a feedback sound has been added for each character and the sound will be produced to display the respective character. The device can be controlled, or the alphabet or numbers can be changed using smartphones through the Bluetooth and even by TV Remote. The device can be controlled by giving voice commands such as "next" for the next letter or number and "previous" for the previous letter or number, and "menu" to move to the menu. In addition, the display of respective alphabet or number will also provide feedback voice, which will provide fun for children and those with eye problems can also use this device for learning. This can be used as a digital watch that displays the day, date, month and year. Therefore, it will serve as both a learning device and a clock. In addition to the fact that the device is light and small, it can be carried anywhere and even while traveling. Only 12V DC battery is enough to power the display.

II. LITERATURE REVIEW

Perhaps An intelligent LED display technology using a single-chip microprocessor and a programmable logic device (CPLD) was introduced by Xiao Chen and Tang (Chen and Tang, 2009). For the work, a single-chip AT89S52 microprocessor was used to control the data and establish the external connection for this particular system. In the presence of a single-chip microprocessor, the Altera CPLD EPM7128 chip was used as a display hardware controller to display information as desired. Instead of using CPLD to drive the LED display, a MAX 7219 driver IC can be used, so the control circuit will be

much simpler. Moreover, by using the DS3231 real time clock module, better time accuracy will be achieved. A field programmable Gate Array (FPGA) based on Verilog for displaying data on two-color 8X8 LED dot-matrix displays was introduced by Wan-Fu Huang (Huang, 2013a), (Huang, 2013b). To carry out the work, a Spartan-3 FPGA was used and the circuit design was Verilog. The display unit is designed to display characters for four-direction rotation along with two-speed modes i.e., normal speed mode with 0.2 seconds and fast speed mode with 0.1 seconds for a step movement of one row or column.

Tonmoy et al., introduced a digital LED matrix-based educational display for children with wireless control (Tonmoy, Hossain and Hasan, 2019). The device has a 16X16 matrix display to show the letters of the alphabet. A 16X16 display is connected by cascading of four 8x8 displays. Each 8X8 display is driven by the MAX7219 display driver. MAX7219 display drivers send alphabetic data serially from the microcontroller for display. To control the display there are several options. The user can change the display contents by voice commands or using the TV remote control or sending commands from the smartphone or drawing a gesture into the smartphone. As suggested for kids, the screen could be designed more and a sound system also added so that it would be easier for kids to learn alone.

Suman Poudyal presented a paper, Wi-Fi based Scrollable Digital Display with RTC using Arduino (Poudyal *et al.*, 2019). Here hardware and software design to display messages in a LED matrix with the ability to display fixed or scrollable text and adjustable scrolling speed. The author suggested work to deal with a superior notice board. The scroll view feature is mainly developed with the aim of schools and colleges to display daily data continuously. The system was built using a Wi-Fi module to send data from a mobile phone. Moreover, a real time clock module is also included with the system to keep track of the time on the screen. The author did not specify which Wi-Fi module was used. If it is necessary to connect the system via the Internet, the Wi-Fi module will be accurate. But the RF module is also a Wi-Fi module and it is used to transfer data from mobile phones when the internet is not needed. The display can be designed bigger so that the time and notification can be displayed simultaneously.

III. METHODOLOGY

A. *System Overview*

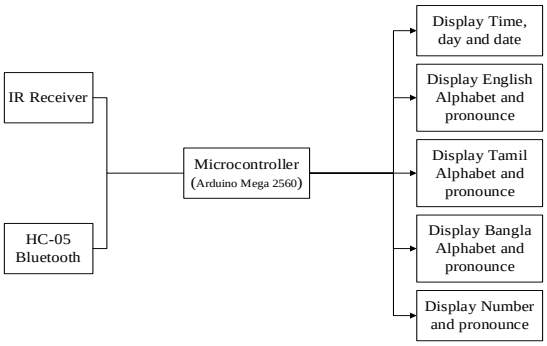


Figure 01: Block Diagram of the system

The block diagram in Fig. 1 shows that the commands are fed to the microcontroller via a Bluetooth module and an IR Receiver and the respective operations. Using TV Remote 32-bit NFC format (Diarah, Egbune and Aaron, 2014) code will be sent to TSOP1738 IR receiver and using UART communication protocol android devices will send the signal at baud rate 9600 bps to HC-05 Bluetooth Module. From these input receivers, the signal will be sent to the microcontroller. According to that the respective letter or number and feedback sound will be the output. The sound will be stored in a microSD in the format of .mp3 and from DF Mini Player the respective sound will be sent to the LM306P audio amplifier for amplification and output sound from the speaker.

B. *System Design*

1) Receiving data from IR remote:

Figure 02: Codes generated for different buttons

The TV remote transmits 32-bit code for a single button. It follows the NEC data for sending code

(Kader et al., 2003). The codes transmitted for different buttons are shown in Fig.2.

2) Display letters on dot matrix display: To display anything in an 8X8 dot matrix display, the microcontroller must send 64-bit or 8-byte data to the display. In this device, four 8×32 (32×32) dot matrix display segments are used. At the end, there are sixteen 8X8 dot matrix display displays. Hence, to display a character in this display, the microcontroller must send 128 bytes (16 x 64 bits) data (Kapoor et al., 2016). Fig 3, shows a simplified circuit diagram showing the connection of an 8X32 dot matrix display pin with a microcontroller.

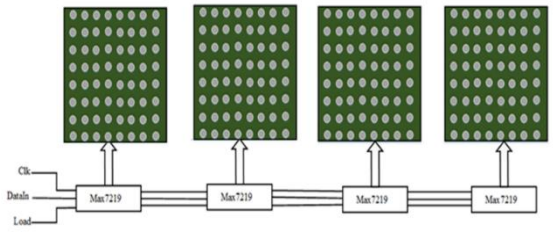


Figure 03: Codes generated for different buttons

To display a character in a 32×32 display, first, a monochrome bitmap format was captured for the respective characters which would be converted into a byte array by the software (Bouazza et al., 2016). Each of the respective characters are placed in a software called "LED Matrix Studio (LED Matrix Studio download | SourceForge.net, no date) to obtain a bit format. A sample design and bit format from the software is shown in Fig 4. After bringing the bits from LED Matrix Studio to the main code, the format of the bits is arranged according to the dot matrix display arrangement of the device.

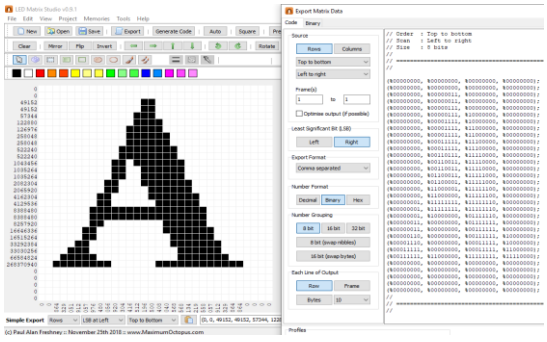


Figure 04: Letter design and respective bit format in LED Matrix Studio

3) Receiving data from Bluetooth via smartphone: The interface of an android application is shown in Fig 5. While pressing each button, it sends a unique ASCII code via the Bluetooth in a baud of 9600 bps to the Bluetooth module using the UART communication protocol (Nanda and Pattnaik, 2016).

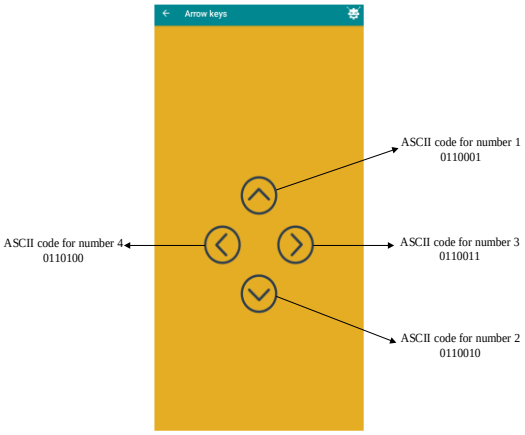


Figure 05: Interface of an android application for arrow key control to share data via Bluetooth

In the same manner, a bluetooth device is used to send voice commands (Alam et al., 2019) too. While a voice command is given, it generates a string and sends the respective ASCII code via Bluetooth. The Interface of an android application is shown in Fig 6. The interface of a bluetooth module with the microcontroller is shown in Fig 7. Here, the RX pin is 10, and the TX pin is 11. Because, if RX and TX pins of the Bluetooth module are connected to the default RX and TX pins of the microcontroller, every time while loading the code to the microcontroller the TX and RX pins must be disconnected from the microcontroller to avoid any interruption while loading code. Therefore, pin 10 and pin 11 were defined as the external RX and TX respectively.

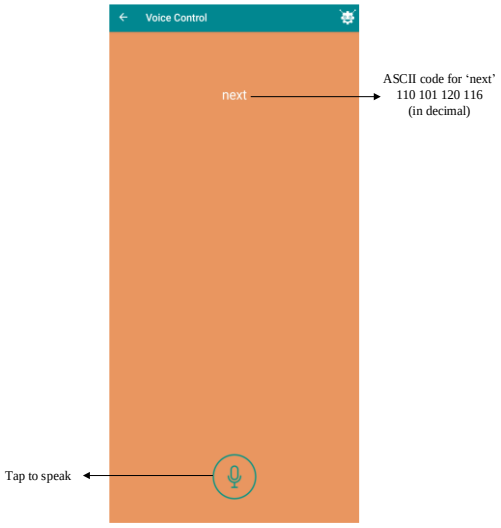


Figure 06: Interface of an android application for voice command control

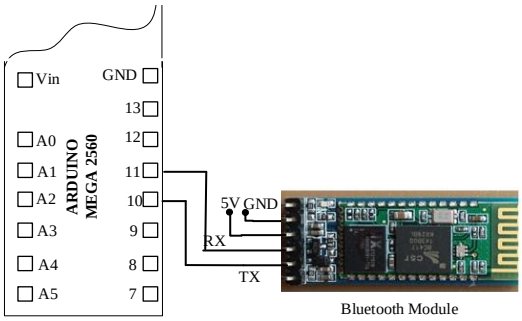


Figure 07: Interface HC05 Bluetooth Module with Arduino

4) Interfacing RTC module with Arduino: DS1307 RTC module uses an I2C communication protocol (RezaKhan, Kabir and Ara Hossain, 2012) to transfer data with the microcontroller. Arduino always acts as Master so that is responsible for the clock signal (Interfacing DS1307 RTC Module with Arduino & Make a Reminder - Arduino Project Hub, no date) and, hence DS1307 is the slave. DS1307 RTC module has a total of 12 pins on both sides and pins SCL and SDA are those two pins for I2C communication. And Arduino Mega 2560 has in-built SCL and SDA pins.

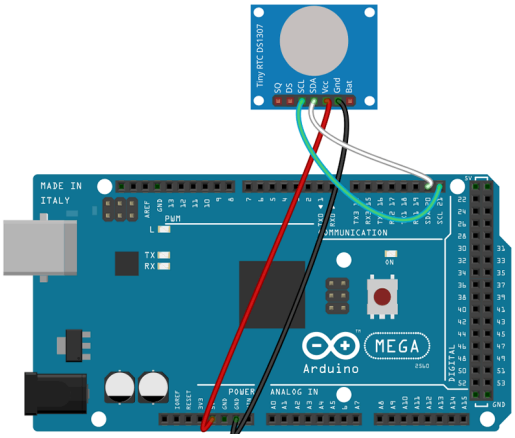


Figure 08: DS1307 RTC Module interfaced with Arduino Mega 2560

To read the data and utilize it, Arduino provides a special library called the "RTClib" library and since the communication between Arduino and RTC module is an I2C communication a library called "Wire.h" also included. Which will allow communication with I2C devices.

5) Interfacing DF Mini-Player module with Arduino: The module has a total of 16 pins, and among them, VCC, RX, TX, and GND pins are necessary for Arduino interfacing (Dada et al., 2018).

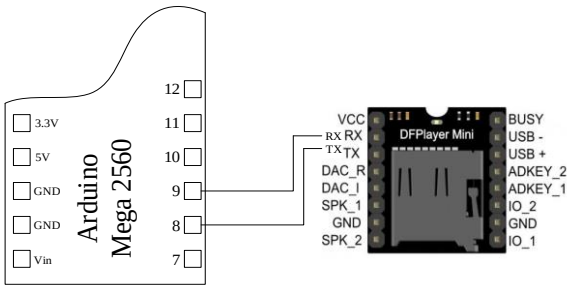


Figure 09: Interfacing DF Player Mini wih Arduino

As shown in the above figure 9, the RX and TX pins are connected to Arduino pins 9 and 8 respectively. In the Arduino, pin 8 and pin 9 are allotted as RX and TX respectively as same as done for the Bluetooth module to avoid any communication interferences. Then to play the respective audio, the file is created and stored on the SD card in .mp3 format by naming each file with a four-digit number such as "0001.mp3", "0002.mp3", "0003.mp3" and placed inside the "mp3" folder.

SPK_1 and SPK_2 pins of DF Mini Player are connected to the speaker so that we can hear the feedback voice.

6) Circuit Diagram:

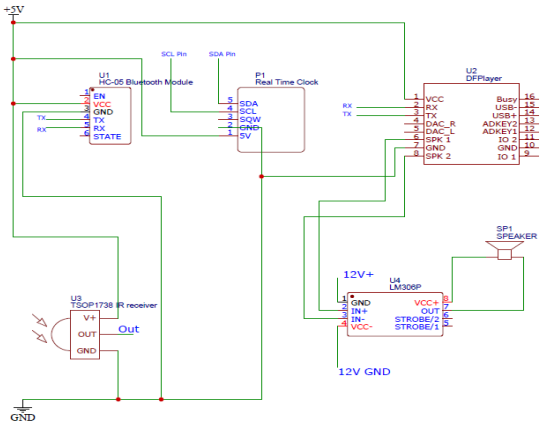


Figure 10: Circuit Diagram

IV. RESULTSN AND DISCUSSION

A. Programming

HC-05 Bluetooth module and IR Receivers are transmitting data to the microcontroller. Hence, at first, the UART and IR Receivers have to be enabled or initialized. Since an LED dot matrix display is used here, and alphabets of three different languages and numbers from 0 to 9 are to be displayed, has to be designed so that, there will be character patterns. Furthermore, all the

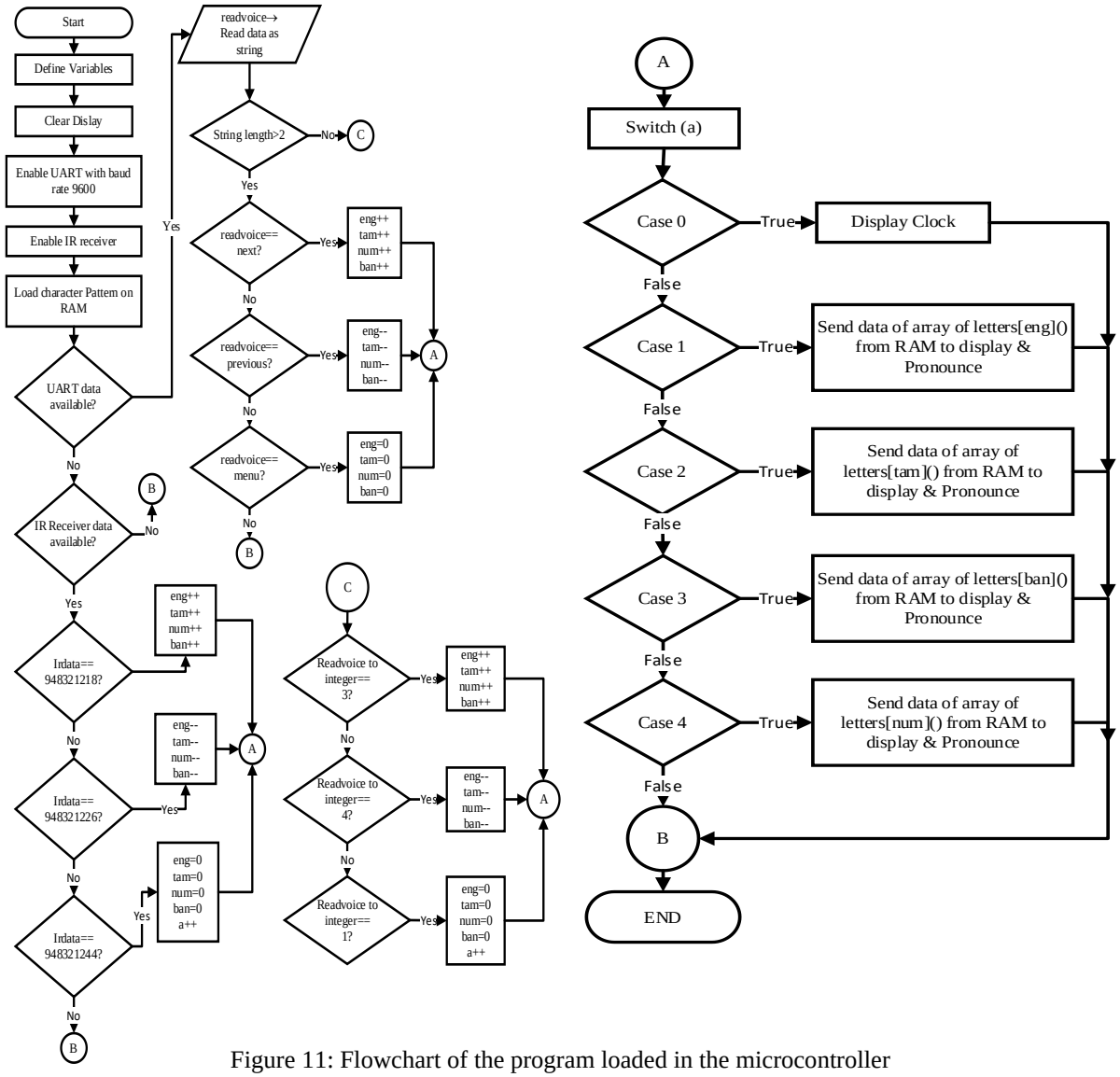
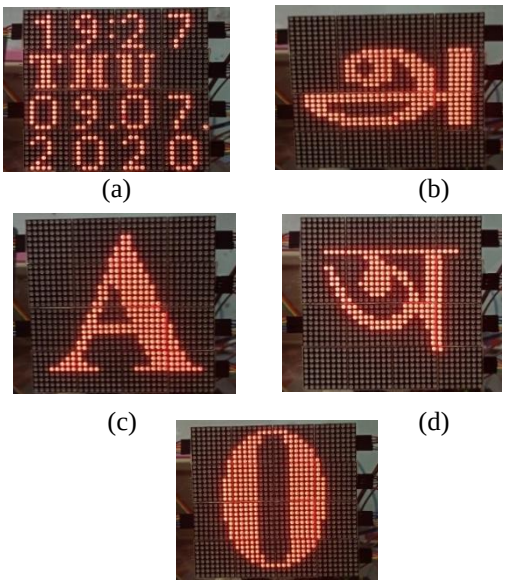


Figure 11: Flowchart of the program loaded in the microcontroller

necessary characters to display the real-time clock were designed separately. All of these patterns have to be loaded to the RAM of the Arduino. Then the microcontroller has to check for the data from the Bluetooth or IR Receiver. If there is any command via Bluetooth module, UART has to be checked, and if not the IR Receiver. If there is any command via Bluetooth, then the given command will be analyzed based on its length. According to the program written here, if the length of the given command is more than two, it will be categorized as voice command and if not, the command is from the smartphone. If there is no data in the UART, then the IR Receiver will be checked. According to the button pressed from the remote, a unique code will be sent to the IR Receiver. The flowchart for this program is given below in figure 11.

B. Result



(a) (b) (c) (d) (e)

Figure 12: Result of implemented system

The system by default set to show time, day and, date once the device is turned on. Other functions described above are obtained through the implementation of the device and some results are shown in figure 12. In figure 12(a) the clock is shown. In there the time is shown in 24 hours format. It is displayed as an hour and minute respectively. Then the day of the week is displayed. After that, the date, month, and year are displayed respectively. Figures 12(b), 12(c) and, 12(d) are showing the displays of letters, and figure 12(e) is showing the display of a number. Along with these displays, the respective feedback sound is also produced.

V. CONCLUSION

The century in which humans live is fully interfering with modern technology and smart technology. Therefore, there is a necessity for this device that will attract kids and at the same time will teach kids. Further, technologically, it can be controlled via TV remote control and smartphone and also using voice commands. It can be used in homes and even in schools for engaging learning so that there are opportunities for teachers to be loved by students. As it shows the alphabets of three different languages like English, Tamil and Bengali, it simultaneously gives the pronunciation of the respective letters as feedback. In addition to that, it has another additional feature of a real-time clock, which displays the current time, day, date, month and year as well. When the respective next button from the TV remote control or smartphone or the "Next" voice command is received by the microcontroller, it will display the next following letter one by one and the respective pronunciation will also be produced by the DF mini-player, in which there is a microSD card consist of all mp3 files of each character, it will be sent to the filter circuit along with the noise. The filter circuit will significantly reduce noise and feed the speaker connected to it. When it receives the respective previous button from either IR remote control or smartphone or the "previous" voice command, it displays the previous letter one by one along with its pronunciation. When the menu button either from IR remote or the smartphone or the voice command "menu" is received, the next category from which the device currently belongs will be displayed in the order of the real time clock, the alphabets in the order of English, Tamil, Bengali and Numbers.

The feedback sounds produced contain some noise which cannot be filtered by the designed filter circuit. Hence, controlling the device via voice commands is not accurate in a noisy environment. However, it can still be used in homes, classrooms, schools, and offices as a digital clock. While the device is in clock mode, the brightness of the LED display can be adjusted and even can be turned off by the remote control and the smartphone. Because it is made of microcontroller, the power consumption is very low. Therefore, it can be used in territories where famine has enabled electricity, using 12V battery, the cost is also low. We can make teaching more successful by incorporating some additional features, such as music, animation, and mathematical search. It has some limitations like the voice command is not effective in a noisy environment and the voice command must be given in English. In the future, voice commands in other languages but English can be added.

REFERENCES

Alam, M. E. et al. (2019) 'Development of a Voice and SMS Controlled Dot Matrix Display Based Smart Noticing System with RF Transceiver and GSM Modem', 2018 21st International Conference of Computer and Information Technology, ICCIT 2018, pp. 1–5. doi: 10.1109/ICCITECHN.2018.8631914.

Bouazza, H. et al. (2016) 'New and low cost product solution for LED matrix display', Proceedings - 2016 International Conference on Engineering and MIS, ICEMIS 2016. doi: 10.1109/ICEMIS.2016.7745301.

Chen, X. and Tang, C. (2009) 'Intelligent LED display technology with SCM and CPLD', 3rd International Symposium on Intelligent Information Technology Application, IITA 2009, 1, pp. 260–263. doi: 10.1109/IITA.2009.240.

Dada, E. G. et al. (2018) 'Available online www.jsaer.com Research Article Android Based Bluetooth Controlled MP3 Player', 5(9), pp. 86–94.

Diarah, R., Egbune, D. and Aaron, B. (2014) 'Design And Implementaion Of A Microcontroller Based Home Automation System Using Aiwa Remote', International Journal Of Scientific Research And Education, 2(3), pp. 575–588.

Huang, W. F. (2013a) 'Designing a display unit to drive the 8×8 LED dot-matrix displays', Proceedings - Winter Simulation Conference, pp. 385–388. doi: 10.1109/INEC.2013.6466054.

Huang, W. F. (2013b) 'Three approaches to light an 8×8 LED dot-matrix display', ISNE 2013 - IEEE International Symposium on Next-Generation Electronics 2013, pp. 37–40. doi: 10.1109/ISNE.2013.6512274.

Interfacing DS1307 RTC Module with Arduino & Make a Reminder - Arduino Project Hub (no date). Available at:

https://create.arduino.cc/projecthub/electropeak/interfacing-ds1307-rtc-module-with-arduino-make-a-reminder-08cb61 (Accessed: 27 April 2021).

Kader, M. A. et al. (2003) 'LED matrix based digital learning display for children with wireless control', 2014 17th International Conference on Computer and Information Technology, ICCIT 2014, pp. 397–400. doi: 10.1109/ICCITechn.2014.7073134.

Kapoor, D. et al. (2016) 'Ijesrt International Journal of Engineering Sciences & Research Technology Electronic Dice Using Dot Matrix Display', International Journal of Engineering Sciences & Research Technology, 5(5), pp. 315–321. doi: 10.5281/zenodo.51429.

LED Matrix Studio download | SourceForge.net (no date). Available at: https://sourceforge.net/projects/led-matrix-studio/ (Accessed: 27 April 2021).

Nanda, U. and Pattnaik, S. K. (2016) 'Universal Asynchronous Receiver and Transmitter (UART)', ICACCS 2016 - 3rd International Conference on Advanced Computing and Communication Systems: Bringing to the Table, Futuristic Technologies from Arround the Globe. doi: 10.1109/ICACCS.2016.7586376.

Poudyal, S. et al. (2019) 'Wi-Fi based scrolling digital display with RTC using arduino', 2019 2nd International Conference on Intelligent Communication and Computational Techniques, ICCT 2019, pp. 199–202. doi: 10.1109/ICCT46177.2019.8969057.

RezaKhan, S., Kabir, A. and Ara Hossain, D. (2012) 'Designing Smart Multipurpose Digital Clock using Real Time Clock (RTC) and PIC Microcontroller', International Journal of Computer Applications, 41(9), pp. 39–42. doi: 10.5120/5573-7668.

Tonmoy, A. I., Hossain, M. F. and Hasan, S. Z. (2019) 'Voice, Gesture and IR Remote Controlled Alphabet Learning Display for Kids Based on 16×16 LED Dot Matrix Display', 2nd International Conference on Electrical, Computer and Communication Engineering, ECCE 2019, pp. 1–5. doi: 10.1109/ECACE.2019.8679208.

An Optimized Algorithm to Select the Most Appropriate Gate Type for a Given Level Crossing in Sri Lanka

J.L.P.K. Fernando[1], M.D.S. De Silva[2], B.A.I. Bulathsinhala[3] & S.K. Wijayasekara[4*]

[1,2,3,4]*Department of Electrical, Electronic and Telecommunication, General Sir John Kotelawala Defense University Ratmalana, Sri Lanka*

[1]fernandopumudi@gmail.com, [2]d.sandalika@gmail.com, [3]anujaisuru@gmail.com, [4*]sanika.w@kdu.ac.lk

Abstract- *The current railway system in Sri Lanka, there are 1687 Railway Level Crossings Systems (RLC) with three types of RLCs protection methods namely RLCs with barriers, RLC with bell and light, and unprotected RLCs. As per our observation, we identified that there is no decision criterion on identifying the most suitable RLC protection mode for different RLC environments in the current railway system and this leads to an increase in the collision rate of the road traffic and the train schedule. Therefore, as a solution in this work, an accurate prediction method is introduced based on the 'Regression Tree Analysis' method to identify the most appropriate component out of barriers or bell and light in a specific RLC.*

Keywords: Train Vehicle Unit, Regression tree analysis, Machine learning, RLC, Accidents, Level crossing

I. INTRODUCTION

In 1864 "rails" were introduced to Sri Lanka to transport tea from upcountry to Colombo port. The mainline was extended north to Kandy in the ancient capital of Anuradhapura and north to Kankesanturai and west to Talaimannar for the ferry link of the island to South India, to bring in Indian tea and rubber plantations, as well as to import rice and other foodstuffs not grown in adequate quantities indigenously. Sri Lanka Railway (SLR) is a government department that operates under the Ministry of Transport. It is the leading transport provider of transport services and the only rail transport organization in Sri Lanka. SLR operates under the General Manager of Railway (GMR), the GMR shall report to the Secretary Secretary-General of the Ministry of Transport. Currently, the Sri Lanka Railway operates and manages 1561 km of railway lines with a broad gauge of 1,676 mm, having 72 locomotives, 78 power sets, and a signaling network. In the current railway line, there are single track, double track, three tracks, and four tracks available throughout the route. Around 396 trains operate on Sri Lanka Railway line daily commutating passengers to their workplaces, taking the passengers to their respective destinations, including 67 long distance and 16 intercity trains, and transports approximately 3.72 million passengers per day (SriLankan Government ,2020).

The railway network consists of nine railway lines and it is given in Figure 01. They are Mainline (Colombo to Badulla), Matale Line (Peradeniya Junction to Matale), Puttalam Line (Ragama to Noor Nagar), Coastal Line (Colombo to Beliatta), Kelani Valley Line (Colombo to Avissawella), Northern Line (Polgahawela to Kankesanthurai), Mannar Line (Medawachchiya Junc. To Talaimannar), Trincomalee Line (Gal Oya Junc. to Trincomalee) and Batticaloa Line (Maho Junc. to Batticaloa).

Both the train passengers and the public have been quite concerned about the increasing trend of rail accidents in the past few years. As the railway track is unfenced, it is very much prone to accidents involving pedestrians, passengers as well as animals. There are many kinds of rail incidents and some of them are accidents at level crossings, accidents in railway stations, collisions on railways, derailments, and suicides. From the years 2018-2020 total of 1273 suicides have been taken place and a total of 552 accidents have been taken place (SriLankan Government ,2020).

There are two main types of level crossings in Sri Lanka called active and passive level crossings. Active level crossings can be categorized as manually operated barriers, electrically operated barriers, farm farm-type barriers, and bell and lights. Passive level crossings are the level crossings which doesn't provide any information whether the train is approaching or not. Only stop and giveaway signs are available.

In the current Railway system, there is are no specific criteria to determine what is the best

protection method as such as Barrier, Bell, and Light or unprotected for a level crossing. They use parameters like "Traffic congestion, Train Density, Road type, number of accidents" to determine the protection method, or else the pedestrians should complain to the Sri Lankan Railway that the level crossing is unsafe for them to use.

This research will be a quantitative approach to the issue at hand where the primary focus is on building up a model to determine the protection type needed to the level crossing by using machine learning.

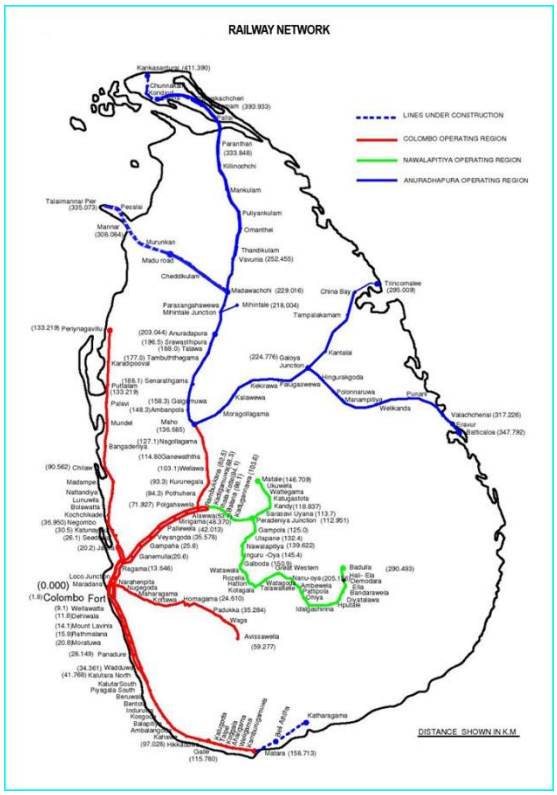


Figure 01: Railway network of Sri Lanka (SriLankan Government ,2020)

II. RELATED WORK

In the early days, the probability of collision of trains sharing the same track was small because there were fewer number of trains and a considerably long-time gap between two trains kept the risk of collision low. Therefore, in the present railway system, having a proper and accurate signaling system is a must because the train density and the trains are scheduled very frequently. Unlike vehicles on roads, trains cannot be steered away to stop collisions. It is confined to the railway track and even taking a bend at high speed will derail the train and end up in disaster (Tan, 2019). The evolution of the railway signaling system was initiated by mechanical systems, which led to Multiple Aspect Colour Light Signaling System (MAS) to Communication Based Train Control (CBTC) (Jayasundara, 2019). The current system was upgraded in the most effective, feasible, cost-effective, and easily manageable way for Sri Lanka by using Q-type latch relays. Latch relays were used in this system to acquire safety interlocking with a lesser number of relays compared to the existing system (Jayasundara, 2019).

A Block system can be described as a system that prevents a train from entering a specific sector of the railway track until the train that is already within that particular sector leaves. These block systems can consistently record distance intervals between trains. In the modern railway system, block signaling has been upgraded into Automating Block Signaling (ABS) (Britannica, 2011). A fixed block signaling system is an artificial separation between train can be created between train using fixed block signaling by separating the track into small blocks, which determines the distance between two trains. This will avoid train collisions and provide safety. Even though this provides safety, it challenges the signal engineers when designing the size of the block as it should be designed for optimum headway and safety concurrently (Ali, 2019).

There are two main types of level crossings. They are active level crossings and passive level crossings (Amarasingham et al. 2017; Fambro et al. 1998). All the countries in the world have both protected and unprotected railway crossings. Despite the traditional railway systems, the developed countries also have many advanced high-speed railways transportation methods such as light rail system, monorail system, metro system, maglev train, and high-speed trains (Britannica 2013; Britannica 2012;Paranirubasingam 2018; Regulation 2007).

A general understanding of the key circumstances and other contributory factors for having a protected RLC is provided by the study of deaths from railway-related accidents. Since the number of RLC injuries and events is troubling, the need to introduce policies which that contribute to improving the protection at RLCs which will reduce the injuries and accidents, has risen (Nedeliakováa et al. 2015). Improving the standard of protections used in RLCs can be accomplished either by decreasing the risk of an accident or by reducing the effect of incidents, or

by integrating them. Protection enhancement is expensive, but it is a necessary expense that cannot be eliminated or be neglected (Pyrgidis 2016; Weerakoon 2011).

To avoid disturbance in the circuit track, the researchers have proposed and designed an online monitoring system and management platform for monitoring railway signal infrastructure. This focuses on a simulation-based approach using optical fiber sensing for supporting a threshold analysis aimed at identifying the maximum number of trains to be operated on a line for the given the related infrastructure. The proposed design by the group of researchers can perform signal processing, chart display, acousto-optic alarm, user authority. This project is based on the graphical programming language labVIEWLabVIEW, the obtained results from this show that the basic signaling equipment for monitoring and managing railway systems can transmit data correctly and steadily. Thereby it is proven that this design is resulting in convenient and ideal for operations (Ma et al. 2018).

III. METHODOLOGY

The project was started with the initiative of Increasing the reliability of the existing Bell and Light protection system through an optimized algorithm to select the most appropriate Gate type for a given location in Sri Lanka Railway. The primary concern of the Railway department officials is to safeguard the train passage of the commuters. Over the years, there have been drastic measures taken by the department to ensure the safety of the commuters. Therefore, fatal accidents that the commuters have been subjected to over the years have been diminished. But with the increasing complexity of railway networks due to the development throughout the country, there has been a trend of commuters getting into accidents, some of which are fatal. Most of these accidents occur near the railway level crossings. Due to the nature of these accidents, it is tough to regulate and prevent such incidents. Therefore, a way to reduce these accidents has to be found in a methodical and systematic manner.

In exploring this avenue, we conducted interviews, surveys and went through a plethora of literature in this context to find out what are the most common factors that are needed to be considered when installing the level crossing protections. As the preliminary step for this project, it was required to identify the factors that affect the decision decision-making of installing the protection method for an existing level crossing. The expected outcome of this is to show the most optimum type of level crossing to be installed by the Sri Lankan Railway.

The information required for this project was gathered by conducting the interviews with railway officials, distributing questioners, contacting research centers, interviewing a guard who operates a barrier, and surveying other related research articles and other data and systems in foreign countries. Considering all the data collected, 11 main factors have been identified which can be utilized to develop the algorithm. After gathering data Train Vehicle Unit (TVU) was calculated using the following formula in Eq. (1) which calculates the total train and vehicle units passing a level crossing per.

$$TVU = \text{no.of train units} \times \text{no.of vehicle units} \times 24 \quad (1)$$

When the data is plotted on a time-plot containing missing data, gaps emerge on the plot where missing data occurs in the data set, which results in data acquisition failures in both input and output signals. In order tTo handle outliers, a boxplot has been used. If there are a lesser number of outliers, the data set is kept as it is because data will not be biased. If there is a higher number of outliers, those outliers must be removed because if not, the data will be bias.

Generally, using the correlation analysis method the strength of the relationship between the factors can be identified. If there is a high correlation between two or more variables, it means that they have a strong relationship among the factors else the correlation relationship is weak, which states that the variables hardly relate to each other. Therefore, in this project, Spearman's correlation is used since the chosen variables do not follow the assumptions of linearity, interval or ratio level, and bivariant normal distribution. The main goal of the project is to build up a model that makes a prediction with a given set of uncertain data and this is called “supervised learning”. Regression and classification are the two main methods used in supervised learning where the regression method predicts a continuous measurement for the observation and, the classification method allocates a class from a finite set of classes. This work is focused on predicting and observation of

continuous dependent variables/data and regression analysis is the best method to use.
Considering the correlation analysis, it exhibits that all factors that have been chosen do not always have a strong positive or negative relationship with the response variable as the data is scattered. Despite having a weak relationship between two factors and not having a linear relationship, the variables show equal importance in developing the model. Hence, the Linear regression model doesn't fulfill the necessary requirements. If this model is used, factors with weaker relationships have to be dropped out of the considering factors. Even though there is no mathematical correspondence between some aspects, it is not feasible to drop those factors as they might contribute to the development of the model.

Based on the background domain knowledge and set of intensive simulations the regression trees (RTs) model is identified as the most suitable model for this project since the considered response variables/factors are dependent and continuous. In the RTs analysis, the cvpartition function is used to randomly partition the set of data of specified size. Using this partition, it is possible to create test and training sets to validate a mathematical model using cross-validation. In order tTo build up this model, the cross-validation method is chosen since the gathered data set is small. Cross-validation is carried out to eliminate overfitting and underfitting of data and a K-fold cross-validation partition is used with K = 10 to carry out the model. In this partitioning process, the data set is randomly divided into 10 folds approximately with the same number of entries and approximately 10% of total entries are included in the test set.

Based on the observation of the carried out correlation analysis and the details are given in Tan (2019) and Jayasundara (2019), 10 main factors which can be utilized to develop this model were identified. Gate mechanism which identifies the unmanned/manned gates, number of accidents at unmanned/manned level crossings, Train Vehicle Unit (TVU), visibility conditions, signaling system, alarm system, vegetation, number of tracks, road bendy, and communication system are the factors that have been chosen to utilize the model. Using the selected features, sets of different numbers of features were fed into the model at a time and the results were obtained. To choose the most suitable result following parameters from Eq. (2) to Eq. (7) were considered. Where y_i is actual response value of the model, $i \in 1,2,\dots,n$ and $\hat{y}_i$ is the value estimated by the regression model. $\bar{y}$ is the mean response.

$$Root\ Mean\ Square\ Error(RMSE) = \sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i - \hat{y}_i^{\,2}} \quad (2)$$

$$Total\ Sum\ of\ Squares(SST) = \sum_{i=1}^{n} y_i - \hat{y}_i^{\,2} \quad (3)$$

$$Sum\ of\ Squares\ Error(SSE) = \sum_{i=1}^{n} y_i - \overline{y^2} \quad (4)$$

$$R^2 = \frac{SST-SSE}{SST} \quad (5)$$

$$Mean\ Squares\ Error(MSE) = \frac{1}{n}\sum_{i=1}^{n} y_i - \hat{y}_i^{\,2} \quad (6)$$

$$Mean\ Absolute\ Error(MAE) = \frac{1}{n}\sum_{i=1}^{n} y_i - \hat{y}_i^{\,2} \quad (7)$$

To perform analyzationanalysis, the model has been trained by feeding training data, and then it can be tested by using test data. In addition, simulated results are analyzed and used as a method for better understanding and improving the performance and reliability of the structures where the simulation is often commonly used to validate the accuracy of the designs. In validation, the identification of the acceptability of the built model is important. In this situation, the software should be modified to fit the features of the current system and the effects of the model can be compared to those of the actual system. To check the validation in this model rMetrics parameters with training data and test data are compared to check the accuracy.

IV. RESULTS AND DISCUSSION

From the questionnaire carried out, it was shown that most of the accidents happen at the unprotected level crossings due to the carelessness of the pedestrians or road vehicles. And also, it

was revealed that most of the responders had faced failures at level crossings often.

When finding the correlation, it is observed that there is a strong relationship between Accidents versus Gate type, and Train vehicle unit versus gate type. The reason behind the observation was that there is a high probability of happening an accident in unprotected RLC as well as the high value of TVU impact on the selection of Gate type to be Protected most of the time. The correlation between the response variable and 'visibility' is calculated as 0.5595, which is important that visibility of rail track along both sides of RLC and also whether rail track is bendy or not, was measured and correlation is calculated which does not show a strong relationship, but it is essential to consider the fact that, no line of sight with train can lead to accidents. The same procedure was applied to other predictive variables and checked an impact on the response variable.

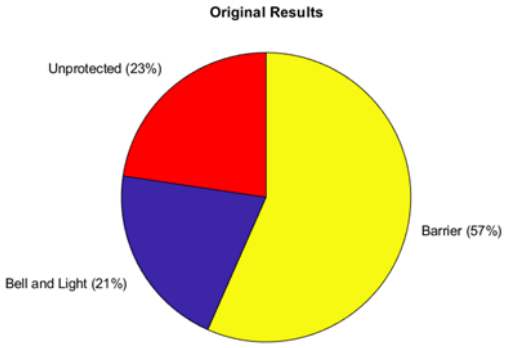


Figure 02: Original Results

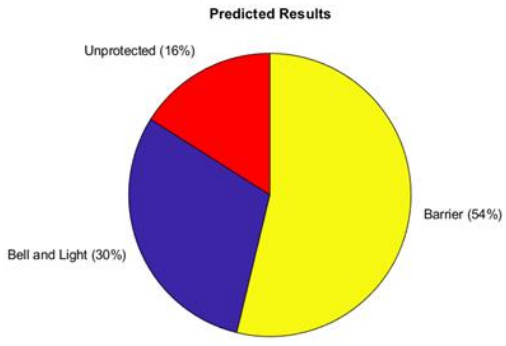


Figure 03: Predicted results

It is observed, there is a significant improvement in unprotected RLCs turned into bell and light protection. This results in a smaller number of accidents and also there is a decrease in the percentage of barrier protection, where the model predicts the existing barriers should be bell and light. It is identified that with more training data, the results can be further optimized to get a highly accurate decision.

V. CONCLUSION AND RECOMMENDATIONS

In Sri Lanka, the safety of RLC becomes the most essential concern since RLC deaths are reported throughout the year. Based on the conducted qualitative assessments it is identified that most railway accidents occurred in RLC due to the unprotected RLC and the carelessness of vehicles/passengers. Further, it is founded that there was no proper justified quantitative metric or thorough statistical analysis based on accident/incident data to convey the need for an appropriate type of gate to protect the RLCs in the current Sri Lankan railway (SLR) system. Therefore, in this work, we implemented an optimized model which can predict the most appropriate gate type for a given RLC and this is beneficial to SLR to make the decision on which gate protection to be installed. This result not only in reduction of railway accidents /collisions and may save many human lives while preventing the material/economic losses due to disruption of train operations and shutdown of road traffics. It is quite apparent that a larger database with the appropriate data is beneficial in creating a well appropriate model.

REFERENCES

Ali, N., (2019) 'Moving Block vs Fixed Block Signaling - Which is Better?', Available at: https://www.linkedin.com/pulse/moving-block-vs-fixed-signalling-which-better-naeem-ali# (Accessed: 3rd February 2020).

Amarasingham, N., Gunathilaka, O.H.D.C., Ragulan, K., Aravinda, M.P.N., Fernando, W.S.H.R., (2017) 'Characteristics of Railway-Roadway Level Crossings at Coastal Railway Line in Sri Lanka', KDU International Research Conference, Malabe.

Britannica, T.E.O.E., (2012) 'Light Rail Transit', Available: https://www.britannica.com/technology/lightrailtransit (Accessed: 25th April 2020).

Britannica, T.E.O.E., (2011) 'Railroad Signal: Additional Information', Available: https://www.britannica.com/technology/railroadsignal#ref1074438/ (Accessed: 13th March 2020).

Britannica, T.E.O.E., (2013) 'Rapid transit', Available: https://www.britannica.com/technology/rapid-transit (Accessed: 10th June 2020).

Fambro, D. B., Lee, A.S., Bartoskewitz, R.T., Frieslaar, A.H., (1998) 'Highway-Rail Grade Crossings', Texas Department of Transportation, Texas.

Jayasundara, J., (2019) 'An Innovative Approach to Railway Signaling in Sri Lanka: Appraisal of Technical and Economic Rationale', Research for Transport and Logistic Industry. Colombo.

Paranirubasingam, P., Perera, W.N.S., (2018) 'Deaths on rail roads: a study from Colombo North Teaching Hospital, Sri Lanka', vol. 9, no. 2, pp. 10-20.

Ma, C.Y., Li, B. , (2018) 'Software Design of a Railway Signal Monitoring System based on Optical Fiber Sensing', International Journel of Online and Biomedical Engineering, vol. 14, no. 8, pp. 134 - 146,.

Nedeliakováa ,E., Sekulováa, J, Nedeliakb , I., (2015) 'A New Approach to the Identification of Rail Risk at Level Crossing', 9th International Scientific Conference, Transbaltica.

Pyrgidis, C., Papacharitou E., Eleftheriadis, A., (2016)'Risk management at railroad grade crossings: proposal for a decision support system', 6th Transport Research Arena.

Regulation, O.O.R., (2007) 'Policy on level crossings', Available: https://eastsussexgovuk.blob.core.windows.net/media/2159/lewes_uckfield_appendix11.pdf.

SriLankan Government (2020) 'Sri Lanka Railways (SLR)', Available at: http://www.railway.gov.lk/web/ (Accessed: 2nd January 2020).

Tan, B.T.G., (2019) 'The Physics of Railway Signalling', The Physics Educator, vol.1(1950001), pp. 11-18.

Weerakoon, K., (2011) 'Evaluation of Parameters Influencing Delays for the Road Users at Railway Level Crossing in Sri Lanka,' University of Moratuwa, Moratuwa.

Intelligent Vehicle Diagnostic System for Service Center using OBD-II and IoT

Uyaam Maalik[1*] & P. Pirapuraj[2]

[1,2]*Department of Information and Communication Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*]uyaammaalik@gmail.com, [2]pirapuraj@seu.ac.lk

Abstract- *Vehicles are an essential source for traveling around the world. It is vital to keep the vehicles maintained well. We were proposing subscription-based vehicle maintenance solutions for the people who do not have the time for the repair and maintenance of his/her vehicles. An IoT device will be connected to the OBD II Slot of the vehicles, send all diagnostic data to a server, and notify the customer through a mobile application about the vehicle status if a customer wants to repair or do regular maintenance. The proposed system will send a request to all the dealers and repair shops nearby to get a quotation, availabilities of parts, and estimates the time of completion (ETC). Then, the customer can choose where he wants to repair it. Through the app, customers can request roadside assistance, vehicle recovery, and loaner vehicles.*

Keywords: Service Center, Vehicle Malfunction, OBD-II, Artificial intelligent, IoT

I. INTRODUCTION

Vehicles are having very complex structures need a well-thought-out maintenance plan. More safety packages are currently added to modern vehicles, so many sensors and actuators are used. Predictive maintenance, corrective maintenance, and preventive maintenance are mandatory as modern vehicles have complex systems.

According to a statistics (*World Vehicle Population,2016*), the total population of the vehicle in the world will be doubled in every 20 years. More than two billion vehicles were on the road at the end of 2016, increasing over eightfold in the last two decades from 670 million in 1996. Coincidentally, it grew at roughly the same rate from 1976 to 1996, increasing by over 342 million. That study predicts we'll that roughly 2.8 billion cars on the planet by the year 2036.

Based on the survey mentioned above, vehicle usage is increasing rapidly and the accident too. The need for maintaining vehicles is essential in this era. Most road accidents are happening because of vehicle errors and bad vehicle maintenance. It will be challenging to find a repairing center while getting repair in the middle of traveling. These kinds of problems have to be solved quickly. We proposed AI-based Service Centers for those traveling long far. The transportation chip will send the erroneous code to our server through the vehicles' On-Board Diagnostics II (OBD II) system. The system will send the request to the nearest Service Center with the error report. Our app will notify the client about the error and the nearest Service Center for the repair. If the client accepts, the repair system will request the Service Center to get an appointment quickly, or the client will choose a mobile repair service.

II. RELATED WORK

Bartosz Kowalik said that On-Board Diagnostics (OBD) is utilized for diagnostic purposes in the new car. OBD is used to read car parameters and also collect diagnostic data of the vehicle. But preventing gasket failure is impossible based on gathered data from the car's diagnostic interface. While the eventual crash was unavoidable, some data can be used to develop a detection system for future malfunctions. Lots of information were already available for implementing ecological solutions for cars with traditional engines (Kowalik, 2018).

Balázs Bánhelyi and Tamás Szabó said every new has an OBDII port that can be utilized to get vehicle diagnostic data with fault detection. They have developed an application and set of parameters that measure those observations and algorithms, which perform relevant analysis on the resulting data and figures to verify whether they are correct. Their system can detect rare data, and if the data appear, users can be alerted (Bánhelyi and Szabó, 2020).

Kavian Khorsravini and his colleagues predict that the number of internet-connected electric vehicles will increase in the near future. Growth is being supported for the monitoring, controlling, and

following of electric vehicles with new technologies. Until now, no distinct system has been built to incorporate all these disparate elements into a single package. They created a controller area network that communicates with On-Board Diagnostics through the Electric Vehicle diagnostics. Signals that are both interesting and useful are found through the monitoring of the CAN bus protocol IDs. In planning, it's possible to implement the new CAN (Controller Area Network) diagnostic in the vehicle system. There are numerous new vehicle-access features available in their mobile application (Khorsravinia *et al.*, 2017).

The researcher's Chin Lin and others developed a diagnostic system using On-Board Diagnostics (OBD) to detect system issues and alert the driver. In almost all cases, the operators usually will not make any change. Their paper introduces a new system with real-time vehicle condition acquisition and transmission through GPRS mobile phone to the On-Board Diagnostics using the internet to a Server of Maintenance Center (SMC). Implementation of an Online Diagnostics and Early Warnings system for vehicles can allow the Internet of Things to provide diagnostic and warning in real-time This paper's design and system verification phases could successfully route the DTC. on the report findings, the auto service department will offer repairs as a service (Lin *et al.*, 2005).

Another study was conducted by J V Moniaga and et al. using Raspberry Pi and iSaddle Bluetooth OBD-II tools to store and analyze the vehicle diagnostics data from the OBD-II port. Individuals can also communicate their vehicle to control (Moniaga *et al.*, 2018).

Siddhanta Kumar Singh and et al. developed intelligent diagnostic systems via deploying an IoT device in the automotive sector to avoid the road accident rate. They mentioned in the study that the internal problem of the vehicle is also one of the reasons for a road accident. To solve the issues mentioned above, they suggested a solution based on the OBD-II port of the vehicle is connected to an IoT system (Raspberry pi and Nano Bluetooth Dongle) and smartphone (Singh, Singh and Sharma, 2021).

Uferah Shafi and her colleagues are investigating vehicle remote vehicle health monitoring and predictive maintenance techniques, which allow repair centers to replace components before they fail. A methodology for identifying faults of the four major subsystems of a vehicle is described in that post: vehicle propulsion, fuel system, ignition system, exhaust system, and cooling system; this study connects the car's on-the-board diagnostic port to an IoT device to gather diagnostic data (Shafi *et al.*, 2018).

III. METHODOLOGY

For the time of repair, the client has to go to the service center, and after the repair technician needs to connect the On-Board Diagnostics II (OBDII) scan tool and need to find the problem. This client has to wait sometime to repair his vehicle. It is time-consuming work for those who are spending their valuable time on their work.

A. On-Board Diagnostic II

In almost every type of vehicle engine, OBD II is part of the On-Board Diagnostics. Continuous emission performance monitoring uses data from sensors to judge how well emission controls are working (Sensors do not directly measure emissions). Currently, the on-board diagnostics systems have been configured to help monitor the powertrain and its emission-control systems for the possibility of system failure and deterioration at all times while in use.

The general requirements for OBD II are:

- Virtually all emission control systems must be evaluated.
- We will have to identify potential malfunctions before exceeding regulatory limits (generally 1.5 X emission standard).
- On average, failures should be found within two cycles of the first one completed drive of use.

A problem that can lead to an increase in air emission is identified, the Malfunction Indicator Light (MIL) lights on the dashboard to warn the driver. Can detect various vehicle systems by plugging into the standardized connector, then they can use the scan tool to connect to the Diagnostics and Data Link connector (DCL). (Lyons, 2015).

OBD II vehicles can provide three pieces of information via a scan tool:

- The ON or OFF setting of the Malfunction Indicator Light.
- What diagnostic error codes (DTCs) are stored.

- The condition of the loggings.

B. Malfunction Indicator Light

The instrument panel will illuminate a warning light when there is a malfunction. (Lyons, 2015).

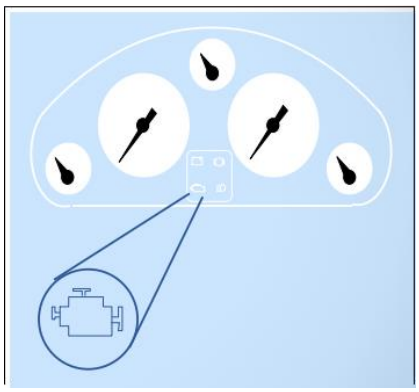


Figure 1. Malfunction Indicator Light (MIL)

C. Bluetooth OBD 2 Scanner

It is necessary to have a thorough knowledge of the OBD2 protocols and convert them to the standard PC serial data. While OBD-II is more practical for our current conditions, we could implement Bluetooth PDLS in the future. Only approved protocols for Bluetooth OBD-II readers can be used with Bluetooth OBD-II Scanners. Moreover, the wireless OBD-II scanner requires no wires, nor does it need batteries.

Figure 2: Bluetooth OBD 2 Scanner

D. Proposed System

While the repairing task, the client has to go to the service center, and after the repair technician needs to connect the On-Board Diagnostics II (OBDII) scan tool and find the problem. As discussed earlier, the client has to wait sometime to repair his/her vehicle. It is a time consume work. Generally, in the service center, the technician uses an OBD II scanner to find the diagnostic in the vehicle, but that diagnostic scanner is not needed here. Already plugged in, the scanner will send the diagnostic data to the mobile, and the installed mobile app will send the diagnostic data to the server. The Bluetooth OBD II scanner has to plug into OBD II port to read all of the vehicles' diagnostic code detail and send the data to the mobile application. If the internet is available, the mobile application will send those diagnostic codes to the server. If not, the application will send the data to the server once it gets the internet.

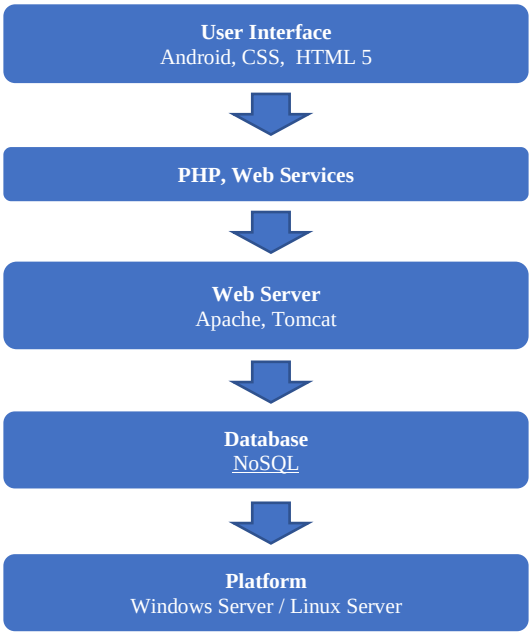


Figure 3: Technology Stack for the proposed system

The technology infrastructure illustrated in figure 3 encompasses the processes of AI development and deployment. The server will connect to the mobile application through the internet, and once the server gets diagnostic data from the mobile application, it will start responding to that request. When the server receives the diagnostic data, it will analyze the diagnostic level. The server will access the mobile devices' Global Positioning System (GPS). The server will search the nearest service center to fix the issue using the mobile device's GPS. If it finds the nearest service center, the server will send the diagnostic data to that Service Center and request time availability. Once it sent the data to the service center also alerts the user. The server will send a request about the malfunction and notify the user.

Once the server sends the request to the user, the mobile application will convey that to the user. For the user, the application will show the malfunction detail category-wise. There are two types of categories here it will mention.

- Critical
- Intermediate

Critical kinds of malfunctions have to repair immediately. The server will automatically send a request to the service center for these kinds of malfunctions and get an appointment to repair the vehicle. The server will mention to the technician that "critical issue need to repair immediately". Then the user just has to go to the service center. And it will display the maximum suitable time to fix this. Users can request another convenient time from the appointed service center once the user cannot reach the service center at the correct time. This user has to pay an additional mobile charge.

For the intermediate kinds of malfunction, the server will automatically send a request to the service center and ask for an appointment to repair the vehicle. But, nothing will be mentioned, and the user can cancel the appointment. The technician can give the appointment for repair depend on the malfunction. If it is a critical malfunction, the technician has to provide the most recent suitable time. If he doesn't have the time, he can cancel the order or transfer to another service center. When the server does not respond to the requested technician, the server will request another service center.

E. The tools and technology suggested for developing the proposed system

If you want to run more than one NoSQL instance for different purposes, use an open-source like Cassandra to serve multiple databases. Apache web server: Apache on top of a Windows server to provide websites, databases, and business applications. Like UNIX, Linux is a Unix-like operating system that Like UNIX, Linux is a Unix-like operating system available under open source and free software development. A software operating system designed for handheld devices such as tablets and smartphones runs Google's Android OS. The software was developed by the Open Alliance, a group of Google developers. Android app development is helped along by a group of specialized software development kits (SDKs). An HTML was the world's first software language for the Web; it provides a standard way to structurally and presentational lay out and present web content. PHP was originally developed for web development and is still very useful for it today. If you use this script to design your mark-up document, you'll have to describe the presentation semantics in a second script called cascading style sheets. (Desai and Kallaganiger, 2013).

A figure to illustrate the overall architecture of the AI-Based Service Center is shown in the above diagram. The technology stack, user profiles, and means for accessing the application are all aspects of the solution. Explanations of these aspects are covered in depth in the following. This system contains mainly three actors that use AI in their services.

- Administrator
- User
- Service center

A native Android Service Center app will be employed by the user and service center to improve user satisfaction by providing direct access to application settings and features. The data from OBDII will be acquired by using Bluetooth by Service Center Application.

The Service Center system has five main subsystems, and they are 1. Admin Subsystem, 2. User Subsystem, 3. Service Center Subsystem, 4. OBD 2 Code Reader, 5. Core Logic Subsystem. And the Administrator will have the following functionalities: Admin can update/delete the information about the user and service center, the admin will have also handled the escalation mechanism, admin can record the feedbacks given by the user and service center, and admin can update/delete OBD 2 readings.

At the same time, the user will have the following functionalities: Users can view the malfunction detail about the vehicle, cancel the appointment of the service center, view the service center location via Service center application, apply for additional appointments for other services, will get the appointment details by the service center from Service center application, view the distance and route path from his/her current location to the destination and view the repair cost with additional service charges.

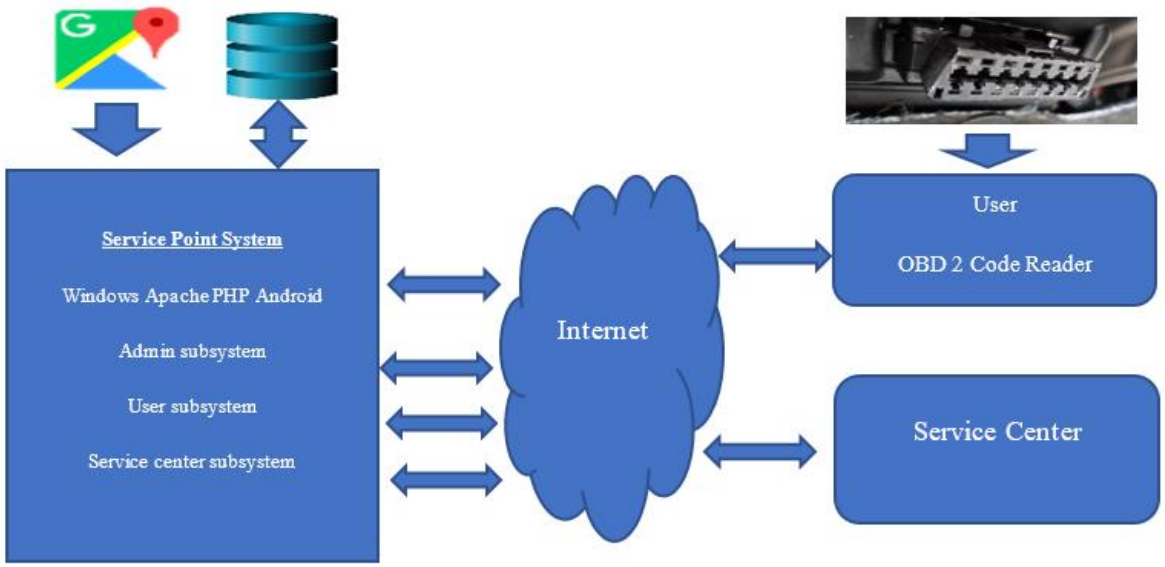


Figure 4: The Architecture of the proposed system.

The service center will have the following functionalities: Giving an appointment for the user, cancel the appointment, can view the malfunction detail, and can view the distance and route path from the service center location. And the OBD 2 Code Reader responsibilities such that, Read the code coming from the OBD 2 scanner and identify the malfunction and categorize the malfunction.

Finally, the Core logic subsystems are responsible for all the operations in the system. It handles all the requests from the clients. It works on IIS / Apache webserver, has all the web services needed to serve client requests, is implemented using PHP, receives data from the database, and sends it to the client. In addition, the system has the functionality to manually find the nearest Service Center and make an appointment. Users can get to know their vehicle's condition at any time.

IV. CONCLUSION

A system presented in this paper has full functionality with a single need concept of Service Center according to the current scenario of common vehicle errors. This system will help the people who do not have the time to maintain their vehicles. Significantly, the women can get full of help from this system. The suggested system is built using freely available tools and techniques. The proposed system may upgrade with new features such as fuelling, medical emergency, and self-defense in the future.

REFERENCES

Bánhelyi, B. and Szabó, T. (2020) 'Data mining and analysis for data from vehicles based on the OBDII standard', *CEUR Workshop Proceedings*, 2650, pp. 30–37.

Khorsravinia, K. *et al.* (2017) 'Integrated OBD-II and mobile application for electric vehicle (EV) monitoring system', *Proceedings - 2017 IEEE 2nd International Conference on Automatic Control and Intelligent Systems, I2CACIS 2017*, 2017-Decem(October), pp. 202–206. doi: 10.1109/I2CACIS.2017.8239058.

Kowalik, B. (2018) 'Introduction to car failure detection system based on diagnostic interface', *2018 International Interdisciplinary PhD Workshop, IIPhDW 2018*. IEEE, pp. 4–7. doi: 10.1109/IIPHDW.2018.8388233.

Lin, C. E. *et al.* (2005) 'Development of on-line diagnostics and real time early warning system for vehicles', *Proceedings of the ISA/IEEE 2005 Sensors for Industry Conference, Sicon'05*, (February), pp. 45–51. doi: 10.1109/SICON.2005.257868.

Lyons, A. (2015) 'On-Board Diagnostics (OBD) Program Overview', (April), pp. 1–43.

Moniaga, J. V. *et al.* (2018) 'Diagnostics vehicle's condition using obd-ii and raspberry pi technology: Study literature', *Journal of Physics: Conference Series*, 978(1). doi: 10.1088/1742-6596/978/1/012011.

Shafi, U. *et al.* (2018) 'Vehicle remote health monitoring and prognostic maintenance system', *Journal of Advanced Transportation*, 2018. doi: 10.1155/2018/8061514.

Singh, S. K., Singh, A. K. and Sharma, A. (2021) 'OBD - II based intelligent vehicular diagnostic system using iot', *CEUR Workshop Proceedings*, 2786, pp. 511–515.

World Vehicle Population Rose 4.6% in 2016 :: Wards Intelligence (no date). Available at: https://wardsintelligence.informa.com/WI058630/World-Vehicle-Population-Rose-46-in-2016 (Accessed: 6 May 2021).

Automated Software Testing and Tool Selection: Case Study Based on Security Testing of Popular E-commerce Applications in Malaysia

M.M.F. Naja[1*], A.R.F. Shafana[2] & A.F. Musfira[3]

[1]*Department of Software Engineering, Universiti Malaya, Malaysia*
[2]*Department of Information and Communication Technologies, Asian Institute of Technology, Thailand*
[3]*School of Multimedia Technology and Communication, Universiti Utara Malaysia, Malaysia*
[1,2,3]*Department of Information and Communication Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*]mmfnaja@seu.ac.lk, [2]arfshafana@seu.ac.lk, [3]ameermusfi@seu.ac.lk

Abstract- *Advancements in software engineering and software development processes have paved the way for the introduction of new processes and the use of advanced tools for these processes. Automation of software processes and the use of automated tools have gained popularity in the recent past. Thus, the use of automated tools for software testing in ensuring the quality of a software system or application has also found a reach in recent times. Although the importance of these tools has been studied by various researchers in the field, a lack of knowledge on the selection of tools among the practitioners is a challenge. It is because of the availability of an abundant number of tools and the absence of clarity about the tools. Hence this study primarily focuses on investigating the automated tools while trying to identify the better tools for security testing of applications or systems. For this purpose, five e-commerce applications that are popular in Malaysia have been chosen. Also, five tools identified after a thorough study on the tools available for executing automated testing have been used to identify the best tool out of the chosen ones. Although the research work involves studying e-commerce applications available in Malaysia, this research at no instance intends to analyse the applications, rather the tools only.*

Keywords: Software Automation, Test Automation, E-commerce Security, Software Quality, Automated Testing Tools

I. INTRODUCTION

Software Testing is considered as one of the important phases in any software development used to ensure the quality of a software product. In every software development lifecycle (SDLC), the software testing phase is given importance. At the same time, it is said that 50% of the total software development cost is spent on the software testing phase (Gao et al., 2014). While this is being an important note regarding software testing, the emergence of automation practices has paved a way to reduce this cost. Although automation is applied in every phase of SDLC, it has been said that automation in software testing has gained more attention (Hooda and Singh Chhillar, 2015) due to the advantages it thus provides. Apart from that, automation in software testing tends to make the testing process effective while reducing the total cost spent on testing. While talking about software testing, it is mainly about quality assurance.

A number of testing techniques and tools are available which could be used to ensure the quality of a product. But the wise choice in the selection of those testing tools is crucial (Raulamo-Jurvanen, 2017). And when it comes to software like e-commerce and banking, it is mandatory to secure the whole transaction. With that in mind, this study focuses on investigating the importance of security testing, which is one type of testing, and analyze the existing automated tools used in software testing. This research involves performing automated security testing on five well-known e-commerce website widely used in Malaysia for online shopping. After thorough research on automated tools based on security testing, different automated tools have been chosen to test the selected e-commerce sites which affect the ranking of such e-commerce websites. To analyze the existing automated software tools and the importance of selecting the tools, few well-known e-commerce websites, namely, Lazada, Shopee, Lelong, 11Street, and Mudah, have been chosen. Since the websites are all well established, the purpose is not to primarily analyze them but to analyze the tools based on the experience of the websites used, i.e., to check if the analysis of the tools matches the already acquired experience of the users of the websites. In the article, it has been mentioned which website is better for a particular tool, and such information

was only used to analyze the tool itself, not the website.

This research work is intended on analysing the automated testing tools only. This is under no circumstances intended to criticize any e-commerce websites that have been tested using the tools under observation. The opinions expressed are in good faith and while every care has been taken in preparing this article, the authors of this report make no representations and give no warranties of whatever nature in respect of this article, including but not limited to the accuracy or completeness of any information, facts and/or opinions contained therein. The opinions are based on the results obtained only during the testing duration, which may vary with time due to many reasons like change/upgrade of websites used for analyzing the tools, the tools used for testing analysis, etc. sections of this paper.

II. RELATED WORKS AND EXISTING LITERATURE

Although the concept of automated testing and tools used for this have been studied by previous researchers, the realization of which tool could best suit our purpose is still a question. Also, the concept of security testing is vital these days and recent researches on this further proves this. In the work by Pan (2019) on investigating interactive application security testing, he highlights the importance of security testing. Moreover, while we have a look at the work by Alhawi and his co-authors (Alhawi, Akinbi, and Dehghantanha, 2019) on investigating security testing approaches in IoT applications, it highlights that the security testing concept is given importance for a range of applications not only just desktop and web applications only. Considering this importance, the study focus is given to security testing. Apart from this, many existing studies have focused on analyzing e-commerce applications to analyze their usability. Although usability and testing are two different topics, software testing to ensure quality products shall indeed impact the usability of the product. In that way, many existing studies (Hussain et al., 2019; Hussain et al., 2017) have focused on analyzing usability while taking the scope to e-commerce applications. Hence, the scope of this study is chosen to be e-commerce applications. This section of the article discusses few concepts and key terms related to the topic by highlighting the facts discussed in the existing literature.

A. Software Test Automation

The concept of software testing and automation has been a topic of research for a long period. The development in the particular field is yet growing with the introduction of new concepts and practices in the software development industries and software engineering field. Thus, the recent developments in software engineering practices have brought up the concept of automation in almost all the phases of the software development lifecycle (SDLC). As of that the use of automated tools in software engineering and especially in software testing.

In every test activity, it is always essential to find out why an approach is selected. Since software testing is one of the major phases in any software development, it is labor-intensive and expensive. According to the literature, it is stated that testing takes up to 50% of the total cost of any software development. It is sometimes even more than that, according to some literature (Gao et al., 2014). As this is the fact regarding testing cost, it is essential to manage it and that is the main goal of automation testing. Another importance of automation testing, according to literature is, minimizing human error (Jensen, Prasad and Møller, 2013). Mistakes made by human beings become errors that tend to become faults and failures. Another advantage of automated testing is making regression testing easier (Jensen, Prasad and Møller, 2013), meaning that when automation testing is executed to find the errors in any software testing, it makes the process of finding any consequences of any patch works done during a bug fix. Thus, this will ease the problem of overcoming any possible future errors caused by a bug fix. Though these facts highlight the point that automated testing has proven to be a better option for testing, the adoption of automation testing isautomation testing still seems to be challenging due to some prevailing challenges in adopting automated testing tools in software engineering project development.

B. E-commerce and Software Testing

E-commerce is a rapidly growing technology for online shopping and certain online shopping outlets have gained popularity (Hussain et al., 2017). With the exponential increase in such business and the ever-growing demands from customers, the importance of having high high-quality websites also rises; as of this, the importance of enhancing the quality. This is highlighted by Chan et al., as the privacy risk has

a relationship with the purchase intention of the users (Chan et al., 2018). Thus, proper testing of the websites becomes mandatory to ensure their reliable, robust, and high-performing operation. This is the main reason behind the choice of e-commerce application for this case study and since security testing is chosen as the type of testing.

C. *Security Testing*

Security testing is one of the types of software testing executed to ensure that the system or application that is being tested is free of threats or risks or even vulnerabilities that may cause any losses. Security testing is about identifying any possible loopholes and weaknesses of any application that may result in any possible loss of data or confidential information or the information being accessed by any unauthorized party (Mahendra and Muqeem, 2018 The main aim of this testing is meant to find out the threats and investigate the consequences of any potential vulnerabilities that may stop the application from malfunctioning or stop functioning. This also aids in detecting the possible risks and helps to fix them with security features to avoid any negative consequences that may affect the application or system in the future. This is also helpful in implementing all the possible security features to protect the application. Unlike the other testing like the functional test, which is used to prove that a certain function exists and complies with the specification, security testing ensures that certain behavior is not in the application, including reasonably complex testing procedures (Malek et al., 2012). Though, this testing is important to avoid future problems of unauthorized access. As this is the concept behind security testing, to achieve one of the objectives of this study which is to investigate the right tool in testing, security testing is chosen as it is one of the most important types of testing that should always be considered.

III. METHODOLOGY

Intending to investigate the importance of security testing and the selection of automated tools for security testing, this study adopts an approach of performing security testing on certain selected web applications with certain tools selected for testing. This process is performed in a step-by-step manner, starting from tools selection e-commerce application identification to writing test plans up to reporting the results. Key steps in the methodology adopted are selecting the automated tools for testing, identifying e-commerce applications for testing, executing testing, interpreting the results, and comparing them. Further elaborations on the key steps are discussed as follows.

A. Selection of automated Tools for Security Testing

This involves the selection of appropriate tools from a list of tools available. Although there are many tools available for use in online and offline mode providing several facilities to carry out the intended testing, it is hard to choose all and impractical to analyze all of them in practice. The identified tools were screened based on their relevancy of provided features, tool availability as open-source, and recommendation of experts. Figure 01 further depicts the processes involved in this stage.

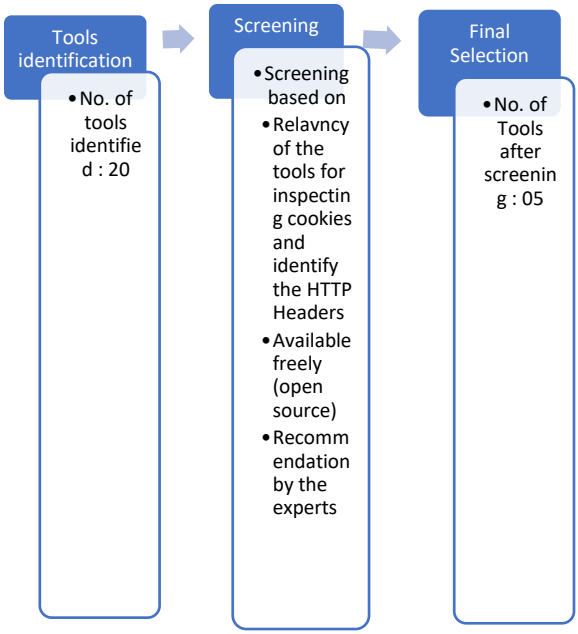


Figure 01: Selection process of automated tools for testing

B. *Selection of E-commerce Application*

For this study, e-commerce applications available in Malaysia are chosen. Though there is a considerable list of applications, only five is chosen as the scope of the study is intended to be with a limited number of applications. Hence, the choice of application is based on the popularity of the application among Malaysian. Details on this process is depicted in figure 02 as follows.

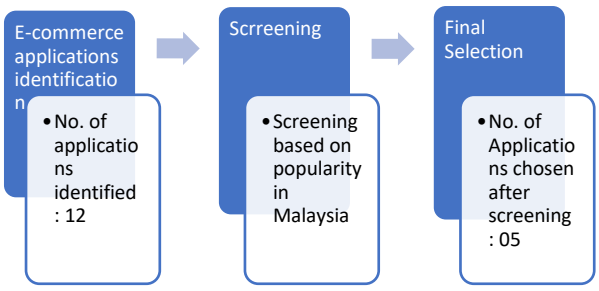


Figure 02: Selection of e-commerce applications for testing

C. *Test Planning and Execution*

At this phase of test planning and execution, the actual testing is performed. The main purpose of creating a test plan is to have a systematic plan logically to test the selected e-commerce websites. Test planning includes the test case preparation and documentation, and the test execution includes performing the test on the selected e-commerce application with the identified test automation tools. Table AA provides a test case description table including all the tests carried out for the study.

Table 01: The sample test case

Test Case ID	Tool_WebApplicationName (Eg: OWASPZAP_Lazada)
Tester	Researchers A, B, and C
Test Purpose	1. To check if the website contains essential security headers. 2. To inspect cookies
Test Procedures	1. Launch the tool. 2. Execute the testing by creating a session for each new session. 3. Interpret the results and analysis. 4. Close each session.
Test Data	URL of the website to be tested: URLs of the selected e-commerce application
Tool Used	OWASP ZAP 2.7.0, Security Header (Online Tool), ImmuniWeb (Online Tool), Sucuri (Online Tool), Pentest tool
Expected Results	To list the missing essential security headers To inspect the cookies
Actual Results	Lists the missing essential security headers and inspects cookies and provides results report for each test case executed
Status	Success

Totally 25 test cases were written. However, a summary of the sample is given in table 01. In the table, the test case ID is denoted with the tool name and the application name. For example, OWASPZAp_ Lazada denotes the test case for testing Lazada's e-commerce application with the OWASPZAP tool. Likewise the rest 24 tests were carried out for the elected five e-commerce applications with selected five tools (05*05=25 Test cases in total).

D. *Results Interpretation and Comparison for Analysis*

After executing the software testing on selected e-commerce applications with the chosen tools, the results produced by the tools were analyzed and the results were compared. Further recommendations and suggestions given in the conclusion section was also based on the results of this step

IV. RESULTS AND DISCUSSION

As discussed in the methodology section of this article, to achieve the objectives of the study, automated software testing was executed on selected e-commerce applications and the results are analyzed in the following sub-sections of this section. Two main security principles have been mainly identified and checked if the tested e-commerce applications comply with the standards and implement the security features.. Although the study focuses on security testing and there are many sub-testing under that, only the availability of HTTP security headers and cookies inspection has been studied during the testing. The main reason for this is that applications selected as the case study for this study are already hosted applications and the primary source code is not available for the public. Therefore, another security feature like penetration testing isn't possible within the scope of the study.

The detailed summary of the testing executed in the selected e-commerce application is discussed as follows. The results are discussed based on the tools used.

A. ImmuniWeb

ImmuniWeb was chosen as one of the tools for security testing for the study. According to the results, this tool is proven to be one of the best tools for security testing as the tool produces a detailed report on the results. This tool provides detail of available HTTP security headers and also inspects the cookies in the application being tested. Apart from that, this tool also produces a summary of the test output and a grade given to the tested application, which implies the level of the application's quality based on the testing it carries out. Detailed reports produced by the tool are tabulated and given in table 02, table 03, and table 04, and figure 03. The detailed test results of all the e-commerce applications selected for this study are given in one shot in the following tables and figures.

Table 02: Summary of available headers in each website listed by ImuniWeb

Security Headers	**Lazada**	**Shopee**	**11street**	**Mudah**	**Lelong**
Strict-Transport-Security	v	v	v	v	v
X-Frame-Options	v	v	v	v	v
X-XSS-Protection	v	v	v	v	v
X-Content-Type-Options	v	v	v	v	v
Expect-CT Feature-Policy	v	v	v	v	v

Table 03: Summary of cookies inspection by ImmuniWeb

Cookie	**Lazada**	**Shopee**	**11street**	**Mudah**	**Lelong**
COOKIE: BROWSERID	-	-	-	-	v
COOKIE:__REQUESTVERIFICATIONTOKEN	-	-	-	-	v
COOKIE: THW	v	-	-		-

Table 04: Summary of test outputs produced by ImmuniWeb

Security Analysis	**Lazada**	**Shopee**	**11street**	**Mudah**	**Lelong**
CMS Security Analysis (No of Issues found)	FAILED	None	None	3	None
GDPR Security Analysis (No of Issues found)	2	1	None	None	1
PCI DSS Security Analysis (No of Issues found)	3	1	None	1	None
HTTP Headers Security Analysis (No of Issues found)	6	6	8	5	5
Content Security Policy Security Analysis (If available)	Missing	Missing	Missing	Missing	Missing
Overall Score	F	C	C	C	C+

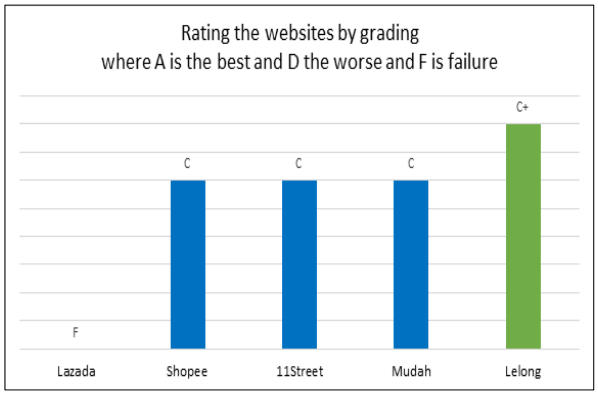


Figure 03: Graph of the analyzed results based on grading by ImmuniWeb

The summary of the test outputs produced by the ImmuniWeb tool is very comprehensive compared to the results produced by other selected tools used here. This is very useful for the developer community to identify the possible doors of penetration and secure them by implementing the security mechanisms that may stop this. Apart from that, the cookies inspection report produced by this tool is also very useful and important when it comes to ensuring the quality and confidentiality of the application users.

B. Security Header

SecurityHeader is yet another tool selected for the study and as implied by the name, this particular tool only produces the list of available HTTP headers and highlights the common HTTP headers which are missing. Apart from this, the tool also rates the application being tested and produces a rating based on grades and this rating seems to be based on the available and missing HTTP headers only. A detailed summary of the results produced by this tool is given in table 05 and figure 04.

Table 05: Summary of the test results produced by Security Header

HTTP Security Headers	**Lazada**	**Shopee**	**11street**	**Mudah**	**Lelong**
Strict Transport Security	V	-	-	V	V
Content-Security-Policy	-	-	-	-	-
X-Frame-Options	-	-	-	-	-
X-XSS-Protection	-	-	-	-	-
X-Content-Type-Options	-	-	-	-	-
Referrer-Policy	-	-	-	-	-
Feature-Policy	-	-	-	-	-
Overall Summary	D	F	F	D	D

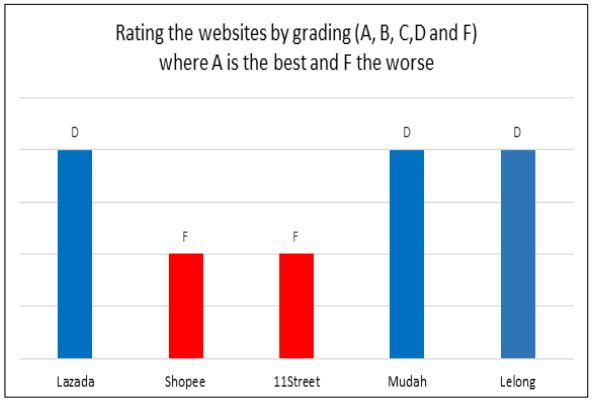


Figure 04: Graph of the analyzed results based on grading by SecurityHeader

C. Sucuri

Sucuri tool also lists the available HTTP headers only and it doesn't even report anything on the important HTTP headers that are missing. Thus, this tool is ought to be less comprehensive compared to all other tools used in the study. The results produced by Sucuri are given in table 06 and figure 05. Figure 05 is the analyzed summary of the rating given by the tool. The rating is based on the risk level analyzed by the tool. Although the detail on how the risk is calculated is not given in the results, it seems it is calculated based on the available HTTP headers as the tool only provides that result.

Table 06: Test results summary by Sucuri

Security Headers	**Lazada**	**Shopee**	**11street**	**Mudah**	**Lelong**
XSS Protection	v	v	v	v	-
Content Type sniffing.	v	v	v	v	-
Strict-Transport-Security security header	-	v	v	v	-
Risk Rate	Low	Low	Low	Mediu	Critical

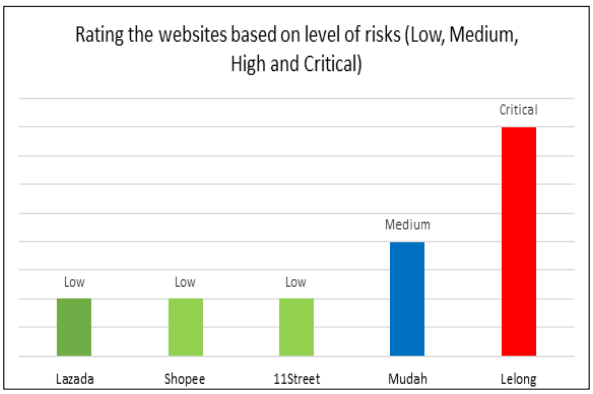


Figure 05: Analyzed results based on level of risk by Sucuri

D. *OWASP ZAP Tool*

The desktop version of the tool was used in the study. Although the tool was chosen for the study based on the recommendation given by the experts in the software testing field, the tool is ought to be complicated compared to the other tools selected for the study. Though, it has a standard user manual to guide the tester. This tool again provides a summary of the available HTTP security headers and inspects the cookies as well. Unlike the other web application tools, this tool does not rate any application and rather provides the test results only The detailed results produced by the tool while executing secrutiy testing are discussed in tables 07 and 08. According to table 8, the tool produces the cookies inspection results of Cookie Without Secure Flag and Cookie No HttpOnly Flag. The tool also gives a detailed description of the important HTTP headers and the solutions for missing headers. Since the tool provides detail of suggestions for missing important HTTP headers, this tool is one of the best tools used in the study. This could be a suggested tool for anyone who performs security testing. This recommendation is based on the experience of the researchers while using this tool for the study.

Table 07: Summary of available headers in each website by OWASP ZAP tool

Security Headers (Included/Missing)	Lazada	Shopee	11street	Mudah	Lelong
X-Frame-Options Header Not Set	V	V	V	-	V
Cross-Domain JavaScript Source File Inclusion	V	V	V	V	-
Web Browser XSS Protection Not Enabled	V	V	V	V	V
X-Content-Type-Options Header Missing	V	V	V	V	V

Table 08: Summary of cookies inspection in each website by OWASP ZAP tool

Cookies	Lazada	Shopee	11street	Mudah	Lelong
Cookie Without Secure Flag	V	-	-	-	-
Cookie No HttpOnly Flag	V	V	-	-	V

E. *PenTest tool*

PenTest tool was another tool selected for the study and this tool, like all other tools chosen for the study, provides detail on the HTPP security headers on the application being tested. The results of that are analyzed and given in Table 09. Apart from this, this tool also gives a detailed description of cookies inspection as analyzed and given in table 10 and a rating for the application being tested. It is given as a graph in figure 06 that plots the rating of all the e-commerce applications used in the study. According to the results, the rating given to the tested applications is primarily based on cookies inspection.

Table 09: Summary of Available Headers in Each Website provided by PenTest Tool

HTTP Security Header	Lazada	Shopee	11street	Mudah	lelong
X-Frame-Options	V	V	V	-	-
X-XSS-Protection	V	V	V	V	V
Strict-Transport-Security	-	V	V	V	V
X-Content-Type-Options	V	V	V	V	V

Table 10: Summary of cookies inspection in each website provided by PenTest tool

Insecure HTTP Cookies	Lazada	Shopee	11street	Mudah	Lelong
__RequestVerificationToken	-	-	-	-	V
BrowserID	-	-	-	-	V
SPC_F	-	V	-	-	-
SPC_T_ID	-	V	-	-	-
REC_T_ID	-	V	-	-	-
SPC_EC	-	V	-	-	-

SPC_U	-	V	-	-	-
SPC_IA	-	V	-	-	-
SPC_T_IV	-	V	-	-	-

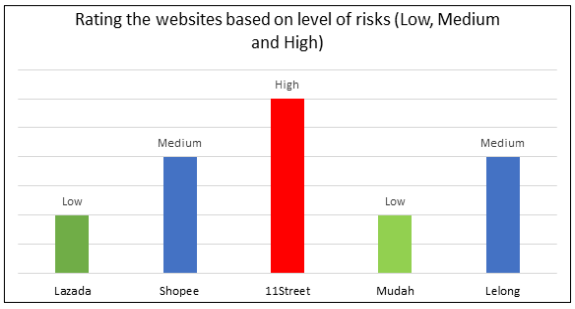


Figure 06: Summary of cookies inspection in each website by Pentest tool

V. CONCLUSION

The results of the security testing carried out using various tools have proven that the selection of automated tools for testing is a tedious task. One of the important facts noted based on the results is which tool is comparatively better based on which criteria. Accordingly, some of the recommendations are derived from the study. It is based on the experience of the researchers while using the tool for the study and results produced by the tools and features supported by the particular tool. Accordingly, the OWSAP ZAP tool wins the race to be the topmost best tool for security testing according to the detailed results produced by the tool. Although the tool is a little complicated to be handled, the technical guidance document of the tool makes this easy. Other than that, the PenTest tool is also considered a wise choice of the tool as it also produces comprehensive cookies inspection results. Since all the tools selected for the study produce a report on the HTTP security headers, the tools are not compared.

Apart from the analysis of the automated security tools, since the study adopts a case study-based investigation and e-commerce applications popular in Malaysia have been chosen for the study, the study results are also useful in identifying the security features implemented in the selected applications. The results of this study hence highlight the quality of the e-commerce applications studied here. Although the main objective of the study is not to rate the applications chosen for the study, the results still pave the way to know about the selected e-commerce applications as well.

Based on investigating automated security testing and proper selection of tools for that, there have been a few realizations by the researchers while carrying out this study and after completing this research. As seen from the results produced by various tools, it is pronounced that one tool is not good enough to test an application/ system. Not much documentation is there to guide through the usage of a particular automated tool or test, which is a trouble for the practitioners. This was based on the experience of the researchers while using the tools chosen for the study. Hence, effective documentation by testers, including their real-life experience of factors affecting a certain tool, for example, can be of great use for future testers.

Apart from this, the results produced by the tools have awakened how well these security features could be implemented to highly secure the applications. The results of the study also highlight the quality of existing e-commerce applications which are popular in Malaysia. Also, this research work paves the way for future research on investigating the suitability of available automated tools for testing software applications or systems for other parameters like performance, functionality, and accessibility.

REFERENCES

Alhawi, O., Akinbi, A. and Dehghantanha, A., 2019. Evaluation and Application of Two Fuzzing Approaches for Security Testing of IoT Applications. *Handbook of Big Data and IoT Security*, pp.301-327.

Chan, S., Ahmad, M., Zaman, I., Omar, S., Ramlan, R. and Tam, C., 2018. Privacy perceptions of online shopping behaviour amongst Malaysian Lazada online shoppers.

Gao, J., Bai, X., Tsai, W. and Uehara, T., 2014. Mobile Application Testing: A Tutorial. *Computer*, 47(2), pp.46-55.

Hooda, I. and Singh Chhillar, R., 2015. Software Test Process, Testing Types and Techniques. *International Journal of Computer Applications*, 111(13), pp.10-14.

Hussain, A., Mkpojiogu, E., Abubakar, H. and Hassan, H., 2019. A Mobile Usability Test Assessment of an Online Shopping Application. Journal of Computational and Theoretical Nanoscience, 16(5), pp.2511-2516.

Hussain, A., Mkpojiogu, E., Jamaludin, N. and Moh, S., 2017. A usability evaluation of Lazada mobile application.

Jensen, C., Prasad, M. and Møller, A., 2013. Automated testing with targeted event sequence generation. *Proceedings of the 2013 International Symposium on Software Testing and Analysis*,.

Mahendra, N. and Muqeem, M., 2018. An Approach for the Inception of Security Testing in the Early Stages of Software Development. *2018 International Conference on Computational and C*Malek, S., Esfahani, N., Kacem, T., Mahmood, R., Mirzaei, N. and Stavrou, A., 2012. A Framework for Automated Security Testing of Android Applications on the Cloud. *2012 IEEE Sixth International Conference on Software Security and Reliability Companion,.haracterization Techniques in Engineering & Sciences (CCTES)*.

Pan, Y., 2019. Interactive Application Security Testing. *2019 International Conference on Smart Grid and Electrical Automation (ICSGEA),*.

Raulamo-Jurvanen, P., 2017. Decision Support for Selecting Tools for Software Test Automation. ACM SIGSOFT Software Engineering Notes, 41(6), pp.1-5.

Users' Perception Towards the Usage of 'Athan' App in Sri Lanka through the Lens of the Technology Acceptance Model (TAM)

A.F. Musfira[1*], M.M.F. Naja[2] & A.R.F. Shafana[3]

[1]*School of Multimedia Technology and Communication, Universiti Utara Malaysia, Malaysia*
[2] *Department of Software Engineering, Universiti Malaya, Malaysia*
[3]*Department of Information and Communication Technologies, Asian Institute of Technology, Thailand*
[1,2,3]*Department of Information and Communication Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*] ameermusfi@seu.ac.lk, [2]mmfnaja@seu.ac.lk, [3]arfshafana@seu.ac.lk

Abstract- *The use of Islamic religious mobile apps has become common in the digital era, where various Islamic apps to enhance the life of a Muslim is widely used all over the world. Among the used applications, "Athan" is one of the well-known apps used by 5 million Muslims globally. A study to identify the opinion and perception of the users is essential in many aspects. Hence this paper identifies the perceived usefulness and perceived ease of use of the "Athan" mobile app. A quantitative survey has been administered through the lens of the Technology Acceptance Model as the framework for the study. The study reveals that the "Athan" app users are positive towards the usefulness of the application, and it has not been impacted by the respondents' socio-demographic diversity.*

Keywords: "Athan" Mobile Application, Perceived usefulness, Perceived Ease of Use, Technology Acceptance Model, Islamic Mobile Applications

I. INTRODUCTION

Information and communication systems dominate today's world. One of the main features which dominate the world is the exponential growth of mobile applications. At this point, apps are an integral part of our daily lives. The marketplace is crowded with all types of mobile apps. Every business that never would have needed mobile apps in the past era is getting into the game itself. While specific cohorts are doing their best to stay ahead of the technological curve, many simply admit people's need and demand for an app that makes their lives easier.

The number of users of mobile applications is increasing rapidly year to year. Mobile usage in the world is increasing 58% year to year. In Sri Lanka, it is in rapid growth with the increase of Smart Phone usage in adjacent years. Users spend 90 % of their time in mobile apps than mobile web. Users download on average 8.8 apps per month with app installs up to 5% year over year (Mobile App Development | Mobile Applications | Android App | iOS App | Sri Lanka, 2021). The number of mobile connections in Sri Lanka increased by 2.2 million (+7.5%) between January 2019 and January 2020 (DataReportal, 2021). The statistic depicts the number of mobile-cellular subscriptions in Sri Lanka from 2000 to 2019. In 2019, the number of mobile subscriptions in Sri Lanka was 30.78 million from 0.43 in 2000 (O'Dea, 2021). This statistic shows the estimated number of smartphone users in Sri Lanka from 2010 to 2025. The number of smartphone users is projected to reach 9.1 million by 2025 (Degenhard, 2021). The number of mobile connections in Sri Lanka in January 2020 was equivalent to 149% (Simon.K,2020). The above statistics clearly show the achieved and growing popularity of mobile apps in Sri Lanka.

Different mobile apps are used for different purposes. Mobile apps can be categorized into different categories such as Lifestyle mobile apps, which are used to enhance the users (Ex: Spotify, TripAdvisor, Uber), Social media apps which are used to build one social network (Facebook, Instagram, Snapseed), Utility Mobile apps which are used often without thinking about them as apps indeed. (Ex, Reminders, Calculator, Whether), Games or Entertainment apps (Angry Birds, Clash of Clans, Candy Crush Saga), Productivity mobile apps which are used to help their users to accomplish a task quickly and efficiently (Docs, Wallet, Evernote), News /Information outlet apps that supply their users with the news and information they are looking for in an easy-to-understand layout. (Ex. Buzz Feed, Yahoo News digest) (Duckma, 2021).

Technology, when used efficiently, can help to lead an effective and efficient life. In that line, technology can help people in religious affairs as well. In that line, many apps exist in the market

which can help Muslims get closer to Allah. There are many apps today that help Muslims in their daily life to regularize their daily Islamic rituals. Such as One path network, Muslim Pro, Athan, Never Miss Fajr, Quran Companion, iQuran, and more. Among all these apps, one app was so popular that the MuslimPro has around 98 million users worldwide. This app was high in success, and many Muslims got used to it. However, Muslims looked for other similar apps after a news spread that said that Muslim Pro sells the user data to the US military (Aliya, 2020, Aljazeera, 2020). Therefore, people have started to use another app similar to the MuslimPro called "Athan" recently.

When an app is developed with new features inclusive of new technological icons, a need to study the apps from different perspectives. Such as to what extent the app has made an impact on the users, to what extent the user interface has been appreciated by the users, to what level the audience has accepted the technology, how the usability is achieved in terms of the factors like screen resolution, hardware limitations, data usage, connectivity issues and level of interaction and more. Hence this research aims to study the level of perception of the "Athan" app through the lens of the Technology Acceptance Model (TAM).

II. LITERATURE REVIEW

Curiosity in techno-spiritual habits (Bell, 2006) has arisen with the appreciation that technology has been used across the globe to endorse a range of spiritual activities. For instance, Catholics receive Pope's daily thoughts via SMS, Orthodox Jews use "kosher phones," and Protestant Christians download carols as ringtones (Bell, 2006). There are an estimated 1.9 billion Muslims live worldwide (Worldpopulationreview,2021). Muslims have historically been relied on technology to aid their religious practices. For example, Muslims developed compasses to determine Qiblah's direction and developed and telescopes to watch the sun's locations for daily prayer and more. Hence adapting to mobile technology is highly feasible and can enhance the Islamic religious lifestyle of a Muslim

A. Brief Introduction To The Prayers And Other Daily Rituals Of A Muslim

Muslims differ broadly in terms of their traditions and daily religious rituals. Praying the god "Allah" five times a day is compulsory for every adult and child older than ten years in the Muslim community. The time for the prayer varies from place to place and even from day to day. The ritual begins with adhan the call to prayer. Following the call, Muslims perform "Wudhu," washing parts of their body, and perform two to four ritual cycles called raka'ahs while facing the qibla, or Mecca's direction. Other than that, Muslims recite different Arabic verses called "Dua" or" Dhikr" or "Azkar" on different occasions daily. Furthermore, reciting the Holy Quran is a common practice in Islam. Hence having a technological aid to perform these rituals reminds the time for the prayer, reminding the user to recite Quran or Dua, and more can be beneficial to the community.

B. Islamic Mobile Applications

In the digital era, every portion of our lives has become handy. Almost all of our daily activity has been transferred from the conventional approach to the smart approach accomplished handy smart digital gadgets that are the smartphone to access whatever they want in few clicks being at the same place. In that line, millions of Muslims are using smart devices to recite Quran and other spiritual material using mobile applications. According to Shameera and Nadhira (2017), there exist more than 450 religious applications inclusive of 190 Islamic religion-related applications. (Shameera and Shiby, 2017) revealed in their study that nearly 80% of Muslim people had used several technologies for aiding in Qur'an memorization and recitation.

A study was done by Hafizah and Ruslan (2016) under the topic of "a study of the Malaysian youth perception toward 'Muslim pro' apps through the smartphone in Malaysia using technology acceptance model (TAM), "and another study by (Shameera et al., 2018) under the topic of "Sri Lankan Youth Perception (User) Toward 'Muslim Pro' Apps Through Smart Phone" have indicated that the "Muslim pro" application is beneficial to the majority of the youth in Malaysia as well in Sri Lanka as they stated that it improves their quality as Muslim lifestyle.

III. PROBLEM STATEMENT

The use and popularity of mobile applications are increasing day by day, and people tried to use mobile applications instead of desktop applications to enhance their lifestyle; especially mobile apps developed to perform religious rituals effectively have become trendy. The majority of Muslim people are using one of the apps to

enhance their daily religious rituals. The "Athan" mobile app is one of the apps that Muslims use next to "Muslim pro." Muslim Pro is popular among the majority of Muslims in Sri Lanka. However, Muslims are using the "Athan" app as well. Therefore, this paper tries to identify users' perceptions towards the "Athan" mobile app and the level of usefulness of the "Athan" app.

IV. OBJECTIVE OF STUDY

A. Overall Objective:

To identify the perceived usefulness and perceived ease of use of the “Athan” mobile app.

B. Specific Objectives

1) To identify the opinion of Sri Lankan Muslims toward using lifestyle mobile applications.
2)To identify the perception of Sri Lankan Muslims towards the “Athan” mobile app.
3)To find the level of usefulness of the “Athan” app among Sri Lankan Muslims.

V. RESEARCH QUESTIONS

1)What is the opinion on using mobile lifestyle applications by Sri Lankan Muslims?
2)What is the perception of Sri Lankan Muslims toward the “Athan” mobile app?
3)How does the usefulness of the ‘Athan’ mobile application perceive by Sri Lankan Muslims?

VI. MATERIALS AND METHODS

A quantitative research design has been handled in this research in which entire data has been collected using an online structured questionnaire.

A. Study Population:

The data was collected from 44 participants using the convenience sampling technique. The convenience sampling technique is a type of nonprobability sampling in which the entire population is sampled simply because they are "convenient" sources of data for the study. The participants were selected based on their interest to be a participant in the study having a condition as the participant should have used the "Athan" app for at least a month. Moreover, the participants have been achieved with the help of Facebook and WhatsApp groups.

B. Study Tool/Instrument And Data Collection:

A structured questionnaire has been used as a study instrument to collect information regarding the perceived usefulness of the “Athan” mobile app. Questions in the questionnaire were constructed into three main categories based on the objectives of the study.

C. Statistical Analysis:

All the quantitative responses obtained were analyzed using MS EXCEL 2016.

VII. THEORETICAL FRAMEWORK

The framework used by this study is the “Technology Acceptance Model” which is used to study the level of acceptance of new technology by the audience. (Davis, 1989)

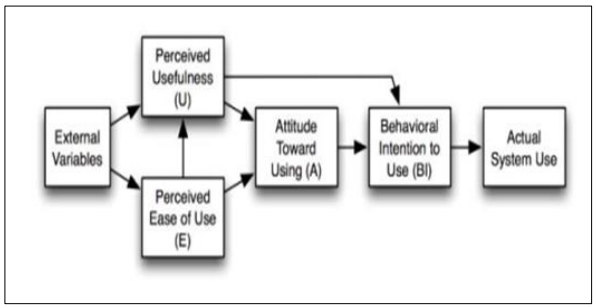


Figure 01: Technology Acceptance Model (TAM) by Fred Davis (1989)

VIII. RESULTS AND DISCUSSION

According to the survey, the first segment of the questionnaire is about demographic. Table 01 summarizes all the baseline details about the participants. Most of the participants are Female with 52.3% with a slightly different (4.6 %) unalike with male participants. Majority of the participants (50 %) are among 21 – 30 years old. At this junction it could be concluded that generation boomers are not supposed to be interested in using the app and only few of the Generation X had shown interest in using the app. This might be the result because of the generation Gap in terms of digital age.

Table 01: Baseline characteristics of the participants

Participants	Value(n=44)
Gender	
Male	21
Female	23
Age Category	
Less than 15 Years	0
15 to 20 Years	2 (4.5%)
21 to 30 Years	22 (50%)
31 to 40 Year	16 (36.4%)
41 to 50 Years	4 (9.1%)
51 to 60 Years	0
Above 60 years	0
Location (District in Sri Lanka)	
Ampara	39 (88.6%)
Colombo	02 (4.5%)
Trincomalee	01 (2.3%)
Gampaha	01 (2.3%)
Kalutara	01 (2.3%)
Marital Status	
Married	30 (81.6%)
Unmarried	14(31.78%)
Employment Status	
Student	11 (25%)
Employee	25 (56.7%)
Housewife	07 (15.9%)
Owning a business	01 (2.3%)
Number of lifestyle apps installed in a smartphone	
Less than 5	11 (25%)
5 to 10	20 (45.5%)
10 to 15	05 (11.4%)
More than 15	08 (18.2%)

The second segment of the questionnaire contained the questions to assess the interest in using mobile apps to enhance their lifestyle or ease their lives. The importance of using mobile apps to enhance living was assessed, which revealed that 86% of the respondents were much positive towards using mobile apps to ease their lifestyle. Nearly 11.6% of the respondents were not sure about their interest in using mobile apps.

According to Table 01, most respondents (46.5%) are using five to ten mobile apps to ease their lives, and a considerable percentage of respondents are using at least one app. "No app installed" choice was not given as the respondents were chosen from the population using the "Athan" app. Furthermore, respondents have indicated that mobile apps are essential (69.8%) to enhance and ease their life. In addition to that, 30.2% have mentioned that mobile apps are essential. So, all the respondents were extremely positive about the importance of using mobile apps. Hence, the above results answer research question 01 as summarized that the Sri Lankan Muslims are positive towards using a lifestyle mobile app to ease and enhance their lives.

The third segment of the questions was asked to clarify Sri Lankan Muslims' perception towards a specific religious application called "Athan." Respondents have been asked for how long they are using the "Athan" app. About 38.9 % of the respondents were using the "Athan" app for more than a year, and 29.5% of the respondents were using the app for less than a month. It reveals that a considerable number of the population has used the "Athan" app for more than a year. It emphasizes the popularity of the "Athan" app. Moreover, 97.7% of the respondents have mentioned that the "Athan" app was useful to perform their daily religious rituals without fail. If a technology wants to succeed, one of the main features that the developers need to be considered by the developers is that the technology should be user-friendly. It applies to mobile apps as well. Figure 03 shows how the respondents find that the "Athan" app is user-friendly. Respondents were asked to rate user-friendliness on a scale of 1 to 5. The one was coded as "Poor," and the five were coded as "Excellent." Therefore, Figure 03 indicated that most of the respondents were rated that the "Athan" app is excellent in being user-friendly. About 22.7% of the respondents were neutral about the user-friendliness of the app, and a negligible amount of the respondents have rated that the "Athan" app is poor in terms of being user-friendly.

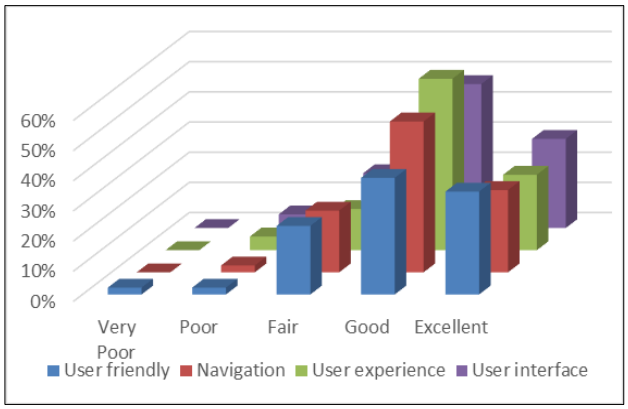


Figure 02: The extent to which the "Athan" app is user-friendly.

Moreover, 100% of the respondents have mentioned that they will recommend the app to others. In addition to that, 95.3 % use the free version of the app, which contains advertisements. The rest are using the premium version by paying

around 2500 LKR as annual subscription fees to avoid advertisements.

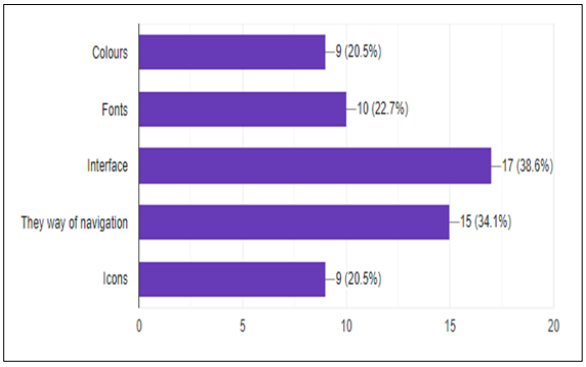


Figure 03: Cherished features in the "Athan" application in terms of the user interface.

Respondents were asked to reveal what they like more in the "Athan" app in terms of its feature to answer research question 02 partially. The results from Figure 03 show that the interface of the "Athan" app has been liked by the majority (38.6%). Similarly, other features like color, font, navigation, and icons are also considerably cherished by the users.

of the "Athan" app. Figure 05 summarizes the responses. The majority of the respondents have mentioned that the app has helped them to regularize their prayer on time (90%), praying without fail (83%), able to recite Quran often (79%), which reflects the positively perceived usefulness of the "Athan" app. Only a negligible number of respondents have indicated that the app is a disturbance (02%), and the app was boring to use (02%). The notification sound might cause a disturbance for them.

Apart from that, 81.4% of the respondents have mentioned that they use the "Athan" app to track their daily religious rituals. The tracking feature can positively persuade them for a behavior change in terms of performing religious rituals properly. Hence nearly 65.4% of the respondents have mentioned that the "Athan" app persuaded them for a behavior change to perform their ritual perfectly. Hence it can be assumed that the "Athan" app has followed the elements of persuasive technology as tailoring, tunneling, suggestion, reminders, self-monitoring (Torning and Oinas-Kukkonen, 2009) as the app navigate

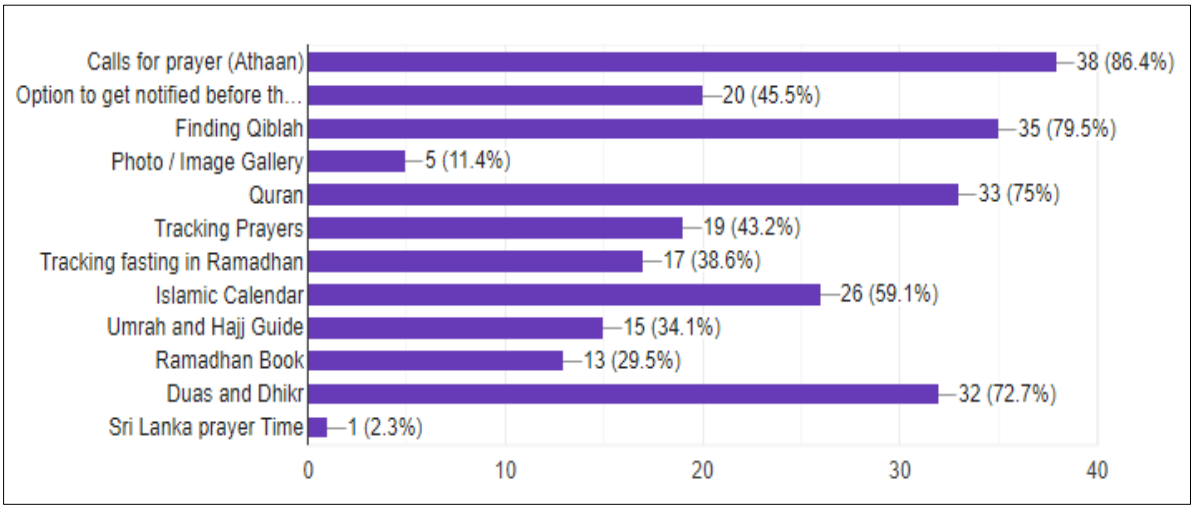


Figure 04: Cherished features in "Athan" application in terms of functionalities

According to Figure 04, the most liked functionality (86.4%) of the "Athan" app's calls for prayer followed by finding Qiblah which is the direction of performing prayers by 79.5%. Other than that, all most all the available functionaries are cherished by the users. However, the least liked is checking Sri Lankan prayer time. It might be the result because users do not want to check the time. They might have been interested in enabling notification before every prayer call (45.5%). In order to answer research question 03, respondents were asked to reveal their perception

the user towards organizing ad performing their rituals.

In order to answer research question 03, respondents were asked to reveal their perception of the "Athan" app. Figure 05 summarizes the responses. The majority of the respondents have mentioned that the app has helped them to regularize their prayer on time (90%), praying without fail (83%), able to recite Quran often (79%), which reflects the positively perceived

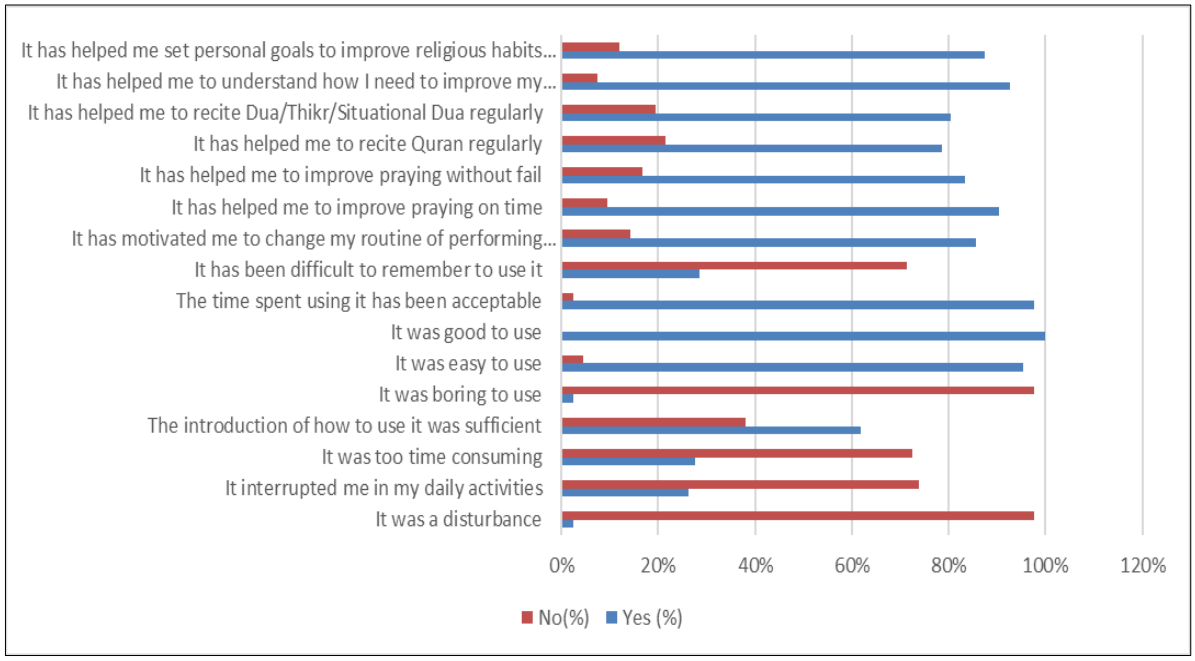


Figure 05: Level of perceptions (Perceived Usefulness & Perceived Ease of Use) towards using the "Athan" App.

usefulness of the “Athan” app. Only a negligible number of respondents have indicated that the app is a disturbance (02%), and the app was boring to use (02%). The notification sound might cause a disturbance for them.

Apart from that, 81.4% of the respondents have mentioned that they use the “Athan” app to track their daily religious rituals. The tracking feature can positively persuade them for a behavior change in terms of performing religious rituals properly. Hence nearly 65.4% of the respondents have mentioned that the “Athan” app persuaded them for a behavior change to perform their ritual perfectly. Hence it can be assumed that the “Athan” app has followed the elements of persuasive technology as tailoring, tunneling, suggestion, reminders, self-monitoring (Torning and Oinas-Kukkonen, 2009) as the app navigate the user towards organizing ad performing their rituals.

Finally, respondents have given a positive response to the question regarding the overall opinion about the app. The majority of the responses were like "Overall Satisfied," "It is good," "It is good for Muslims," Sufficient," Time management for prayers and duas," "Masha Allah very efficient," "Easy to follow the prayers routine," "It is good to use for Muslims," Daily use of this Athan app is very comfortable," "This Athan App easy to use & good.". As A Result, it is widely accepted that the “Athan” app is beneficial to the users in many aspects.

IX. CONCLUSION

The ‘Athan’ religious application is a mobile application similar to the well-known application named” Muslim Pro.” It can be observed that the sample audience had given an enormous positive perception of using the “Athan” app. The majority of the respondents were satisfied with the user

interface and the technical features, and the functionalities f the app. Furthermore, the users agreed that using the app gives them a pleasant experience and benefits them in terms of positive behavior change, which is quite challenging to achieve by usual conventional efforts. This ‘Athan’ application is beneficial to the majority in Sri Lanka as they stated that it improves their quality as Muslim lifestyle. In conclusion, it can be said that the user’s perception of the perceived usefulness and perceived ease of use is on the positive side of the continuum.

X. LIMITATIONS AND FUTURE RESEARCH

This study highlighted the perception and opinion of Sri Lankan Muslims towards using one of the religious lifestyle mobile applications. This study is a preliminary pilot-level study conducted to know the perception of the users. The sample size is highly law compared to the entire Muslim population who might have used the “Athan” app. Therefore, a large number of samples would give

more precise results in terms of this research topic. Besides, this study was completely quantitative. However, a mixed-method study, especially an exploratory mixed-method study in which a qualitative study is performed, followed by a quantitative study, would be more beneficial in getting a more detailed view of users.

Additionally, descriptive analysis had given a certain percentage as an indicator of how the users percept using the 'Athan' religion application. So run an enhanced survey with detailed statistical analysis on data would give more insights into the objective of the research.

REFERENCES

Aliya, K., (2020). People Are Deleting This Muslim Prayer App After Learning Data Was Shared With U.S. Military.NowThis News. Available at: <https://nowthisnews.com/news/people-are-deleting-the-muslim-pro-prayer-app-after-learning-data-was-shared-with-us-military> [Accessed 6 May 2021].

Bell, G. (2006) 'No more SMS from Jesus: Ubicomp, religion and techno-spiritual practices', Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 4206 LNCS, pp. 141–158. doi: 10.1007/11853565_9.

Digital 2020: Sri Lanka — DataReportal – Global Digital Insights (2021) Available at: <https://datareportal.com/reports/digital-2020-sri-lanka> [Accessed 5 May 2021].

Davis, F. D. (1989) 'Perceived usefulness, perceived ease of use, and user acceptance of information technology', MIS Quarterly: Management Information Systems, 13(3), pp. 319–339. doi: 10.2307/249008.

Degenhard, J.,(2021) Smartphone users in Sri Lanka 2025.Statista. Available at: <https://www.statista.com/forecasts/1146256/smartphone-users-in-sri-lanka> [Accessed 3 May 2021].

DuckMa (2021) The 6 Main Types of Mobile Apps: Industries and Functionalities.Available at: <https://duckma.com/en/blog/types-of-mobile-apps> [Accessed 12 May 2021].

Fathima Shameera,A.W. and Shibly,A. (2017) Digitalization of Holy Quran (Quranic Applications): Challenges and Concerns. Special reference with 4th year students of South Eastern University of Sri Lanka, 4th International Symposium-2017 at South Eastern University of Sri Lanka

Hafizah,R. and Ruslan,A.R.(2016). A Study of the Malasian Youth Perception Toward 'Muslim Pro' Apps Through Smart Phone in Malaysia,. ISME COLLOQUIUM 2016.

Islam, M. R., Islam, M. R. and Mazumder, T. A. (2010) Mobile Application and Its Global Impact Applied Information Technology. 15th October 2016. Vol.92. No.1. © 2005 - 2016 JATIT & LLS. All rights reserved.PP20

Mobile App Development | Mobile Applications | Android App | iOS App | Sri Lanka (2021). edesignerslanka. Available at: <https://www.edesignerslanka.com/our-services/mobile-app development.html#:~:text=Mobile%20App%20usage%20is%20growing,increase%20of%20Smart%20Phone%20usage> [Accessed 16 May 2021].

Muslim Population By Country 2021 (2021), Worldpopulationreview ,Available at : https://worldpopulationreview.com/country-rankings/muslim-population-by-country [Accessed 3 May 2021]

O'Dea, S., (2021) Sri Lanka mobile cellular subscriptions 2000-2019. Statista. Available at: <https://www.statista.com/statistics/501125/number-of-mobile-cellular-subscriptions-in-sri-lanka/> [Accessed 3 May 2021].

Shameera, A., Mansoor, C., Nadhira, A. and Shafrana, A., (2018). Sri Lankan youth perception (user) toward 'Muslim pro' apps through smart phone. In: 8th International Symposium - 2018.

Torning, K. and Oinas-Kukkonen, H. (2009) 'Persuasive system design : State of the art and future directions', ACM International Conference Proceeding Series, 350. doi: 10.1145/1541948.1541989.

US military buys location data of popular Muslim apps: Report.(2020).Aljazeera.Available at: <https://www.aljazeera.com/news/2020/11/17/report-us-military-buying-location-data-on-popular-muslim-apps> [Accessed 6 May 2021].

Assessing the E-commerce Websites for Performance using Automated Testing Tools

A.R.F. Shafana[1*], A.F. Musfira[2] & M.M.F. Naja[3]

[1]*Department of Information and Communication Technologies, Asian Institute of Technology, Thailand.*
[2]*School of Multimedia Technology and Communication, Universiti Utara Malaysia, Malaysia*
[3]*Department of Software Engineering, Universiti Malaya, Malaysia*
[1,2,3]*Department of Information and Communication Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1*]arfshafana@seu.ac.lk, [2]ameermusfi@seu.ac.lk, [3]mmfnaja@seu.ac.lk

Abstract- *The number of users accessing an e-commerce website is generally high. The performance of websites to cater to the increased number of concurrent users is inevitable to manage the growing online business needs. The architecture of the company's website should be robust enough to manage the expected traffic on heavy load. The inability to support the growing customer needs would return frustration that leads to heavy business loss. Therefore, it is mandate for e-commerce websites to perform load testing to assess the robustness of their architecture to support scalability. This study features the assessment of e-commerce websites for its performance based on throughput, availability and response time. The study utilizes Apache JMeter to perform load testing on selected five e-commerce websites in Thailand by emulating customer behaviors at heavy load levels. The paper proposes a methodology that could help future testing practitioners and researchers to perform load testing efficiently.*

Keywords: Load Testing; Quality of Service; E-Commerce; Apache JMeter; Performance Metrics.

I. INTRODUCTION

E-Commerce is a platform that serves a multitude of online users concurrently and the usage increases even higher during extreme shopping periods (Janani and Krishnamoorthy, 2015). The outbreak of COVID19 has increased the momentum of people purchasing online significantly, giving rise to the number of concurrent online users accessing e-commerce websites. The Quality of Service (QoS) of such a large-scale system is typically measured in response time, throughput, and availability (Menascé and Mason, 2002). Thus, e-commerce web applications fail when they could not scale up to meet the growing concurrent accesses leading to lost business opportunities (Jiang and Hassan, 2015). Therefore, the infrastructure of such websites needs to be assessed timely and upgraded to obtain the required return on investment (ROI) for the growing business needs.

Load testing becomes crucial at places where hundreds of millions of users access a website simultaneously. This study applies load testing on popular e-commerce websites in Thailand to assess their quality of service in terms of concurrency. Measuring the performance of e-commerce websites has been a subjective topic since the past, and many scholars have suggested the use of many metrics (Ghandour, Benwell and Deans, 2010). However, this study is one-dimensional that aims to investigate the capability of such websites for growing customers alone and does not discuss the usability, accessibility, security, or other measures relevant to the target websites.

The primary objective of this study is to analyze the performance issues of e-commerce websites under heavy load. Five popular e-commerce websites namely Lazada, Shopee, JD Central, Power Buy, and JIB have been chosen to investigate their performance towards increased users. Apache JMeter has been used to simulate a test environment during a peak shopping period with thousands of clients sending requests to each of the websites. The tests on each website have been conducted simultaneously using the same machine. The websites have been assessed in terms of their throughput, response time, and availability.

Test results show that the suitable metrics to evaluate the performance of the website under heavy load are throughput, availability, and response time. The evaluation of websites across such metrics could help the websites rectify the issues encountered when many users access the same URL concurrently. Thus, load testing is an important phase during the development of large-

scale systems and testers should focus on load testing besides the testing carried out for functionalities and features.

The contribution of this paper is two-fold. First, the methodology presented here would be useful for load testing practitioners and researchers interested in load testing. Secondly, this study highlights the importance of load testing for an e-commerce application. It promotes the developers of such applications to include load testing and the conventional functional testing procedures. Although the case study is undertaken for e-commerce websites in Thailand, the findings are not subjective. This could be integrated to implement different business policies and tactics in any large-scale systems where concurrency is inevitable.

II. RELATED WORKS AND EXISTING LITERATURE

A. Assessment of e-commerce websites

The extant literature forwards several measures as Web Performance Metrics. However, the measure of performance for e-commerce websites has been one of the controversies since the past (Ghandour, Benwell and Deans, 2010). After an extensive review, the researcher suggests using termed usage, financial returns, and user satisfaction as key measures. Hamid, Bawany, and Zahoor (2020) assessed the usability and accessibility of e-commerce websites from Pakistan. The researchers emphasize that the level of satisfaction towards an e-commerce application would be vital to measure the success of such websites. The study also included design suggestions to improve the usability and accessibility of e-commerce sites to increase customers. Stefani and Xenos (2009) developed a framework of performance metrics to evaluate e-commerce websites specifically. They stated that the quality is subjective based on the stakeholder and mapped their identified metrics to the quality characteristics such as Functionality, Usability, Efficiency, and Reliability. The term efficiency in their work defined the capability of the web application to provide appropriate performance respective to the amounts of used resources under specified conditions. Zhao et al., (2019) conducted a behavior analysis of the system and the user of e-commerce trading systems. They analyzed the e-commerce systems using four types of network user behavior analysis methods such as the web browsing behavior of users, keystroke behavior of network users, network transaction behavior of users, and mobile terminal behavior. They concluded that this kind of analysis is important for building assessment standards. Usability is another important metric that e-commerce has been assessed upon. Scholarly works have proved that the usability and quality of service of e-commerce websites can have significant effects on the performance and satisfaction of online users (Wahyuningrum, Kartiko and Wardhana, 2020; Wijaya et al., 2021).

B. Load Testing

Menascé and Mason (2002) emphasized the importance of load testing in e-commerce applications. He affirms that the important metric in large-scale systems like e-commerce web applications is its performance. Further, he imposes that the load testing needs to be carried out at several business requirement levels. Jiang et al. (2009) put forwards that many of the field problems in relation with the web applications are the deficiency of systems to cater to the increased load. They further mention that load testing could uncover both functional and performance problems under load, and when the results are systematically analyzed, this can be used to uncover any underlying problems. Jha and Popli (2017) identified that the features and functionalities are not only the main concern of a website and describe the vital necessity of the systems' performance to work properly under its expected workload. They further mention that the application of load testing can eliminate performance bottlenecks greatly. Another work (Khan and Amjad, 2016) also describes the importance of load testing for website applications. The researchers suggested that metrics such as the end-user response time, response time of CPU, and memory statistics gathered from the load testing are inevitable for the critical analysis of application behavior. Yin et al. (2021) conducted a mass tourism data analysis API based on e-commerce platform. The system was tested for its performance using automated testing tools. The tool was preliminarily used to test the response speed of the system, concurrency, and stability index. Although the system adhered to the design principles, the test found out that the system was not able to process API requests of more than 4200 failing in stress testing of the system. Another work much closer to the methodology adopted in this study is from Musthafawi et al. (2020). Using the similar methodology utilized in this study, their research was conducted to explore the enthusiasm of online users and how it is affected by the COVID19

pandemic. The objective of the study was to compare the performance of an e-commerce website before and during the pandemic. To achieve this objective, the researchers used Apache JMeter in line with the questionnaire on enthusiasm assessment. The researchers claimed that this load testing is essential to identify the system deficiencies.

III. METHODOLOGY

A. Tools and Technologies

Apache JMeter is a desktop-based Java application developed by Stefano Mazzocchi of the Apache Software Foundation (Dhiman and Sharma, 2016). The software can be utilized for various performance testing. The load testing of HTTP requests of Apache JMeter has been utilized for this specific study. The application also allows multiple listeners to view the results. This study mainly uses the Graph Results to observe the deviation, the Response Time Graph to visualize the variation of the responses, and the Aggregate Report listener to obtain the performance report of each sample.

B. Experimental Design

Five e-commerce websites of Thailand based on user preference were chosen for the study. A short-structured interview from 50 participants on the popular websites they use for everyday shopping was used to choose the websites. The websites thus chosen are Lazada, Shopee, JD Central, JIB, and Kaidee. The Apache JMeter has been used to perform load testing on the target websites. A thread group of 1000 was created to simulate 1000 virtual users accessing the website simultaneously. The test plan of each website was similar and the tests were conducted in 05 iterations and the mean and median values were recorded. The results obtained were analyzed to get insights into the infrastructure of the websites and their capability to support concurrency under heavy load.

IV. RESULTS

The average time taken for a request, median time, the minimum and maximum amount of time taken for an HTTP request can be obtained from the listeners like an aggregate report. The results from 05 listeners are aggregated into Table 01 below.

Table 01: Response Information of the 5000 samples

E-Commerce Websites	Median (ms)	Mean (ms)	Minimum (ms)	Maximum (ms)
Lazada *(https://www.lazada.co.th/)*	3624	5033	332	60682
Shopee *(https://shopee.co.th/)*	5870	11591	0	51256
JD Central *(https://www.jd.co.th/)*	17703	20467	137	178578
JIB *(https://www.jib.co.th/web/)*	24722	122142	10	128737
PowerBuy *(https://www.powerbuy.co.th/en/)*	5457	101790	0	566761

The graph results listener of Apache JMeter showed many deviations of HTTP requests for each of the websites. Thus the responses are not normally distributed. Therefore, the median is considered as a metric to evaluate the time taken by the sample as the median value represents that 50% of the samples did not take more than this time. The median value is represented in Figure 01.

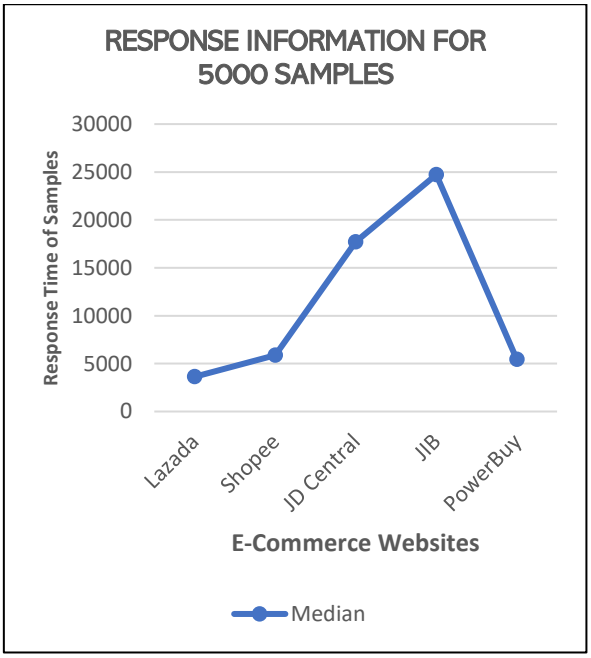


Figure 01: Response Information for 5000 samples (Metric: Median)

From the graph, it could be seen that the time taken to get the HTTP request from Lazada is the minimum and JIB consumes the maximum time. Further, the performance of Shopee and PowerBuy is comparatively better than that of JD Central. It could be inferred that the response time taken by the two least performing websites on heavy load is almost five times higher than that of the average performing websites.

The websites were also assessed in terms of their throughput during a heavy load of 5000 HTTP requests simultaneously. Throughput measures the number of requests catered by the website per second. The results are depicted in Figure 02.

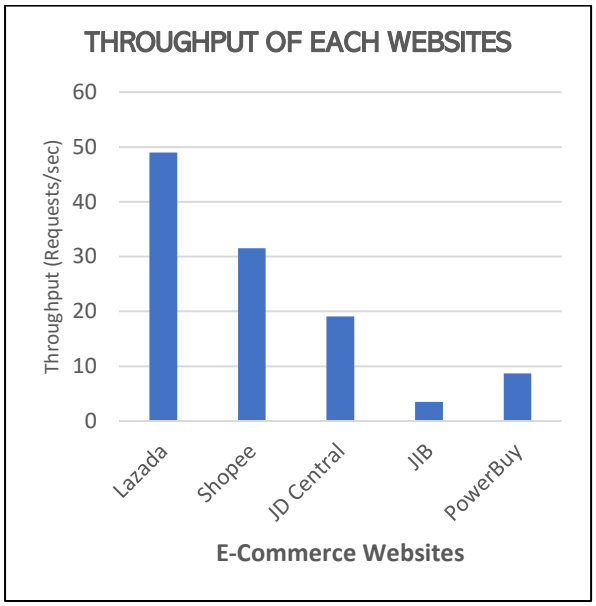


Figure 02: Throughput of each website (Requests/second)

The graph in Figure 02 shows that the throughput of Lazada is very high even at a heavy load of about 49 requests per second and JIB was able to support only around 3.5 requests per second. The throughput of PowerBuy is still lower (8.7 requests/second) when compared with Shopee (31.5 requests/second) and JD Central (19.1 requests/second).

The study also considered the use of error rate in evaluating the performance of websites during heavy load. Thus, the percentage of requests with errors was also recorded for analysis. The graph in Figure 03 gives a concise view of the error rate of the selected e-commerce websites.

JD Central website outperforms the other websites in terms of error rate, where it was error-free. The website Lazada also gives a tough competition with that of only 0.12%. On average, Shopee was producing an 18.52% of error rate while the error rate of JIB and PowerBuy was huge compared to others reaching almost 61.84% and 75.96%, respectively.

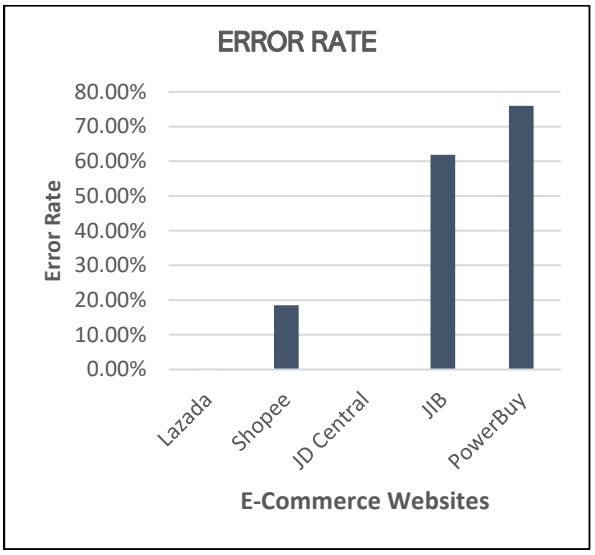


Figure 03: Error Rate (Percentage)

The listener "*Response Time Graph*" of Apache JMeter was used to generate the Response time graph of each website. Figure 04 provides a comparative view of the response time graphs. The response time graph of JIB is highly fluctuated. Comparatively, the response times of PowerBuy and Shopee remain high with the increase of load. Although the response time of JD Central was high initially, it has reduced greatly with time. The response time graph of Lazada is quite outstanding, where the time was high initially and turned low considerably quite earlier and reaching almost 100 milliseconds finally.

V. DISCUSSION

The performance of five websites for increasing load has been tested with the standard Apache JMeter tool. The websites were assessed based on the time taken to respond to an HTTP request, throughput, error rate. The above metrics were chosen based on the guidelines from the work of Menascé and Mason (2002). As in the same work, response time is calculated as the median time taken by the particular website to respond, availability is measured via error rate, and the requests per second are considered as the throughput. The comparison of results and the ranking provides an insight into the performance of the websites under heavy load. Figure 05 below

summarizes the findings from the study. The scores are given based on the ranking of the websites for a given metric.

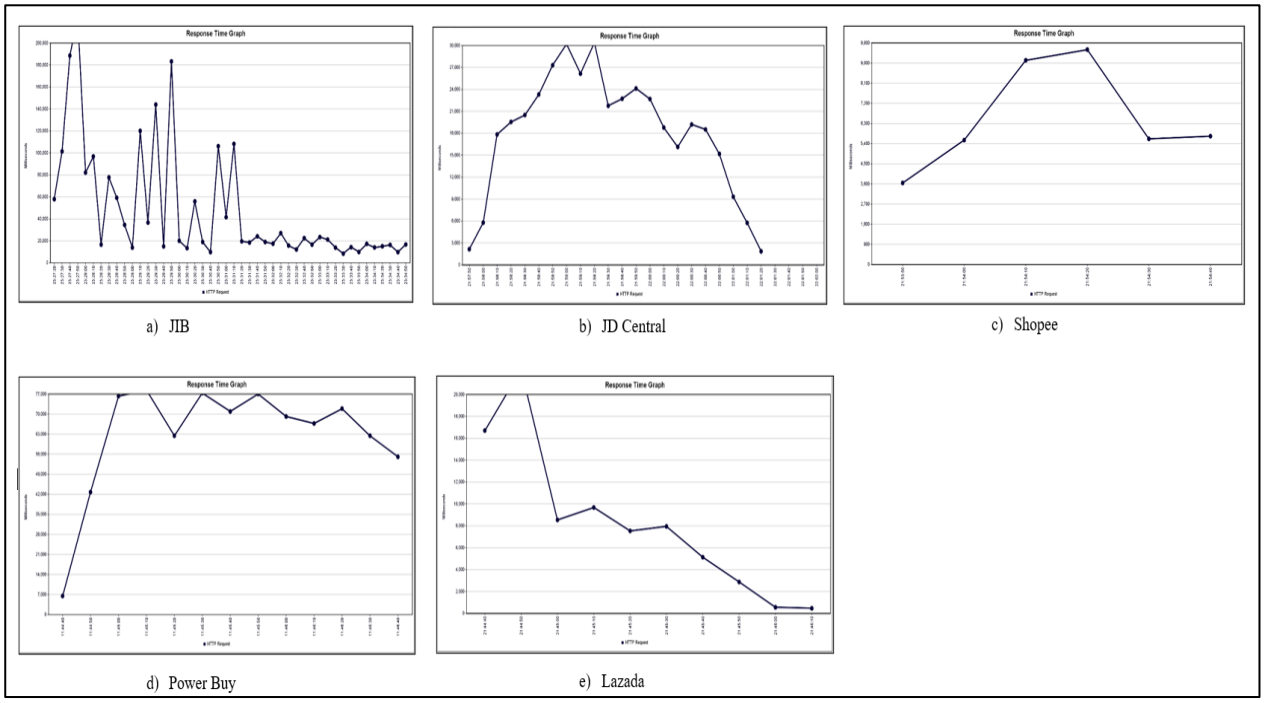


Figure 04: Response Time Graphs of websites

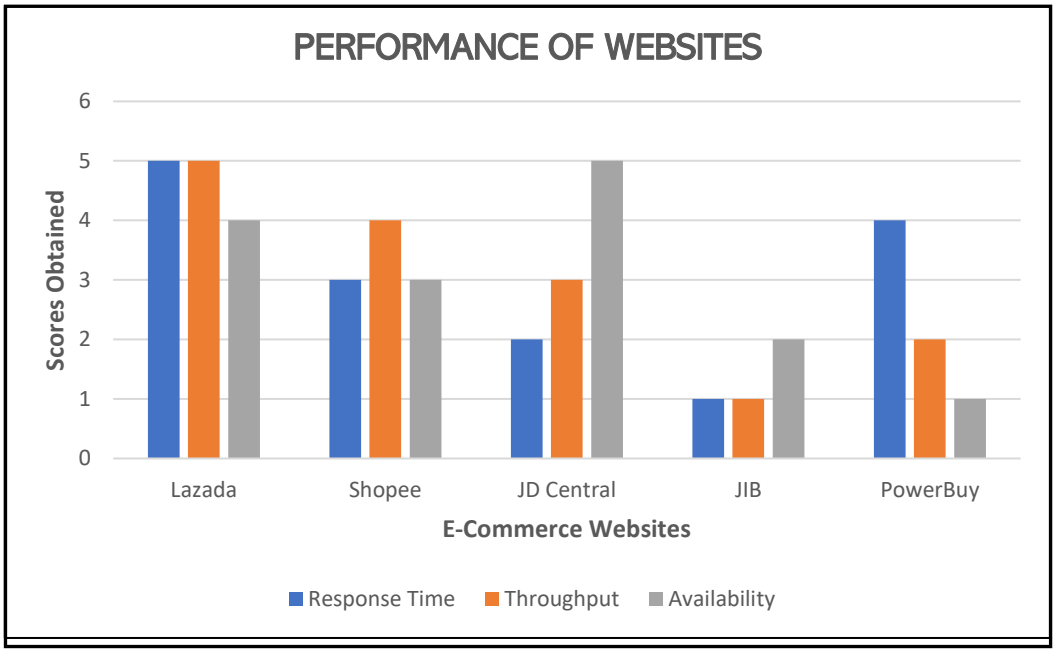


Figure 05: Comparison of websites under heavy load based on performance metrics.

An e-commerce website can be measured on various metrics such as its performance, usability, security, accessibility, and many others. However, performance is an essential measure since the outreach of a website depends on its performance. And for a large-scale system like e-commerce websites, the performance is a key measure since there is a high chance of getting hundreds or thousands of users simultaneously and the system should support concurrency. Thus, this paper serves as a model for performing load testing on e-commerce websites. The methodology of this paper can be utilized by developers and testing practitioners for testing their websites for their capability to support multiple concurrent users. The methodology can serve many large-scale software systems irrespective of their genre. The study is not intended to criticize the performance of websites rather use the selected websites to devise a methodology for load testing.

VI. CONCLUSION

The study utilizes the load testing feature of Apache JMeter to investigate the performance of 05 selected e-commerce websites in Thailand. The metrics used for evaluation are throughput, availability, and response time. The study was able to rank the e-commerce websites based on their performance metrics, where Lazada outperform the other websites. It could be seen that the architecture of Lazada supports multiple concurrent users. The study also highlights the importance of load testing on large-scale systems like e-commerce websites and proposes a methodology that testers and developers could utilize to assess their websites. The methodology presented here would be readily available for those interested in load testing without the need to review the literature every time. The study concludes that the appropriate metrics to assess the performance are throughput, availability, and response time. The e-commerce website architecture is considered robust if it has higher throughput, higher availability, and lower response time.

REFERENCES

Dhiman, S. and Sharma, P. (2016) 'Performance Testing: A Comparative Study and Analysis of Web Service Testing Tools', *International Journal of Computer Science and Mobile Computing*, 5(6), pp. 507–512.

Ghandour, A., Benwell, G. and Deans, K. (2010) 'Measuring the performance of ecommerce websites', *PACIS 2010 - 14th Pacific Asia Conference on Information Systems*, (January 2014), pp. 284–295.

Hamid, S., Bawany, N. Z. and Zahoor, K. (2020) 'Assessing ecommerce websites: Usability and accessibility study', *2020 International Conference on Advanced Computer Science and Information Systems, ICACSIS 2020*, (December), pp. 199–204. doi: 10.1109/ICACSIS51025.2020.9263162.

Janani, V. and Krishnamoorthy, K. (2015) 'Evaluation of cloud based performance testing for online shopping websites', *Indian Journal of Science and Technology*, 8(35). doi: 10.17485/ijst/2015/v8i35/76200.

Jha, N. and Popli, R. (2017) 'Comparative Analysis of Web Applications using JMeter.', *International Journal of Advanced Research in Computer Science*, 8(3), pp. 774–777. Available at: http://libproxy.wustl.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=asf&AN=122961322&site=ehost-live&scope=site.

Jiang, Z. M. *et al.* (2009) 'Automated performance analysis of load tests', *IEEE International Conference on Software Maintenance, ICSM*, (September), pp. 125–134. doi: 10.1109/ICSM.2009.5306331.

Jiang, Z. M. and Hassan, A. E. (2015) 'A Survey on Load Testing of Large-Scale Software Systems', *IEEE Transactions on Software Engineering*, 41(11), pp. 1091–1118. doi: 10.1109/TSE.2015.2445340.

Khan, R. and Amjad, M. (2016) 'Performance testing (load) of web applications based on test case management', *Perspectives in Science*, 8, pp. 355–357. doi: 10.1016/j.pisc.2016.04.073.

Menascé, D. A. and Mason, G. (2002) 'of Web Sites', *Ieee Internet Computing*.

Musthafawi, A. Z. *et al.* (2020) 'Performance testing on the shopee website in the pandemic period of COVID-19', *ACM International Conference Proceeding Series*, pp. 195–199. doi: 10.1145/3427423.3427457.

Stefani, A. and Xenos, M. (2009) 'Meta-metric Evaluation of E-Commerce-related Metrics', *Electronic Notes in Theoretical Computer Science*, 233(C), pp. 59–72. doi: 10.1016/j.entcs.2009.02.061.

Wahyuningrum, T., Kartiko, C. and Wardhana, A. C. (2020) 'Exploring e-Commerce Usability by Heuristic Evaluation as a Compelement of System Usability Scale', *2020 International Conference on Advancement in Data Science, E-Learning and Information Systems, ICADEIS 2020*, pp. 1–5. doi: 10.1109/ICADEIS49811.2020.9277343.

Wijaya, I. G. N. S. *et al.* (2021) 'E-commerce website service quality and customer loyalty using WebQual 4.0 with importance performances analysis, and structural equation model: An empirical study in shopee', *Register: Jurnal Ilmiah Teknologi Sistem Informasi*, 7(2), pp. 107–124. doi: 10.26594/register.v7i2.2266.

Yin, X. *et al.* (2021) 'Mass Tourism Data Analysis API Based on E-Commerce Platform', *Journal of Physics: Conference Series*, 1881(2). doi: 10.1088/1742-6596/1881/2/022065.

Zhao, P. *et al.* (2019) 'Behavior analysis for electronic commerce trading systems: A survey', *IEEE Access*, 7, pp. 108703–108728. doi: 10.1109/ACCESS.2019.2933247.

TRACK - UBIQUITOUS COMPUTING TECHNOLOGIES

Towards Robust Ubicomp: A Comprehensive Review on the Grand Challenges of Ubiquitous Computing

G.W.Y.S. Boralessa[1], K.W.A.H. Samarasinghe[2], T.N. Ahamed[3] & A.R.F. Shafana[4*]

[1,2,3,4]*Department of Information and Communication Technology, Faculty of Technology, South Eastern University of Sri Lanka, Sri Lanka*

[1]*geethyapa@gmail.com,* [2]*achisamareee@gmail.com,* [3]*nuskyahamed18@gmail.com,* [4*]*arfshafana@seu.ac.lk*

Abstract- *Ubiquitous Computing is a concept that consists of qualities that enable people to move away from traditional desktop computing systems and toward computer systems, where everything is available and accessible everywhere through various devices while being essentially invisible. The purpose of this paper is to provide a comprehensive review of the literature on the challenges of ubiquitous computing with the objective of synthesizing existing knowledge and offering direction for future research. Furthermore, systematic reviews of challenges that obstruct ubiquitous computing's success are scarce. Therefore, this paper carefully reviewed a number of published papers based on their contributions to the body of knowledge in ubiquitous computing and has identified six grand challenges that are critical to the future of ubiquitous computing. Such as social, legal, and ethical Issues, technical issues, architectural issues, human and environmental challenges, security challenges and system maintenance challenges. Since the empirical study, development, and validation of Ubicomp systems are still in their early stages, this may deter practitioners from using solutions from the literature. In that ground, our findings would enable academics and practitioners to construct robust Ubicomp systems with the knowledge transfer from this study. Since our study consolidates the vulnerable challenges in one place, the findings of the study could be readily adapted to overcome challenges when building ubiquitous systems and services.*

Keywords: Ubiquitous Computing, Societal Issue, Ubiquitous Manufacturing, Pervasive, Ubicomp

I. INTRODUCTION

Knowledge has become immediate, automatic, and pervasive as everyone can now view information everywhere, at any moment, and in a customized manner due to the advanced technology such as the miniaturization of microprocessors and sensors in combination with the proliferation in networking technology. The trend in recent years, with both the development of digital data and information technologies, has been to outsource data collection and processing to cloud-based platforms, which now shapes the architectures of ubiquitous computing and connectivity (Qiu *et al.*, 2019). Ubiquitous computing is an emerging technology in computer science (Mirani *et al.*, 2017). The most significant technologies are those that vanish, and they blend into the fabric of ordinary life until they are undetectable (Weiser, 1999) thus commenced the vision of ubiquitous computing, often known as pervasive computing.

The aim of ubiquitous computing is to make machines available in a nonintrusive manner in the physical world, making them almost, if not completely, invisible to the user (Weiser, 1993). Also as a basic necessity of time, technology is swiftly finding its approach and changing states quicker than speed into every part of our existence. Since the pervasive environment allows communication between devices at any time and from any location, systems are becoming more pervasive in the modern world (Shaheed *et al.*, 2015). Overall ubiquitous computing infrastructure offers a network that can combine various computation tools in software and hardware while offering a pay for use service for end users.

Applications of ubiquitous computing are widespread across Retail, Industrial production and material management, Transport logistics, Personal identification and authentication, Health care and Mobility and transport (Friedewald and Raabe, 2011). Also there are many applications derived from each respective path. However, as the number of individuals using ubiquitous computing grows, the problems also arise. Further, there is a trend toward ubiquitous computing, which refers to the use, development, encoding, dissemination, and storing of information in a way that is both transparent and invisible. Everyday objects are evolving into smart objects that are networked, respond to their

surroundings, and communicate with their users (Sen, 2010). This is a major influence for the difficulties which occur with ubiquitous computing. In the perspective of the process, smart and intelligent, embedded or stand-alone ubiquitous computing environments are seen as vastly different from conventional desktop computing environments in terms of design, creation, and execution. Actually, these have proved to be difficult challenges, necessitating the consideration of many technical, societal, operational, and environmental factors (Horváth and Vroom, 2015).

As ubiquitous computing and its associated challenges are at a rapidly increasing pace, this demands a critical analysis of the challenges encountered to propose a mechanism and a framework to overcome these challenges. Therefore, this study aims to analyze a compendium of literature in the domain of ubiquitous computing and identify the most critical challenges of ubiquitous computing. The outcome of this research can be utilized by ubiquitous computing service providers and application developers to mitigate it during the development process.

Despite the rapid advancement of information and networking technologies, which has resulted in the existence of ubiquitous computing, there are still many legal, ethical, and technological barriers that preclude society from reaping the benefits of such advancement (Mahmoud, 2016). Thus, this work is important to obtain the potential benefit of ubiquitous computing in its fullest form while mitigating the challenges. The rest of the paper is organized as follows. Review of challenges in ubiquitous computing are identified and described respectively. Afterwards the findings from the review are discussed to provide research perspectives followed by the conclusion of our study.

II. RELATED WORKS

Iwaya, Ahmad and Ali Babar (2020) undertook a systematic mapping study on mobile health and ubiquitous health systems with special attention to privacy and security concerns. The study was able to systematically analyze state-of-the-art literature on the relevant field and listed potential challenges encountered in the specific field. The researchers suggested that many of the challenges in ubiquitous health systems are still under-represented and provided a list of challenges in the field. However, this work is confined to ubiquitous health systems and our study focuses on the ubiquitous systems as a whole.

The research of Mirani *et al.* (2017) is quite significant for its contribution in identifying the applications, challenges and the elements of ubiquitous computing. However, the study was pivoted around the challenges relevant to the performance of ubiquitous computing in contrast to our work that combines many challenges around. Another comprehensive survey analyzed the challenges of ubiquitous computing with special reference to location based services alone (Jiang *et al.*, 2021). Comprehensive surveys in ubiquitous computing and Internet of Things by Hashemi and Zarei (2021) identified resource management and security issues as challenges while security issues were spotted as major challenge in the works of Adat and Gupta, (2018); Burhan *et al.*, (2018); and Malhotra *et al.*, (2021).

Many systematic studies have been undertaken to identify the potential challenges in the domain of ubiquitous computing. However, the challenges are widespread across several literature that does not allow the practitioners to readily identify all the prominent challenges and adopt the measures when employing ubiquitous systems. Thus, this secondary study facilitates the interested group with the consolidated knowledge and evidence with easy access.

III. METHODOLOGY

Systematic approach has been employed to undertake our study to achieve its objectives. An in-depth investigation of various learning techniques has been used to protect the Ubicomp system in one way or another. This review was conducted using related research publications in the field of ubiquitous computing. The methodology adopted is presented in Figure 01.

The focus of this research is to investigate the available literature in order to gain a better knowledge and insight into recent developments and challenges in the ubicomp field. This technique lays out the fundamental procedures for locating, comprehending, and analyzing research publications, which would help to identify supporting evidence easier. A proper professional planning and validation of search strings was carried out as part of the search plan. The research articles are mainly from Scopus database that are recent and with high citations. Scopus was chosen

as it is a comprehensive source of research articles. From the search results, the peer-reviewed and high-quality database journals and reputed conferences like IEEEXplore, Springer, Wiley, ACM, Elsevier, and Google Scholar were filtered to investigate the challenges in ubiquitous computing.

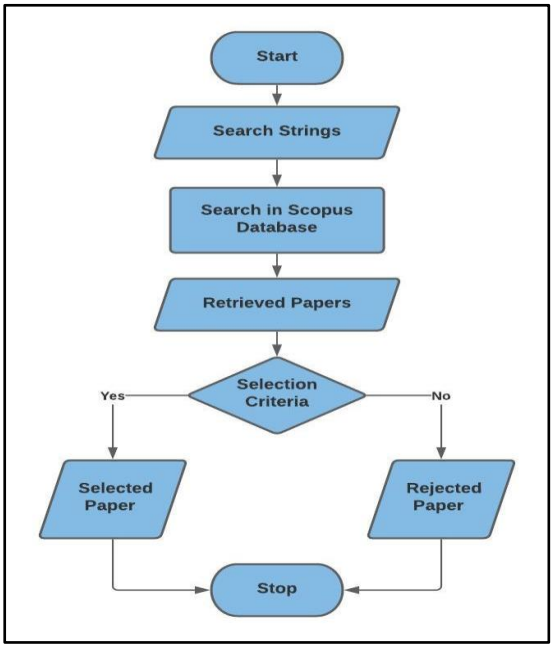


Figure 01: Adopted Methodology

The search phrases were carefully crafted in response to the research question. The search keywords were adjusted several times in order to assemble practically all of the relevant papers. As a result, several search strings with different combinations of words were utilized to find relevant papers. "Ubiquitous Computing" AND "Challenges" AND "Social, Legal, and Ethical Issues" OR "Technical Issues" OR "Architectural Issues" OR "Human and Environmental Challenges" OR "Security Challenges" OR "System Maintenance Challenges". An automated search was conducted using these search strings using the search engines of numerous digital libraries. The paper selection criteria were then used to further filter out the most relevant research in this field. The rest of the paper discusses the grand challenges of Ubicomp which we derived from the review.

IV. GRAND CHALLENGES IDENTIFIED

A. Security Challenges

Security has been identified as one of the major challenges in ubiquitous computing over the past studies. This becomes a serious challenge since people never liked to disclose their personal, sensitive, and mission-critical information over a model or in ubicomp as they consider that is not safe or not considered to be secure. In a ubiquitous computing environment, eavesdropping on communication media, denial of service (DOS), and data manipulation are examples of hackers' attack getting control of user instruments or devices (Sharifi, Khosravi and Shah, 2013). Security has been a serious challenge since the past and it still serves as the most vulnerable one. Burhan *et al.* (2018) presents main security issues commonly found in areas like ZigBee Technology, Bluetooth Technology, Radio Frequency Identification, Wireless Sensor Network, Wireless Fidelity and 5G Networks. In an ubiquitous computing environment, as sensitive information flows through such systems, the author believes that the need of a preventive mechanism to ensure the safety of information from the attackers is highly necessary during design process.

The main issue is that users are generally unaware when they come across many networks even if some harmful or insecure networks capture their personal or important information in the background. The widespread use of wireless devices have been the root cause of these challenges (Lyytinen *et al.*, 2004). Wireless infrastructure has some potential challenges, and these challenges could direct us to possible change or deletion, as well as denial of services. Wireless and mobile infrastructure security created from the use of various incompatible security schemes and inherent weakness in some wireless security algorithms (such as wireless LANs (Lyytinen *et al.*, 2004). Furthermore, poor execution, feature interactions, unplanned development, and new challenges that are created by prior attacks are also encountered in an ubiquitous environment. Furthermore, every ubiquitous computing device has an efficiency that is capable of saving power (i.e., sleeping mode), in this case attackers try to deal with this to shut down or reduce its efficiency. Even with the state-of-the-art technological advancement, the above issues persist and jeopardize the security in the ubiquitous computing environment. This is well defined and explained by Iwaya, Ahmad and Ali Babar (2020) who conducted a recent comprehensive study on ubiquitous health systems and its challenges. They pinpointed the security challenge to be a pressing need which needs a thorough comprehension during software development.

Since an infinite number of devices are connected in a ubiquitous computing environment, keeping track of them will also be harmful to the security of such systems. Many of the challenges relevant to the security concern have been identified in widespread literature and the key challenges can be consolidated as listed below;

- protection from unauthorized user (authorization),
- prevention of access by an attacker through unauthorized techniques (integrity),
- providing accessibility for user entirely (availability),
- avoiding an entity from refusing former actions (non-repudiation),
- confidentiality,
- authentication and
- accessibility.

Figure 02 further describes the security related issues as discussed by Shaheed *et al.*, 2015.

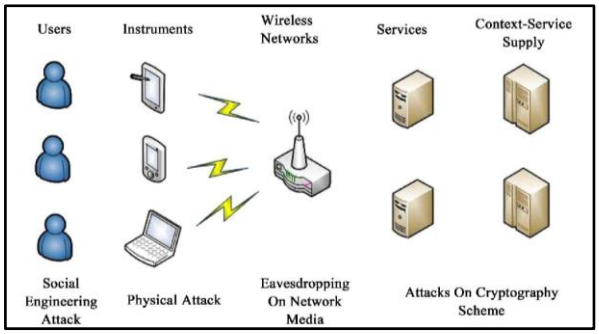


Figure 02: Ubiquitous environment and issues (Shaheed et al., 2015)

As security has been quoted as the most vulnerable issue, Malhotra *et al.* (2021) investigated the security perspectives in ubiquitous environments. The researchers forwarded a platform to deal with such issues through an understanding in proper detection and prevention of the attacks that are caused by the insecurity of the devices. The researcher gives a quick rundown of potential threats and anomalies at various levels and layers. Further research in this domain suggests a secondary line of defense in practical applications in addition to the cryptographic defense system that has a less addressing power on active attacks and exploitation of vulnerabilities. Based on this, Adat and Gupta (2018) proposed an Intrusion Detection System for an IoT scenario that can safeguard from security breaches if properly configured and built.

B. Social, Legal and Ethical Issues

Within a small period of time, Ubiquitous computing was able to adapt into human lifestyle easily in different forms. However, one of the grand challenges of ubiquitous computing is social, legal and ethical issues. Almost everyone carries a digital device with them at all times, whether it's a laptop, tablet, smartphone, or Etc. Data is available at all times and in almost any format the user wishes. Of course, this can be a benefit, but it might be difficult for someone seeking to safeguard customer privacy while providing uninterrupted service. As a result, businesses should think about it. Several authors have shown many issues in this category. Information privacy is frequently considered as an ethical issue in computing as being endangered by computing infrastructures that promote the transmission and use of personal data (Hilty, 2015). When more programs connect with the user, the user's privacy is jeopardized greatly (Shaheed *et al.*, 2015). The authors further mentioned that the main challenge is to provide a structure capable of changing daily living situations while also providing privacy to each individual user in an extremely dynamic pervasive environment. The study further stated that the trust is required for ubiquitous computing to demonstrate promising results. Based on the quote, “The substance that holds certainty and reliance on another's integrity and dependability is trust. In any interaction between nodes, trust is also a representation of dependability, security, and trustworthiness”. When it comes to privacy in ubiquitous computing, an interesting point that is worth mentioning is, users would be skeptical of such services if the ubiquitous devices upon which a flow is redirected kept track of flow details (Anjum, 2006). The author believes that providing such a guarantee might be a key challenge.

Another challenge those ubiquitous devices often face is legal issues as discussed by Chen and Tsai (2017). According to the researchers, trust concern is a key factor in ubiquitous manufacturing (UM) since UM generally involves multiple factories to manufacture a single product. In such contexts, there is a possibility of the leakage of technical secrets as a recipe is transferred from one factory to the other. This makes the legal issue a serious concern in Ubiquitous Computing as the stakeholders will not be willing to undertake ubiquitous manufacturing that causes legal concerns to the company. The interoperability based on mutual trust is an essential feature when

it comes to a manufacturing that is entirely ubiquitous. Thus, this makes the legal and ethical concern a grand challenge in Ubiquitous Computing.

An open debate exists on the use of location service in devices whether it is a violation of privacy or not. The usage of location to improve services can potentially be used to track users' whereabouts (Anjum, 2006). Location data is one of the most prevalent kinds of contextual data in the field of ubiquitous computing, and it is used to power a wide range of applications. The work of Jiang *et al.* (2021) is well-recognized in the field of location based services. They were able to identify practicality, quantification and personalization as the open issues that affect the performance when designing Location Privacy Preserving Mechanisms (LPPM). Furthermore, the authors believe that when it comes to Internet of Things (IoT) the existence of side channel data is the grandeur issue which developers should pay attention when designing such LPPMs. However, when location systems follow users automatically and in real time, a massive amount of potentially sensitive data is collected. Users might not necessarily want to turn off all access to their location data because some applications can benefit from it, but they do want to be in charge. So, when designing these ubiquitous devices, the developers should consider this challenge.

C. Technical Issues

Another grand challenge that ubiquitous computing has to overcome are technical issues. There are several technical challenges associated with ubiquitous computing such as performance, consistency, availability, designing, quality and testing (Anjum, 2006). Many researchers have addressed the technical issues encountered in a ubiquitous computing environment. The trade-off between consistency, availability, and resilience over a network split is one of the inherent challenges in making ubiquitous computing infrastructures expand to a huge number of people, devices, and sensors (Hong and Landay, 2002). Ubiquitous devices are capable of attracting many users simultaneously. The authors have proposed that the consistency, availability and partitioning should be taken into account as key challenges when designing ubiquitous devices. On the other hand, testing and evaluating such services will obviously present their own set of challenges. This is a difficult problem due to the intricacy of the services. As those services are expected to be used by a large number of people when they are deployed, investigating the influence of scalability on such services becomes an issue (Anjum, 2006).

The study has also discussed performance as one of the key challenges in the technical domain. According to the author, ubiquitous services must be delivered without compromising on the performance. The services, maybe in conjunction with the policies, will have to determine whether the available resources like bandwidth are adequate, and if not, then migrate to an interface with the necessary resources (Anjum, 2006). Davies and Gellersen (2002) focus their study solely on a branch of UM process which is deploying the systems. Authors have been able to explain the technical and sociological challenges of creating such systems that extend beyond just laboratory prototypes. The authors have provided an example and through that they make the point that even though the system can determine decisions there is a challenge to make the correct association between various components in providing this information. They further suggested, even though this process is easy for humans it is extremely difficult in software. Because there is lots of data that needs to be fed for the system in order to make a decision such as what criteria does the system use to decide and automate. Thus, a grasp of the delicate nature of the situation is essential. Before developing adequate defensive mechanisms, a system is absolutely necessary. As described by Malhotra *et al.* (2021) there are many ways to harm data integrity and confidentiality by hackers thus the need for a defensive mechanism of ubicomp development arises.

Chen and Tsai (2017) includes “quality” as a key challenge in ubiquitous computing. The authors explain the importance of quality and the problems and challenges faced by a factory when establishing a UM system. The author explains the composition of quality via an example which says that the parts of these ubiquitous computing equipment are made overseas. However, for the purpose of maintenance, a factory may be reluctant to wait for service from an overseas vendor. Instead, they would settle for a local business. This issue directly affects the quality of the UM. The authors mention that a remote diagnostic system can be used to overcome this challenge as it makes the vendor more prepared. One solution to overcome the above issue was forwarded by Hong and Landay (2002). A fact which is worth mentioning is, that just like a

recommender system does, end users must be able to easily review why a given action was made and adjust their preferred behavior for the system in a ubiquitous computing system because otherwise it would lead customers into confusion. According to them this is a key challenge when it comes to designing such systems. In a ubicomp setting, an end user may not notice an unwanted activity until much later after it has occurred. For these reasons, it will be beneficial to keep track of actions conducted on an individual's behalf, as well as a description of which device or services did the action, an explanation of why the action was taken, a method of quickly modifying the behavior, and tools for visualizing and interpreting the log.

D. Architectural Issues

The integration of a multitude of devices also challenges the architecture of ubicomp systems. Smart Homes are one such system designed to enhance people's lives by using ubiquitous computer technology that improves communication, awareness, and usefulness (Keith Edwards and Grinter, 2001). Hundreds of device manufacturers sell an extensive variety of products that are embedded in the home space, based on a multitude of technologies and specifications. This complexity has a strong impact on the rise in problems in Smart Homes. In the perspective of privacy in home automation systems, the usage of encryption keys in home automation deployments generates a slew of issues, including massive resource consumption and encryption key distribution efficiency (Batalla, Vasilakos and Gajewski, 2017). A cyber or physical assault by an enemy or even a malicious consumer might target various interactions among Smart Home entities (Komninos, Philippou and Pitsillides, 2014). As a result, the most prevalent challenges in ubiquitous computing are smart homes and associated potential risks and their probable implications. Adding more features to the protocol both raises the cost and decreases the protocol's simplicity of use (Risteska Stojkoska and Trivodaliev, 2017). Furthermore, ubicomp systems developers face an extreme issue when trying to fit their product to different kinds of environments. This situation is well described by Mirani *et al.* (2018). For an example, take an IOT home electronics manufacturing company. When designing their products, they simply cannot monitor each and every kind of home whether their environment suites the product or not. As stated in their paper this situation would create chaos and complexity for the ubicomp management. Furthermore, maintaining the systems would also be an issue. Still however, the most advanced glimpses of the potential future of domestic technologies can be found in home automation systems and challenges also increasing with it.

E. Challenges on human and environment

The challenge of Ubiquitous computing upon humans and the environment is unavoidable. As this technology has progressed, an unprecedented form of pollution in the form of electromagnetic radiation has been exposed to humans and has caused severe illnesses. Anyhow, human existence today would not be possible without electricity and telecommunication infrastructure (Lingvay *et al.*, 2018). We are enthralled by electromagnetic radiation because we use technology. This effect is extremely detrimental to everyone, regardless of age. According to Przystupa *et al.* (2020), the memory of infants suffers the greatest when they are exposed to low-intensity electromagnetic frequencies. The human immune system has a high level of sensitivity to electromagnetic frequency. However, the impacts of the built-up of the Ubiquitous computing idea on materials also present issues. Materials are concurrently subjected to many physical, chemical, and microbiological stress factors in built-up media, which operate synergistically with disruptive electromagnetic fields to promote material deterioration, with implications for building and installation durability and safety (Lingvay *et al.*, 2018). Thus, the impact of ubiquitous computing upon the environment is yet another challenge.

F. System Maintenance Challenges

As ubiquitous computers are becoming more and more into one system, the system maintenance employment problem have been emerging since the past. This forces the individuals to become an administrator for their own system. However, the individual does not possess potential capabilities to administer a system. At many instances, the users are not vigilant on security as well which may cause security threats & technical problems. Another challenge to consider is on the methodology to handle a large amount of data and how to allow users to search “effectively” for information in the ubiquitous environment (Lyytinen *et al.*, 2004). In these instances, there is a high possibility of information leakage even without the knowledge of users. Information

leakage by insiders is more problematic and crucial while the asset value of information is relatively higher. Therefore, it is most important to employ well trained administrators or an artificial intelligence bot to overcome this challenge which applies more strict control on internal information leakage whereas enabling staff inside the company to access internal information at any time in any place supporting high work efficiency. This issue is well described by Mirani *et al.* (2017) who makes a significant point by stating that the absence of system administrator is a pressing issue when it comes to ubicomp systems as when using such systems their users are lacking the knowledge on important concepts like the system's basic functionalities and performance. This necessitates the role of a system administrator to a ubicomp system.

V. DISCUSSION AND CONCLUSION

One way to define ubiquitous computing is "any-time" "any-where" access to computing resources. The nature of the ubiquitous environment allows communications and devices to traverse openly, anytime and anywhere, so modern computing networks have become increasingly ubiquitous. However, there are many challenges of ubiquitous computing to get its better performance. Therefore, this paper has summed up some grand challenges of ubiquitous computing with reference to extant literature available. The identified challenges can be listed as social, Legal and ethical issues, Technical issues, Application Issues, Challenges on human and environment, security challenges and System Maintenance challenges.

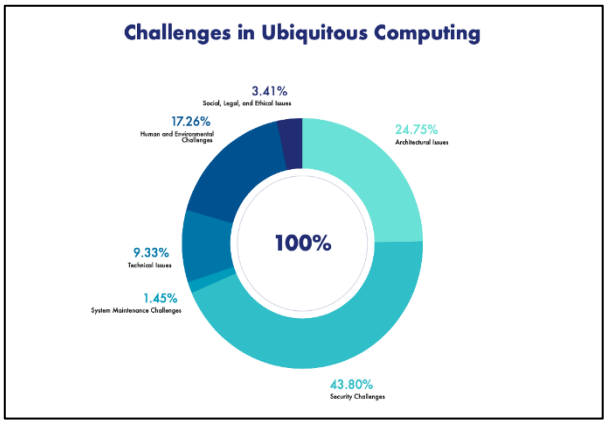


Figure 03: Challenges in ubicomp based on review

This study was able to identify major and trending challenges of ubiquitous computing. The critical analysis of the literature was able to categorize the challenges based on its impact and vulnerability. The challenges identified were ranked accordingly with the support of the scholarly articles. Social, legal and ethical issues were identified as the most challenging in ubiquitous computing whereas the impact on the human and environment was the least. The six challenges and their impact are illustrated in Figure 03.

Research interests of academics and industry are often quite different, however there are opportunities to produce good academic research that can assist industry (Prideaux, no date). Many ubiquitous applications these days are developed by the developers of the industry with the help from the research and development section, but academic researchers carry out exploratory studies in a systematic manner. If we could bridge the gap between the academic research and the relevant industry, we can build better applications. To develop errorless and robust ubicomp models we recommend to elegant designers by helping them see better work that goes into everyday security, trust and privacy. Hence, research in this field should build familiarity with the impacts of applying specific methods and should help selecting whatever design methodology is most appropriate for the configuration of current workload. To accomplish this objective, we propose to develop the security methodologies, debug the technological issues and make the model compatible with the environment. Many challenges we present here are sensible, applicable and within reach, making them prime challengers for rich future advancements. Our present study is limited with the Scopus database as Scopus is considered as the world's largest abstract and indexing database however, we plan to expand our research to undertake a systematic mapping study across various other databases in future.

REFERENCES

Adat, V. And Gupta, B. B. (2018) 'Security In Internet Of Things: Issues, Challenges, Taxonomy, And Architecture', *Telecommunication Systems*, 67(3), Pp. 423–441. Doi: 10.1007/S11235-017-0345-9.

Anjum, F. (2006) 'Challenges On Providing Services In A Ubiquitous, Mobile Environment', *2006 3rd Annual International Conference On Mobile And Ubiquitous Systems: Networking And Services, Mobiquitous*. Doi: 10.1109/MOBIQ.2006.340453.

Batalla, J. M., Vasilakos, A. And Gajewski, M. (2017) 'Secure Smart Homes: Opportunities And Challenges',

ACM Computing Surveys, 50(5). Doi: 10.1145/3122816.

Burhan, M., Rehman, R.A., Khan, B. and Kim, B.S., (2018) 'Iot Elements, Layered Architectures And Security Issues: A Comprehensive Survey', *Sensors (Switzerland)*, 18(9), Pp. 1–37. Doi: 10.3390/S18092796.

Chen, T. And Tsai, H. R. (2017) 'Ubiquitous Manufacturing: Current Practices, Challenges, And Opportunities', *Robotics And Computer-Integrated Manufacturing*, 45, Pp. 126–132. Doi: 10.1016/J.Rcim.2016.01.001.

Davies, N. And Gellersen, H. W. (2002) 'Beyond Prototypes: Challenges In Deploying Ubiquitous Systems', *IEEE Pervasive Computing*, 1(1), Pp. 26–35. Doi: 10.1109/MPRV.2002.993142.

Friedewald, M. And Raabe, O. (2011) 'Ubiquitous Computing: An Overview Of Technology Impacts', *Telematics And Informatics*, 28(2), Pp. 55–65. Doi: 10.1016/J.Tele.2010.09.001.

Hashemi, S. And Zarei, M. (2021) 'Internet Of Things Backdoors: Resource Management Issues, Security Challenges, And Detection Methods', *Transactions On Emerging Telecommunications Technologies*, 32(2), Pp. 1–25. Doi: 10.1002/Ett.4142.

Hilty, L. (2015) 'Ethical Issues In Ubiquitous Computing—Three Technology Assessment Studies Revisited', *Hilty, Lorenz (2015). Ethical Issues In Ubiquitous Computing—Three Technology Assessment Studies Revisited. In: Kinder-Kurlanda, Katharina; Ehrwein Nihan, Céline. Ubiquitous Computing In The Workplace. Cham: Springer, 45-60.*, (333), Pp. 45–60. Doi: 10.5167/Uzh-109998.

Hong, J. I. And Landay, J. A. (2002) 'Four Technological Challenges In Ubiquitous Computing And Their Influence On Interaction Design'.

Horváth, I. And Vroom, R. W. (2015) 'Ubiquitous Computer Aided Design: A Broken Promise Or A Sleeping Beauty?', *CAD Computer Aided Design*, 59, Pp. 161–175. Doi: 10.1016/J.Cad.2014.10.006.

Iwaya, L. H., Ahmad, A. And Ali Babar, M. (2020) 'Security And Privacy For Mhealth And Uhealth Systems: A Systematic Mapping Study', *IEEE Access*, 8, Pp. 150081–150112. Doi: 10.1109/ACCESS.2020.3015962.

Jiang, H., Li, J., Zhao, P., Zeng, F., Xiao, Z. and Iyengar, A.,. (2021) 'Location Privacy-Preserving Mechanisms In Location-Based Services: A Comprehensive Survey.', *ACM Computing Surveys*, 54(1), Pp. 1–36. Available At: Http://10.0.4.121/3423165%0Ahttp://Search.Ebscohost.Com/Login.Aspx?Direct=True&Db=Buh&AN=150035736&Site=Ehost-Live.

Keith Edwards, W. And Grinter, R. E. (2001) 'At Home With Ubiquitous Computing: Seven Challenges', *Lecture Notes In Computer Science (Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics)*, 2201, Pp. 256–272. Doi: 10.1007/3-540-45427-6_22.

Komninos, N., Philippou, E. And Pitsillides, A. (2014) 'Survey In Smart Grid And Smart Home Security: Issues, Challenges And Countermeasures', *IEEE Communications Surveys And Tutorials*, 16(4), Pp. 1933–1954. Doi: 10.1109/COMST.2014.2320093.

Lingvay, I., Bors, A.M., Lingvay, D., Radermacher, L. and Neagu, V. (2018) 'Electromagnetic Pollution Of The Environment And Its Effects On The Materials From The Built Up Media', *Revista De Chimie*, 69(12), Pp. 3593–3599. Doi: 10.37358/Rc.18.12.6800.

Lyytinen, K.J., Yoo, Y., Varshney, U., Ackerman, M., Davis, G., Avital, M., Robey, D., Sawyer, S. and

Sorensen, C. (2004) 'Surfing The Next Wave: Design And Implementation Challenges Of Ubiquitous Computing', *Communications Of The Association For Information Systems*, 13(July). Doi: 10.17705/1cais.01340.

Mahmoud, M. (2016) 'Ubiquitous Computing: Applications And Challenges', (April), Pp. 1–6. Available At: Https://Www.Researchgate.Net/Publication/311410466_Ubiquitous_Computing_Applications_And_Challenges.

Malhotra, P., Singh, Y., Anand, P., Bangotra, D.K., Singh, P.K. and Hong, W.C.. (2021) 'Internet Of Things: Evolution, Concerns And Security Challenges', *Sensors*, 21(5), Pp. 1–35. Doi: 10.3390/S21051809.

Mirani, A.A., Memon, M.S., Bhati, M.N., Soomro, M.A. and Rahu, M.A.,. (2017) 'Taxonomy Of Ubiquitous Computing', *2017 International Conference On Information And Communication Technologies (Icict)*, Pp. 202–208. Available At: Https://Ieeexplore.Ieee.Org/Stamp/Stamp.Jsp?Tp=&Arnumber=8320191.

Prideaux, B. and Campus, C. (2012) 'Bridging The Gap Between Academic Research And Industry Research Needs'.

Przystupa, K., Vasylkivskyi, I., Ishchenko, V., Pohrebennyk, V. and Kochan, O., (2020) 'Electromagnetic Pollution: Case Study Of Energy Transmission Lines And Radio Transmission Equipment', *Przeglad Elektrotechniczny*, 96(2), Pp. 52–55. Doi: 10.15199/48.2020.02.11.

Qiu, H., Kapusta, K., Lu, Z., Qiu, M. and Memmi, G.,. (2019) 'All-Or-Nothing Data Protection For Ubiquitous Communication: Challenges And Perspectives', *Information Sciences*, 502, Pp. 434–445. Doi: 10.1016/J.Ins.2019.06.031.

Risteska Stojkoska, B. L. And Trivodaliev, K. V. (2017) 'A Review Of Internet Of Things For Smart

Home: Challenges And Solutions', *Journal Of Cleaner Production*, 140, Pp. 1454–1464. Doi: 10.1016/J.Jclepro.2016.10.006.

Sen, J. (2010) 'Ubiquitous Computing: Potentials And Challenges', (February 2010). Doi: 10.13140/RG.2.1.3717.4005.

Shaheed, S. M. *Et Al.* (2015) 'Solving The Challenges Of Pervasive Computing', *Journal Of Computer And Communications*, 03(09), Pp. 41–50. Doi: 10.4236/Jcc.2015.39005.

Sharifi, A., Khosravi, M. And Shah, A. (2013) 'Security Attacks And Solutions On Ubiquitous Computing Networks', 3(4), Pp. 40–45.

Weiser, M. (1993) 'Ubiquitous Computing', *Computer*, 26(10), Pp. 71–72. Doi: 10.1109/2.237456.

Weiser, M., (1999) 'The Computer For The 21st Century'. ACM SIGMOBILE Mobile Computing and Communications Review, 3(3), Pp.3-11.

OPD-PMMAS: Patient Management and Mobile Alert System for OPDs in Sri Lankan Hospitals-A Prototype

M.A.C. Akmal Jahan[1*], Subodha Rathnayake[2], Madhureka Kalansuriya[3] & Faarija Subair[4]

[1,2,3,4]*Department of Computer Science, Faculty of Applied Sciences, South Eastern University of Sri Lanka, Sri Lanka*

[1*]akmaljahan@seu.ac.lk, [2]subodha94@gmail.com, [3]madhurekakalansuriya@gmail.com, [4]faarijasubair.55@gmail.com

Abstract- *Unorganised crowds and queues of the people are a major issue in the public services and organisations, especially with the increased number in the population. Outdoor Patients Departments (OPDs) of the government hospitals are often observed to have uncontrolled areas of long queues of patients, especially during the peak hours of clinics and in infection seasons. Currently, there are different types of systems and simulation models experienced for the OPD system to manage the patients. The focus of our study is to develop a prototype for managing patients in OPDs to simplify the process of patient inspection, treatment and conveniently managing their time by sending alerts about the current updates of available patients. This prototype introduces the development of a patient information registration and management system for patients and hospital staff, and a Mobile application-based alert system for patients. The system was developed using JAVA and MySQL. The Mobile application-based alert system was developed in JAVA and an Android mobile device was used as the GSM Modem or SMS gateway to send SMS alerts to the specific mobile number within few minutes. The prototype was tested with users from both hospital staff and patients and produced higher user satisfaction after evaluation through demonstration and questionnaires. The proposed prototype will resolve the difficulties patients faced by minimizing the long queues and will further enhance the efficacy of the services provided to the patients by the hospital systems.*

Keywords: Patient management system, Android application, Mobile alert system, Outdoor Patients Departments

I. INTRODUCTION

The health care systems play a major role in the development of the country's economy and people should experience the services on time. The government hospitals play an important role in providing people with health facilities (Ngowtanasuwan and Ruengtam, 2013). Hospital is one of the most public crowded places in Sri Lanka due to rapid population growth. Outdoor Patients Departments (OPDs) in the hospitals are currently experiencing a high-level of crowdedness. Also paves the path to form queues to get public services. The crowd may lead to the spread of the COVID19 virus in public places and the mass gathering of patients disturb other patients in the hospitals.

The Outdoor Patients Departments (OPDs) of the government hospitals in Sri Lanka are often observed to have long and uncontrolled areas of long queues of patients, especially during the rush hours of clinics and in flu seasons. Many hospitals still use manual, paper-based methods for patient management which leads to lots of difficulties for OPD staff when managing the patients. Not only the staff but also the patients who come to assist them also face some inconveniences due to lack of facility to manage them and therefore, the people have to wait long hours to get their work done. However, in most of the government hospitals in Sri Lanka still, there is no proper mechanism to manage the OPD patients and most of the work is yet done manually or ad-hoc manner. A project named Hospital Health Information Management System (HHIMS) has been introduced to a few government hospitals in Sri Lanka starting from 2010 (Jagoda, Samarakoon, Rathnayake, 2014). The project has been implemented in Base Hospitals at Dambadeniya, Mahaoya, Awissawella, District Hospital Dompe and Base Hospital Karawanella. The HHIMS is capable of doing functionalities such as patient registration when arriving at OPD, report generation (OPD registers, dispensed drugs) and retrieving patient information. However, a mechanism to alert patients through SMS and online patient registration and management is not available in this currently implemented HHIMS system in government hospitals in Sri Lanka (Kulathilaka, 2013; Hewapathirana and Rathnayake, 2014). On the other hand, Multi-Disease Surveillance (MDS) project has been implemented in over 20 government hospitals in Eastern province including Chenkalady Rural Hospital, Batticaloa

Teaching Hospital, Trincomalee General Hospital. The MDS is also limited to certain functions such as storing patient information, drug control and so on. However, the MDS system also does not consist of any alert mechanism to send SMS notifications to patients or to register patients online without coming to the hospital (Pole, 2010). This depicts that online patient registration and patient alert systems are not yet implemented in government hospitals in Sri Lanka.

Therefore, people have to wait in long queues to get their work done and the increased number of people in the OPD section will cause the spread of infectious diseases in current pandemic situations. Insufficient space for seating patients and the people who assist them make them so inconvenient as a large number of people arrive at peak time to the OPD (Ngowtanasuwan and Ruengtam, 2013). Therefore, hospital administration is seeking an alternative approach to managing the crowded patients and following some ad-hoc methods to provide their services uniformly. Our study is focussing on developing a prototype for the Patient Management System in OPD which will help to resolve most of the issues faced by the patients as well as the staff in the existing system in hospitals.

The main goal of this work is to introduce a prototype for a patient management system, particularly in OPDs in Sri Lankan government hospitals which will eventually help both the staff as well as the patients. Therefore, we are introducing a patient's management system with mobile technology to send time to time alert messages to the registered patients by indicating how many patients are in the waiting queue within a particular time, so that any incoming patients can manage their time based on the availability of existing patients and doctors. The patients can register at the hospital using two methods, by arriving at the OPD or by registering through the web-based application when staying at home without arriving at the OPD. By registering through both methods, related information can be sent through alert messages. This not only reduces the unnecessary gathering at the OPD reception but also the workload of the receptionists. The overall system is well secured and password protected. The patients' treatment information can be viewed only by the doctors, nurses and other related staff. The solution will reduce the waiting hours of the patients; effectively manage the work and time of patients and hospital staff to indirectly support the social distancing concept due to the pandemic.

To achieve the goals, the following objectives are performed:

i. Development of patient information registration and management system for OPD.
ii. Integration of the patient alert system using the mobile application with the patient management system.

II. LITERATURE REVIEW

Many recent studies have been performed not only to develop new systems but also to analyse the existing simulation techniques in order to manage the patients in the hospital's OPD. Zero Queue Management System (ZQMS) in the past work used an Android application named "*Smart Medicare*" consists of a waiting list option that informs patients of the availability through SMS and the medical records can be viewed by using a one-time password (OTP) that is sent to the patient's mobile number. The doctor's fingerprint is taken when he enters and leaves the cabin to ensure the doctors' availability. The cloud server and the website are updated with the help of the Arduino through the Wi-Fi module and by the cloud server respectively (Thirupathieswaran *et al*., 2021).

In the work performed by Kavitha, Ramana and Raj (2012), an Embedded Management System for OPD was designed to help patients to identify the relevant doctor's cabin by displaying their token number and their name on a TFT screen which is placed outside the doctor's cabin. The number of TFT screens used depends on the number of departments in the hospital. The system comprises various embedded devices like Microcontrollers, SD card, LCD, RS-485, SPI, keyboard, and each Consultant's room has OPD slaves which are used to inform the Master OPD unit to send the corresponding consultants' token number. In another work (Soman *et al*., 2020), focused on Mobile-Augmented Smart Queue Management System for Hospitals, which is capable of generating unique tokens by using algorithms. The system provides various facilities such as estimation of patient's waiting time, generation of multiple tokens for the same family member, notifications and messages services at token generation and also notifications about the waiting time and the patients turn at the specific counter.

The work in Chandran *et al*. (2017) introduced Multiple Queue Management systems with real-time tracking that facilitates patients to make appointments after registering through the internet, by checking the doctors' available time slots. The appointments are given according to the date and time, the relevant department, the available doctor and the patients have to wait in separate digital queues for each doctor in different departments in each time slot. The appointment status is informed through messages and the cancel appointment, update appointment and waiting appointment options are available. In another work by Aizan *et al*. (2019), 'Walk-Away' Queue Management System Using MySQL and Secure Mobile Application is controlled by a central server, facilitates the patients to leave the area after getting the digital token and they are called back by the remainder messages send through Telegram app or SMS, five numbers before calling the specific ticket. The system uses an Android phone to replace the Callpad terminal and the token dispenser in the normal QMS. However, the bandwidth and transmission were detected as the main system issues in this system. The work in Ngorsed and Suesaowaluk (2016), introduced the Hospital Service Queue Management System which used wireless devices to monitor the queue status which can be accessed online through an open-source web application. An Arena simulation model was introduced in the work Kulkarni *et al*. (2021) and used to study the patient flow in different OPD sections. The patient movements are recorded when they enter the OPD and the patient flow data distribution at each section is determined by the Input Analyzer. Rema and Sikdar (2021) recently analyzed the flow of patients in an Indian hospital by considering a single consultant for a period of three hours and the time taken by patients to complete particular tasks were noted through observations, and snow ball sampling technique was used to take the general data by distributing a questionnaire among 25 OPD staff. Furthermore, the Monte Carlo simulation technique was used to analyze the queuing patterns where the results depict the ways to minimize the delays and increase their service. From the analysis of the recent literature review, there are some attempts that tried to sort out the issues of patients in hospitals. However, there are some issues in each approach and we try to introduce a simple and convenient method for both hospital staff and the public.

For the mobile technologies utilised in different applications, there are several methodologies used to send alerts messages from a computer system to a mobile phone through SMS. GSM (Global System for Mobile communications) modem is a device that is capable of sending and receiving SMS and data over a GSM Network. It not only provides the easy development of systems but also works in a remote area without telephone line connections (Sukanesh *et al*., 2010). A computer can send SMS messages when it is connected to a mobile phone or GSM/GPRS modem, but this method has a minimum transmission speed of about six messages per minute. Another method of sending SMS is sending the message from the computer to the recipient through the SMS centre or SMS gateway of a wireless carrier. Although this method is fast, this requires a higher amount of routing and network wiring (Ueng, Tsai and Chang, 2007).

The Ozeki message server consists of an SMS gateway application that enables users to send and receive SMS messages to mobile devices from a computer. The messages can be sent and received when a GSM mobile phone is attached to the computer using a data cable or through IP SMS technology (Abdel-qader, 2011). A computer equipped with messaging software such as Ozeki can be used as a Short Message Entities (SME's) that act as the source and destination for SMS messages (Mhapsekar *et al*., 2012). There are various systems developed using this Ozeki message server. A mobile-based medical alert system (MAS) was built to send SMS alerts to patients' and medical practitioners' handheld devices such as mobile phones and PDAs. The SMS alert message is forwarded in MAS using the Ozeki SMS server that consists of a GSM modem. The system consists of a MYSQL database, application and web server. An automated scheduler that runs with PHP and Ozeki SMS server integrates to execute this application (Watfa, Johnston and Snavely, 2011).

In another way, FrontlineSMS is freely available open-source software that provides facilities to send large scale SMS messages (Mahmud, Rodriguez and Nesbit, 2010). A two-way text messaging hub was created by connecting a computer running with FrontlineSMS to a GSM modem or a cell phone. The phone numbers with a valid SIM (Subscriber Identity Module) can receive and send SMS to and from the console. This software facilitates the users with various options such as managing contacts, auto-forwarding and replies. There is a work that uses IoT devices to send and receive messages

(Rajkumar, Srikanth and Ramasubramanian, 2017). Raspberry pi is a high-performance computer that can be programmed using programming languages like Python to send SMS alerts that are used in implementing health monitoring systems. Raspberry Pi can be combined with a GSM module through a serial port to send and receive SMS using AT commands (Gupta, Patchava and Menezes, 2015). Since the existing systems have so many software-hardware modules to be integrated, we have introduced a simple implementation that can send SMS alerts to the patient's mobile phone from a Java based patient registration and management system.

III. METHODOLOGY

An overview of the overall Patient Management System in OPD is shown in Figure 1.

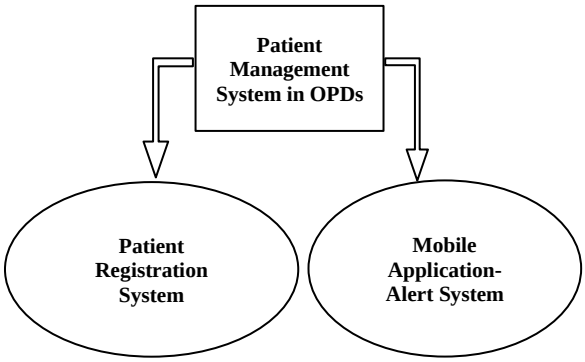


Figure 1: An overview of the overall Patient Management System in OPD which consists of patients' registration and mobile application modules.

The overall system consists of two intrgrated research componenets.

i. Development of a patient's information registration and management system for OPD.
ii. Development of mobile application based alert system for the patients.

A. Development of patients' information registration & management system.

The patient's information registration and management system consist of several processes. The receptionist is able to add the users to the system. A user (receptionist and doctor) can thereafter login to the system with the user credentials and can direct into the main form which consists of several processes such as patient registration, doctor registration, channel creation, view channel, create items, create user, view doctor and log out. The receptionist is also able to register the patients who are coming to the hospital by putting their information such as the patient's name, age, address and a mobile number which should be an active number as it is used for the mobile alert system for patients. In the system, the patient's registration number is a unique number that is generated by the system. The patient can use his or her registration number whenever they visit the OPD. The patients' information can be updated and deleted. The *Create User* function in the main form is used to insert users for the system by the receptionist.

The doctor is also able to register using the *Doctor button* with information such as Name. The doctor is able to delete, add and update the information. The receptionist can use the *Create channel* button to create a channel. The receptionist can select the doctor's name from the drop-down list and the patient's name, room number and channel date can be entered. The doctor is able to view the channel and also to add items.

B. Development of mobile based alert system for patients and hospital staff.

Mobile technology is not only used for making calls but also controlling the crowdedness in public places. Today, gaining government services in public places is threatening everyone's health due to the pandemic. The report provided a mobile alert system to control the crowd in Out Patient Department (OPD) in hospitals. The purpose of producing this framework is to reduce the waiting time in the queue and control the crowd of patients at OPDs. The proposed system consists of two main parts: Mobile application and Mobile alert system. They explain how the patients receive alert messages from mobile applications with the number of patients and time through SMS. The alert system was developed using the JAVA programming language. The proposed framework produces an effective method to alert the patients when the crowd is high in OPD. The system consists of two main parts. One is the mobile-web based application and mobile alert system. The report depicts how these two main parts work together to control the crowd in the OPDs in Sri Lanka. Mobile applications can only be used by those who have phones.

The mobile alert system has the ability to send the alert message to the patients when they are registered at the hospital's OPD. The web-based mobile alert system facilitates the users to register themselves at home without arriving at the hospital, and the system is capable of sending alerts as an SMS to the patient's phone number

which they gave during the registration process. The proposed system can be used by both Android users as well as normal mobile phone users. The mobile alert system is capable of sending SMS to the patients' normal type mobile phone when they go to the hospital and get registered if there is no facility to register through the web-based application or any Android phone usage. This alert system was developed using JAVA and an Android mobile device was used as the GSM Modem or SMS gateway to send the SMS alert to the specific number.

The tools and techniques used for this system are:

C. *Patients' information registration and management system:*

The system was developed in JAVA using NetBeans IDE 8.2 and MySQL is used to create the database using Xammp Control Panel v3.2.4.

D. *Mobile application based alert system for patients and hospital staff:*

The patient mobile alert system was developed in the JAVA programming language by using the NetBeans IDE 8.2. An Android mobile device was used as the GSM Modem or SMS gateway to send SMS alerts to the specific number within a few seconds. This exposes a set of APIs for two operations, sending and receiving SMS. This supports programming languages such as Java, Spring, C, C++, PHP, Laravel, Codeigniter, C#, ASP.NET, etc.

IV. DESIGN

A. *Object oriented based analysis and design of the patient management system*

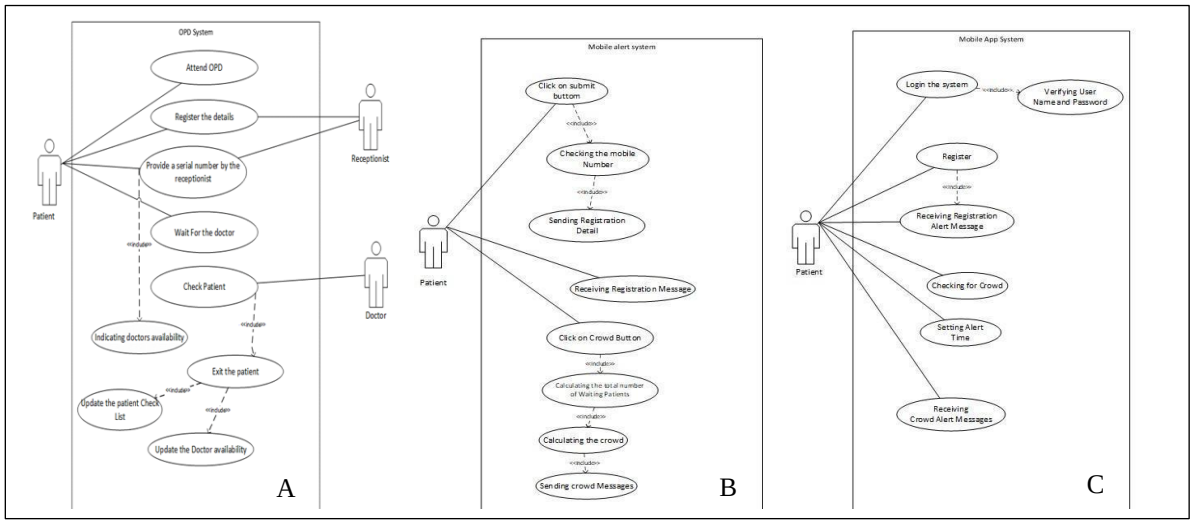


Figure 2: The use case diagram of: A) Patient's information and management system that illustrates how the system interacts with its users; B, C) mobile-based alert system illustrates how the system interacts with patients.

V. IMPLEMENTATION

A. *Patient management system*

The patient management system is used to facilitate the hospital staff and the patients who arrive at OPD to get their treatments. It helps to reduce the waiting time of patients. Figure 3 depicts the Login screen. There are different users with different user privileges.

The administrator is able to create users such as doctor, receptionist and other roles using *create user* button for the system and is able to create a user by giving a username and password. The patient registration process is done by the receptionist by selecting the *patient button* on the *Main Page* or online based by the patients. Figure 3-C depicts the patient registration page where the receptionist can add, update and delete patient information. They can enable the system to send alert messages time to time to the registered patients. The receptionist can also create a channel by the *Create Channel* button on the main page and the doctor is able to view the channel through the doctor login as shown in in Figure 4. *Create Item* page is available to the doctor login option where the doctor or doctor's assistant is able to create prescription items, update and delete them in the existing list (Figure 5C). The top-level administrator has more privileges and each user is provided required access and process in the system.

Receptionist's View

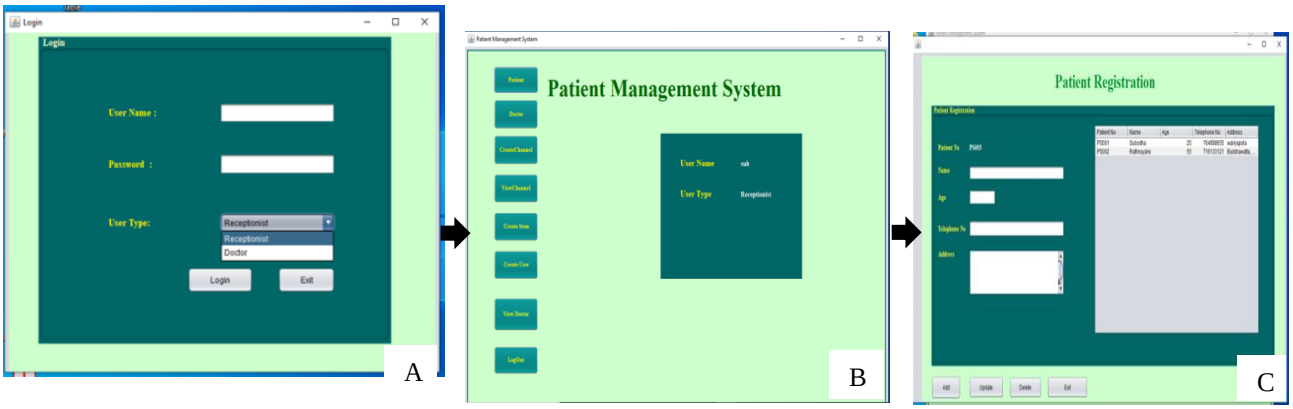


Figure 3: Patient management system- Initial login environment of the system with different users who need different user privileges; The Main Page consists of main processes of the system such as patient registration, doctor registration, create user, create channel, create drug items etc. The user creation process is handled by administrator by giving user credentials and the receptionist registers, updates patients' records and create channel.

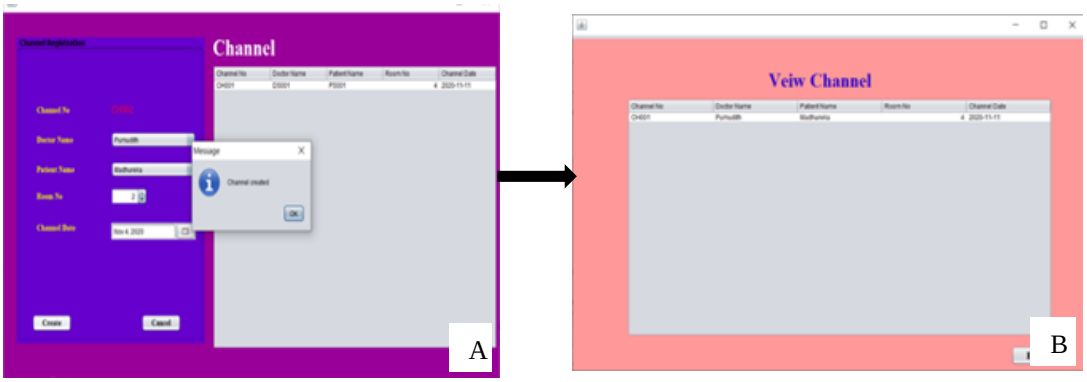


Figure 4: *Channel Creation* Process: A) The channel creation page where the users are registered under various doctors and room numbers; B) The view channel option is visible to the doctor where it contains information about the channel number, doctor name, patient name, etc.

Doctor's view

The user is directed to the *Main Page* when they login to the system as a doctor. The doctor can register, update and delete the details using this page as shown in Figure 5B; C) Create Item page is available to the doctor login option where the doctor or doctor's assistant is able to create and update prescription items.

B. Mobile based alert system

The mobile alert system has the ability to send alert messages to the patients when they are registered at the hospital's OPD. The web-based mobile alert system facilitates the users to register themselves at home without arriving at the hospital. The alert is sent as an SMS to the patient's phone number which they gave during the registration process and is sent to the patient from time to time when the patient management system gets updated. This facilitates the patients to identify the number of patients in the relevant doctor counter at a specific time and also to know about the current ongoing patient's number that is called at the doctor counter although they are not at the hospital premises. This will help to reduce the unnecessary gathering at the OPD.

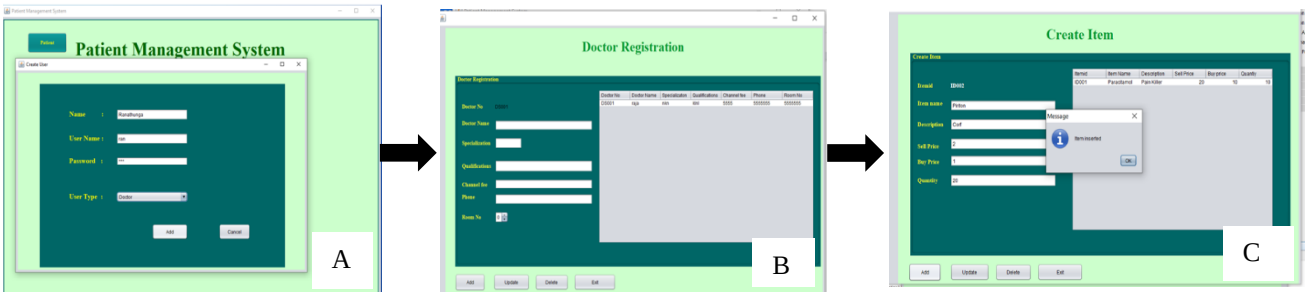


Figure 5: Patient management system-A doctor's view where the doctor can register, update, delete the doctor's information: A) Log in process of staff; B) Registration process of clinical staff; C) Create drug items.

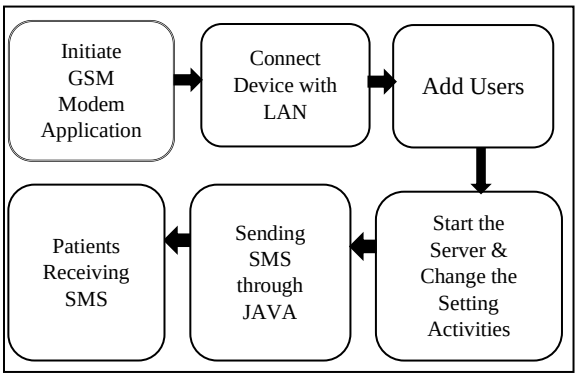


Figure 6: This model shows the overall process of sending the SMS alert messages to the registered patients.

The following steps are exploited during the process of mobile-based alert system:

i. Initiate the GSM

Initial and final state of the interfaces of the GSM modem application with its components at initial state.

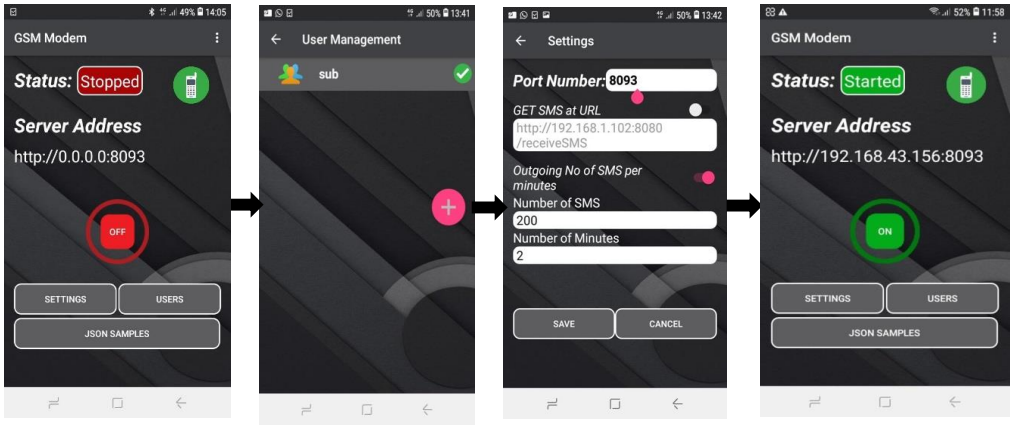
ii. Addition of users with the password.

Users must be added for authentication before sending a request for SMS.

iii. Changing the setting activities.

iv. Request for sending SMS.

The Android device and the computer must be connected to the same Local Area Network to communicate with each other. Then the SMS server must be started (The Red Circle button becomes green). Then search through the Chrome browser to get the HTTP request in the browser with the credential parameters. This will send the JASON in return. Next, the JAVA code has to be executed by adding the suitable parameters such as the patient's mobile number and the message, which then will be sent to the relevant patients and the status of the message is represented as a response. The sender's and receiver's view of the mobile alert system is depicted in Figures 7 and 8B, respectively.



The initial interface of the GSM modem application with its components at initial state.	Addition of Users with the password.	The interface of the settings section and its components at final state.	The final interface when sending SMS, the server address is also displayed.

Figure 7: Mobile alert system: Sender's view

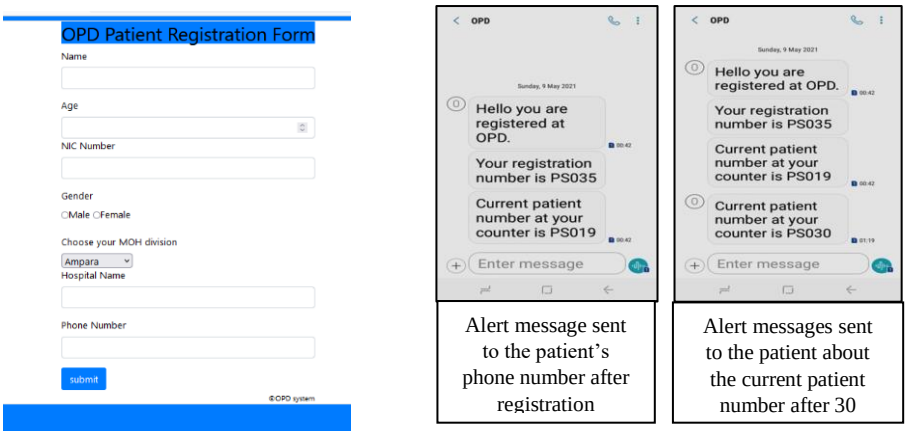


Figure 8: Web-Based Registration & Mobile Alert System: A) Mobile-web based alert system interface where the users can register through the interface; B) Mobile alert system: Receiver's view

We have tested the prototype using several sample users with different types of mobile phones. We have selected around eighty-six users from different age groups particularly, elders and youngsters in both patients and staff category. From the questionnaire made with the users, a higher percentage of user satisfaction is achieved as the simplicity of the system. It was analysed that 87.2% of the users were satisfied with the prototype while 77.9% of users found the prototype is easy to use. It is successfully working well and users are convenient about the system. The suggestions and feedback obtained from the users are considered to the revised version of the system in the future with an automated crowd detection module.

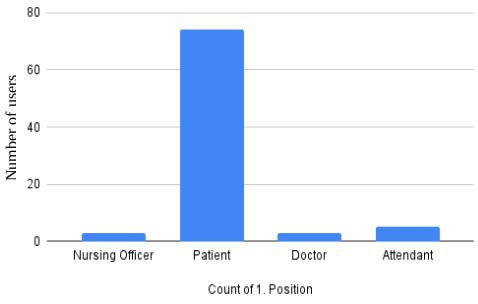


Figure 9: The prototype was tested using doctors, nursing officers, attendants and the general public who become patients

Challenges

There are some challenges faced during the development of the alert system. The major challenge is finding a suitable SMS gateway. There are so many SMS gateways available to use, but they are not freely available. Although SMS APIs enable the integration of SMS services with systems easily, most of the APIs such as Textlocal's SMS API does not support signing up from Sri Lanka.

VI. DISCUSSION

Our study was focused on developing a prototype for the Patient Management System in OPDs which will help to resolve most of the issues faced by the patients as well as the staff in the existing system. The major challenge we faced while developing the system was the development of a mobile application (alert system). It was difficult to find a suitable SMS gateway. There are so many SMS gateways available to use, but they are not freely available. Although SMS APIs enable the integration of SMS services with systems easily, most of the APIs (for example, Textlocal's SMS API) do not support sign up from Sri Lanka.

The patient management system in OPD that we have developed differs from the existing system due to the availability of sending SMS alerts for the patients. The patients who receive the SMS alerts do not need to install any software or mobile app on their phones. Their phones do not need to be any Android or smartphone. SMS service is available to all kinds of mobile phones which have a phone number registered at OPD. This will facilitate the people with different economic levels to access the service without any technical or financial difficulty. The other feature of the system is people can access the system at home and register and update their details and get alert messages and plan their visit to OPDs at their convenient time. For this purpose, we are developing the system with Angular JS front end,

Java back end and MySQL database, which enables the system to be accessed by any patients outside of the hospitals.

The future work of this system will be the adding of new features and introducing automated crowd detection techniques using deep learning. The state-of-the-art methods will be investigated to develop a novel technique for crowd detection in public hospitals and OPD premises. This will help to eliminate hospital staff and indicate those who are inside the OPD premises.

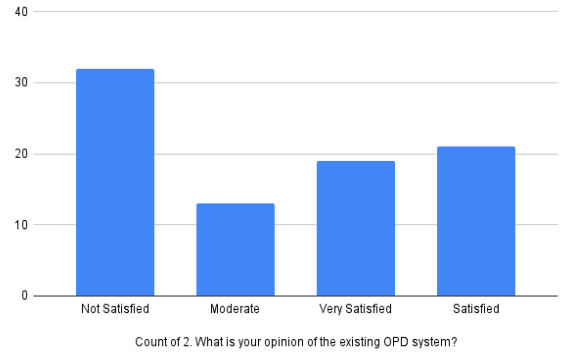


Figure 10: The opinion of the existing manual OPD system and the proposed prototype model: Test with manual system where 37.2% are not satisfied with the existing manual system while 15.1% of users are moderately satisfied, which depicts the need for a new system;

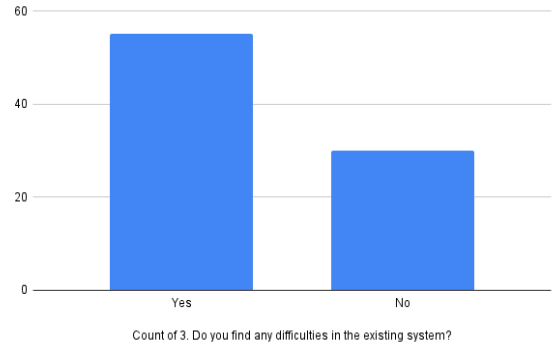


Figure 11: The opinion of the existing manual OPD system and the proposed prototype model: 58.1% found that they are having difficulties in the existing manual system.

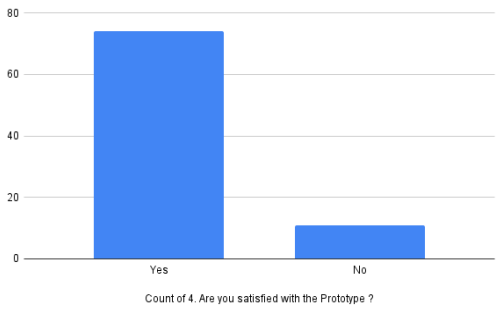


Figure 12: The opinion of the existing manual OPD system and the proposed prototype model: The prototype is tested with the users and 87.2% of them are satisfied with the developed prototype.

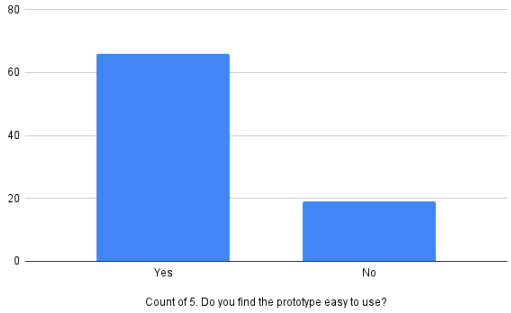


Figure 13: The opinion of the existing manual OPD system and the proposed prototype model: User satisfaction with the prototype testing where 77.9% of them found that the prototype was easy to use.

VII. CONCLUSION

The current work presents the development of a prototype for the patient management and mobile alert system in OPD where the overall system consists of two integrated research components. The patient's information registration and management system was developed to provide an effective service to the patients as well as the staff as a solution to the difficulties they faced in the current manual process. The mobile alert system was developed to provide alert messages to the patients, which will facilitate the patients to identify the number of patients in the relevant doctor counter in a specific time period and also to know about the current ongoing patient's number that is called at the doctor counter although they are not at the hospital premises. This system will help to solve the problems with time management and over crowdedness of the current OPD systems.

REFERENCES

Abdel-qader, M., Al-Jaber, A. and Al-Hamami, A. (2011) 'Using Short Message Service (SMS) to Support Business Continuity', 1(2), pp. 34–38.

Aizan, A.L., Mukhtar, A.Z., Bashah, K.A.A., Ahmad, N.L. and Ali, M.K.A.M. (2019) 'Walk - Away" Queue Management System Using MySQL and Secure Mobile Application', 1(1), pp. 1–4.

Chandran, D.V., Diyya, P., Pooja, G. and Arati, G. (2017) 'Multiple Queue Management with Real Time Tracking for OPD Scheduling in Hospitals', (02), pp. 33–36.

Gupta, M.S.D., Patchava, V. and Menezes, V. (2015) 'Healthcare based on loT using Raspberry Pi', pp. 796–799.

Jagoda, A.I., Samarakoon, M.A.C.S. and Rathnayake, S. (2014) 'Policy issues in implementing Open-Source Electronic Health Record Systems in Sri Lankan Hospitals'.

Kavitha, C., Ramana, A.V. and Raj, S.S. (2012) 'Embedded management system for outpatient department', *International Journal of Pharmacy and Technology*, 8(4), pp. 20297–20302. doi: 10.5121/ijesa.2012.2305.

Kulathilaka, S. (2013) "eHospital-Dompe "project–the story of the transformation of a district hospital in Sri Lanka. Sri Lanka Journal of Bio-Medical Informatics, 4(2).

Kulkarni, S.D., Roshni, V., Varshitha, S., Sandeep, M.V., Monish, T. and Venkataraman, V. (2021) 'Modelling the patient flow in an out-Patient Department (OPD) of a hospital using simulation techniques', *IOP Conference Series: Materials Science and Engineering*, 1059(1). doi: 10.1088/1757-899X/1059/1/012041.

Luschi, A., Belardinelli, A., Marzi, L., Frosini, F., Miniati, R. and Iadanza, E. (2014) 'Careggi Smart hospital: A mobile app for patients, citizens and healthcare staff', *2014 IEEE-EMBS International Conference on Biomedical and Health Informatics, BHI 2014*, pp. 125–128. doi: 10.1109/BHI.2014.6864320.

Mahmud, N., Rodriguez, J. and Nesbit, J. (2010) 'A text message-based intervention to bridge the healthcare communication gap in the rural developing world', 18, pp. 137–144. doi: 10.3233/THC-2010-0576.

Mhapsekar, A., Kulkarni, P., Nagarsekar, U. and Kalbande, D.R. (2012) Voice enabled Android application for vehicular complaint system: Using GPS and GSM-SMS technology. In *2012 World Congress on Information and Communication Technologies*, pp. 520-524.

Ngorsed, M. and Suesaowaluk, P. (2016) 'Hospital service queue management system with wireless approach', *Lecture Notes in Electrical Engineering*, 375, pp. 627–637. doi: 10.1007/978-981-10-0539-8_61.

Ngowtanasuwan, G. and Ruengtam, P. (2013) 'Applied Simulation Model for Design of Improving Medical Record Area in Out-patient Department (OPD) of a Governmental Hospital', *Procedia - Social and Behavioural Sciences*, 101, pp. 147–158. doi: 10.1016/j.sbspro.2013.07.188.

Pole, D. (2010). 'Electronic patient records in Sri Lankan hospitals', *Sri Lanka Journal of Bio-Medical Informatics, 1*(1).

Rajkumar, S., Srikanth, M. and Ramasubramanian, N. (2017) 'Health Monitoring System using Raspberry PI', pp.116-119.

Rathnayake, S., & Hewapathirana, R. (2014) Impact of electronic: health records in Sri Lanka-case study of four government hospitals. *Cmb. Academia. edu*.

Rema, V. and Sikdar, K. (2021) 'Optimizing Patient Waiting Time in the Outpatient Department of a Multi-specialty Indian Hospital: The Role of Technology Adoption and Queue-Based Monte Carlo Simulation', *SN Computer Science*, 2(3). doi: 10.1007/s42979-021-00595-8.

Soman, S., Rai, S., Ranjan, P., Cheema, A.S. and Srivastava, P.K. (2020) 'Mobile-augmented smart queue management system for hospitals', *Proceedings - IEEE Symposium on Computer-Based Medical Systems*, 2020-July, pp. 421–426. doi: 10.1109/CBMS49503.2020.00086.

Sukanesh, R., Rajan, S.P., Vijayprasath, S., Aishwarya, N.S. and Angela, P.G. (2010) 'Intelligent wireless mobile patient monitoring system 1', pp. 540–543.

Thirupathieswaran, R., Prakash, C. S., Krishnan, R. S., Narayanan, K. L., Kumar, M. A., & Robinson, Y. H. (2021) 'Zero Queue Maintenance System using Smart Medi Care Application for Covid-19 Pandemic Situation'. In *2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV)* (pp. 1068-1075). IEEE

Ueng, T. S., Tsai, Z. D. and Chang, J. C. (2007) 'SMS alert system at NSRRC', pp. 401–403.

Watfa, M. K., Johnston, L. and Snavely, J. (2011) 'E-Healthcare Systems and Wireless Communications: Current and Future Challenges'.

TRACK - MULTIMEDIA AND GAMING TECHNOLOGIES

Impact of Interactive Whiteboards in Academic Activities

S.L. Fathima Ruksana[1*]

[1*]*Department of Information Technology, Faculty of Arts and Culture, South Eastern University of Sri Lanka, Sri Lanka*

[1*]*fathimaruksanasl@gmail.com*

Abstract- *Now technology plays a major role in the world. According to that use of digital devices is also one of the main advantages for humans to fulfill their daily needs. There are many digital devices that are used in academic studies to meet academic requirements. So Interactive whiteboards are one of the main advantages for the students who are eager to learn education by using technical devices. So, this study was carried out to explore the impact of using Interactive whiteboards in academics. This research was conducted among information communication technology specialized students in arts and culture, South Eastern University of Sri Lanka at Oluvil. This research explored that interactive whiteboard have a considerable impact on students. When we take higher education, the outcome of learning is more appreciated, and the Interactive whiteboards are used by the students in the lecture hall to make their learning perfect and effective. Interactive boards are impacted studies and improve the progress in their learning and enhance the teaching techniques. Many digital devices used by the students for many purposes include interactive boards that impact student's education and their studies. The main focus of this study is to guide students to use interactive boards in their education field.*

Keywords: Interactive, boards, digital, impact, education

I. INTRODUCTION

According to smart technology, the use of Interactive whiteboards is one of the fundamental tools used in the educational field. It helps to improve the performance of the students and enhance the progress of the students in the field of education. There are a lot of questions that have arisen by the rapid growth of using Interactive whiteboards in education. So, this study of the impact of using interactive whiteboards in academic activities to address the questions which arose on this impact of Interactive whiteboards.

With the rapid development of information technology, the spread of using Interactive whiteboards is very highly appreciated. The fundamental use of these Interactive whiteboards helps to give proper learning and teaching to enhance the performance and the progress of the students. These Interactive whiteboards were recognized to use this digital device in education for teaching and learning.

Most of the governments were provided many Interactive whiteboards to the students who are studying in schools and universities to enhance their progress and take an interest in studies. Digital opportunity projects were introduced by many countries for making an effective environment for the students and teachers on learning and teaching.

And if we take teachers, they can make their teaching through these Interactive whiteboards meaningfully and successfully and can do multiple tasks using Interactive whiteboards and also provide multimedia facilities and also many fun and enjoyment can get by these Interactive whiteboards while studying and teaching.

Internal and external variables were analyzed for this research. If we see about the interactive digital board, these are most fundamental teaching devices for higher education and development for this purpose; we have used the condition of digital interactive boards for the south eastern university information communication technology special students in the following years of

(2017/18), (2016/2017), (2015/2016), (2015/2014). The use of the interactive digital board applied to the development of personal, academic, and professional competencies is a part of the university goal. By those applications, good progress will be gained by the students in academics and professional competencies, and the students' performance will be increased by these interactive digital boards, and students can improve their performance in studies by the interest of the interactive digital boards.

II. LITERATURE REVIEW

Based on (Shi et al, 2012); they stated under the heading of" The impact of the Interactive whiteboards on education" whiteboard is one of the potential tools for collaboration, and also it helps to improve learning outcomes and helps to the lesson planning and also the mentioned Interactive whiteboards one of the teaching strategies which is a method to develop in education. Traditional equipment is not unable to meet the modern educational requirements, and also they mentioned the positive side of Interactive whiteboards as well as the negative side also, such as frequent technical problems occurred, the latency of response, and difficulties in operations.

According to (Tufan,2013) stated under the heading of "Interactive whiteboards factor in education: student's points of view and their problem", some countries introduced Interactive whiteboards to elementary students' education, and the government believes that Interactive whiteboards will raise the students' learning efficiency. By the use of Interactive whiteboards, it increases the interest in the lessons and helps to motivate the students and helps to make joy in their studies .and he mentioned that Interactive whiteboards have a positive effect on students' attitudes as well as it is effecting on teacher's attitudes. And Interactive whiteboards are an innovative tool used for learning and teaching processes very effectively. And also, he mentioned problems related to the Interactive whiteboards, which means technical problems, lack of technical skills to operate Interactive whiteboards and analyzed that female students have more positive attitudes towards the Interactive whiteboards than male students.

According to (Gregorcic, Etkina and Planinsic,2018), under the heading of "A new way of using the Interactive whiteboards in high school physics classroom: a case study." Interactive whiteboards help the school to improve the class teaching by adding visual impact to the lessons and interactivity. And Interactive whiteboards have become a common tool for academic activities in western countries' schools. And also, Interactive whiteboards play a crucial tool to explain the teacher to the students in a visual way. And in some countries, Interactive whiteboards use almost a common tool in primary and secondary education. And also, he mentioned that some problems related to Interactive whiteboards like a lack of technical skills, and some teachers have lack of knowledge of how to use interactive whiteboards, and having lack of appropriate teaching material to use with interactive whiteboards. And students can involve in studies by observing video recordings, voice records related to the studies.

According to (Swan, Schenker and Kratcoski, 2008) under the heading of "The effects of the use of interactive whiteboards on students achievement" that the use of interactive whiteboards can be used to increase the students' achievement .and it helps to improve the students' scores and standards, and also interactive whiteboards help in mathematics, reading, language, art and for classroom management .and also by his analyzing about interactive whiteboards usage for a particular subject, the students who used the interactive whiteboards performed well in that particular subject.

According to (Davidovitch and Yavitch, 2017) , they mentioned under the heading of **"The effect of smart boards on the cognition and motivation of students",** students are called as a digital learner because they are using many digital devices for their learning process by the use of these technologies. 72% of students satisfied and helps to understand the material taught in the class by using this digital smart equipment for their studies; it can be motivated and boost their studies and help to show the studying material visually to the students. And it is a common technology tool used in the classroom, and it helps students to understand the material and improve students' achievement in their studies. And mentioned the advantages and disadvantages of smartboards for students and teachers and also and analyzed that smartboard is an important mechanism for students' evaluation. And mentioned changes that occurred with introduced of technology and smart board to the school system.

III. PROBLEM STATEMENT

The goal of this study is to determine the impact of using interactive boards in academic activities in the learning performance of the students in the faculty of arts and culture students in information communication technology special. Especially it helps to solve the following problem.

1. Lack of interest to the students in learning with manual ways.
2. It is difficult to use the manual boards to explain to the students.

3. It is difficult to study without a visual method
4. Find new ways to use the interactive boards

Those problems were inspired by this research on the theme of the impact of using Interactive whiteboards in academic activities.

IV. METHODOLOGY

This study was conducted at south eastern university of Sri Lanka. This educational place consists of information communication technology special students in the faculty of arts and culture. First, we have conducted the interview individually and in the group among the students who are doing information communication technology as a special subject. We have requested the details of the students who are studying in information communication technology special to the dean office and collected the number of students who are studying in information communication technology special. According to that, there are 350 students studying in the faculty of arts and culture, including that 60 are the information communication technology special students from 1st, year 2nd, year 3rd year, and 4th year. We have used qualitative research techniques to check whether how interactive digital boards are impacted students in academic activities. Semi-structured questionnaires were used for the purpose of data collection.

The questionnaire has four parts as the first part consists of respondents' background second part related to the what are the subjects mostly Interactive whiteboards are used third part consists of the uses of interactive whiteboards during academic activities the final part consists of identifying the misuse of the digital interactive board in academic activities. According to these questions, the respondent's response to the open and closed-ended questions.

These questionnaires were distributed among the students who are studying information communication technology as a special subject in south eastern university of Sri Lanka because these students are highly involved with the digital environment and devices.

Table 1: Uses of Interactive whiteboards in academic activities.

Uses of Interactive white boards	% of never use	% of always use
Prepare for lesson	5%	85%
Collect resources	20%	70%
Use ppt for teaching	45%	60%
Prepare exercise	60%	30%
Communicate online	35%	60%
Online library	40%	30%
Video clips for teaching	20%	65%

Table 2: Misuse of Interactive whiteboards in academic activities.

Ways of Misusing the Interactive Whiteboards	Percentage of Misusing Interactive Whiteboards
Use for Playing Games	45%
Use for Personal Needs	65%
Use for Watching Films	30%
Use as A Video Conference Tool to Communicate Unwanted Ones	5%
Accessing Social Media	50%

Table 3: The percentage of using interactive whiteboards in a variety of subjects for learning.

Subjects mostly used Interactive whiteboards for learning	Percentage of students used an interactive whiteboard for learning subjects
Practical subjects (word, PowerPoint, Excel, graphic design. etc.)	90%
Programming (VB, python, java, etc.)	80%
Web technology subjects(html, CSS,)	85%
Theory subjects	60%

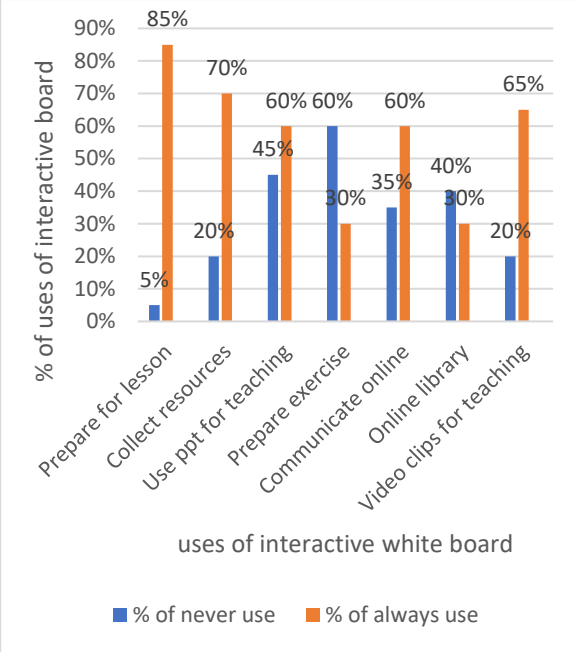


Figure 01: Uses of Interactive whiteboards by the information communication technology special students in academic activities.

V. RESULTS AND DISCUSSION

In this section, the results analyzed and choose the students to do the research from information communication technology special students who are in 1st-year 2nd year 3rd year and 4th year from arts and culture in the south eastern university of Sri Lanka because they are the students who mostly interact with digital devices and most of the governments are issued these Interactive whiteboards to the universities and schools. In this survey, 60 students have participated.

The ratio of females and males of this survey was 54:6 .and following chart showing the uses of Interactive whiteboards among the students in arts faculty in south eastern university of Sri Lanka the analyzed the uses of Interactive whiteboards in academic activities, above 50% of the students have used the Interactive whiteboards in their academic studies and get benefit in their learning activities, and interactive whiteboards were misused by some students and also most students were used Interactive whiteboards for learning many subjects .so by the use of these Interactive whiteboards, can increase the progress of the students and not only in studying but also they can become an innovative student in the world.
So, the bar and pie chart shows the students were used Interactive whiteboards in their academics and used in many subjects.

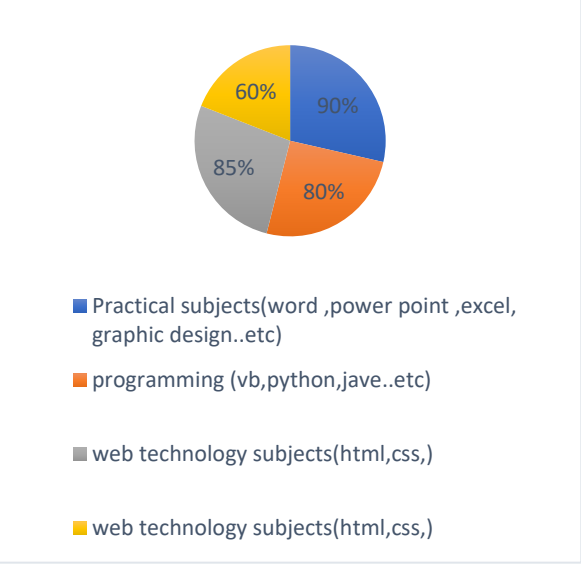


Figure 02: Percentage of students using interactive whiteboards for learning a variety of subjects.

The end of this study found something related to the impact of Interactive whiteboards.

- Averagely 57% of the students have always used the Interactive whiteboards in their academic activities, and 33% of the students are never using the Interactive whiteboards in their academic activities.
- And if we analyzed the misuse percentage, averagely Interactive whiteboards are misused by 43% of students.

- Furthermore, 80% of the subjects are learned by the use of Interactive whiteboards.
- With the use of interactive boards, we can use many applications.
- Most of the teachers and students are using Interactive whiteboards for their teaching and learning purposes.
- Most of the students are very interested while they are studying with a digital device (interactive whiteboard)
- Most of the teachers and students will use Interactive whiteboards for all learning and teaching purposes.
- If we take a class, all the students cannot get the same use of interactive whiteboards.

So those are the findings have found through this study of the impact of Interactive whiteboards in academic studies.

VI. RECOMMENDATION

A very vital and successful way to improve the students' performance is establishing Interactive whiteboards in their learning process to learn with interest without any difficulties and can study in an effective manner. And want to give proper digital devices for their study purpose to enhance their progress. In some classes, this interactive facility is not available and very poor, so they want to fulfil this lack of shortage. And by introducing practical based subjects like visual graphics, animation subjects and can show practical with the help of interactive whiteboards. And provide internet connection facilities to every Interactive whiteboard to access the internet. And provide a free wi-fi facility to use the Interactive whiteboards. And also want to conduct an awareness program about the effects of the Interactive whiteboards on the students when they misuse them.

VII. CONCLUSION

This study provides the significance of using digital interactive boards in academic studies. in earlier literature we can understand that the learners and teachers used these Interactive whiteboards for their teaching and learning process to motivate the students' performance and their progress in studies and make fun and enjoyable class. Can note the changes in the progress and the improvement of learning and in the education process of the students when comparing who are using a manual whiteboard and Interactive whiteboards for their study purposes and can note the impact of it in academic activities. It can ensure that ubiquitous and digital innovation with information communication technology. And it easy to understand the way of using Interactive whiteboards, which is very useful for students rather than studying manually. And Interactive whiteboards it has a positive impact at the same time it has a negative impact on academics when they use them in negative ways. Still, if we compare the positive impact with negative impact, the positive impacts are mostly can be derived from the use of Interactive whiteboards in academic studies than the negative impact. So by analyzing all, we can note that the students can interact with other students and make communication and also can enhance knowledge with the use of Interactive whiteboards.

REFERENCES

Davidovitch, N. and Yavitch, R,2017. The effect of smart boards on the cognition and motivation of students. Higher education studies,7(1), p.60.

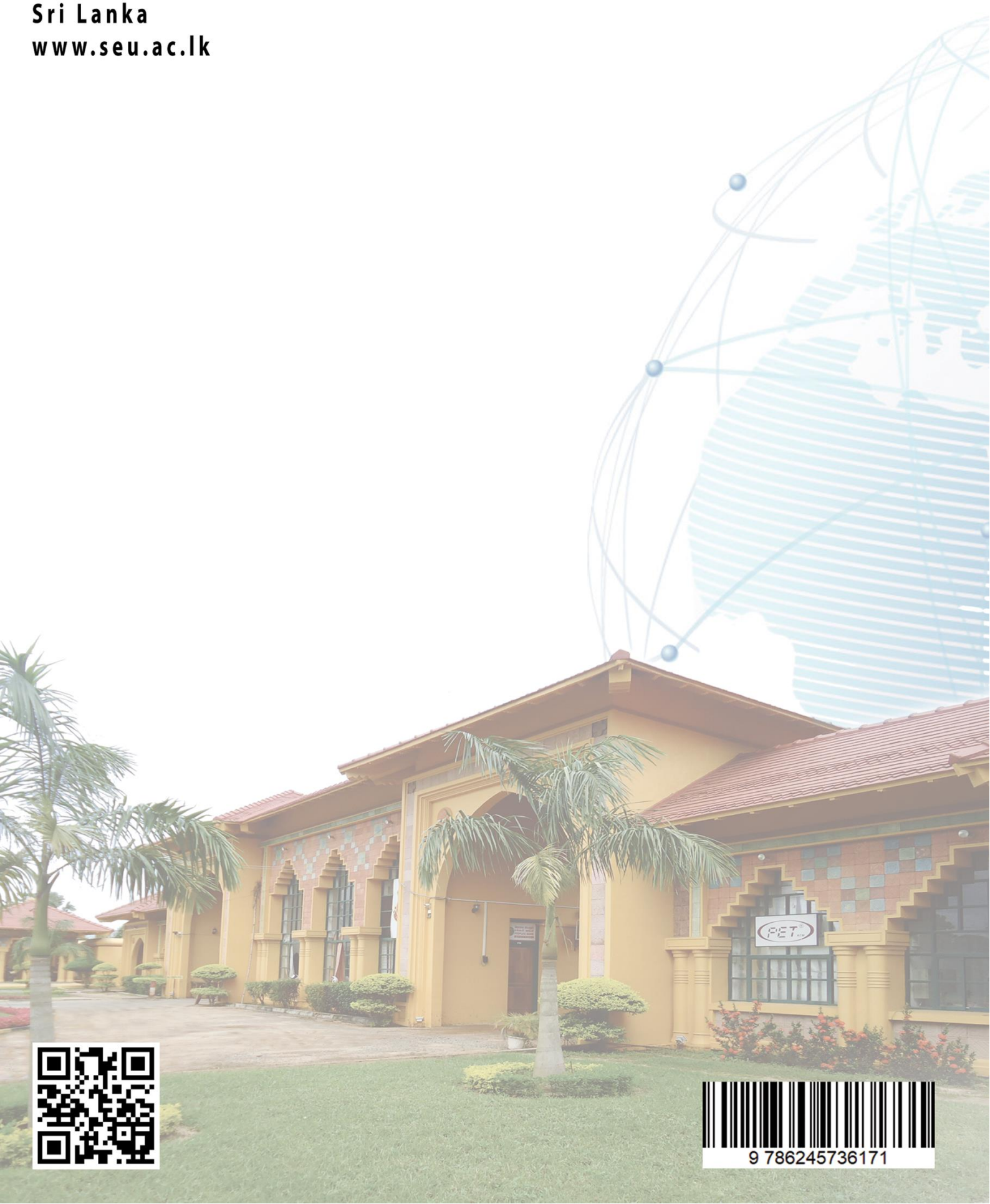
Gregorcic, B., Etkina, E. and Planinsic, G., 2018. A new way of using the interactive whiteboard in a high school physics classroom: A case study. Research in Science Education, 48(2), pp.465-489.

Shi, Y., Yang, Z., Yang, h.and liu, s., 2012.The impact of Interactive white boards on education. proceeding of 4th international conference on internet multimedia computing and service-icimcs'12.

Swan, K., Schenker, J. and Kratcoski, A., 2008, June. The effects of the use of interactive whiteboards on student achievement. In EdMedia+ Innovate Learning (pp. 3290-3297). Association for the Advancement of Computing in Education (AACE).

Tufan, A.,2013. Interactive whiteboards factor in education: student's points of view and their problem. National engineering research center for E-learning, vol.8(20), pp .1907-1915.

Faculty of Technology
South Eastern University of Sri Lanka
University Park
Oluvil
#32360
Sri Lanka
www.seu.ac.lk



9 786245736171