Industrial Technology Institute
Ministry of Science & Technology

CISIR

INNOVATION FOR IMPACT: ITI'S RESEARCH JOURNEY

R&D ACHIVEMENTS - 2010-2020

ISBN 2815



INDUSTRIAL TECHNOLOGY INSTITUTE

Published in September 2025
ISBN – 2815
First Edition

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FOREWORD

The Industrial Technology Institute (ITI), successor to the Ceylon Institute of Scientific and Industrial Research (CISIR), Sri Lanka, has a long history and tradition, with significant research achievements accumulated since its establishment in 1955. The institute has pioneered multidisciplinary Research and Development (R&D) in the country to fulfill its vision, "To be a Center of Excellence in Scientific and Industrial Research for National Development". The institute's R&D is focused on covering broad scientific disciplines of Food Technology, Herbal & Natural Product Technology, Materials Technology, Environmental Technology, Biotechnology, Electrotechnology, Chemical Technology, Physical Technology and Industrial Metrology, to make its vision a reality. The R&D projects conducted by the institute are based on industry demand, national priority needs and national policy framework and are funded either by the government treasury or international and local funding agencies. ITI, on its journey to make a mark on the global map as a unique institute of R&D excellence, the expert scientific teams of the institute have collaborated with other local and international scientists of relevant disciplines to conduct innovative R&D and nurture the research culture within the country. ITI scientists are committed to creating new value for our partners from industry and government agencies, through translating the R&D into commercial outcomes that will bring a positive impact to society. The R&D performance of the institute is measured in terms of technologies developed, technologies transferred to relevant industries and commercialized, analytical methods developed and accredited, scientific papers & communications published, patents granted and licensed and S&T awards received by the ITI scientific teams. I am grateful to all international and local funding authorities, including the Sri Lanka Treasury, for the financial assistance provided to conduct the R&D activities.

I am delighted to present the publication of the R&D profile of the institute from 2010-2020, highlighting the research strengths and contributions made for national development. It is an important document not only for the institute but also for the industry, other R&D institutions and Universities to gain an insight into the research capabilities and achievements of the ITI. This will also avail the R&D services of the institute and help to initiate new R&D collaborations and technology commercialization avenues. More importantly, it would help in disseminating the R&D related achievements of the institute among the academia and the scientific community of the country and the globe broadening further, collaborative research and R&D commercialization. This would also serve to highlight the achievements of the contributing scientists of the institute and may also provide encouragement to promote cutting-edge, innovative and socially significant research.

Prof. (Ms.) Ilmi G. N. Hewajulige, *PhD*
Director General/ CEO
Industrial Technology Institute (ITI)
September 2025

Industrial Technology Institute

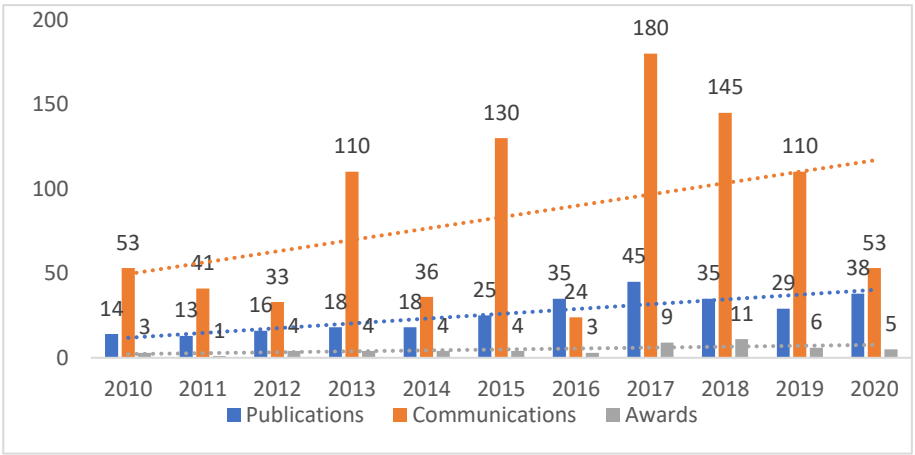
The Industrial Technology Institute (ITI) is a statutory body that came into existence on 01st April 1998 under the Science and Technology Act No. 11 of 1994. ITI is the successor to the Ceylon Institute of Scientific and Industrial Research (CISIR), which was established in 1955 under the Parliament Act No. 15 of 1955 (CISIR Act) to support Industrial Development in the country. The ITI is the government-owned country's leading and largest scientific R&D and service organization with a complement of multi-scientific staff. With the vision 'to be a Center of Excellence in Scientific and Industrial Research for National Development' the institute's core businesses are geared for the promotion of industrial development through Research & Development (R&D), technology transfer, consultancy, training and the provision of testing and calibration services. In order to fulfill the mission of the institute, testing laboratories of ITI are accredited for ISO 17025 to provide internationally competitive technical services while R&D laboratories are quality certified for ISO 9001 to conduct innovative R&D to accelerate industrial development for the benefit of the people of Sri Lanka. All the accredited and other laboratories are equipped with state-of-the-art scientific instruments, while R&D laboratories are comprised of pilot-scale facilities for scaling up the laboratory-scale products. The Institute consists of a highly qualified staff of Research Scientists, Research Engineers and Research Technologists with diverse expertise in multidisciplinary fields.

ITI conducts demand-driven, nationally important, high-tech research in multidisciplinary fields of food technology, herbal technology, biotechnology, environment technology, materials technology, chemical/ physical technology and industrial metrology through the state-of-the-art R&D laboratories at Modern Research and Development Complex, Malabe and in Colombo facilities. Research & Development Division provides solution-focused innovations and engages in activities connected with technology transfer, the adaptation of technologies and the development of new technologies for industrial promotion and entrepreneurship development targeting the Micro, Small, and Medium Enterprises (MSME), Startups, Women Enterprises and Small Businesses. The Institute is a key technology provider in the country to enhance the Export Industry and for import alternatives and domestic value addition. The Technical Services Division has become the pioneer in laboratory testing and calibration services expanding its scope of accreditation and ensuring the accuracy, precision and international acceptability of its test reports and services. This facility has high-end analytical testing and modern monitoring equipment, and an air quality and stack monitoring mobile laboratory to support the rapid industrialization of the country. ITI is the authorized testing laboratory for exporters, government organizations and local and international regulatory authorities.

ITI contributes to National issues through testing, consultancy and R&D in multidisciplinary fields and undertakes and collaborates in national development projects, especially on power and energy, road development, highways and railway sectors and in the survey and monitoring of environmental pollution and recommendations for remedial measures to mitigate such pollution.

ITI is the Center of Excellence of the Commission on Science & Technology for Sustainable Development in the South (COMSATS) in Sri Lanka and the focal point of the World Association of Industrial and Technological Research Organization (WAITRO) and International Bamboo and Rattan Organization (INBAR) and conducts joint activities with international entities including United Nations Industrial Development Organization (UNIDO), United Nations Development Programme (UNDP), Japan International Cooperation Agency (JICA), Food and Agriculture Organization of the United Nations (FAO), International Finance Corporation (IFC), UK Center of Environment, Fisheries and Aquaculture Science (Cefas) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

During the period 2010-2020, the institute achieved many 'Scientific Merits' in terms of scientific publications, communications, technology development and transfer, and obtaining local patents and science, technology and innovation-related national and international awards and recognition.



Number of papers published in refereed journals, scientific communications in local and international journals and Scientific awards received by ITI from 2010-2020

ITI Premises Colombo and Malambe

FOOD TECHNOLOGY

We are pioneering in providing food and beverage technology and process know-how to SME's and large-scale food industry in Sri Lanka. ITI is equipped with food processing and analytical laboratories, a food pilot plant facility and advanced pilot plant equipment.

Scientists and Technical staff of ITI, including Food Technologists, Microbiologists, Chemists, Food Process/Chemical Engineers, Food Safety and Quality Experts contribute to the development of the food industry in Sri Lanka by providing technology, training, consultancy and analysis.

Research and development on health benefits and value addition to traditional rice varieties of Sri Lanka enabling market opportunities, locally and internationally

Grant Nos: TG-6, TG 11-36, TG 11-37, TG 18-146 and TG 18-165
Project Team: *Dr. (Ms.) N. Ediriweera,
*Prof. G.A.S. Premakumara,
*Dr. (Ms.) J. Goonaratne
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Dr. (Ms.) H.M.T. Herath
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*Prof. (Ms.) I.G.N. Hewajulige
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Ms. M. D.W. Samaranayake
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Ms. R.C. Pitipanaarachchi
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Prof. K.R.R. Mahanama
Prof. P.A. Punyasiri
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Project Period: 2010 - 2020
Funded by: Sri Lanka Treasury

**Principal Investigators of the projects*

Background

Rice is the dietary staple in Sri Lanka and a range of traditional and improved rice varieties are grown in the country. Based on traditional knowledge, the traditional rice varieties are claimed to have varying physico-chemical and functional properties. Since no comprehensive study has been conducted in the country to evaluate the nutritional, functional and bioactive properties of traditional rice varieties grown in Sri Lanka, such studies were initiated at the Industrial Technology Institute (ITI) in 2005. To date, a range of analytical studies has been conducted to prove the functional properties of traditional rice compared to improved varieties in order to popularize them among the general public targeting to combat prevalent Non-Communicable Diseases (NCDs) such as diabetes, cancer, cardiovascular diseases, anemia and obesity. Research on new product development was also conducted targeting the value addition to traditional rice and rice bran, a potential nutritious byproduct of rice. The studies aimed to popularize the nutritional and bioactive properties of traditional rice varieties not only in Sri Lanka but also to the world, which are health-conscious in their food patterns. Traditional rice varieties used in the studies were**:** Batapolal, Beheth Heenati, Dahanala, Devaraddari, Dik Wee, Goda Heenati, Herath Banda, Hondarawalu, Kahata Wee, Kahawanu, Kalu Bala Wee, Kalu Heenati, Kattamanjal, Kottayar, Kurulu Thuda, Madathawalu, Masuran, Murungakayan, Pachchaperumal, Rath Suwandal, Rathal, Rathu Heenati, Sudu Heenati, Suduru Samba, Sulai, Suwanda Samba and Wanni Dahanala. With this ITI initiative on claiming health and functional properties, local traditional rice varieties have become very popular today, both in the local and international markets.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Database developed on traditional rice varieties grown in Sri Lanka which included the morphological characteristics and health-promoting aspects. A booklet with the above information was published in 2011.
- Traditional rice varieties were screened for iron, zinc and phytates.
- The micronutrient contents in polished rice varieties were documented.
- Bio-availability studies of rice and screening of rice varieties for amylose, fiber and Glycemic Index (GI) were carried out and documented.
- Information on health properties was provided to the Rice Research Institute (RRI) of the Department of Agriculture for breeding programmes of new rice varieties.
- **New testing methodologies/techniques were developed and used in ITI testing services offered for the food and herbal industries.**

Anti-diabetic related assays

- α-amylase inhibition assay
- α-glucosidase inhibition assay
- Anti-glycation assays (BSA-glucose and BSA-MGO mediated glycation models)
- Glycation reversing assays (BSA-glucose and BSA-MGO mediated glycation reversing models)
- Acetylcholinesterase (AChE) inhibition assay
- Butyrylthiocholinesterase (BChE) inhibition assay
- In vitro glycaemic index (in vitro dialysis)
- Amylose content
- Dietary fiber (enzymatic assay)
- Resistant starch (enzymatic assay)
- Yeast cell glucose uptake assay

Anti-oxidant assays

- DPPH radical scavenging assay
- ABTS radical scavenging assay
- Oxygen Radical Absorbance Capacity assay (ORAC)
- Superoxide radicals scavenging assay
- Nitric oxide radicals scavenging assay
- Ferric Reducing Antioxidant Power assay (FRAP)
- Ferrous iron chelating assay
- H_2O_2 radical scavenging assay
- Hydroxyl radical scavenging assay
- Total polyphenolic content estimation assay
- Total flavonoid content estimation assay

Anti-lipidemic bioassays

- HMG-CoA reductase inhibition assay
- Anti-lipase assay
- Anti-cholesterol esterase assay
- Cholesterol micellization inhibition assay
- Bile acids binding assay

Anti-inflammatory assays

- COX1 and COX2 enzyme inhibition assays
- Superoxide radicals scavenging assay
- Nitric oxide radicals scavenging assay
- Oxidative burst assay for whole blood
- Oxidative burst assay for polymorphonuclear leukocytes
- Oxidative burst assay for macrophages
- Assay for nitric oxide (cell-based assay)
- Inhibition of TNF-α production (cell-based assay)
- Inhibition of IL-1 β production (cell-based assay)

Anti-cancer-related bioassays

- Glutathione-S-transferase enzyme inhibition assay

- Bioavailability of iron in some rice varieties was identified. Rice varieties of Kalubala Wee, Pachchaperumal, Dahanala, Rath Heenati, Kattamanjal and Rathel have relatively high iron and protein levels and are good for anemic conditions.
- The Glycemic Index of selected rice varieties was determined to select the suitable varieties with low glycemic index for diabetic patients - Suwadal, Masuran, Dikwee and Gonabaru were proven to show low starch hydrolysis (indication of low glycemic index).
- Antioxidant properties of selected rice varieties – Kalubala Wee, Pachchaperumal, Rath Suwandal and Kaluheenati, were proven to have high antioxidant levels.
- Traditional and new improved rice varieties suitable for rice-based value-added product development were selected and a range of value-added products using rice and rice bran were developed.
- Traditional rice varieties (red) Sudu Heenati, Goda Heenati, Masuran and Dik Wee were selected with proven anti-diabetic activity, antioxidant activity, anti-inflammatory activity and anti-cancer activity.
- Selection of rice varieties suitable for rice-based value-added products was carried out.
- While contributing to the advancement and strengthening of scientific knowledge, the findings on the impact of cooking and post-processing techniques on the amino acid compositions of rice provided insight to consumers and nutritionists in deciding food consumption patterns and for rice producers to revisit the processing techniques of milling and parboiling.
- Furthermore, the findings should assist policymakers in making timely interventions for redefining the consumption patterns of the people and in the popularization of rice consumption and for rice breeders in the identification of traits in breeding varieties rich in amino acids of high nutritional quality and climatic resilience, to assure food and nutritional security in the country.
- Development of a database on nutritional, chemical and morphological characteristics of selected traditional and widely consumed improved rice varieties of Sri Lanka: Suitability to use as chemical and molecular fingerprints in identifying rice varieties at the grain level is in progress.

Based on the traditional rice-related ITI research findings;

- Cultivation of traditional rice varieties in Sri Lanka expanded.
- Consumption of traditional rice varieties improved.
- Traditional rice varieties came to supermarket shelves with nutritional information declared through ITI research.
- Sri Lankan traditional rice varieties received market shelf space in international markets due to proven health benefits.
- Rice-based and rice bran-incorporated products were introduced to the market.

Traditional Rice Varieties

Publications in Refereed Journals

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Books and Book Chapters

1. Rajapakse, D., Premakumara, G.A.S., Herath, T., Bentota, A.P., Wijesundara, S.M. and Ediriweera, N. (2011). Properties of some traditional rice varieties of Sri Lanka. Industrial Technology Institute, Sri Lanka and Department of Agriculture, Sri Lanka. Published in Sinhala, English and Tamil languages. ISBN: 978-955-8394-18-2.
2. Abeysekera, W.K.S.M. and Premakumara, G.A.S. (2016). Health food properties of traditional rice in Sri Lanka. LAP Lambert Academic Publishing, Germany. ISBN: 978-3-659-87525-0.
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4. Abeysekera, W.K.S.M., Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2021). Chapter 04 - Ancient rice domestication and traditional and indigenous rice (*Oryza sativa* L.) of Sri Lanka. In: *Ancient Grains in Modern Soils. (*Ed. Raymond Cooper, PhD), Consultant, St. Louis, Missouri, USA, DESTech Publishers, USA. ISBN: 978-1-60595-559-9.

Post Graduate degrees (MPhil/PhD)

1. Ms. H.M.T. Herath obtained a PhD degree in Food Chemistry and Nutrition from the University of Kelaniya in 2013. Thesis Title: Levels of iron, zinc, phosphorus and bio-availability of iron in some selected varieties of rice grown in Sri Lanka.
2. Ms. W.K.S.M. Abeysekera obtained a PhD degree in Chemistry and Biochemistry from the University of Colombo in 2013. Thesis Title: Physicochemical and bioactive properties of some Sri Lankan traditional rice varieties.
3. Ms. G.V.V. Liyaanarachchi obtained a PhD degree in Analytical Chemistry from the University of Colombo in 2020. Thesis Title: Amino acid profiling of selected Sri Lankan rice varieties using liquid chromatographic techniques.
4. Ms. M.D.W. Samaranayake, registered for a postgraduate degree at the Department of Chemistry, Faculty of Science, University of Colombo (PhD Ongoing).
5. Ms. K.D.S.M. Karunarathne, registered for a postgraduate degree at the Department of Chemistry, Faculty of Science, University of Colombo (PhD Ongoing).

Awards

1. National Research Council (NRC) Merit Award 2013 for the paper titled “Antioxidant, anti-amylase and anti-glycation potential of brans of some Sri Lankan traditional and improved rice (*Oryza sativa* L.) varieties”. – W.K.S.M. Abyesekera, and G.A.S. Premakumara.
2. Sri Lanka Association for Advancement of Science (SLAAS), Postgraduate Research Award 2015. This was awarded in recognition of an outstanding contribution to postgraduate research carried out in Sri Lanka. - W.K.S.M. Abeysekera.
3. Best Poster Award, 2015 for the paper titled “Enhanced physicochemical and antioxidant properties of rice extracts added yoghurts in comparison to plain yoghurt” at the Annual Research Symposium, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka. - H.P.D Srimali, K.M Somawathi, W.K.S.M. Abeysekera, S.A.S Jayawardana and G.A.S. Premakumara.

4. Best Oral Presentation Award 2015 for the paper titled "Enhanced physicochemical and bioactive properties of two newly formulated red rice noodles in comparison to selected commercially available rice and wheat noodles" at the Annual Research Symposium, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka. - W.K.S.M. Abeysekera.
5. Best Poster Award 2016 for the research paper titled "A study of the antioxidant potential of the bran of red and white rice varieties from Sri Lanka" in the area of Food & Agriculture, National Science Foundation Research Summit, Sri Lanka. - W.K.S.M. Abeysekera, G.A.S. Premakumara, W.P.K.M. Abeysekera and P. Ranasinghe.
6. Presidential Awards for Scientific Publications 2018 for journal publication "Validation of a reversed-phase high-performance liquid chromatographic method for the determination of free amino acids in rice using L-theanine as the internal standard". - *Food Chemistry* 240, 196-203 -G.V.V. Liyanaarachchi, K.R.R. Mahanama, H.P.P.S. Somasiri and P.A.N. Punyasiri.
7. A project titled 'Anti-diabetic properties of selected traditional rice varieties from Sri Lanka' was selected among 10 finalists at the Science Research Projects Competition 2018, organized by the National Science Foundation, Sri Lanka: Supervisor – Dr. W.K.S.M. Abeysekera.
8. Best Poster Award 2018, Sri Lanka Association for Advancement of Science (SLAAS), Section E2, 2018. Paper: Physiochemical and nutritional properties of selected traditional foods of Sri Lanka. S.R.H. Kandamby, W.K.S.M. Abeysekera, I.G.N. Hewajuilge, U.K. Jayasundara and S.L. Liyanage.
9. Best Oral Presentation Award 2019 at Food and Nutrition Sessions, Symposium on Agro biodiversity for Climate Change Adaptation, Plant Genetic Resource Centre, Gannoruwa, Sri Lanka for the paper on Antioxidant properties of selected pigmented and white long grain rice varieties of Sri Lanka at market available polishing rates - W.K.S.M. Abeysekera, W.P.K.M. Abeysekera, S.A.T. Lakshan, M.D.W. Samaranayake, S.L. Liyanage, G.A.S. Premakumara, W.D. Ratnasooriya and D.S.Z. Abeysiriwardena.
10. Best Presenter at the Annual Research Symposium of the University of Colombo, 2019 for presenting the communication on Variation in free and total amino acid profiles of selected Sri Lankan rice varieties upon milling - G.V.V. Liyanaarachchi, K.R.R. Mahanama, H.P.P.S. Somasiri, P.A.N. Punyasiri, K.V.T. Gunawardhana and J.D. Kottawa-Arachchi.
11. Best Presenter at the Annual Research Symposium of the University of Colombo 2020 for presenting the communication on Variation in amino acid composition of rice as affected by the cooking technique - G.V.V. Liyanaarachchi, K.R.R. Mahanama, H.P.P.S. Somasiri, P.A.N. Punyasiri and M.A.B. Ranatunga.

Popularization Activities

Articles published in newspapers/newsletters/TV/Radio discussions etc.

- ITI develops rice varieties to address health problems. Sunday Observer Newspaper (21.09.2008).
- Brown rice could aid diabetes control. 2009. https://www.scidev.net/global/news/brown-rice-could-aid-diabetes-control/
- Best rice for diabetes: Sudu Suwadal. Lakbima Newspaper (01.07.2010).
- Traditional brown rice to prevent diabetes, ITI Bulletin, **18**(3), 1&3. May-July 2010.

- Sudu Henneti, Goda Heeneti, Masuran and Dik Wee for diabetes complications management, Silumina Newspaper (04.07.2010).
- Masuran best rice for diabetes. Daily News Newspaper (17.07.2010).
- Red rice bran good for diabetes control. Sunday Observer Newspaper (27.03.2011).
- Anti-cancer drug leads from Sri Lankan Traditional red rice. ITI Bulletin, **20**(2), 3. February-April 2012.
- Traditional rice for prevention and management of diabetes and lung cancer (Sinhala article). Rivira Newspaper (22.07.2012).
- Sri Lankan rice varieties for cancer prevention. Mawbima Newspaper (15.09.2013).
- Sudu Henneti, Goda Heeneti, Masuran and Dik Wee – good for diabetes control, Mawbima Newspaper (17.11.2013).
- Properties of traditional rice in controlling diabetes. Mawbima Newspaper (24.11.2013).
- Traditional rice contains chemical compounds for the prevention and management of cancer and diabetes. Rivira Newspaper (18.12.2013).
- Sri Lankan traditional red rice: a super staple food for better health. Nutrition Focus, Nutrition Society of Sri Lanka. **7**(1), 7-8. July 2015.
- Traditional Sri Lankan rice for a better, healthy life. Amma Newspaper (31.06.2017).
- Importance of Sri Lankan traditional rice (Sinhala article). Vidya, Dinamina News paper (25.10.2017).
- Sri Lankan scientists reveal the importance of traditional rice (English article). Vidya, Daily Newspaper (25.10.2017).
- Traditional rice varieties of Sri Lanka, Mihira Newspaper (14.01.2019).
- Our traditional rice varieties will make the nation healthy. Vidurava, The Science Magazine of the National Science Foundation. 36, 19-21. (Jan-March) 2019.
- New Research findings on Sri Lankan rice, Silumina Newspaper (03.03.2019).
- Red Rice Vs White Rice: Which is Healthier? The Sri Lankan Scientist. The Premier Science Magazine in Sri Lanka. **5**(1), 20-21. 2019.
- Rice rich in amino acids. Vidya Quarterly Newsletter of NSF, 22(3), September 2020.
- Millet and Sorghum: Healthy Food Grains for the Future. The Sri Lankan Scientist. The Premier Science Magazine in Sri Lanka. Vol 07, Issue 02, pp. 10-12. 2021.

Research and development to elevate the Kithul sector in Sri Lanka

Grant Nos: FP 85, FP 90, TG-11-39, TG 15-105
Project Team: *Prof. G.A.S. Premakumara
Dr. P. Ranasinghe
Dr. H.P.P.S. Somasiri
Ms. D. Rajapakshe
Ms. A. Fernando
Mr. P.C. Perera
Mr. U. Chanaka
Project Period: 2010 - 2020
Funded by: Ministry of Rural Industries,
Sri Lanka Treasury

Principal Investigator

Background

Kithul sector development-related research and development activities at the Industrial Technology Institute (ITI) were first started with a grant from the Ministry of Rural Industries in 2003. During that period, kithul was not recognized even as a small-scale industry and existed as some traces of traditional practices of kithul tapping and preparation of toddy, treacle and jaggery. Since the tapping of kithul trees was legally restricted, harvesting of sap from kithul inflorescence was done by very limited communities in rural areas under considerable hardships, including legal harassment, safety issues and social burdens. However, the natural sweetener produced using kithul sap, which is kithul treacle was gaining popularity during the last decades of 1990-2000 due to the emergence of lifestyle NCDs such as diabetes. This led to an increase in demand for kithul treacle and jaggery while raw material supply was considerably hampered mainly due to legal barriers and lack of know-how in tapping. As a result, heavy adulteration of original kithul products was in practice. In the first phase of R&D during 2003-2004, major issues related to the upliftment of kithul sector as an industry including tapping know-how, treacle and jaggery quality, standard manufacturing procedure, product authentication, health claims, social constraints, legal barriers, marketing and sector promotion concepts were studied almost island-wide visiting the relevant communities. In addition, a new treatment mixture for the tapping of kithul inflorescence was introduced with the brand name of KASPER. Other than the KASPER treatment, the novel tapping process was also invented and introduced, breaking the knowledge limitation of the industry which was a critical limiting factor in the upliftment of raw material supply. This project further delivered scientific inputs for the manufacturing of treacle and jaggery with improved hygienic conditions and introduced several non-conventional value-added products to the industry. The invention of a new tapping method (KASPER) penetrated the industry as a breakthrough invention and this started to change the dimension of the kithul sector. Following the first project, a number of research projects were carried out at ITI with funding from different ministries and the government treasury to uplift the kithul sector in Sri Lanka.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Kithul Activation and Sap Product Enhancing Reagent (KASPER), a new treatment for Kithul tapping - This treatment mixture for kithul tapping was developed and tested for its efficacy in different kithul tapping locations such as Deraniyagala, Athwelthota and Kotmale. KASPER was manufactured at ITI as an incubation project and distributed to farmers through the Industrial Development Board (IDB).
- A field test kit for the detection of adulteration of kithul treacle/sap with sugar: This kit was developed based on sugar composition and its natural variation as a field test kit, having a Confidence Interval (CI) of 20%.
- Training of tappers, master trainers and officers on kithul tapping techniques.
  About 250 awareness and training programmes for kithul tappers were conducted to cover all major kithul cultivating districts in Sri Lanka. Other than the kithul tappers, officers of IDB and Science and Technology officers (Vidatha- STO) of the Ministry of Science and Technology were also trained on the new kithul tapping technology during these programmes.
- Development of a range of value-added food products from fresh kithul sap and treacle.
  At the beginning of the kithul development project kithul industry was operated as a 'Cottage level self-employment' in rural villages. Kithul sap was utilized only to make kithul treacle and jaggery as value-added products. Thus, during the first two phases of the project, many new value-added products were introduced to the industry: Kithul sap-based non-alcoholic beverage, kithul marmalade, kithul sap-based chocolate spread, kithul toffee, kithul flour-based porridge, kithul flour-based pudding, kithul chocolate, kithul jelly and Kithul sugar are among the new kithul-based products developed.
- Establishment of chemical composition parameters for authentication of kithul sap, treacle and jaggery, leading to the introduction of new Sri Lanka Standards (SLS) for Kithul treacle.
- Isolation of yeast strains associated with the fermentation of 'kithul Raa' (Kithul Toddy) and development of fermented alcoholic and non-alcoholic beverages.
- Development of Kithul seed germination technology for the successful germination of kithul seed collected from any flower. Techniques were developed for the successful establishment of field plantations.
- Introduction of heat shock treatment for short-term preservation of kithul sap enabling transportation and central processing.
- Introduction of flue-fan evaporator (from Maple industry) for continuous production of kithul treacle.

Publications in Refereed Journals

1. Ranasinghe, P., Premakumara, G.A.S., Wijayaratne, C.D. and Ratnasooriya, W.D. (2011). Antioxidant activity of *Caryota urens* (L.) sap. *Tropical Agricultural Research*, **23**(2),117-125.
2. Wimalasiri, G.E.M., Ranasinghe, P., Gunaratne, D.M.A. and Vidhana Arachchi, L.P. (2016). Antioxidant and anti-diabetic properties of *Caryota urens* (Kithul) flour. *Procedia Food Science*, **6,**181–185.
3. Fonseka S.I., Adikari, S., Jayasekera, L.R., Ranasinghe, P. and Premakumara, G.A.S. (2017). Seed germination inhibitory effect of *Caryota urens* L. seed pericarp on rice and associated weeds. *Tropical Plant Research*, **4**,1-6.

Scientific Communications

1. Ranasinghe, P., Premakumara, G.A.S., Wijayaratne, C.D. and Ratnasooriya, W.D. (2006). Free-radical scavenging property of natural sweet sap of Kithul palm (*Caryota urens). Proceedings of the 26th Annual Session*, Institute of Biology, Sri Lanka. p.27.
2. Somasiri, H.P.P.S., Premakumara, G.A.S. and. K.R.R, Mahanama. (2008). Organic acids and sugar composition of Kithul palm (*Caryota urens), Proceedings of ASOMPS XIII International Symposium,* Hyderabad, India, November. p.3-6.
3. Premakumara, G.A.S., Ranasinghe, P. and H.P.P.S, Somasiri. (2009). Evaluation of traditional *Caryota urens* (Kithul) tapping methods in Sri Lanka. *Proceedings of the 29th Annual Sessions,* Institute of Biology, Sri Lanka. p.26.
4. Somasiri, H.P.P.S., Premakumara, G.A.S. and K.R.R. Mahanama. (2009). Nutrition information of Kithul palm *Caryota urens* sap, treacle and jaggery. *Proceedings of the Annual Sessions,* Nutrition Society of Sri Lanka.
5. Somasiri, H.P.P.S., Premakumara, G.A.S. and K.R.R. Mahanama. (2009). Use of organic acids and polyphenolic compound profiles of *Caryota urens* (Kithul), *Cocos nucifera* (Coconut) and *Saccharum officinarum* (Sugar cane) treacle for the authentication of the treacle type. *Chemistry in Sri Lanka*, **26**(2),19-20.
6. Ranasinghe, P., Premakumara, G.A.S., Wijayaratne, C.D. and Ratnasooriya, W.D. (2010). Isolation and mass culture of carotenoid producing yeast, *Rhodotorula mucilaginosa* from *Caryota urens* L sap. *Proceedings of the 3rd International Symposium*, Sabaragamuwa University of Sri Lanka. p.57.
7. Somasiri, H.P.P.S., Premakumara, G.A.S. and K.R.R. Mahanama. (2010). Free amino acid profile of *Caryota urens* L. (Kithul palm) treacle as a marker for authenticity. *Proceedings of the Annual Research Symposium,* University of Colombo. p.110.
8. Ranasinghe, P., Premakumara G.A.S., Wijeyarathna, D.C. and Ratnasooriya, W.D. (2011). Effect of *Caryota urens* L. (Kithul treacle) on serum lipid parameters of normal rats. *Proceedings of the Annual Research Symposium*, University of Colombo, Sri Lanka. p.273-276.
9. Ranasinghe, P., Premakumara G.A.S., Wijeyarathna, D.C. and Ratnasooriya W.D. (2012). Bioactivities of *Caryota urens* L. (Kithul) treacle. *Proceedings of the 3rd Biennial Conference*, South Asian Association of Physiologists (SAAP). p.69.
10. Ranasinghe, P., Premakumara, G.A.S., Wijeyarathnsa, D.C. and Ratnasooriya W.D. (2012). Safety evaluation of *Caryota urens* L. (Kithul) treacle in rats. *Proceeding of the Annual Research Symposium*, University of Colombo. p.314-316.
11. Somasiri, H.P.P.S., Premakumara, G.A.S., Ranasinghe, P. and Mahanama, K.R.R. (2011). A simple test kit for the detection of adulteration of *Caryota urens* L. (Kithul palm) sap and treacle with cane sugar. *Proceedings of the Annual Research Symposium,* Young Scientist Forum, Colombo, Sri Lanka. p.23.
12. Somasiri, H.P.P.S., Premakumara, G.A.S. and Mahanama, K.R.R. (2012). Free amino acid profile of *Caryota urens* L. (Kithul palm) sap, treacle and jaggery. *Proceedings of the Annual Research Symposium*, University of Colombo. p.324-326.
13. Wimalasiri, G.E.M., Ranasinghe, P. and Vidhana Arachchi, P. (2014). Antioxidant properties of *Caryota urens* L. (Kithul) flour. *Proceeding of the 2nd International Symposium on Driving Research Towards Economy: Opportunities and Challenges*. Sri Lanka Academy of Young Scientists. p.46.
14. Adikari, T.N., Ranasinghe, P., Wijesinghe, R.A.N.K., Premakumara, G.A.S. (2018). Glycemic index of *Caryota urens* (kithul) treacle and jaggery; traditional natural

sweeteners of Sri Lanka. *Proceedings of the 24th ISCB International Conference*, Manipal University Jaipur, Rajasthan India, 11-13 January 2018. p.419.
15. Jayathilaka, I.D.D.N., Ranasinghe, P., Wimalasiri, L.E.M. and Vidhana Arachchi, P. (2022). A primary model for estimating biomass and carbon accumulation in Kithul (*Caryota urens* L.). *Undergraduate Research Symposium*, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka, 4th August 2022. p.14.

Book Chapter

1. Somasiri, H.P.P.S., Premakumara, G.A.S. and Mahanama, K.R.R. (2018). Free amino acid profile of Kithul palm *Caryota urens* L. treacle and its potential application in authentication of treacle types. In: *Technology for Food Quality* (Eds. Glenn Graham, Michael Netzel, Trudy Graham, Mary Flectcher, Gloria Karagianis, Cindy Liles, Ujang Tinggi and Pieter Scheelings), Health and Food Sciences Precinct, Queensland, Australia.

Post Graduate degrees (MPhil/PhD)

1. Mr. Pathmasiri Ranasinghe obtained a PhD degree from the University of Colombo in 2014. Thesis Title: Bioactive properties of *Caryota urens* (L) sap, treacle and molecular characterization of some selected yeasts from fermenting sap.
2. Mr. H.P.P.S. Somasiri obtained a PhD degree from the University of Colombo in 2016. Thesis Title: Chemical characterization and authentication of *Caryota urens* (Kithul) sap and products.

Awards

1. KASPER technology - This invention was recognized by National Award for best innovative technology for raw material production sector in 2005 and offered by the National Science Foundation, Sri Lanka - G.A.S. Premakumara, P. Ranasinghe and H.P.P.S. Somasiri.
2. Best innovative technology award 2005 at the 50th Anniversary Celebration of the ITI in 2015 - G.A.S. Premakumara, P. Ranasinghe and H.P.P.S. Somasiri.
3. WAITRO (World Association of Industrial and Technological Research Organization) innovation award 2016 - Kithul Activation and Sap Production Enhancing Reagent (KASPER) was selected as a finalist in the Business Innovation category – G.A.S. Premakumara, P. Ranasinghe and H.P.P.S. Somasiri.

Biologically based postharvest quality maintenance and disease control for mango and papaya

Grant No: FP 86
Project Team: * Dr. (Ms.) R.S. Wilson Wijeratnam
Prof. (Ms.) I.G.N. Hewajulige
Dr. (Ms.) C. Wijesinghe
Ms. M.G.D.S. Perera
Ms. C. Wickramathilaka
* Prof. Robert E. Paull
Dr. (Ms.) Nancy Chen
Project Period: 2010 - 2011
Funded by: HortCRSP and USAID, USA

**Principal Investigators*

Background

This was an international project on postharvest management of perishables conducted in collaboration with the University of Hawaii, USA and ITI, Sri Lanka. This project brought together two parallel research programs: the use of natural coating and herbal extracts in Sri Lanka and efforts in using natural epiphytic microorganisms to control postharvest diseases in Hawaii. Essential oils are complex volatile compounds produced in various plant parts such as leaves, flowers, bark and roots. Volatile compounds from plants can inhibit the growth of fungal pathogens and evaporate without leaving residues and are considered benign from a health perspective. Epiphytic microorganisms isolated from papaya fruit were evaluated for their ability to control postharvest disease by their actions as antagonistic microorganisms to pathogens. This research paved the path for the successful isolation of a yeast for pineapple postharvest disease control. The project also developed and evaluated a biological-based, nontoxic, environmentally suitable approach for postharvest disease control. The output from this project provided an alternative postharvest disease control approach to fungicide use in conventional and organic mango and papaya production. The technology developed in this research, the novel wax formulation, was introduced to extension officers via workshops held at the 'Vidhatha' collection and distribution centers in Sri Lanka.

Project Achievements/Outcomes

Technologies/Processes/Methods developed

- Fruit coating to extend the storage life of fruits was developed and the effectiveness of the coating and essential oils in controlling postharvest disease of mangoes and papaya while maintaining fruit quality.
- Integrated postharvest disease control protocol from harvest through storage using coatings, essential oils and selected microorganisms in simulated shipping was introduced.
- Transferred the findings of this research via training of trainers' workshops.

Patent

- Novel wax formulation for fruits to extend the storage life (Sri Lanka Patent No. 13519).

High iron and protein containing rice-based products

Grant No: TG 11- 34
Project team: * Ms. D. Rajapakse
Dr. (Ms) H.M.T. Herath
Ms. D.M.K. Aponso
Ms. A.W.D. Priyangani
Ms. P.S.F. Perera
Project Period: 2011 – 2013
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Rice, the staple food of Sri Lankan people, is consumed mainly in boiled form by the local community though many diversified rice-based products are popular and commonly consumed in Southeast Asian countries. Sri Lanka is targeted to become self-sufficient in rice production. Hence, it was considered important to develop rice-based nutritious products and popularize consumption among the local community to match their busy lifestyles. In this study, high iron and protein-containing brown rice-based products and Gamma Amino Butyric Acid (GABA) rich rice-based products were formulated to address the inadequacy of rice-based functional foods in the local market. GABA is an amino acid widely distributed in nature and contributes as a neurotransmitter in the brain. GABA helps to improve memory, learning ability and lower the risk of heart diseases like non-communicable diseases. Therefore, in the formulation of rice-based functional foods, GABA rice was incorporated in the form of germinated unpolished or brown rice.

Project Achievements/Outcomes

Technologies/Processes/Methods developed: Four rice-based products were developed

- **Nutritious granola bar:** Nutritious granola bar was developed using puff brown rice, mung bean flakes and roasted ground nut bound in food binders.
- **Nutritious biscuits:** Nutritious biscuits were developed using brown rice flour, mung bean flour, crushed ground nut and other food ingredients.
- **Complementary food:** Complementary food was developed using red rice, soya bean, mung bean and sesame.
- **GABA rich porridge:** An Instant mix of GABA rich porridge was developed using germinated brown rice.

Technologies transferred/Commercialized

- Technologies of Nutritious granola bar and Nutritious biscuits were transferred to Maliban Biscuits Manufactories (Pvt) Ltd.
- Technology of the Complementary food mix was transferred to Gajamuthu (Pvt) Ltd.

Scientific Communications:

1. Herath, H.M.T., Rajapakse, D. and Aponso, D.M.K. (2013). Formulation of a nutritious biscuit using brown rice as a functional food ingredient. *Proceedings of the Scientific Session*, Nutrition Society of Sri Lanka. p.32.

2. Gimanie Kasunmala, I.G., Wansapala, J. and Herath, H.M.T. (2015). Development of a high-calorie nutritional porridge formula enriched with vitamin A & iron, for primary school children. *Proceedings of the 71st Annual Sessions,* Sri Lanka Association for the Advancement of Science. p.21.

Book Chapter

1. Kasunmala, I.G.G., Wickramasinghe, I. and Herath, H.M.T. (2018). Food as nutritional source to prevent malnutrition among developing countries. In: *Trends and Prospects in Technology, Processing and Preservation.* (Eds. Paul P.K., Mahawar M.K., Arghya M., Abobatta W & Panja Payel), p. 457-479. Today and Tomorrow's Printers and Publishers, New Delhi, India.

Popularization Activities

- Article titled "Products from Indigenous rice" was published in Vidya News Paper (31.01.2018).

Enhancing the quality of 'Jaadi'

Grant No: TG 11- 41
Project team: *Mr. S.S.K. Madage
Dr.(Ms.) D.M.W.D Divisekara
Ms. S. Rajapakse
Mr. W.U.D. Medis
Ms. T.M.D.A. Jayawardane
Dr. (Ms.) J. Goonaratne
Period covered: 2011 - 2014
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Jaadi is a simple traditional fish preservation technique commonly practiced in Sri Lanka. According to its manufacturing process, there is a high potential for association with probiotic microorganisms. However, data was not available on the quantity and quality of production of *Jaadi* or its traditional processing technique. Therefore, this study was conducted to improve the process and quality of manufacturing *Jaadi* in Sri Lanka while evaluating the physicochemical and microbial quality of *Jaadi* produced in the western coastal area of the country. Characterization of the microorganisms associated with *Jaadi* production, with identification of them at the molecular level, was also conducted. A field survey conducted revealed that the processing conditions generally facilitate the growth of halophilic bacteria. High microbial counts observed ranging from 10^5 to 10^8/g in the studied *Jaadi* samples indicated that all *jaadi* processing in selected places was unhygienic and unsafe. Fifteen organisms associated with *jaadi* were identified and characterized by PCR (Polymerase Chain Reaction) techniques and some human pathogens, (*Acinetobacter baumannii*, *Staphylococcus saprophyticus*, *etc.*) were also found among them. During this project period, an improved formulation of *Jaadi* was processed at ITI by upgrading the traditional method. Physiochemical parameters (water activity, colour, texture, pH, total volatile nitrogen content, degree of hydrolysis of protein and salt content) and microbiological changes that occurred during processing were studied and compared with the traditional method and ITI developed a method for a period of three months. This study revealed that *Jaadi* preservation in traditional processes is mainly due to osmotic dehydration rather than microbial fermentation and the preservation of fish by making *Jaadi* alone is not a sufficient technique to assure quality and safety. Therefore, an additional processing hurdle is needed to maintain the keeping quality.

Project Achievements/Outcomes

Technologies/Processes/Methods developed

- A field survey on *Jaadi* processing was conducted covering eight pre-identified places along the coastal belt from Galle to Chilaw.
- Microbiological analysis of collected samples was carried out aiming to isolate the associated microorganisms.
- The molecular level identification of isolated microorganisms was carried out and isolated DNA sequences were deposited at NCBI GenBank.

- Developed a fermented fish product with potential probiotics based on Tuna fish (*Kelawalla*) using commercially available starter culture for fermentation. Microorganisms that survived after fermentation were isolated, characterized (morphological and biochemical) and identified as *Pediococcus acidilactici* (AB680157.1), *Lactococcus lactis* (CP006766.1), *Lactococcus lactis* (KJ690920.1) and *Weissella paramesenteroides* (HQ009793.1).

Publications in Refereed Journals

1. Divisekera, D.M.W.D., Madage, S.S.K., Jayawardana, T.M.D.A., Medis, W.U.D., Indunil, R.K.P.N. and Gooneratne, J. (2021). Pathogenic and spoilage-causing microorganisms associated with the traditional seafood product Jaadi manufactured in the Southern and Western coastal belt of Sri Lanka. *Asian Food Science Journal*, **20**(10), 25-35.

Scientific Communications

1. Divisekara, W., Madage S.S.K., Ramasinghe, I. and Goonaratne, J. (2012). Evaluation of quality of *Jaadi* produce in Western and Southern coastal belt in Sri Lanka. *Proceedings of the 68th Annual Sessions, Sri Lanka Association for the Advancement of Science.* p.97.
2. Divisekara, D.M.W.D., Niyangoda, H.R.W.M.G.C. and Madage, S.S.K. (2015). Isolation identification and characterization of probiotic bacteria associated with fermented fish products, extended abstracts of papers. *Proceedings of the NARA Scientific Sessions 2015*. p. 97- 104.

NCBI GenBank submissions

- Thirteen (13) new strains of *jaadi* preserved fish of Sri Lanka-associated bacteria are deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Establishment of a testing facility to assess imported fish feed

Grant No: TG 11- 42
Project team: *Mr. S.S.K. Madage
Mr. W.U.D. Mendis
Ms. I. Ramasinghe
Period covered: 2011 - 2013
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Importation of feed and feed ingredients is increasing rapidly with the expansion of fish farming and animal husbandry. Even though the physical quality of pelleted feed plays a vital role in evaluating its performance, it remains a less-concerned and hidden aspect. There is no evidence or data on the physical quality of the imported feed in the country. Farmers are mostly unaware of the physical quality, whereas feed processors are simply ignoring the fact. According to farm experiences, 10-20% feed loss occurs during transportation, storage and feeding, due to poor stability and durability. This leads to low productivity in animal husbandry and fish farming, ultimately affecting the product cost (fish, meat, eggs). However, there is no facility available to test the physical quality of feed in Sri Lanka. Therefore, it is very important to evaluate the physical quality of imported (pelleted) feed and make farmers and feed processors aware of testing the physical quality of feed in order to improve productivity.

Project Achievements/Outcomes

- Established standardized methods to evaluate the physical quality of feed by developing and adapting methods/equipment to estimate water stability and sinking properties.
- Imported a benchmark pellet durability tester.
- Based on the collected data on feed imports from the Department of Animal Production and Health and Sri Lanka Customs, random samples of imported fish and shrimp feed from different markets were collected and the proximate composition and physical properties of the collected samples were analyzed. The majority of the samples were found to be of inferior physical quality.
- The stakeholders were made aware of the ITI capability in feed testing.

Popularization Activities

- News release: “Quality and safety of animal feed”, *Ceylon Today* (13.09.2013).

Value addition to fruit and vegetables by clarifying, concentrating and separating bio-active components using membrane filtration technology and process modelling

Grant No: FP 96
Project Team: *Dr. (Ms.) J. Goonaratne,
Eng. S.G. Walliwala
Eng. N. Ranaweera
Ms. E.N. Wijedeera
Project Period: 2011 - 2013
Funded by: National Science Foundation, Sri Lanka

**Principal Investigator:*

Background

The consumer interest in healthier and more natural products has been growing. It is also observed an increase in the consumption of juices and fruit-based drinks such as nectars, cocktails and drinks which are lighter and refreshing products presenting new flavours and mixtures of fruits. In the food processing industry, the application of conventional methods such as juice concentration requires a high thermal load and is known to destroy the antioxidant capacity of the fruit, including total phenolic compounds. The aroma and most vitamins are also heat sensitive, mainly in the presence of oxygen, losing or reducing their activity when subjected to thermal processes. To overcome this issue, non-thermal preservation methods such as membrane filtration technology can be used in the fruit and vegetable industry. A large variety of new products based on clarified fruit juices has appeared in the international market. Thus, applying the membrane filtration process in fruit and vegetable juice clarification is a promising area since it's a high-value addition. Hence, the aim of this study was to clarify and separate the phenolic constituents of fruit and vegetable juice using membrane filtration technology and process modelling.

Project Achievements/Outcomes:

Technologies/Processes/Methods Developed:

- Phenolic content and antioxidant activity of a range of fruits and vegetables (pumpkin, tomato, carrots, king yam, snake gourd, okra (ladies' finger), gotukola (*Centella asiatica*) and mukunuwenna (*Alternanthera sessilis)* were determined and documented.
- Process development of membrane filtration with a filtration unit for the preparation of clarified juices was established. The application of mathematical modelling of the data to enhance the output of the processing unit was established.
- Product development – tomato juice and beetroot juice preparation technologies via microfiltration were established.

Scientific Communications

1. Wijedeera E.N. and Gooneratne J. (2012). Total phenolic content and free radical scavenging activities of ethanolic extracts of fruits and vegetables commonly used in Sri Lanka. *Proceedings of the 68th Annual Sessions,* Sri Lanka Association for the Advancement of Science. p.21.
2. Walliwala S.G., Ravichandran R. and Gooneratne J. (2013). Clarifying and separation of phenolic constituents of beet root juice using membrane filtration technology and process modelling. *Proceedings of the Annual Research Symposium,* Industrial Technology Institute. p.14.

Utilization of tamarind seeds for small-scale food industrial applications

Grant No: TG 11- 00- 03
Project Team: *Dr. (Ms.) S. Chelvendran
Mr. M.M.N.P. Gunasekera
Mr. M.S.N. Perera
Project Period: 2011 - 2012
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Tamarind (*Tamarindus indica* L.) is a multipurpose tropical tree used primarily for its fruits. The seeds are rich in protein (18%), fat (6%), carbohydrate (70%), crude fiber (3%) and ash (3%). The jellose obtained from seed kernel powder is used as a jelling agent in food applications. Tamarind seed jellose is stable under a wide range of pH and prolonged heating. The food industries are using imported fruit pectin to stabilize jam and marmalade-like products. This project was focused on the full utilization of tamarind seeds as a potential substitute for imported pectin.

Project Achievements/Outcomes: Technologies/Processes/Methods Developed:

- Tamarin seed-based pectin extraction.
- Developed two products; mango jam and orange marmalade using tamarind pectin to check the suitability of the newly developed pectin.
- Biscuit made using tamarind kernel powder and wheat flour.

Enhanced preservation of fruits using nanotechnology

Grant Nos: FP 101 , FP-116
Project team: *Dr. (Ms.) R.S. Wilson Wijeratnam
*Prof. (Ms.) I.G.N. Hewajulige
Mr. M.M.N.P. Gunasekera
Ms. M.D.Y. Milani
Ms. M.G.D.S. Perera
Dr. D.S. Samarawickrema
Eng. A. Sooriyaarachchi
Ms. M. Wijemanne
Period covered: 2012 – 2014: Phase I
2015- 2018: Phase II
Funded by: Canada's International Development Research Centre (IDRC) with financial support from the Government of Canada provided through Global Affairs Canada (GAC)
(An International Collaborative project with 6 countries: Canada, India, Sri Lanka, Kenya, Tanzania and Trinidad)

Principal Investigators

Background

The overall objective of this project was to address the national priority area of postharvest loss reduction and the Millennium Goal of eliminating extreme poverty and hunger. The lead collaborating team from the University of Guelph, Canada, developed and patented a Hexanal formulation known as EFF (Enhance Freshness Formulation) to extend the tree life of fruits. This was shared with the project partner countries: India, Sri Lanka, Tanzania, Kenya and Trinidad, to develop innovative products to meet the needs of the respective countries. The project was conducted in 2 phases where Phase I (2012 -2014) included laboratory-scale innovative product development and stakeholder awareness. In Phase II of the project (2015-2018), the technology outputs with commercial potential that would contribute effectively to food security and the elimination of poverty were selected, upscaled and commercialized. Phospholipase D (PLD) is the key enzyme involved in the initiation of membrane deterioration and destabilization during the ripening process of fruits. Increased firmness of fruits due to the enhanced membrane stability could be obtained by inhibiting the activity of PLD. Hexanal is a naturally occurring compound in plants that is known as a potent inhibitor of PLD activity. The project team selected mango and papaya, two main commercially grown fruits of Sri Lanka with export potential, to address pre- and postharvest loss reduction. The hexanal-based EFF technology shared by Canadian scientists was improved and introduced by the ITI team as TFF (Tree Fresh Formulation) to extend the tree life and also to reduce the postharvest loss of mango. Bio wax formulation developed by the ITI team was patented and commercialized targeting to extend the storage life of fruits such as mango, papaya, pineapple, king coconut and lime. This project also aimed at expanding the utilization of agricultural waste banana pseudo-stems, to develop a banana fiber-based fruit packaging material while improving environmental sustainability and creating new business opportunities for farmers.

Project Achievements/Outcomes

Technologies/Processes/Methods developed

- Five technologies were developed;
  - Two Bio wax formulations (with and without hexanal incorporated) – to extend the postharvest storage life of fruits.

- Hexanal-based Tree Fresh Formulation (TFF) to extend the tree life/harvest season of mango.
- Banana fiber-based paper – to use as a fruit wrap.
- HICM (Hexanal incorporated composite material) – to delay ripening and extend the storage life of mango.

- Two major equipment, HPLC (High-Performance Liquid Chromatograph) and FTIR (Fourier Transform InfraRed) A spectrophotometer and a vehicle were purchased by ITI through this project's funds.

Technologies Transferred

- Technologies of bio-waxes and tree fresh formulation were successfully transferred to Hayleys Agriculture Pvt. Ltd.
- Banana paper-making technology was disseminated to two banana fiber-making centers in Embilipitiya and Nirvely Jaffna (Banana Farmer Association).

Patents

- Processing technology of papers/boards from banana fiber for sorption and slow-release applications (Sri Lanka, Patent No.: 17575).
- Processing technology of banana fiber-polymer composite material for slow-releasing applications of trapped active compounds (Sri Lanka, Patent No.: 18029).
- Processing Technology of natural anti- senescence and anti-microbial agents incorporated edible wax formulation for postharvest preservation of perishable fruits (Sri Lanka, Patent No.: 18030).

Publications in Refereed Journals

1. Hewajulige, I.G.N**.,** Wilson Wijeratnam, R.S., Perera, M.G.D.S. and Fernando, S.A. (2015). Extending storage life of commercially important tropical fruits using bio-waxes. *Acta Horticuturae*, **1091**, 283-289.
2. Milani, M.D.Y., Samarawickrama, D.S., Dharmasiri, G.P.C.A. and Kottegoda, I.R.M. (2016). Study the structure, morphology and thermal behavior of banana fiber and its charcoal derivative from selected banana varieties. *Journal of Natural Fibers*, **13**(3), 332-342.
3. Hewajulige, I.G.N., Wijeratnam, R.S.W., Gunesekara, M.M.N.P., Gunethilaka, R.M.S.I., Perera, M.G.D.S., Paliyath, G. and Jayasankar, S. (2018). Pre-harvest 'Tree Fresh' spray treatment reduces disease incidence and extends the harvesting season of Mango var. TJC grown in Sri Lanka. *Acta Horticulturae*, **1201**, 49-54.
4. Wilson Wijeratnam, R.S., Fernando, K. and Hewajulige, I.G.N. (2018). Models adopted for commercializing new postharvest technology for minimizing post-harvest loss of fruits in Sri Lanka. *Acta Horticulturae*, **1201**, 177-182.
5. Gunesekara, M.M.N.P., Wijeratnam, R.S. Wilson., Perera, M.G.D.S., Hewajulige, I.G. N., Paliyath, G. and Jayasankar, S. (2018). Extending storage life of Mango (*Mangifera indica* L.) using a new edible wax formulation incorporated with hexanal and cinnamon bark oil. *Tropical Agriculture,* **95** (Special Issue), 97-11.
6. Samarawickrama, D.S., Milani, M.D.Y., Perera, P.S.D., Weeratunge, H.D., Wijeratnam, R.S. Wilson., Dissanayake, D.P., Hewajulige, I.G.N., Lim, L.T., Paliyath, G. and Subramanian, J. (2018). A hexanal incorporated composite material (HICM) made of

banana fiber and polymers extends storage life of mango fruit. *Tropical Agriculture*, **95** (Special Issue), 111-119.
7. Wijeratnam, R S Wilson, Fernando, K., Finnis, E., Ranmuthugala, M.E.P., Hewajulige, I.G.N. and Subramanian, J. (2019). Reflections on moving agricultural research from laboratory to farm. EPW, *Economic & Political Weekly*, **41**, 36-42.
8. Milani, M.D.Y., Samarawickrama, D.S., Wijeratnam, R.S.W. and Hewajulige, I.G.N. (2020). Production and commercialization of eco-friendly packaging material for transportation of fruits and vegetables. Proceedings of the IV International Conference on Postharvest and Quality Management of Horticultural Products of Interest for Tropical Regions. *Acta Horticulturae*, **1278**, 59-64.
9. Champa, W.A.H., Gunasekera, Nisala., Wijeratnam, S. Wilson., Hewajulige, I.G.N., Weerasinghe, W.M.S.S.K. and Kumara, B.A.M.S. (2020). Postharvest treatment of cinnamon (*Cinnamomum zeylanicum*) bark oil and hexanal incorporated bio-wax maintains quality and extends marketable life of lime (*Citrus aurantifolia* Swingle). *International Journal of Fruit Science*, **20**(1), 76-88. DOI: 10.1080/15538362.2019.1597823.

Scientific Communications

1. Hewajulige, I.G.N., Wilson Wijeratnam, R.S., Perera, M.G.D.S and Fernando, A. (2013). Extending storage life of commercially important tropical fruits using bio-waxes. *Proceedings of the International Conference on 'Managing Quality in Chains'* Cranfield, UK.
2. Kemali, R.W., Hewajulige, I.G.N. and Rathnayake, R.H.M.K. (2015). Effect of Enhanced Freshness Formula (EFF) on control of stem end rot disease caused by *Bortrydiplodia theobromae* in Papaya (*Carica papaya*). *Proceedings of the 14th Agricultural Research Symposium*, Wayamba University of Sri Lanka. p.15-19.
3. Pavithra, K.G.N., Hewajulige, I.G.N. and Ratnayake, R.H.M.K. (2015). Effect of Enhanced Freshness Formula (EFF) on control of stem end rot disease caused by *Colletotrichum gloeosporioides* in Papaya (*Carica papaya*). *Proceedings of the 14th Agricultural Research Symposium*, Wayamba University of Sri Lanka. p. 25-29.
4. Milani, M.D.Y., Samarawickrama, D.S., Dharmasiri, G.P.C.A. and Kottegoda, I.R.M. (2015). Characterization of banana fiber extracted from common banana varieties in Sri Lanka. *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.45.
5. Wijaratnam, R.S.W., Gunasekara, M.M.N.P., Gunathilaka, R.M.S., Perera, M.G.D.S. and Hewajulige, I.G.N. (2015). Improving quality of mango (*Mangifera indica*) var. Karthakolomban by postharvest application of new edible wax formulations. *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.12.
6. Gunasekera, M.M.N.P., Gunathilaka, R.M.S., Wijeratnam, R.S.W., Perera, M.G.D.S., Sarangi, K.A.N. and Hewajulige, I.G.N. (2016). Effect of new edible wax formulations on postharvest quality of mango (*Mangifera indica*) var. Karuthacolomban, *Proceedings of the Wayamba University International Conference*, Sri Lanka. p.158.
7. Hewajulige, I.G.N., Wilson Wijeratnam, R.S., Gunathilaka, R.M.S.I., Gunasekara, M. M.N.P., Perera, M.G.D.S., Paliyath, G. and Jayasankar, S. (2017). Pre-harvest "tree fresh" spray treatment reduces disease incidence and extends the harvesting season of mango "TJC" grown in Sri Lanka. *Proceedings of the VII ISHS International Conference on Managing Quality in Chains (MQUIC)*, Stellenbosch, South Africa. p.26.

8. Wilson Wijeratnam, R.S., Fernando, K. and Hewajulige, I.G.N. (2017). Models adopted for commercializing new postharvest technology for minimizing postharvest loss of fruits in Sri Lanka. *Proceedings of the VII ISHS International Conference on Managing Quality in Chains (MQUIC).* Stellenbosch, South Africa. p.56.
9. Wijeratnam, S.W., Yoga, M., Samarawickrama, D. and Hewajulige, I. (2017). Production and commercialization of eco-friendly packaging material for transportation of fruit and vegetables. *Proceedings of the IV International Conference on Postharvest and Quality Management of Horticultural Products of Interest for Tropical Regions,* Kandy, Sri Lanka. p 2.
10. Samarawickrama, D.S., Weeratunge, H.D., Gunasekara, M.M.N.P., Milani, M.D.Y., Hewajulige, I.G.N., Wilson Wijeratnam, R.S. and Dissanayaka, D.P. (2017). Headspace characterization of hexanal incorporated composite material (HICM) for postharvest application on mango fruits, *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.58.
11. Champa, W.A.H., Gunasekera, M.M.N.P., Wijeratnam, R.S.W., Hewajulige, I.G.N., Weerasinghe, W.M.S.S.K. and Kumara, B.A.M.S. (2017). Biowax coating improves quality and extends storage life of lime fruits (*Citrus aurantifolia* L.). *Proceedings of the 3rd Annual Research Session, IFSTSL*, Sri Lanka. p.22-26.
12. Samarawikrama, D.S. (2017). Analysis of consumers' purchasing decision making of mangoes through KANO model. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.60.

Book Chapters

1. Hewajulige I.G.N. and Dhekney S.A. (2016). Papayas. In: *Encyclopedia of Food and Health* Vol. 4. (Eds. Caballero, B., Finglas, P., and Toldrá, F.) Oxford: Academic Press. p. 209-212.
2. Hewajulige, I.G.N., Wijeratnam, R.S.W. and Hutchinson, M.J. (2019). Papaya. In: *Postharvest Biology and Nano-Technology*, (Eds. G. Paliyath, Subramanian J, Loong-Tak L., Handa A., Mattoo A.). John Wiley & Sons, USA. p.199-214.

Post Graduate degrees (MPhil/PhD)

1. Mr. D. S. Samarawickrama obtained a PhD degree from the University of Colombo in 2020. Thesis Title: Development of natural fiber-based, smart packaging material to address the postharvest losses of mangoes in Sri Lanka.
2. Ms. M. Wijemanna registered for a postgraduate degree at the University of Colombo (PhD Ongoing).

Awards:

International Awards

1. WAITRO IMPACT Award 2022 - An International Award from the Worlds Association of Industrial & Technological Research Organizations (WAITRO) for SDGs impact. Selected as a Finalist in the competition held from 14-15 November 2022 in Cape Town, South Africa, for the project outcomes presented on "Enhancing preservation of fruits using Nanotechnology; Developing and Adopting new technologies to minimize postharvest losses in Sri Lanka and its impact on Sustainable Development Goals". I.G.N. Hewajulige (PI) received this award on behalf of the IDRC project team.

Presidential Award for Patented Inventions 2018

1. Gold medal for the Sri Lankan patent No. 18030: Processing Technology of natural anti-senescence and anti-microbial agents incorporated edible wax formulation for postharvest preservation of perishable fruits-N. Gunasekara, S.W. Wijeratnam, I.G.N. Hewajulige and S. Perera.

National Awards

1. National Science and Technology Award - NASTA Award 2018 - National Science and Technology Award for "Excellence in international collaboration for the advancement of S&T 2018 awarded by the National Science Foundation, Sri Lanka- IDRC project team- I.G.N. Hewajulige (PI), S. Wilson, Y. Milani, N. Gunasekara, S. Perera, D. Samarawickrama, A. Sooriyarachchi and M. Wijemanna.
2. National Inventors Awards 2018 - Gold medal for 'Bio-wax' formulation at Sahasak Nimavum Inventors exhibition/National Inventors Day-N. Gunasekara, S.W. Wijeratnam, I. G.N. Hewajulige and S. Perera.
3. National Award for Excellence in Agricultural Research 2019 - 1st place in plantation crops category –awarded by CARP (Council for Agricultural Research Policy) -IDRC project team- I.G.N. Hewajulige (PI), S. Wilson, Y.Milani.

ITI Recognition/Awards

1. Best Innovative Technology -2018 – Bio-wax formulation- at the ITI 4th Biennial Research Symposium 2019-N. Gunasekara, S. Wilson, I. G. N. Hewajulige and S. Perera.
2. Best Innovative R&D project of the biennium 2018-2019 -at the ITI 4th Biennial Research Symposium 2019. Project team, IDRC/ ITI Canada funded project. I.G.N. Hewajulige (PI), S. Wilson, Y. Milani, N. Gunasekara, S. Perera, D. Samarawickrama, A. Sooriyarachchi and M. Wijemanna.

NCBI GenBank submissions

- Fifteen isolates of post-harvest pathogens of Mango are deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Popularization Activities

- Information on postharvest loss reduction of mango papaya and banana was disseminated through workshops.

Postharvest information dissemination workshops were conducted by the ITI/IDRC team from 2012 to 2018: 30

- Training farmers/members of farmer association- 1000
- Training of exporters/ supermarkets and industry participants – 100
- Training of government officials/agriculture officers/ extension officers -200
- Training of school teachers on Postharvest Management – 400
- Training of University students/ school children on Postharvest Management – 400
- Information dissemination on Pre and Postharvest Management of Mango, Papaya and Banana via Dialog "Govi-Mithuru-Farmers' Friend" mobile app.

ITI/IDRC project team, the Content provider on postharvest technology for mango, papaya and banana.

- Newspaper articles on the project and project outcomes were published.
- A magazine article on the project was published in Business LK.
- Link to project summary in the YouTube, uploaded in 2018. *https://www.youtube.com/watch?v=slYzHTTydRk*

Formulation of probiotic foods as an alternative treatment for *Helicobacter pylori*

Grant No: FP 102
Project team: *Dr. (Ms.) J. Gooneratne
*Prof. (Ms.) I.G.N. Hewajulige
Dr. (Ms.) D.M.W.D. Divisekera
Eng. A.B.C.G.J. De Silva
Ms. T.M.D.A. Jayawardana
Period covered: 2012 - 2016
Funded by: National Science Foundation, Sri Lanka

**Principal Investigators*

Background

Helicobacter pylori is a gram-negative, motile, helical and microaerophilic microorganism, considered as one of the most successful pathogens due to persistent infection in the human stomach. *H. pylori* is the etiologic agent of both gastric (gastric malignancy, peptic ulcer, chronic gastritis) and extra-gastric diseases. The patients infected with this bacterium should be treated; complete eradication of *H. pylori* improves peptic ulcer and mucosa-associated lymphoid tissue (MALT) lymphoma,as well as reduces the risk of gastric cancer and autoimmune liver disease. The infection is treated with antibiotics which may have several side effects on humans and will also destroy the commensal bacteria that are colonized in the intestinal tract resulting in the severity of the infection. Besides that, around 20% of the patients fail to respond due to resistance developed by the organism to antibiotics. An alternative solution to this problem is a treatment with a probiotic-prebiotic combination including various Lactobacilli strains with probiotic attributes and antibacterial activity against *H. pylori.* The antagonistic effect of probiotics against *H. pylori* happens through organic acid production, competitive inhibition for the binding sites of mucus cells and immunomodulation. However, the synthesis of bacteriocin-like compounds has rarely been associated with these antagonistic effects. Probiotics compete directly with *H. pylori* and help restore the gut microbial environment; these living microorganisms are comparatively more effective than the standard triple antibiotic regimen in the management of symptoms related to pathogenic bacteria. Our approach to this problem was to formulate prebiotic foods containing probiotics that will demonstrate antagonistic activity against *H. pylori* using indigenous food materials. The food material combination included cereals, pulses, coconut milk and cow's milk. No previous studies have been reported within the country to evaluate the antibacterial effect of prebiotic foods against *H. pylori*.

Project Achievements/Outcomes

Technologies/Processes/Methods developed

- One of the major contributions of this project was the isolation of an anti-*Helicobacter pylori probiotic* strain from Sri Lankan indigenous rice, *Madathawalu*. This was an initiation to
develop therapeutic food using locally isolated strains and local raw materials.
- Bio-efficacy, mucosal adherence ability and oral safety of newly isolated probiotic strains were investigated and established. The sequences were deposited in GenBank of NCBI, USA.
- A fermented beverage containing *Madathawalu* rice as the major ingredient containing anti- *H. pylori* strain *Pediococcus pentosaceous* was developed and studied its kinetics.

Scientific Communications

1. Divisekera, D.M.W.D., Gooneratne, J. and Jayawardana, T.M.D.A. (2014). Isolation, characterization and identification of lactic acid bacteria and yeasts from fermented organically grown rice and coconut milk. *Proceeding of the International Research Conference*, University of Peradeniya, Sri Lanka. p.210.
2. Warunasinghe, W.A.A.I., Divisekera, D.M.W.D. and Gunaratne, D.M.A. (2014). Isolation characterization and identification of lactic acid bacteria and yeast from fermented commercially available rice. *Proceeding of the International Research Conference*, University of Wayamba, Sri Lanka. p.236.
3. Divisekera, D.M.W.D., Warunasinghe, W.A.A.I. and Hewajulige, I.G.N. (2014). Isolation, characterization and identification of lactic acid bacteria from fermented indigenous rice flour. *Proceedings of the Young Scientists Forum.* p. 53-56.
4. Divisekera, D.M.W.D., Warunasinghe, W.A.A.I., Hewajulige, I.G.N., Gooneratne, J. and Gunaratane, D.M.A. (2014). Isolation, characterization and identification of lactic acid bacteria from fermented barley. *Proceeding of the 70th Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.35.
5. Wijemanna, N.D., Divisekera, D.M.W.D., Hewajulige, I.G.N., Gunasekera, M.M.N.P., Goonaratne, J. and Marapana, R.A.U.J. (2015). Determination of sugar utilization by *Pediococcus pentosaceus* in fermentation of *Madathawalu. Proceedings of International Research Symposium on Engineering Advancements.* p.287-290.
6. Divisekera, D.M.W.D., De Silva, A.B.G.C.J., Goonaratne, J., Jayawardana, T.M.D.A. and Hewajulige I.G.N. (2016). *In vitro* antimicrobial activity of *Pediococcus pentoceus* isolated from rice variety, *Madathawalu. Proceedings of the Research Summit*, National Science Foundation, Sri Lanka. p. 85.

NCBI GenBank submissions

- Ten new strains of probiotic potential lactic acid bacteria from indigenous rice varieties of Sri Lanka were deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Development of maturity indices for selected fruits and vegetables

Grant No: TG 12- 00 - 01
Project team: *Dr. (Ms.) R.S. Wilson Wijeratnam
Prof. (Ms.) I. G.N. Hewajulige
Ms. H.H.K. Achala
Ms. M.G.D.S. Perera
Period covered: 2012
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The postharvest phase of an agricultural crop begins with field harvesting. Harvesting at the correct or optimum stage of maturity is a crucial factor in maintaining the quality and reducing postharvest losses of agricultural commodities. The maturity index provides details on visual observations, colour development, physicochemical parameters and other relevant details to judge the stage of maturity for harvesting in order to maintain the quality of fruits and vegetables. These indices help to harvest commodities according to the target market destination (either export or local market), storage duration and the intended use (either fresh consumption or processing) and thereby help to reduce postharvest losses. The maturity charts with related quality attributes are important for fruit and vegetable harvesters, collectors, exporters, wholesalers, retailers, supermarkets, food processors, students and researchers to judge harvest maturity, based on the target market and the intended use. Therefore, this project aimed to develop maturity index charts for selected fruits and vegetables that have export potential and make the maturity charts available for the use of the fruit and vegetable industry.

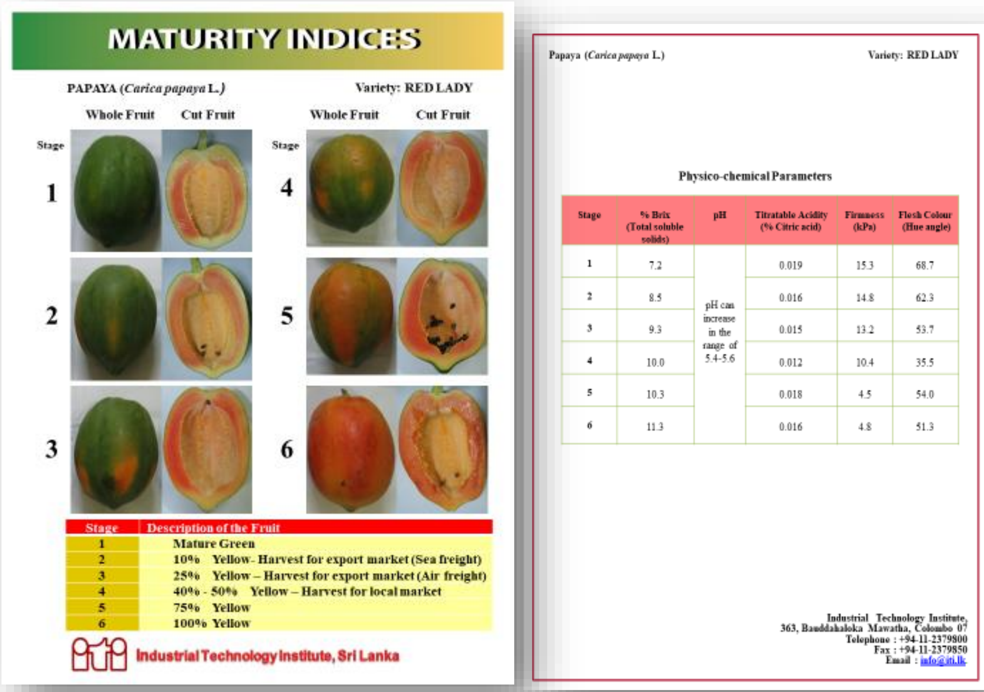
Project Achievements / Outcomes

Technologies/Processes / Methods developed

- The maturity index charts for Banana (Ambul variety), Pineapple (Kew variety and Mauritius variety), Papaya (Rathna variety and Red Lady variety), King coconuts, Mango (Karathakolamban variety and Betty variety), Rambutan (Malaysian red variety, Malaysian Yellow variety and Malvana special variety) and Chilli were developed.
- The maturity indices charts were printed for research activities and for the use of the fruit and vegetable industry as a part of postharvest protocols developed for export, local and supermarket channels.

Technologies Transferred

- The knowledge on harvest maturity and maturity indices has already been disseminated to relevant stakeholders through postharvest and fruit & vegetable processing-related workshops, Vidhatha training programs, exhibitions, individual technology transfer and training programmes.
- Launched the maturity indices charts and sample charts were presented to selected leading fruit and vegetable cultivators and exporters.
- Maturity charts were disseminated among exporters/entrepreneurs during workshops/ training programmes.



MATURITY INDICES

PAPAYA (*Carica papaya* L.) Variety: RED LADY

Whole Fruit | Cut Fruit

Stage 1, 2, 3, 4, 5, 6

Stage	Description of the Fruit
1	Mature Green
2	10% Yellow- Harvest for export market (Sea freight)
3	25% Yellow – Harvest for export market (Air freight)
4	40% - 50% Yellow – Harvest for local market
5	75% Yellow
6	100% Yellow

Industrial Technology Institute, Sri Lanka

Papaya (*Carica papaya* L.) Variety: RED LADY

Physico-chemical Parameters

Stage	% Brix (Total soluble solids)	pH	Titratable Acidity (% Citric acid)	Firmness (kPa)	Flesh Colour (Hue angle)
1	7.2	pH can increase in the range of 5.4-5.6	0.019	15.3	68.7
2	8.5		0.016	14.8	62.3
3	9.3		0.015	13.2	53.7
4	10.0		0.012	10.4	35.5
5	10.3		0.018	4.5	54.0
6	11.3		0.016	4.8	51.3

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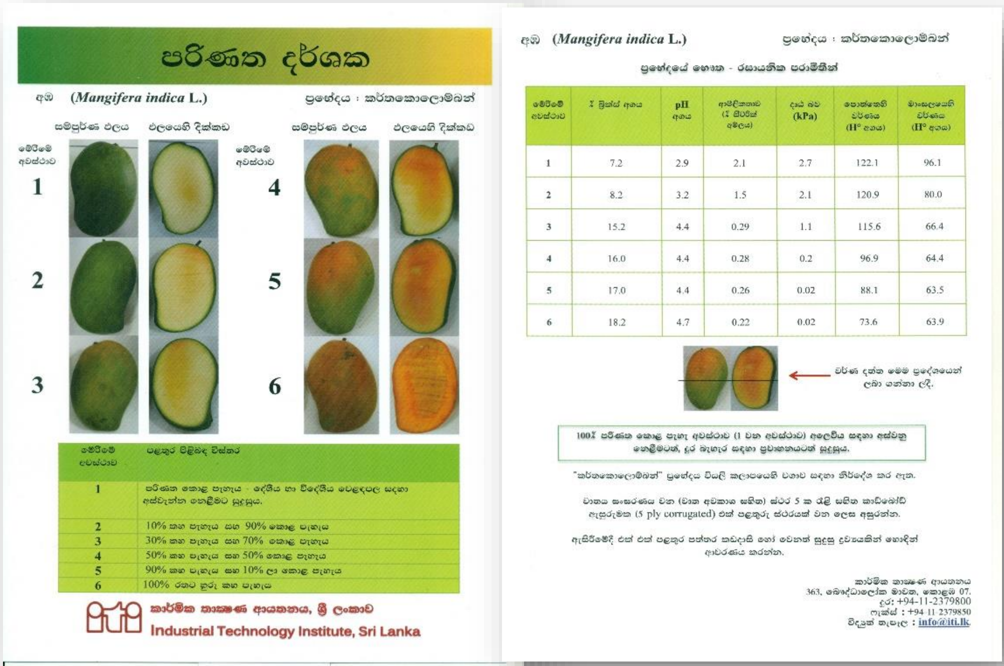

පරිණත දර්ශක

අඹ (*Mangifera indica* L.) ප්‍රභේදය : කර්තකොළොම්බන්

සම්පූර්ණ ඵලය | ඵලයෙහි දික්කඩ

මේරීමේ අවස්ථාව 1, 2, 3, 4, 5, 6

මේරීමේ අවස්ථාව	පලතුර පිළිබඳ විස්තර
1	පරිණත කොළ පැහැය - දේශීය හා විදේශීය වෙළඳපල සඳහා අස්වැන්න නෙළීමට සුදුසුය.
2	10% කහ පැහැය සහ 90% කොළ පැහැය
3	30% කහ පැහැය සහ 70% කොළ පැහැය
4	50% කහ පැහැය සහ 50% කොළ පැහැය
5	90% කහ පැහැය සහ 10% ලා කොළ පැහැය
6	100% රනට හුරු කහ පැහැය

කාර්මික තාක්ෂණ ආයතනය, ශ්‍රී ලංකාව
Industrial Technology Institute, Sri Lanka

අඹ (*Mangifera indica* L.) ප්‍රභේදය : කර්තකොළොම්බන්

ප්‍රභේදයේ භෞත - රසායනික පරාමිතීන්

මේරීමේ අවස්ථාව	% බ්‍රික්ස් අගය	pH අගය	ආම්ලිකතාව (% සිට්‍රික් අම්ලය)	දෘඩ බව (kPa)	පොත්තෙහි වර්ණය (H° අගය)	මාංසලයෙහි වර්ණය (H° අගය)
1	7.2	2.9	2.1	2.7	122.1	96.1
2	8.2	3.2	1.5	2.1	120.9	80.0
3	15.2	4.4	0.29	1.1	115.6	66.4
4	16.0	4.4	0.28	0.2	96.9	64.4
5	17.0	4.4	0.26	0.02	88.1	63.5
6	18.2	4.7	0.22	0.02	73.6	63.9

වර්ණ දත්ත මෙම ප්‍රදේශයෙන් ලබා ගන්නා ලදී.

100% පරිණත කොළ පැහැ අවස්ථාව (1 වන අවස්ථාව) අපනයනය සඳහා අස්වනු නෙළීමටත්, දුර බැහැර සඳහා ප්‍රවාහනයටත් සුදුසුය.

"කර්තකොළොම්බන්" ප්‍රභේදය වියළි කලාපයෙහි වගාව සඳහා නිර්දේශ කර ඇත.

වාතය සංසරණය වන (වාත අවකාශ සහිත) ස්ථර 5 ක රැලි සහිත කාඩ්බෝඩ් පැසුරුමක (5 ply corrugated) එක් පළතුරු ස්ථරයක් වන ලෙස අසුරන්න.

ඇසිරීමේදී එක් එක් පළතුර පත්තර කඩදාසි හෝ වෙනත් සුදුසු ද්‍රව්‍යයකින් හොඳින් ආවරණය කරන්න.

කාර්මික තාක්ෂණ ආයතනය
363, බෞද්ධාලෝක මාවත, කොළඹ 07.
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ෆැක්ස් : +94-11-2379850
විද්‍යුත් තැපෑල : info@iti.lk

Suitability of selected Sri Lankan tomato varieties for the development of physicochemically and functionally sound tomato puree under different processing conditions

Grant No: TG 13 - 65
Project team: *Prof. (Ms.) I.G.N. Hewajulige
Ms. R.C. Pitipanaarachchi
Eng. S.G. Walliwala
Dr. (Ms.) W.K.S.M. Abeysekera
Ms. M.G.D.S. Perera
Ms. H.H. Iflal
Period covered: 2014 - 2015
Funded by: Sri Lanka Treasury

Principal Investigator

Background

Tomatoes are preserved as puree/paste to be used as an ingredient for tomato-based product processing. Most of the tomato sauce processing industries in Sri Lanka import tomato paste from other countries, claiming that the tomato varieties and the methodology used in Sri Lanka are not feasible for paste manufacturing. ITI has developed a methodology to prepare tomato paste using locally available tomato varieties such as Thilina and Tharindu using a low-cost, modified open pan method. The paste developed from these tomato varieties showed good sensory properties and can be effectively used to make tomato-based products.

Project Achievements/Outputs

Technologies/Processes/Methods Developed

- Maturity Indices charts were developed for five tomato varieties; Thilina, Tharindu, Maheshi, Bathiya and Rushmi released by the Department of Agriculture (DOA), Sri Lanka.
- Process development to prepare tomato paste using locally available tomato varieties such as Thilina and Tharindu**.**
- Tomato sauce was prepared using locally manufactured paste. Technology on tomato sauce manufacturing using local tomatoes was introduced to cottage-level sauce manufacturers.

Scientific Communications

1. Iflal, H.H., Abeysekera, W.K.S.M., Pitipanaarachchi, R.C., Perera, M.D.G.S., Walliwala, S.G., Hewajulige, I.G.N. and Wijayarathna, C.D.W. (2016). Antioxidant properties at different stages of maturity of widely cultivated tomato (*Lycopersicon esculentum*) varieties in Sri Lanka. *Proceedings of the 36th Annual Sessions,* Institute of Biology. p.25.

Post Graduate Degree

1. Ms. H.H. Iflal obtained a MPhil Degree from the University of Colombo in 2017.
   Thesis Title: Selection of suitable locally grown tomato cultivars (*Lycopersicon esculentum* Mill.) for processing in Sri Lanka.

Development of low-calorie functional bread with clinically proven low Glycemic Index (GI)

Grant No: TG 13- 66
Project team: *Prof. (Ms.) W.K.S.M. Abeysekera
Prof. (Ms.) I. G.N. Hewajulige
Prof. G.A.S. Premakumara
Ms. D.M.K. Aponso
Ms. A.W.D. Priyangani
Period covered: 2013 - 2014
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Bread is one of the most popular wheat-based food products worldwide and there are different types of bread in the world market. Commercial white bread is a popular type of bread in many countries. However, it has a low nutritional value with a high caloric value and is generally associated with a high glycemic response. Such foods are associated with increased blood glucose responses and are risk factors for diabetes, cardiovascular diseases, and obesity. Therefore, consumer awareness of the importance of functional foods has gained much attention in recent years. This is mainly because of their associated health benefits, including maintenance of health and protection from degenerative diseases. Much work has been conducted worldwide on wheat flour substituted with other raw materials in bread formulations to improve the functionality of bakery products having reduced caloric content. This could be achieved by the incorporation of cereal brans and legumes into wheat flour during bread making. However, careful selection of these materials is important to maintain the rheological properties of the dough as some of these materials can interfere with gluten formation and bread stability and modify the macromolecular and molecular water distribution and dynamics. Local availability and the cost of raw materials are also equally important in the formulation of such products.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Technology for multi-grain bread having high protein, fat and dietary fiber along with high anti-oxidant, anti-inflammatory and anti-diabetic related properties compared to the white bread.
- Low glycemic activity was clinically proven.

Popularization Activities

- Live program (Mihithalaya) on health benefits of Sri Lankan rice – SLBC (07.05.2015).
- Radio program on anti-diabetic properties of Sri Lankan rice and product development – SBS, Australia.

Low Glycemic Multi-Grain Bread

Establishment of non-thermal processing technologies for blended fruits and vegetable juices

Grant No: TG 13- 67
Project team: *Dr. P.N.R.J. Amunugoda
Dr. P. Ranasinghe
Eng. A. Sooriyarachchi
Eng. A.B.G.C.J. De Silva
Ms. A.M.C.U. Binduhewa
Eng. S. G. Walliwala
Prof. (Ms.) W.K.S.M. Abeysekera
Period covered: 2013 - 2015
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Thermal processing of juices shows very efficient sterilization and longer shelf life. However, this could result in thermal degradation by destroying many health properties of "freshly squeezed" juices, including their sensory qualities and nutritional value. Novel non–thermal sterilization technologies; Pulsed Electric Field (PEF), Hyperbaric Pressure, Hyperbaric Pressure with Carbon dioxide, Ultrasonic, UV radiation, Gamma Irradiation, Cold Plasma, Magnetic Field, Hydrodynamic Shock, Membrane Filtration and Ozone sterilization are alternatives to thermal sterilization with added advantages of better retention of nutritional and sensory qualities and minimal or no use of preservatives. Each non-thermal process seems to be completely novel to juice processing industries in Sri Lanka. Each technique is product-specific, hence the need to define critical process parameters that must be monitored as part of critical control points.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Thermally processed ready-to-serve drinks were developed from Curry leaf, Aloe-vera, Gotukola and Sugar melon single and blended juices.
- Micro-filtrated single and blended juices were developed from Curry leaf, Aloe-vera, Gotukola and Sugar melon.
- Ultrasonically processed single and blended juices were developed from Curry leaf, Aloe-vera, Gotukola and Sugar melon.
- Active hydrogen estimation method was established (with a test kit) as a quick antioxidant capacity estimation and thereby estimated the antioxidant potential.
- UV sterilization system was established for ready-to-serve juice processing.
- UV juice processing was scaled up, combined with an ultrasonic device and an optional pasteurization unit.

Technologies Transferred

- Technology of ready-to-serve curry leaf beverage transferred and commercialized.

Patent

- Manufacture of ready-to-serve curry leaf beverage (Sri Lanka, Patent No.18319).

Scientific Communications

1. Amunugoda, P.N.R.J., Silva, A.M.C.U. and Abeysekara, W.K.S.M. (2014). Applicable non-thermal technologies to maintain quality of perishable juices. *Proceedings of the 70th Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.18.
2. Amunugoda, P.N.R.J., Jayasinghe, G.D.D.R., Pitipanaarachchi, R. and Hewajulige, I.G.N. (2015). Development of ready-to-serve *Aloe-vera* (*Aloe barbadensis* Mill) beverage. *Proceedings of the 71st Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.111.
3. Amunugoda, P.N.R.J., Rathnayake, D.T., Jayasinghe, G.D.D.R., Sooryaarachchi, A. and Marapana, R.A.U.G. (2015). Efficacy of ultraviolet radiation as a non-thermal technique for reduction of microorganisms in *Aloe-vera* (*Aloe barbadensis* Miller) and curry leaf (*Murraya koennigi*) juice. *Proceedings of the 2nd Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.49.
4. Amunugoda, P.N.R.J., Pitipanaarachchi, R., Jayawardane, S.A.S., Walliwala, S.G. and Niranjan, R.W.M.U. (2015). Development of ready-to-serve curry leave beverage. *Proceedings of the 5th International Research Symposium on Engineering Advancements*, South Asian Institute of Technology and Medicine, Sri Lanka. p.281-282.
5. Walliwala, S.G., De Silva, A.B.G.C.J., Amunugoda, P.N.R.J., Jayasinghe, G.D.D.R., Abeysekara, K.A.S., Jayawardane, T.M.D.A. and Fernando, I.M. (2015). Efficacy of microfiltration and thermal process technology for development of super health drinks. *Proceeding of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.10-11.
6. Fernando, I., Amunugoda, P.N.R.J., Jayasinghe, G.D.D.R. and Marapana, R.A.U.J. (2016). Efficacy of Microfiltration versus conventional thermal processing in the production of a ready-to-serve health beverage. *Proceeding of the Alliance 2016, 2nd Symposium*, B.Sc. Honours Degree in Applied Science. University of Sri Jayewardanepura. p.40.
7. Amunugoda, P.N.R.J., Jayasinghe, G.D.D.R., Abeysekara, W.K.S.M., Jayawardane, T.M.D.A., Fernando, I.M., Marapana, R.A.U.J. and Ranasinghe, P. (2016). Effect of thermal and non-thermal processing techniques on physio-chemical, microbiological and sensory properties of ready-to-serve health beverage. *Proceeding of the International Research Symposium on Engineering Advancements (IRSEA 2016)*, SAITM, Malabe, Sri Lanka. p.183-184.
8. Rathnayake, D.T., Amunugoda, P.N.R.J. Jayasinghe, G.D.D.R., Marapana, R.A.U.G. and Sooriyarachchi, A. (2017). Efficacy of ultraviolet radiation as a non-thermal technology for reduction of microorganisms in juices. *Food Techno 2017, Proceedings of the 3rd Annual Research Sessions of IFSTSL*. p. 16-21.
9. Amunugoda, P.N.R.J. and Jayasinghe, G.D.D.R. (2018). The amount of active hydrogen in perishable juices and changes with thermal and non-thermal (Ultrasonic and Microfiltration) processing techniques. *Food Techno 2018. Proceedings of the 4th Annual Research Sessions of the IFSTSLP*. p.49-54.

Awards

1. Bronze in the Commercialized Category (2018) under the Technical Field of Food Technology for "Ready-To- Serve Curry Leaves Beverage" at the Sahasak Nimavum National Invention Exhibition - P.N.R.J. Amunugoda, R.C. Pitipanaarachchi, S.A.S. Jayawardane, S.G. Walliwala and R.W.M.U. Niranjan.

2. Gold Medal in the Commercialized Category under Technical Field of Food Technology for the Development of Ready-To-Serve beverage from *Aloe-vera* organized by the Sri Lanka Inventors Commission in 2019 – I.G.N. Hewajulige, R.C. Pitipanaarachchi, S.A.S. Jayawardena and H.A.H.M. Mahanama.
3. Silver Medal in Presidential Awards for patented inventions 2022 (Patent No. 18319 – 2018) for "Ready-To- Serve Curry Leaves Beverage" by the National Inventors Commission- P.N.R.J Amunugoda, R. Pitipanaarachchi, S.A.S. Jayawardane, S.G. Walliwala and R.W.M.U. Niranjan.

Ready-To-Serve curry leaf beverage

Formulation of ready-to-drink beverage and herbal tea with Thebu (*Costus speciosus*) and evaluation of bioactivity

Grant No: TG 13- 68
Project team: *Ms. A.M.C.U. Binduhewa
Prof. (Ms.) I.G.N. Hewajulige
Dr. P. Ranasinghe
Prof. (Ms.) W.K.S.M. Abeysekera
Period covered: 2013 - 2014
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Diabetes mellitus is a chronic metabolic disease that has created socioeconomic issues in the country. More than 10% of the Sri Lankan population is affected by diabetes while 12% is affected by impaired glucose tolerance (IGT). There is also an increasing trend in developing diabetes among the urban younger generation. *Costus speciosus (Thebu* in Sinhala*)* is widely used in Indian medicine to treat various illnesses including diabetes. Both aqueous and solvent extracts of the rhizome and leaves have proven antidiabetic activity. Eremanthin and costunolide extracted from *Costus speciosus* showed hypoglycemic and normo-glycemic activities. In addition, it has exhibited antihyperlipidemic, antioxidative, hepatoprotective, antimicrobial, anticarcinogenic and anti-inflammatory activities *in-vitro* and *in-vivo*. The novel trend is to incorporate herbs and formulate functional food products which are more palatable, attractive and economical compared to drugs. Even though *Costus speciosus* is readily grown in Sri Lanka, no related herbal food or beverage products are available in the market. Therefore, these herbal formulations and product quality evaluations are essential for the industry.

Project Achievements/Outcomes

- Rhizome, tender/young leaves and mature leaves of *C. speciosus* indicated moderate antioxidant activity. Mature leaves can be used instead of rhizomes, for processing functional food or beverages.

Technologies/Processes/Methods Developed

- Thebu drink (Shelf life: 08 months at 30 °C ± 1)
- Thebu drink with no added sugar (Shelf life: 08 months at 30 °C ± 1)
- Thebu drink sweetened with kithul treacle (Shelf life: 08 months at 30 °C ± 1)
- Dry Thebu leaves for brewing (Shelf life: 12 months at 30 °C ± 1)
- Carbonated Thebu drink (Shelf life: 06 months at 30 °C ± 1)

Patents

- A carbonated herbal drink with Thebu (*Costus speciosus*) extracts (Sri Lanka, Patent No.18156).

Award

1. Merit Award in Presidential Awards for patented inventions 2022 (Patent No. 18156 – 2018) for "A carbonated herbal drink with Thebu (*Costus speciosus*) extracts" by the

National Inventors Commission-A.M.C.U. Binduhewa, P. Ranasinghe, W.K.S.M. Abeysekara and I. G.N. Hewajulige.

Scientific Communications

1. Suwandarathna, S.H.N.T., Ranasinghe, P., Binduhewa, U. and Perumpuli, B. (2016). Antioxidant activity of Thebu (*Costus speciosus*) rhizome and leaves. *Proceedings of the International Symposium on Agriculture and Environment.* University of Ruhuna, Matara. p. 247-249.
2. Binduhewa, A.M.C.U., Ranasinghe, P., Hewajulige, I.G.N., Abeysekera, W.K.S.M., Suwandarathne, S.H.N.T. and Perumpuli, B. (2018). A bioactive carbonated beverage of Thebu (*Costus speciosus*) extract. *Proceedings of the Asian Symposium on Medicinal Plants, Spices and Other Natural Products XVI.* Colombo. p.97.

Ready to Serve Thebu Drink

Determination of the actual shelf life of bottled drinking water

Grant No: TG 13 - 79
Project Team: *Ms. S. Perera
Dr. (Ms.) S. H. S. Karunaratne
Ms. S. Liyanage
Project Period: 2013 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Bottled water is very popular for many reasons, including taste, convenience, poor water quality, safety and health concerns and as a substitute for sugary drinks. There are two national standards published by the regulatory authority, Sri Lanka Standards Institution; SLS 894 for Bottled drinking water and SLS 1038 for Bottled natural mineral water. The determination of the microbial quality of bottled drinking water was the main concern in this project. According to the SLS 894, microbiological analyses have to be initiated within 12 hours after filling. The shelf life of the bottled water is normally indicated as 12 - 18 months on the product label by producers. However, packaging and environmental factors such as storage temperature and light can affect the quality of the bottled water. In this study, variations were observed in APC (Aerobic Plate Count) and Algal count in bottled water within the storage period of 12 - 18 months. Therefore, these parameters are also important to consider to determine the actual shelf life of bottled water.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A standard testing service was implemented as a customer service in the microbiological area-algal count in water and the method is being used for technical analysis.

Scientific Communication

1. Amarasena, S., Perera, S. and Gunawardena, D. (2017). Portability assessment of marketed bottled drinking water with reference to the chemical and microbiological parameters and evaluation of accelerated shelf life. *Proceedings of the 3rd Symposium*, University of Sri Jayewardenepura. p.82.

Identification of information & research needs of the cereal-based product industry using the critical success factor approach

Grant No: TG 13 - 89
Project Team: *Ms. K.H.T. Abeysekera
Ms. E.M.S. Isanka
Prof. (Ms.) I.G.N. Hewajulige
Ms. C. Samaranayake
Project Period: 2013 - 2014
Funded by : Sri Lanka Treasury

Principal Investigator

Background

Rice, wheat, maize, millet, and sorghum are the major cereals consumed in Sri Lanka while rice and wheat are considered primary cereals. Household surveys revealed that rice and wheat products account for over 99.0% of cereal consumption. Hence, the cereal-based product industry is one of the major sectors in the local food industry. Due to health concerns, people are now moving towards various health-friendly cereal-based products rather than traditional cereal-based products. This move creates a need for new products which in turn demands research & development and information. However, a systematic study has not been carried out to identify the research and information needs of the local cereal-based food industry. Furthermore, cereal-based product development is one of the main research areas of the ITI. Thus, it is imperative to identify the industry needs for cereal-based product development. This study focused on the identification of Critical Success Factors (CSFs) in the cereal-based product industry of Sri Lanka and the identification of information needs of the industry via informal interviews conducted with the executives of selected industries. Moreover, the study was extended to the identification of research and development needs of the industry.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A database of the Cereal Industry was developed.
- R&D and testing needs of the Cereal Industry were identified and relevant information was shared with the R&D sections of ITI.
- Information needs of the Cereal Industry were identified.
- Created a platform for stakeholder discussions.
- Perception of industry on ITI & the ISC (Information Service Sector) was identified.

Scientific Communications:

1. Abeysekara, K.H.T., Isanka, E.M.S. and Hewajulige, I.G.N. (2017). Identification of the information needs of the local cereal-based industrialists and the perception on ITI and ISC using CSFS approach. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.72-73.

Ensuring human health, food & nutritional security through novel cereal and fruit-based prebiotics

Grant No: FP 110
Project Team: *Prof. (Ms.) J.K.R.R. Samarasekera
Dr. (Ms.) J. Gooneratne
Dr. (Ms.) D.M.W.D. Divisekera
Eng. A.B.G.C.J. De Silva
Ms. R. Sutharshana
Dr. (Ms.). S.A.S. Jayawardena
Ms. D.M.K. Aponso
Period covered: 2013 - 2016
Funded by: Indo-Sri Lanka inter-governmental research cooperation via the Ministry of Science, Technology and Research, Sri Lanka

Principal Investigator

Background

The population in Sri Lanka is largely dependent on mono-cereal; rice or wheat-based diets and hence faces challenges of health, nutrition, and emerging life-style diseases. Hence, knowledge sharing to improve diet diversity and provide "health beyond basic nutrition" is critical. Finger millet (*Eleusine coracana*), locally known as 'Kurakkan' is a source of prebiotics comprised of β-glucan and resistant starch and is considered a functional food. It is rich in fiber, iron, calcium, manganese and amino acids and its prebiotic ability to develop fermented beverages has been demonstrated. Bananas are a rich source of fructo-oligosaccharide which act as a prebiotic. Prebiotics can modify both the composition and metabolism of intestinal microbiota, e.g., *Lactobacillus* and *Bifidobacterium spp*. The benefits of probiotic bacteria are anti-carcinogenic, improve lactose tolerance, reduce serum cholesterol and stimulate the immune system. However, no effort has been made to explore the prebiotic potential of finger millet and banana in order to develop functional foods. Synergistic expertise available at ICRISAT (International Crop Research Institute for Semi-Arid Tropics), India and the ITI, Sri Lanka was utilized in achieving project objectives.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Twenty-five bioactive strains of probiotic potential lactic acid bacteria were isolated, identified and characterized.
- The bio-efficacy, mucosal adherence ability and oral safety of bioactive strains of probiotic potential lactic acid bacteria were investigated and established.

Publications in Refereed Journals

1. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J., Choudhary, M. I., Gopalakrishnan, S. and Wahab, A.T. (2019). Lactic acid bacteria isolated from fermented flour of finger millet, its probiotic attributes and bioactive properties. *Annals of Microbiology*, **69**, 79-92.
2. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J., Choudhary M.I. and Gopalakrishnan, S. (2019). Isolation and identification of probiotic potential lactic acid bacteria from fermented flour of selected banana varieties grown in Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, **47**(1), 3-16.

Scientific Communications

1. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2014). Isolation and characterization of probiotic "*Lactococcus lactis"* from Sri Lankan finger millet variety (*Elucine coracana*). *Proceedings of the 2nd International Conference on Ayurveda, Unani, Siddha & Traditional Medicine*. p.150.
2. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2015). Isolation and Characterization of probiotics from Sri Lankan finger millet (*Elucine coracana*) *Proceedings of the 12th Asian Congress of Nutrition*, Japan. p.417.
3. De Silva, A.B.G.C.J., Yathursan, S., Jayawardana, S.A.S., Aponso, D.M.K., Samarasekera, J.K.R.R. and Gooneratne, J. (2015). Study on amylose content, rheological properties and particle size distribution of Sri Lankan banana (*Musa* spp) flour, *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.7.
4. De Silva, A.B.G.C.J., Jayawardana, S.A.S., Aponso, D.M.K., Samarasekara, J.K.R.R. and Gooneratne, J. (2015). Rheological properties and particle size distribution of Sri Lankan Finger Millet (*Eleusine coracana*) Flour, *Proceedings of the 8th International Research Conference*, General Sir John Kotelawala Defence University. p.196.
5. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2015). Isolation and characterization of probiotic "*Pediococcus acidilactici"* from Sri Lankan finger millet variety (*Elucine coracana*), *Proceedings of the 44th Annual Sessions*, Institute of Chemistry Ceylon. **32**(2), 24.
6. Jayawardana, S.A.S., De Silva, A.B.G.C.J., Samarasekara, J.K.R.R and Gooneratne J. (2015). Physicochemical and functional properties of Finger Millet (*Eleusine coracana*) flour and its potential use in food product development, *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.14.
7. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Choudhary, M.I., Wahab, A.T., Farooq, S., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2016). *In vitro* antimicrobial activity of probiotic potential Lactic acid bacteria isolated from Sri Lankan banana varieties. *Proceedings of the 4th International Conference on Ayurveda, Unani, Siddha and Traditional Medicine*. p.146.
8. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Maduwanthi, S.D.T., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2016). Survival of lactic acid bacteria isolated from Sri Lankan finger millet variety. *Proceedings of the 36th Annual Sessions*, Institute of Biology, Sri Lanka. p.29.
9. De Silva, A.B.G.C.J., Jayawardana, S.A.S., Samarasekera, J. K.R.R. and Gooneratne, J. (2016). Assessment of physicochemical and functional properties of Sri Lankan finger millet (*Eleusine coracana)* flour, *Proceedings of the 3rd International Conference on Multidisciplinary Approaches*, University of Sri Jayewardenepura. p.26.
10. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Choudhary, M.I., Gooneratne, J. and Gopalakrishnan, S. (2017). Reporting the *in vitro* antimicrobial activity of *Pediococcus acidilactisi* isolated from Sri Lankan finger millet. *Proceedings of the International Conference on Food Quality, Safety and Security*. p.30.
11. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2017). Sri Lankan finger millet (*Eleusine coracana*) varieties as potential probiotic source. *Proceedings of the International Conference of Industrial Biotechnology*, Zimbabw. p.30.

12. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Choudhary, M.I., Gooneratne, J. and Gopalakrishnan, S. (2017). Reporting the *in vitro* antimicrobial activity of *Lactobacillus curieae* strain *SILI9* isolated from Sri Lankan green banana. *Proceedings of the Research Congress,* Post Graduate Institute of Science. p.36.
13. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Choudhary, M.I., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2017). *In vitro* antimicrobial activity of *Lactococcus* subspp. *lactis* KG8 isolated from Sri Lankan finger millet variety. *Proceedings of the 6th International Conference,* Sabaragamuwa University of Sri Lanka. p.43.
14. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2017). Sri Lankan unripe banana as a potential probiotic source. *Proceedings of the 3rd Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.47.
15. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Choudhary, M.I., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2017). Reporting the *in vitro* antimicrobial activity of *Lactobacillus plantarum* B_16LAB isolated from Sri Lankan green banana (Musa spp). *Proceedings of the International Research Conference,* Kotelawala Defence University, p. 19.
16. De Silva, A.B.G.C.J., Jayawardana, S.A.S., Yathursan, S., De Silva, P.H.L.U., Aponso, D.M.K., Samarasekera, J.K.R.R. and Gooneratne, J. (2017). Assessment of physicochemical properties of Sri Lankan banana (*Musa spp*) flour, *Proceedings of the 9th International Research Conference,* General Sir John Kotelawala Defence University. p.213.
17. Jayawardana, S.A.S., Divisekara, D.M.W.D., De Silva, A.B.G.C.J., Yathursan, S. and Samarasekara, J.K.R.R. (2017). Ensuring human health, food and nutritional security through novel cereal and fruit-based prebiotics and probiotics, *Indo Sri Lanka Joint Research Program, Proceedings of the 1st Symposium to Review the Progress.* p.12.
18. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Iqbal Choudhary, M., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2018). Biofunctional characterization of some probiotic lactic acid bacteria isolated from fermented flour of selected finger millet varieties grown on Sri Lanka. *Proceedings of the International Conference on Multidisciplinary Approaches.* p.150.
19. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J., Choudhary, M.I., Gopalakrishnan, S. and Wahab, A.T. (2018). Novel probiotics isolated from finger millet and banana varieties of Sri Lanka. *Proceedings of the Asian Symposium on Medicinal Plants, Spices and other Natural Products.* p.205.
20. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Choudhary, M.I., Gooneratne, J. and Gopalakrishnan, S. (2018). Non-dairy probiotics: a food as alternative therapy for antimicrobial resistance: A study on antimicrobial activities of probiotics from finger millet and banana. *Proceedings of the 4th Annual Research Sessions of the IFSTSLP.* p. 1-5.
21. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J., Choudhary, M.I. and Gopalakrishnan, S. (2018). Ensuring human health, food and nutritional security through novel cereal and fruit-based probiotics: Finger millet (*Elucine coracana*) and Banana (*Musa* species) varieties of Sri Lanka as potential non-dairy prebiotic substrates. *Proceedings of the 4th International Conference on Agriculture, Food Security and Biotechnology,* Kingdom of Morocco. p.26.

22. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Choudhary, M.I., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2019). Isolation, identification and characterization of novel probiotics from finger millet (*Elucine coracana*) and Banana (*Musa* species) varieties of Sri Lanka and assessment of their repeated dose oral toxicity in rats. *Proceedings of the 6th Annual Scientific Sessions*, Sri Lanka Association for Laboratory Animal Sciences. p.32-33.

Book Chapter

1. Divisekera, D.M.W.D., Samarasekera, J.K.R.R., Hettiarachchi, C., Gooneratne, J. and Gopalakrishnan, S. (2019). Sri Lankan finger millet (*Elucine coracana*) variety 'Raavana' as potential probiotic source. In: *Evolving Industrial Biotechnology in Developing Countries*. (Eds.Ogbadu, L, Ogbadu, G and Mahamadi, C.), NAM S&T Centre Publications, New Delhi. pp. 167-183. ISBN9789388982016.

Post Graduate Degree

1. Ms. D.M.W.D. Divisekera obtained a Ph.D. degree in Microbiology & Food Biochemistry from the University Colombo, Sri Lanka in 2018. Thesis Title: Isolation and characterization of probiotic lactic acid bacteria from selected varieties of *Eleucine coracana* and *Musa* species of Sri Lanka.

Awards

1. Semifinalist in the SLAYS: 3 – Minute Thesis Competition, jointly organized by SLAYS and NSF, Sri Lanka, 2018- D.M.W.D. Divisekara.
2. Best Poster Award in the Basic and Applied Science Section for "Assessment of physicochemical properties of Sri Lankan banana (*Musa spp*) flour" *Proceedings of the 9th International Research Conference*, General Sir John Kotelawala Defence University. - A.B.G.C.J. De Silva, S.A.S. Jayawardana, S. Yathursan, P.H.L.U. De Silva, D.M.K. Aponso, J.K.R.R. Samarasekera and J. Gooneratne.
3. GRC Post Graduate Merit Award 2020 presented by Sri Lanka Association for Advancement of Science - D.M.W.D. Divisekara.

NCBI GenBank submissions:

- Sequences of 24 newly isolated probiotic strains are deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Production of glucose syrup and high protein concentrates from locally available raw materials of broken rice, maize & manioc

Grant No: FP 111
Project team: *Dr. (Ms.) H.M.T. Herath
Eng. A.B.G.C.J. De Silva
Mr. K.V.T. Gunawardhana
Ms. M. D.W. Samaranayake
Period covered: 2013 - 2016
Funded by: National Research Council, Sri Lanka

**Principal Investigator*

Background

Glucose syrup is a viscous liquid product utilized in bulk quantities for many food applications including bakery, confectionery and dairy industries. It is mainly imported to the country and the annual expenditure on the importation of glucose syrup in 2011 was about SLR 450 million, according to the Sri Lanka Customs. Glucose syrup is mostly produced in the world using corn flour which also has a higher importation price. Although corn flour is widely used to produce glucose syrup in Western and European countries, some Asian and African countries have used cassava flour and rice flour successfully. Therefore, in Sri Lanka, there is a high potential to start up a novel industry to produce glucose syrup using local raw materials such as cassava and broken rice which could add commercial value to local raw materials.

Project Achievements/Outcomes

Technologies/Processes Developed

- Cassava Syrup
- Rice Syrup
- Protein concentrates from Corn, Cassava and Rice

Publications in Refereed Journals

1. Samaraweera, S.A.P.U., De Silva, A.B.G.C.J., Samaranayake, M.D.W., Gunawardhane, K. V.T. and Herath, H.M.T. (2016). Potential application of locally grown Sri Lankan corn varieties to utilize in the food industry; Corn Starch and Corn Syrup. *International Journal of Innovative Research in Technology & Science*, **4**(6), 17-22.
2. Samaranayake, M.D.W., De Silva, A.B.G.C.J., Fernando, W.R.D., Gunawardhane, K.V.T. and Herath, H.M.T. (2017). Optimization of liquefaction and saccharification times for laboratory-scale production of glucose syrup from Cassava starch and scaling up process of optimized conditions at pilot scale. *Research Journal of Chemical Sciences*, **7**(7), 1-5.

Scientific Communications

1. Samaranayake, M.D.W., De Silva, A.B.G.C.J., Herath, H.M.T., Gunawardhana, K.V.T. and Fernando, W.R.D. (2015). Optimization of liquefaction and saccharification times for laboratory scale production of glucose syrup from Sri Lankan cassava starch, *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.6.
2. De Silva, A.B.G.C.J., Samaranayake, M.W.D., Kariyawasam, K.D.K.D.L., Gunawardhana, K.V.T. and Herath, H.M.T. (2017). Establishment of laboratory-scale processing for glucose syrup manufacturing using broken rice grains. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.45.

Formulation of high fiber & low sugar healthy cereal-based products from selected local raw materials

Grant No: TG 15- 101
Project Team: *Dr. (Ms.) H.M.T. Herath
Ms. M.D.W. Samaranayake
Ms. D.M.K. Aponso
Ms. A.W.D. Priyangani
Project Period: 2015 – 2016
Funded by: Sri Lanka Treasury

Principal Investigator

Background

The demand for high-fiber and low-sugar foods is increasing in Sri Lanka since people are getting more health-conscious. A majority of people are addicted to eating wheat-based foods, made out of highly refined imported wheat flour with high levels of fat and sugar such as cakes, biscuits and pastries. Those products may eventually lead to many adverse health conditions such as obesity, cardiovascular diseases, hypertension, and diabetes. The intention of this study was to utilize whole grain cereals such as red rice, corn, finger millet and whole-grain legumes such as mung bean, chickpea, and soya, for the formulation of high fiber cereal-based products. Fiber-rich food products formulated in this study were the Multi-grain crackers, Multi-grain noodles, Multi-cereal mix and Multi-grain flakes mix.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Multi-grain crackers formulated with whole grain cereal flour of wheat, millet, rice and whole grain legume flour of soya bean, chickpea and mung bean.
- Multi-grain noodles formulated by incorporating legume flour.
- Multi-cereal mix formulated with red rice, millet and sorghum.
- Multi-grain flakes formulated with sorghum, soya bean, horse gram, cowpea and green gram flakes.

Publications in Refereed Journals

1. Gunathilake, K.G.T., Herath, H.M.T. and Wansapala, M.A.J. (2016). Comparison of nutritional and functional properties of mung bean (*Vigna radiata*) and cowpea (*Vigna unguiculata*) protein isolates processed by isoelectric precipitation. *International Journal of Innovative Research in Technology*, **3**(2), 139-148.
2. Kulasooriyage, G., Gunathilake, T., Herath, T. and Wansapala J. (2016). Comparison of physico-chemical properties of selected locally available legumes varieties (Mung bean, cowpea and soybean). *Potravinarstvo Scientific Journal for Food Industry*, **10**(1), 424-430.
3. Eashwarage, I.S., Herath, H.M.T. and Gunatilake, K.G.T. (2017). Dietary fiber, resistant starch and *in-vitro* starch digestibility of selected eleven commonly consumed legumes. *Research Journal of Chemical Sciences*, **7**(2), 1-7.
4. Sivakumaran, K., Wansapala, M.A.J. and Herath H.M.T. (2017). Comparison of contents of phytates and saponins and the effect of processing in some selected edible beans in Sri Lanka. *International Journal of Food Science and Nutrition*, **2**(2), 96-100.
5. Sivakumaran, K., Wansapala, M.A.J. and Herath, H.M.T. (2017). Total phosphorus, phytate phosphorus contents and the correlation with amylose in selected edible beans in Sri Lanka. *International Journal of Science and Research*, **6**(9), 2002-2006.

6. Herath, H.M.T., Shanaki, K.M B., Priyangani, D. and De Silva, M.S.W. (2018). Formulation and physico-chemical properties of dietary fiber enhanced low glycemic multi-grain noodles for adults using locally available cereals and legumes. *Research Journal of Chemical Sciences*, **8**(4), 1-9.
7. Herath, H.M.T., Rupasinghe, K.M.D.T, Priyangani, D. and De Silva, M.S.W. (2018). Formulation and physico-chemical properties of dietary fiber enhanced low glycemic multi-grain crackers for adults using locally available cereals and legumes. *Research Journal of Chemical Sciences*, **8**(8), 1-8.
8. Herath, H.M.T., Gunathilake, K.G.T., Eashwarage, I.S., Sivakumaran. K. and Ranathunga, R.A.A. (2018). Physico-chemical and *in-vitro* glycemic indices of popular pulse varieties grown in Sri Lanka. *International Journal of Food Science and Nutrition*, **3**(5), 137-143.

Scientific Communications

1. Thanushan, S., Herath, H.M.T. and Perera, O.D.A.N. (2015). Formulation of cereal based instant mix from locally available whole grain cereals with "Good Dietary Fiber source" for elderly population. *Proceedings of the Undergraduate Research Symposium*, Faculty of Livestock Fisheries & Nutrition, Wayamba University. p.35.
2. Rupasinghe, K.M.D.T., Herath, H.M.T. and De Silva, M.S.W. (2015). Formulation of dietary fibre-enhanced cracker for adults using selected locally available whole grain cereals and legume flours. *Proceedings of the Undergraduate Research Symposium*, Faculty of Livestock Fisheries and Nutrition, Wayamba University. p.44.
3. Eashwarage, I.S., Perera, O.D.A.N. and Herath, H.M.T. (2016). Development of dietary fibre-rich multi-grain legumes flake mix. *Proceedings of the Undergraduate Research Symposium*, Faculty of Livestock Fisheries and Nutrition, University of Wayamba. p.28.
4. Shanaki, P.K.M.B., Herath, H.M.T. and De Silva, M.S.W. (2016). Formulation of dietary fibre-enhanced multi-grain noodles for adults using selected locally available whole grain cereals and legumes. *Proceedings of the Undergraduate Research Symposium*, Faculty of Livestock Fisheries & Nutrition, University of Wayamba. p.51.

Books/ Chapters (Training Material)

1. Herath, H.M.T., Ranathunga, R.A.A. and Samaranayake, M.D.W. (2016). Important nutrition information of popular grain legume varieties in Sri Lanka. Agriculture Publication Unit, Department of Agriculture and Industrial Technology Institute, Gannoruwa.

Popularization Activities

- Article titled "Multi-grain Products and Properties" was published in Vidya Paper (03.07 2019).

Study on the effect of processing parameters on the functionality of rice bran oil from local rice varieties and the development of an appropriate bran oil extraction technique for SMEs

Grant No: TG 15 - 102
Project Team: *Mr. K.V.T. Gunawardhana
Prof. (Ms.) W.K.S.M. Abeysekera
Ms. P.S.F. Perera
Ms. A.W.D. Priyangani
Project Period: 2015 - 2018
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Rice bran is a byproduct of rice milling that provides immense nutritional and health benefits. However, the use of rice bran and derived products for human consumption is lacking in Sri Lanka. This research project aimed to study the effect of different rice bran stabilization methods on the quality of the stabilized bran and the extracted rice bran oil. Three rice bran-incorporated food products; rice noodles, rice chips and crackers were developed to popularize rice bran consumption among Sri Lankans. When there is a demand for rice bran-incorporated food products, the demand for stabilized rice bran will be generated. Blended oil products were developed using rice bran oil as one component and therefore the nutritional value of rice bran oil could be utilized with the acceptable sensory properties. The other objective was to establish a method to manufacture rice bran oil using stabilized rice bran which applies to small and medium-scale industries in the country.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Rice bran-incorporated rice noodle was developed. This product exhibits functional health benefits including high antioxidant activity and dietary fiber. Further research work is in progress to incorporate stabilized rice bran to wheat flour noodles as recommended by industries.
- Methodology developed to preserve the rice bran with a shelf life of more than one year.
- A method was developed to extract rice bran oil from the locally available bran using the screw press method.

Scientific Communications

1. Gunawardhana, K.V.T., Rathnayaka, N.M., Hewajulige, I. and Ediriweera, S. (2015). Effect of incorporation of rice bran on cooking, textural and sensory characteristics and nutritional composition of rice noodle. *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.9.
2. Dalukdeniya, D.A.C.K., Gunawardhane, K.V.T., Abeysekera, W.K.S.M., Premakumara, G.A.S. and Sabaragamuwa, R.S. (2015). Enhanced physicochemical and bioactive properties of two newly formulated red rice noodles in comparison to selected commercially available rice and wheat noodles. *Proceeding of the Annual Symposium of the Sabaragamuwa University of Sri Lanka.* p.2.

Studies on microflora in different types of tea produced in three different elevations in Sri Lanka

Grant No: TG 15 - 114
Project Team: *Dr. (Ms.) S.H.S. Karunaratne
Dr. (Ms.) G.A.S.I. Abeygunawardena
Dr. D.L. Jayaratne
Prof. G.A.S. Premakumara
Period covered: 2015 - 2021
Funded by: Sri Lanka Treasury

Principal Investigator

Background

Sri Lanka is the largest producer and exporter of orthodox tea in the world. 'Ceylon tea' is mainly grown in three different elevations as high, medium and low grown. Poor handling and manufacturing techniques result in low-grade tea and Good Manufacturing Practices (GMP) have been implemented in tea factories to improve the standards of the manufacturing process. The tea industry faces new challenges of quality and safety concerns such as pesticide residues, adulteration and chemical and microbial contamination. Microbial contamination of tea can result in lowering the quality and making it hazardous to human health. Therefore, it is vital to identify and quantify the resident bacteria, yeasts and fungi on tea leaves in the whole value chain. The overall objectives were to evaluate the microbiological and physico-chemical quality characteristics of tea leaves along with the diverse relationships among the microbial species associated with tea leaves in different elevations and the effect of environmental factors and other aspects related to the manufacturing of tea.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Data generated through the project is used to improve tea-based guidelines concerning microbiological quality.

Scientific Communications

1. Karunaratne, S.H.S., Abeygunawardena, G.A.S.I., Jayaratne, D.L. and Premakumara, G.A.S. (2019). Microbiological assessment of air & water quality in Sri Lankan tea factories. *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.40.
2. Karunaratne, S.H.S., Abeygunawardena, G.A.S.I., Jayaratne, D.L. and Premakumara, G.A.S. (2020). Effects of different homogenization time durations for enumeration of microorganisms from black tea: A case study in low country tea in Sri Lanka. *Proceedings of the 40th Annual Sessions*, Institute of Biology, Sri Lanka. p.76.
3. Karunaratne, S.H.S., Dissanayake, D.A.T.W.K., Abeygunawardena G.A.S.I., Jayaratne D.L. and Premakumara G.A.S. (2021). Detection and quantification of mycotoxins in black tea by Liquid Chromatography-Tandem Mass Spectrometry. *Proceedings of the 5th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.44.

Post Graduate Degree

1. Ms. S.H.S. Karunaratne obtained a PhD degree from the University of Kelaniya in 2022. Thesis Title: Studies on microflora in different types of tea produced in three different elevations in Sri Lanka.

Study of Poly Aromatic Hydrocarbons (PAH) in selected firewood smoke & development of a cottage-level food smoker

Grant No : TG 15- 115
Project Team : *Mr. S.S.K. Madage
Mr. M.M.N.P. Gunasekera
Eng. A. Sooriyaarachchi
Eng. N.A.T.E.D. Gunasekera
Ms. S. Rajapakse
Mr. W.U.D. Medis
Project Period: 2015- 2017
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

In Sri Lanka, smoking has been used for preserving fish, meat, Jack-fruit, and Goraka-like commodities. Even today, smoking is carried out using very primitive methods without adapting to any technological advancements. However, it is known that smoke generated from combusting wood contains Poly Aromatic Hydrocarbons (PAHs), which are highly carcinogenic and mutagenic for mammals, especially for humans. However, adequate studies have not been carried out to find out the levels of PAHs in smoked foods and also in the wood used to process smoked food. Therefore, this project was initiated with the objective of finding the best firewood to generate smoke for processing smoked fish by screening commonly used wood species in terms of the PAHs produced in wood smoke. The project also intended to upgrade the smoking kiln developed by ITI, evaluate the quality of smoked fish processed with selected wood smoke and transfer the developed process technology to SMEs.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The study of the accumulation of PAHs and physico-chemical quality changes of smoked fish during storage under refrigerated and frozen conditions revealed that PAHs content on the surface of the smoked fish declined while it increased in the center part of the fish chunk during both refrigerated and frozen storage.
- Identification of safe sources of locally available wood for processing smoked fish and meat.
- Availability of a safe smoking kiln for processing of smoked fish and meat.

Technologies Developed

- Developed cottage-level hygienic food smoker.
- Upgraded fish smoking process.
- Identified low-risk freely available firewood types for food smoking.
- Established testing methodologies to analyze PAHs in wood smoke and food at the Food Technology Section, ITI.

Scientific Communications

1. Anoja, P., Wijesekara, R.G.S., Madage, S.S.K. and Gunasekara, M.M.N.P. (2016). Analysis of Polycyclic Aromatic Hydrocarbons (PAHs) to determine the best firewood for smoking fish. *Proceedings of the Undergraduate Research Symposium*, Wayamba University of Sri Lanka. p.59.

2. Wijesuriya, H.G.E., Madage, S.S.K., Gunasekara, M.M.N.P. and Wickramasinghe, I. (2017). Determination of Poly Aromatic Hydrocarbons (PAHs) in fish smoked with different wood smoke. *Proceedings of the 6th International Conference,* Sabaragamuwa University of Sri Lanka. p.54-55.
3. Anoja, P., Madage, S.S.K., Gunasekara, M.M.N.P. and Wijesekara, R.G.S. (2017). Analysis of Poly Aromatic Hydrocarbons (PAHs) to determine the best firewood for fish smoking. *Proceedings of the 6th International Conference,* Sabaragamuwa University of Sri Lanka. p. 56.
4. Lukshani, N., Madage, S.S.K., Wijesekara, R.G.S., Gunasekara, M.M.N.P. and Medis, W.U.D. (2017). Analysis of Poly Aromatic Hydrocarbons of firewood smoke used by indigenous communities. *Proceedings of the Undergraduate Research Symposium*, Faculty of Livestock Fisheries and Nutrition, Wayamba University of Sri Lanka. p.60.

Awards

1. Best Oral Presentation Award 2016 -for the presentation on "Analysis of Polycyclic aromatic hydrocarbons to determine the best firewood for smoking fish" at the Research Symposium, Faculty of Livestock, Fisheries and Nutrition, University of Wayamba – S.S.K. Madage and M.M.N.P. Gunasekara.

Cottage level hygienic food smoker

Testing of Heat Pump Dryer (HPD) for perishables & cereal dehydration

Grant No: TG 15 - 116
Project Team: *Dr. P.N.R.J. Amunugoda
Eng. A. Sooriyaarachchi
Eng. A.B.G.C.J. De Silva
Mr. D. Jayasinghe
Project Period: 2015 - 2017
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The use of different types of dryers for commercial food dehydration has increased in Sri Lanka during the recent past. However, many people are not aware of the best-suited hot air-drying systems for dehydration. Heat Pump Dryers (HPD) are a type of dryer used internationally in the food industry for drying food and have become a booming technology in Sri Lanka. The heat pump dryers mainly consist of a drying chamber connected to a refrigeration system to provide the required conditioned air. This refrigeration system provides heated and dehumidified air using a condenser and evaporator which are the two primary components of the refrigeration system. In heat pump drying, the full or a partial volume of air in the drying chamber is circulated inside the dryer providing a better heat recovery than other dryers. This results in energy efficiency during the drying operation. A survey carried out using 10 closed-type heat pump dryers, kerosene oil, and electric dryers used for food drying in Sri Lanka showed that heat pump dryers are more efficient in terms of energy usage, than the other dryers. Since ITI has been involved in introducing an efficient drying system for the local food industry, the heat pump dryer can be introduced to reduce the drying cost and improve product quality in an environmentally friendly manner. Hence, the project was conducted to test the closed-loop heat pump dryer for perishables and cereal dehydration.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Developed capabilities to design closed-loop heat pump dryers.
- Optimized and established the operation of the closed-loop heat pump dehydration process.
- Coupling of air filtration and ozonation sterilization system to the closed-loop heat pump dryer.
- Operation of heat pump drying with inert gas to control the browning of dehydrated products.
- Designed a method to attach aseptic packaging and AC storage to the closed-loop heat pump dryer.

Technologies Transferred/Commercialized

- Technology of operating heat pump dryer and related quality improvements were delivered to more than 20 individual clients who obtained technology transfers from ITI on food dehydration.
- Awareness on the technology of heat pump drying was delivered during group training on food dehydration to more than 100 participants.

- Dehydrated pineapple was prepared using the Close Loop Heat Pump Dryer (CLHPD) for a sample shipment to a client.
- Advice was given to David Peiris Ltd. on working conditions and further quality upgrading with a sterilization facility to establish a heat pump dryer with a Chinese Machinery Company.
- Advised on closed-loop heat pump drying system for agriculture modernization project of the Ministry of Primary Industry. Along with the ITI recommendation, the Agriculture Modernization project recognized the closed-loop heat pump dryer as the only dryer that can be recommended to the National Food Drying Value Chain Promotion based on the novel techniques and beneficiaries of project outcomes.

Scientific Communications

1. Amunugoda, P.N.R.J., Jayasinghe, G.D.D.R., De Silva, G., Sooriyaarachchi, A. and Samanthilaka, S.H. (2017). Performance of heat pump dryer for perishable dehydration *Proceedings of the 2nd Asia Pacific Conference on Multidisciplinary Research,* (APMR2017). p.38.
2. Amunugoda, P.N.R.J., De Silva, A.B.G.C.J. and Sooriyaarachchi, A. (2017). Fluidized bed coupled vacuum heat pump dryer for high value dehydrated food production - A conceptual paper. *Proceedings of the 3rd Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.64.
3. Amunugoda, P.N.R.J., Jayasinghe, G.D.D.R. and Dunuwila, G,R. (2017). Review of heat pump dryers for food drying. *Proceedings of the 73rd Annual* Sessions, Sri Lanka Association for the Advancement of Science.p.138.

Post Graduate Degree

1. Ms. D.N.A. Dharmasena obtained a MSc degree from the Post Graduate Institute of Agriculture (PGIA), University of Peradeniya. Thesis Title: Studies of Ozone circulation to heat pump dryer for the microbial sterilization of dehydrated products.

Studies on dairy microbiome and potential industrial applications – biodiversity and technological potential of micro-flora from selected Sri Lankan dairies

Grant No: FP 120
Project team: *Prof. (Ms.) I.G.N. Hewajulige
Dr. (Ms.). D.U. Rajawardana
Dr. (Ms.) W.W.P. Rodrigo
Prof. (Ms.) C.M. Nanayakkara
Period covered: 2016 - 2019
Funded by: National Science Foundation, Sri Lanka

Isolation, identification & characterization of potential probiotic lactic acid bacteria of dairy origin in Sri Lanka for future application as probiotic starters

Grant No: TG 15 - 117
Project Team : *Dr. (Ms). D.U. Rajawardana
Prof. (Ms.) I.G.N. Hewajulige
Ms. T.M.D.A. Jayawardhana
Project Period: 2015 - 2017
Funded by: Sri Lanka Treasury

Screening and assessment of lactic acid bacteria from Sri Lankan dairies (under TG 15/117) as the source of functional ingredients for the industry

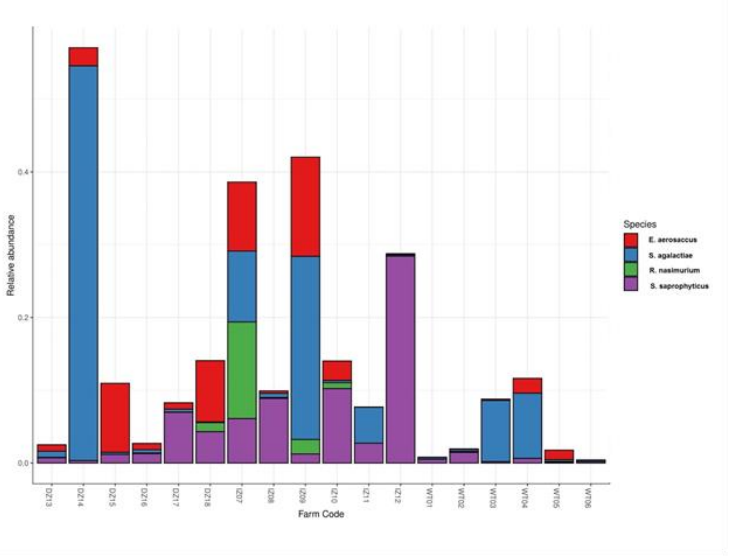
Grant No : TG 18 - 149
Project Team : *Prof. (Ms.) I.G.N. Hewajulige
Dr. (Ms.) D.U. Rajawardana
Mr. M.M.N.P. Gunasekara
Ms. D.A.V. Nilukshi
Prof. (Ms.) W.K.S.M. Abeysekara
Project Period: 2017 – 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The microbial diversity of dairy environments presents an enormous, largely unexploited genetic and biological pool that could be utilized for the recovery of new strains. Preserving and controlling the microbiological quality of raw milk is a worldwide concern, however, only a few studies have examined the bacterial biodiversity of raw milk and many questions exist as to their role in health and disease. In this backdrop, the present study aimed to investigate the microbial diversity of raw milk produced in Sri Lankan dairies by 16S amplicon sequencing of milk microbial DNA using the Illumina MiSeq sequencing platform and to correlate the findings with climatic conditions and milking practices. For the study, raw milk samples from 18 dairy farms (n=90) were collected from the three different climatic zones of the country (wet, dry and intermediate). The milk microbiome was characterized based on V3 and V4 hypervariable regions of the 16S rRNA gene by paired-end sequencing on the Illumina MiSeq device at the genome centre of Massey University, New Zealand. QIIME2, Phyloseq and

Microbiome software were used for sequence filtration and data analysis. Metataxonomic characterization revealed a total of 10,918 OTUs belonging to 23 bacterial phyla, 110 orders, 381 genera and 348 known species. The most abundant genera detected were Macrococcus, Streptococcus, Elizabethkingia, Staphylococcus and Enhydrobacter. The microorganisms such as Atopococcus, Helcobacillus, Millisia and Succinispira genera have not been reported previously in raw milk. The prevailing pathogens were Streptococcus, Rothia, Enhydrobacter and Staphylococcus genera (*S. agalactiae, R. nasimurium, E. aerosaccus* & *S. saprophyticus*) and their prevalence was high in the intermediate and dry zone milk. Wet zone milk had the highest species richness with the lowest abundance of detected pathogens.



Relative abundance distribution of pathogenic bacterial species identified from the milk samples collected from different farms of Sri Lanka. The codes, DZ, IZ and WT represent dry, intermediate and wet zone farms, respectively

Moreover, milk-born Lactic Acid Bacteria (LAB) and Yeasts are of enormous practical significance in human health as well as in food, feed, pharmaceutical and biochemical industries. Sri Lankan industries solely depend on imported starter cultures. Therefore, research on indigenous lactic acid bacterial (LAB) and yeast isolates with functional and technological properties is of immense importance to initiate starter culture production for industry applications and to improve the quality of fermented dairy products. Since no well-defined study has been conducted to isolate, identify and characterize the beneficial microflora of Sri Lankan dairies with special emphasis on applications in functional starters and industrial fermentation, the other part of the study was aimed at fulfilling this gap by evaluating the indigenous LAB and yeast species with probiotic properties for future functional food applications. The isolated LAB strains (TG 15/117) were evaluated for their milk technological properties such as milk fermentation and lactose utilization potential, proteolytic, lipolytic and amylolytic activities, and survival of the strains in milk during processing and cold storage. From over 1825 different isolates obtained, 12 LABs and 20 yeasts possessed strong probiotic properties and were safe for live consumption. The pool of isolates comprised of potent candidates with antimicrobial, cholesterol-lowering, exopolysaccharide-producing, amylolytic

and milk technological properties, and therefore, could be utilized for functional food formulations.

Kluyveromyces marxianus strains were able to produce Single Cell Proteins (SCP) equally better compared to reference strains industrially employed for the production of protein extracts. The beneficial microorganisms with functional and industrial potentials isolated and identified from this study have laid the foundation for the establishment of Sri Lanka's first depository of authentic dairy microbial cultures for research and industrial applications within the Food Technology Section of the Industrial Technology Institute.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Beneficial microorganisms (bacteria and yeast) with functional and industrial potential were isolated and identified and laid the foundation for the establishment of Sri Lanka's first depository of authentic dairy microbial cultures for research and industrial application, at the Food Technology Section of the Industrial Technology Institute.
- The 20 LAB and 14 yeast isolates with strong probiotic properties were obtained from over 1825 different isolates and found to be safe for consumption.
- Identification of native LAB strains with potential industrial applications.
- Assessment of the identified isolates for their milk technological properties.
- Assessment of the identified isolates as the source of functional ingredients for the industry.
- Strengthening the local dairy bioprocessing industry.
- The establishment of laboratory facilities for dairy culture collection, propagation and maintenance at the Food Technology Section of ITI (in progress).
- Technology development for the production of virgin coconut oil with *Lactobacillus* and yeast species isolated from Sri Lankan dairies (in progress).

Publications in Refereed Journals

1. Sandarenu, M.W.A.K., Rajawardana, D.U. and Fernando K.M.E.P. (2017). Probiotic potential and antibiotic resistance of lactic acid bacteria isolated from curd in Sri Lanka. *International Journal of Multidisciplinary Studies*, **4**(2), 9-21.
2. Rajawardana, D.U., Hewajulige, I.G.N., Nanayakkara, C.M., Athurupana, S.K.M.R.A. and Madhujith, T. (2018). Preliminary evaluation of probiotic potential of yeasts isolated from bovine milk and curd of Sri Lanka. *Tropical Agricultural Research*, **30**(3), 27– 41.
3. Rajawardana, D.U., Fernando, P.C., Biggs, P.J., Hewajulige, I.G.N., Nanayakkara, C.M., Wickramasinghe, S., Lin, X.X. and Berry, L. (2022). An insight into tropical milk microbiome: Bacterial community composition of cattle milk produced in Sri Lanka, *International Dairy Journal*, **126**, 105266 https://doi.org/10.1016/j.idairyj.2021.105266.
4. Wijayawardene, N.N., Rajakaruna, S., Dai, Dong-Qin., Jayasekara, S., Warnakula, L., Ariyawansa, K.G.S.U., Fernando, E.Y., Jayasekera, P., Karunarathna, S.C., Singhalage, D., Ukuwela, K., Jayalal, R.G.U., Jayasinghe, R.P.P.K., Muthumala, C.K., Madawala, S., Hewajulige, I.G.N., Rajawardana, D.U., Ediriweera, A., Ediriweera, S., Alawathugoda, D., Rajawatta, K.M.W., Jin, Xing-Chen, Chandana, E.P.S., Nanayakkara, C. and Wijesundara, S. (2022). Necessity of a national fungarium and a culture collection for fungi in Sri Lanka. *Chiang Mai Journal of Science*, **49**(2), 248-271.
5. Chandimala, U.R., Rajawardana, D.U., Liyanage, P.L.N. and Hewajulige, I.G.N. (2023). Isolation and characterization of yeasts from locally available foods. *Journal of Agro-Technology and Rural Sciences*, **1**(2), 17-22.

Scientific Communications

1. Rajawardana, D.U., Athurupana, S.K.M.R.A., Hewajulige, I.G.N. and Nanayakkara, C.M. (2016). Isolation and screening of potential probiotic yeast strains in Sri Lankan dairies. *Proceedings of the 16th International Research Conference of the Science Council of Asia*, (SCA-2016). p.215.
2. Rajawardana, D.U., Athurupana, S.K.M.R.A., Hewajulige, I.G.N. and Nanayakkara, C.M. (2016). Characterization and identification of yeasts from raw cows' milk and fermented dairy foods. *Proceedings of the 9th International Research Conference*, General Sir John Kotelawala Defense University. p.190.
3. Rajawardana, D.U., Hewajulige, I.G.N., Nanayakkara, C.M. and Jayawardana, D. (2016). Enumeration and characterization of lactic micro-flora from bovine milk in selected Sri Lankan dairies. *Proceedings of the 36th Annual Sessions*, Institute of Biology, Sri Lanka, p. 30.
4. Rajawardana, D.U., Hewajulige, I.G.N. and Nanayakkara, C.M. (2017). Identification of potentially probiotic *Lactobacillus* spp. from dairy sources of Sri Lanka as candidates for future food applications. *Proceedings of International Conference on Food Quality, Safety and Security* – FOOD QUALSS 2017. p.29.
5. Rajawardana, D.U., Hewajulige, I.G.N., Nanayakkara, C.M. and W.A.D.S. Shanaka. (2017). Assessment of safety attributes of potentially probiotic lactic acid bacteria (LAB) of Sri Lankan dairy origin for future food applications. *Proceedings of the 4th International Conference on Multidisciplinary Approaches* (*i*CMA), Sri Lanka. p. 64.
6. Rajawardana, D.U., Hewajulige, I.G.N. and Nanayakkara, C.M. (2017). Screening and *in vitro* selection of *Lactobacillus* strains isolated from Sri Lankan dairies with potential bile salt (BSH) hydrolyzing activity. *Proceedings of the 2nd Asia-Pacific Conference on Multidisciplinary Research* (APMR2017), Sri Lanka. p.42.
7. Rajawardana, D.U., Hewajulige, I.G.N. and Nanayakkara, C.M. (2017). Probiotic potential of exopolysaccharide producing *Lactobacillus plantarum sp.* isolated from Sri Lankan dairies. *Proceedings of the 10th International Research Conference*, General Sir John Kotelawala Defence University. p.37.
8. Rajawardana, D.U., Nanayakkara, C.M. and Hewajulige, I.G.N. (2017). Sri Lankan dairy yeasts: isolation, identification and production of single cell protein from whey. *Proceedings of Annual Research Symposium*, University of Colombo. p.263.
9. Rajawardana, D.U., Hewajulige, I.G.N., Nanayakkara, C.M. and Thiwanka, M.S. (2017). Preliminary assessment of yeast diversity originating from raw bovine milk and curd of Sri Lanka. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.43-44.
10. Sandarenu, M.W.A.K., Rajawardana, D.U. and Fernando, K.M.E.P. (2017). Characterization and screening for probiotic potential of lactic acid bacteria isolated from curd. *Proceedings of the 4th International Conference on Multidisciplinary Approaches (iCMA)*, Sri Lanka. p.153.
11. Chandimala, U.R., Rajawardana, D.U. and Lakshman, P.L.N. (2017). Isolation and characterization of yeasts from locally fermented foods. *Proceedings of the 4th International Conference on Agriculture and Forestry* (ICOAF-2017), Sri Lanka. p.66.
12. Rajawardana, D.U., Hewajulige, I.G.N., Nanayakkara, C.M. and Nilukshi, D.A.V. (2017). Safety assessment and antibiotic susceptibility of potentially probiotic yeasts isolated from dairy sources of Sri Lanka. *Proceedings of the Extended Abstracts of FoodTechno 2017* (Innovation to Application), 03rd Annual Research Sessions of IFSTSL, BMICH, Colombo, Sri Lanka. p.1-5.

13. Chandimala, U.R., Rajawardana, D.U. and Lakshman, P.L.N. (2017). Isolation and characterization of yeasts from locally fermented foods. *Proceedings of the International Symposium on Agriculture and Environment* (ISAE-2017), University of Ruhuna. p.6.
14. Ranatunga, S.A.C.L., Rajawardana, D.U. and Ruwandeepika, H.A.D. (2018). Isolation and identification of probiotic yeast from goat milk. *Proceedings of the 38th Annual Sessions*, Institute of Biology, Sri Lanka.p.41.
15. Rajawardana, D.U., Hewajulige, I.G.N. and Nanayakkara, C.M. (2019). Beneficial microorganisms from Sri Lankan dairies as candidates in nutrition, healthcare and biochemical industries. *Proceedings of the 5th COMSATS-ISESCO-INIT International Conference on 'Agriculture, Biotechnology and Food Security: Role of ICTs'*. The Young Affiliates Network (TYAN), Monastir, Tunisia. p.29-31.
16. Rajawardana, D.U., Hewajulige, I.G.N., Nanayakkara, C.M. and Gayani, M.G. (2019). Antimicrobial activity of two probiotic *Enterococcus faecalis* strains isolated from Sri Lankan dairies: a possible alternative source of antimicrobial agents against invading microorganisms. *Proceedings of the 05th Annual Research Sessions of IFSTSL*, Food Techno 2019 (Innovation to Application). p.7-12.
17. Rajawardana, D.U., Hewajulige, I.G.N., Biggs, P.J., Wickramasinghe, S., Nanayakkara, C.M, Gunasekara, M.M.N.P.N. and Perera, S. (2019). Preliminary analysis of milk microbiome data of Sri Lankan dairies using rRNA gene sequencing in Illumina MiSeq platform. *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.14.
18. Artigala, A.D.T.S., Fernando, S.P.C., Rajawardana, D.U., Jayathilake, C.M., Hewajulige, I.G.N. and Nanayakkara, C.M. (2022). Studying the microbial community interactions of Sri Lankan cattle milk microbiota under different climatic conditions. *Proceedings of the 42nd Annual Sessions*, Institute of Biology, Sri Lanka. p.21.
19. Rajawardana, D.U., Hewajulige, I.G.N. and Nanayakkara, C.M. (2022).Technological characterization of probiotic lactic acid bacteria and yeasts from raw bovine milk and curd made with indigenous starters of Sri Lanka. *Proceedings of the 10th International Conference on Fermented Foods, Health Status and Social Well-being.* University of Peradeniya, Sri Lanka & SASNET-Lund University, Sweden. p.94-97.

Post Graduate Degree

1. Ms. Upeka Rajawardane obtained a PhD degree from the University of Colombo in 2020. Thesis Title: Isolation, identification and characterization of health beneficial bacteria and pathogenic micro-flora of dairy origin in Sri Lanka.

Awards

1. 3MT Finalist and Gold Medallist, SLAYS Open Forum 2017 "Research for Impact: March of the Sri Lankan Young Scientists" and 3MT Competition (3 minutes thesis competition for MPhil/PhD students) organized jointly by Sri Lankan Academy of Young Scientists (SLAYS) and National Science Foundation of Sri Lanka (NSF) in collaboration with Coordinating Secretariat for Science, Technology and Innovation (COSTI) and the University of Queensland, 28th February - 1st March 2017, Hilton Colombo Residences, Colombo, Sri Lanka - D.U. Rajawardana.
2. Invitee to participate in the "Program to Develop Human Resources for Enhancing Collaborative Science and Technology Research with Japan" - 04-11 November 2017 – by the Japan International Science and Technology Exchange Centre, Government of Japan - D.U. Rajawardana.

3. Best Research Paper Award for the research paper titled "Safety assessment and antibiotic susceptibility of potentially probiotic yeasts isolated from dairy sources of Sri Lanka" in the 03rd Annual Research Sessions of IFSTSL 2017, BMICH, Colombo, Sri Lanka - D.U. Rajawardana, I.G.N. Hewajulige and C.M. Nanayakkara.
4. Best Research Paper of the Session Award for the research paper titled "Identification of potentially probiotic *Lactobacillus* spp. from dairy sources of Sri Lanka as candidates for future food applications" in the International Conference on Food Quality, Safety and Security – FOOD QUALSS 2017, Colombo, Sri Lanka - D.U. Rajawardana, I.G.N. Hewajulige and C.M. Nanayakkara.
5. Best Student Research Award for the research paper titled "Identification of potentially probiotic *Lactobacillus* spp. from dairy sources of Sri Lanka as candidates for future food applications" in the International Conference on Food Quality, Safety and Security – FOOD QUALSS 2017, Colombo, Sri Lanka - D.U. Rajawardana.
6. Best Presenter of the Session Award for the research paper titled "Preliminary evaluation of probiotic potential of yeasts isolated from bovine milk and curd of Sri Lanka" presented at PGIA Congress, 15th to 16th November 2018 - D.U. Rajawardana.
7. Invitee to participate for the 5th COMSATS-ISESCO-INIT International Conference on 'Agriculture, Biotechnology and Food Security: Role of ICTs' Hosted by The Young Affiliates Network (TYAN), November 4-6, 2019, Monastir, Tunisia to give a lecture on "Beneficial Microorganisms from Sri Lankan Dairies as Candidates in Nutrition, Healthcare and Biochemical Industries" - D.U. Rajawardana.

Popularization Activities

- Paper article published in "Vidusara" about the new inventions from Sri Lankan scientists for the development of the local dairy bio-processing industry (21.02.2018).
- Television Program in Sri Lanka Rupavahini on postgraduate research "Biodiversity and Technological Potential of Micro-flora from Selected Sri Lankan Dairies", The Tuesday Knowledge, 4.30-5.00 pm, (1st& 9th July 2019).

NCBI GenBank submissions

- Sixteen newly isolated dairy yeast strains from Sri Lanka are deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.
- Twenty lactic acid bacteria were identified and sequences were deposited in GenBank of the National Centre for Biotechnology Information (NCBI), GenBank, USA.
- Forty-six beneficial lactic acid bacteria strains are deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Evaluation of bioactive properties of Sri Lankan finger millet and determination of *in vitro* cholesterol assimilation effect of potential probiotics isolated from finger millet

Grant No: TG 16 - 122
Project team: *Prof. (Ms.) J.K.R.R. Samarasekera
Dr. (Ms.) D.M.W.D. Divisekera
Dr. (Ms.) S.A.S. Jayawardana
Period covered: 2016 - 2018
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Finger millet (*Eleusine coracana* (L.) Gaertn.) has been commonly cultivated and consumed in Sri Lanka since ancient times. Few studies have been reported on the bioactive properties of the finger millet varieties that are commonly cultivated in Sri Lanka, namely Ravi, Rawana and Oshadha. Evaluation of the bioactive properties of finger millet-based food products is an advantage in marketing and technology transfer of those products targeting health-conscious consumers. Hence, investigating the efficacy and safety of the probiotic strains of Lactic Acid bacteria isolated from fermented flours of locally grown finger millet varieties is essential prior to *in vivo* human studies and the commercialization of the products. This project was focused on evaluating selected bioactive properties (antioxidant, antidiabetic, anti-inflammatory, anticancer and antibacterial activities) of Sri Lankan finger millet varieties, evaluating antioxidant properties of newly formulated finger millet-based food products as well as evaluating genotoxicities, anti-mutagenic activities, antioxidant activities and cholesterol assimilation abilities of probiotic strains of Lactic Acid bacteria isolated from fermented flours of Sri Lankan finger millet varieties.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- This project provided scientific evidence for the antioxidant, antidiabetic, anti-inflammatory, anticancer and antimicrobial potential of Ravi, Rawana and Oshadha finger millet varieties and supported the potential of utilizing the above varieties as promising ingredients in developing functional foods.
- To the best of our knowledge, this is the first report on antiglycation and glycation reversing activities, oxidative burst inhibitory activities, arachidonate 5-lipoxygenase, xanthine oxidase, hyaluronidase, β-glucuronidase and β-lactamase enzyme inhibitory activities, antibacterial activities and antifungal activities of any extract of any finger millet variety cultivated in Sri Lanka.
- The outputs of the project expanded the current knowledge on the bioactive properties of finger millet varieties commonly cultivated and consumed in Sri Lanka, filled the gaps in food composition databases and acted as a useful guide in selecting foods for daily consumption.
- It confirmed that the incorporation of finger millet flour in yoghurt and biscuit formulations enhanced the antioxidant properties of the yoghurts and biscuits and can be categorized as good sources of antioxidants.

- This is the first report on the characterization of probiotic strains associated with locally grown finger millet varieties and reports their efficacy and genotoxicity for potential commercial applications.
- The project provided scientific evidence on the bioactive properties (antioxidant and cholesterol assimilation ability) of probiotic strains isolated from Ravi, Rawana and Oshadha finger millet varieties.
- It provided strong evidence of the probiotic potential of finger millet as a substrate for the development of fermented functional foods.

Technologies Developed

- Finger millet flour incorporated biscuit.
- Finger millet flour incorporated lacto-vegetarian set yoghurt.
- Fermented finger millet-based probiotic beverage.

Publications in Refereed Journals

1. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Hettiarachchi, G.H.C.M., Gooneratne, M.J., Choudhary, M.I., Imad, R. and Naz, A. (2020). Glutathione S-transferase and β-glucuronidase enzyme inhibitory and cytotoxic activities of ethanolic and methanolic extracts of Sri Lankan finger millet (*Eleusine coracana* (L.) Gaertn.) varieties. *South Asian Research Journal of Natural Products*, **3**(2), 1-9.
2. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Hettiarachchi, G.H.C.M., Gooneratne, J., Maharjan, R. and Choudhary, M.I. (2020). Antimicrobial properties of ethanolic and methanolic extracts of finger millet (*Eleusine coracana* (L.) Gaertn.) varieties cultivated in Sri Lanka. *International Journal of Multidisciplinary Studies*, **7**(1), 78-94.
3. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Hettiarachchi, G.H.C.M., Gooneratne, M.J., Choudhary, M.I. and Jabeen, A. (2021). Anti-inflammatory and antioxidant properties of finger millet (*Eleusine coracana* (L.) Gaertn.) varieties cultivated in Sri Lanka. *BioMed Research International*, Article ID 7744961.
4. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Hettiarachchi, G.H.C.M. and Gooneratne, M. J. (2022). Antidiabetic properties of finger millet (*Eleusine coracana* (L.) Gaertn.) varieties cultivated in Sri Lanka. *Journal of Herbal Medicine*, **32** (155): 100534.

Scientific Communications

1. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Hettiarachchi, G.H.C.M. and Gooneratne, J. (2016). *In vitro* antioxidant properties of Sri Lankan finger millet (*Eleusine coracana*) varieties, *Proceedings of the 3rd International Conference on Multidisciplinary Approaches*, University of Sri Jayewardenepura. p.34.
2. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Hettiarachchi, G.H.C.M., Choudhary, M.I., Jabeen, A. and Gooneratne, J. (2016). Anti-inflammatory effect of finger millet (*Eleusine coracana*) varieties of Sri Lanka on zymosan-induced oxidative burst in phagocytes, *Proceedings of the 9th International Research Conference*, General Sir John Kotelawala Defence University. p.214.

3. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Hettiarachchi, G.H.C.M. and Gooneratne, J. (2017). *In vitro* anti-inflammatory properties of finger millet (*Eleusine coracana*) varieties from Sri Lanka, *Proceedings of the International Symposium on Traditional and Complementary Medicine*, Ministry of Health, Nutrition and Indigenous Medicine and Department of Ayurveda. p.105.
4. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Hettiarachchi, G.H.C.M. and Gooneratne, J. (2017). Nutritional and sensory properties of finger millet (*Eleusine coracana*) flour incorporated biscuits, *Proceedings of the 4th International Conference on Multidisciplinary Approaches*, University of Sri Jayewardenepura. p.56.
5. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Choudhary, M.I., Imad, R., Hettiarachchi, G.H.C.M. and Gooneratne, J. (2017). Cytotoxic properties of Sri Lankan varieties of finger millet (*Eleusine coracana*), *Proceedings of the PGIS Research Congress*, Postgraduate Institute of Science, University of Peradeniya. p.85.
6. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Choudhary, M.I., Maharjan, R., Hettiarachchi, G.H.C.M. and Gooneratne, J. (2017). Antimicrobial properties of finger millet (*Eleusine coracana*) varieties of Sri Lanka, *Proceedings of the Basic and Applied Sciences Session of 10th International Research Conference*, General Sir John Kotelawala Defence University. p. 34.
7. Jayawardana, S.A.S., Samarasekera, J.K.R.R., Hettiarachchi, G.H.C.M. and Gooneratne, J. (2018). Anti-α-amylase, anti-α-glucosidase, antiglycation and glycation reversing potential of Sri Lankan finger millet (*Eleusine coracana*) varieties, *Proceedings of the 5th International Conference on Multidisciplinary Approaches*, University of Sri Jayewardenepura. p.174.

Post Graduate Degree

1. Ms. S.A.S. Jayawardana obtained a PhD degree from the University of Colombo, 2020. Title Thesis: Prebiotic and bioactive properties of Sri Lankan finger millet (*Eleusine coracana* (L.) Gaertn.) varieties.

Award

1. Award for the best oral presentation on 'In vitro antioxidant properties of Sri Lankan finger millet (*Eleusine coracana*) varieties' in the Health and Nutrition discipline of 3rd International Conference on Multidisciplinary Approaches, organized by the University of Sri Jayewardenepura in 2016 - S.A.S. Jayawardana.

NCBI GenBank submissions

- Sequences of five isolated probiotic lactic acid bacterial strains from locally grown finger millet varieties are deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Development of shelf-stable high-energy instant food products from locally available raw materials using gamma irradiation

Grant No: TG 16 - 124
Project Team: *Prof. (Ms.) I.G.N. Hewajulige
Ms. R.C. Pitipanaarachchi
Dr. (Ms.) H.M.T. Herath
Mr. K.V.T. Gunawardhana
Ms. T.M.D.A. Jayawardena
Ms. A.W.D. Priyangani
Dr. (Ms.) S.A.S. Jayawardhana
Ms. P. Ratnayake
Ms. A.A.G. Madurakanthai
Project Period: 2016 - 2018
Funded by: Sri Lanka Treasury

Principal Investigator

Background

Sri Lanka has experienced different emergency situations, including civil wars and natural disasters, such as floods, droughts and landslides. When such an emergency occurs, it is important to provide food for the people who have been trapped in the areas where rescue missions cannot be reached easily and also for the security forces engaged in rescue missions. The emergency food rations used by the security forces are mostly imported from other countries and it differ from the Sri Lankan palate. As a consequence of the increased national interest in the marketing of convenience and prepared foods, the food industry needs to find new ways of producing safe and high-quality prepared meals. One technology with a particular potential to achieve these objectives is food irradiation. Therefore, food rations suitable as breakfast (high-calorie energy bars, high-calorie biscuits), lunch (fried rice mixed with vegetables and chicken) and dinner (Naan and chicken curry) with extended shelf life at room temperature (28 ^{o}C ±2) were developed using gamma irradiation as a preservation method. The main advantage of these ration packs is, they are 'ready to eat' with more than 6 months of storage life at room temperature. These newly developed emergency food rations are highly nutritious and energy providers. They can be considered as import substitutions and suit the Sri Lankan palate.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Shelf-stable high-calorie biscuits and energy bars as breakfast meals.
- Shelf-stable mixed rice in retort pouches as a lunch menu.
- Shelf-stable naan rotti and chicken curry as a dinner menu was developed and the products are ready for technology transfer.

Scientific Communications

1. Dayananda, D.A.U., Pitipanaarachchi, R.C., Madurakanthi, A.A.G., Herath, H.M.T. Hewajulige, I.G.N. and Lakshman, P.L.N. (2016). Effect of gamma irradiation on physico-chemical and sensory properties of a high-energy cereal bar. *Proceedings of the 72nd Annual Session,* Sri Lanka Association for the Advancement of Science. p.89.

2. Pitipanaarachchi, R.C., Mohome, F.F., Aponso, K., Priyangani, D., Jayawardhana, D., Madurakanthi, A.G., Ratnayake, P. and Hewajulige, I.G.N. (2017). Development of gamma irradiated ready-to-eat food to use in disaster relief and emergency conditions. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.51-52.
3. Mahanama, H.A.H.M., Hewajulige, I.G.N., Jayamanne, V.S. and Pitipanaaarachchi, R.C. (2018). Development of granola bars using locally available raw materials and gamma irradiation. *Proceedings of the International Symposium on Agriculture & Environment, Student Session*, University of Ruhuna. p.23.
4. Hewajulige, I.G.N., Pitipanaarachchi, R.C., Priyangani, D., Jayawardhana, D., Gunawardhana, K.V.T., Madurakanthi, A.A.G. and Ratnayake, P. (2018). Food preservation via irradiation technology to combat with climate change-related food security, *Proceedings of the 2nd International Conference on Climate Change*. p.41.
5. Ransilu, P.Y., Mahanama, H.A.H.M., Pitipanaarachchi, R., Binduhewa, A.M.C.U., Perera, M.G.D.S., Jayawardhana, D., Samaranayake, M.D.W., Hearath, H.M.T. and Hewajulige, I.G.N. (2019). Product development and quality assessment of Pearl Millet based high calorie biscuit. *Proceedings of the 12th International Research Conference*, Kotalawala Defence University. p.214.

Awards

1. Best Presentation Award at the 2nd International Climate Change Conference 2018, Climate Change and Technology session award – I.G.N. Hewajulige.

Rapid determination of coconut oil authenticity and quality with NIR Spectroscopy

Grant No: TG 16 - 129
Project Team: *Dr. H.P.P.S. Somasiri
Ms. H.G.T.H. Jayathunga
Project Period: 2016 - 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Coconut oil is the main edible oil used in Sri Lanka and it is also a major export in the country. Due to its health benefits and cosmetic applications, coconut oil has gained much attention in the European market. Especially, virgin coconut oil demand has gone up due to consumers' interest. Coconut oil is subjected to intentional adulteration by cheap oils like palm oil in the Sri Lankan market for unscrupulous financial gains. Consumption of such adulterated oil is not desirable as palm oil contains higher amounts of unsaturated fatty acids like oleic and linoleic acids. Current methods used to detect oil adulteration are normally based on chromatographic techniques. These methods are time-consuming and need tedious sample preparation steps. Therefore, it is necessary to develop a reliable, rapid and cost-effective method to identify the level of adulteration of coconut oil.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Rapid detection of coconut oil adulteration from palm oil.
- Rapid determination of iodine & saponification values of coconut oil.
- Classification of copra coconut oil from other coconut oils.
- Rapid detection of used coconut oil adulteration.

Publications in Refereed Journals

1. Jayatunga, H.G.T.H., Somasiri, H.P.P.S. and Mahanama, K.R.R. (2020). Rapid determination of adulteration in virgin and copra coconut oil using Fourier transform near-infrared spectroscopy. *International Journal of Food Science and Nutrition,* **5**(3), 38-43.

Scientific Communications

1. Jayatunga, H.G.T.H., Somasiri, H.P.P.S. and Mahanama, K.R.R. (2017). Rapid determination of adulteration in coconut oil using FT-NIR spectroscopy. *Proceedings of International Conference on Food Quality, Safety and Security* (FoodQualSS-2017). p.3.
2. Jayatunga, H.G.T.H., Somasiri, H.P.P.S. and Mahanama, K.R.R. (2017). Use of FT-NIR technique to determine the iodine value of edible oils. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.53-54.
3. Jayatunga, H.G.T.H., Somasiri, H.P.P.S. and Mahanama, K.R.R. (2018). Determination of iodine value and saponification of coconut oil using of FT-NIR technique. *Proceedings of the Annual Research Symposium*, University of Colombo. p.228.
4. Jayatunga, H.G.T.H., Weeratunge, H.D., Somasiri, H.P.P.S. and Mahanama, K.R.R. (2019). Identification of aroma constituents in copra coconut oil. *Proceedings of the 4th Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.8.

Postgraduate Degrees

1. Ms. H.G.T.H. Jayathunga registered for a postgraduate degree at the University of Colombo (PhD ongoing).

Determination of mycotoxins and fungal spore contamination in tea brew at the time of consumption

Grant No: TG 16 - 135
Project Team: *Ms. S. Perera
Mr. M.N.A. Mubarak
Ms. S. Liyanage
Ms. D.A.T.W.K. Dissanayake
Project Period: 2016 - 2018
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Brew of dried leaves of the plant *Camellia sinensis*, commonly known as tea, is popular as a stimulant. Various tea types are available in the market such as black tea, green tea, flavored tea and iced tea. Dried tea leaves are a good niche for microorganisms when environmental conditions are favorable. Inadequate processing and storage conditions of tea provide opportunities for microorganisms including potential moulds that produce mycotoxins to grow in dried tea leaves in spite of the antimicrobial properties possessed by tea. Microorganisms that have the ability to withstand the temperature of boiling water and spores, if present, may survive in the tea brew. The aim of the present study was to determine the initial bacterial and fungal levels in different tea types available in the local market and their levels in the respective tea brews.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Method validation for determination of aflatoxins B1, B2, G1 & G2 in tea.
- Establishment of standard test services for customers; detection of B1, B2, G1 & G2 in tea.
- The test method was included in the RAL scope expansions 2020 and the accreditation was obtained from SLAB (Sri Lanka Accreditation Board).

Scientific Communications

1. Dissanayake, D.A.T.W.K., Galappatthi, R.H., Liyanage, S., Jayasekara, G.H.S.D., Mubarak, M.N.A. and Perera S. (2019). Evaluation of the exposure to aflatoxins at the time of consumption of infusions of *Camellia sinensis* (Tea) by Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS). *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.32.

Postgraduate Degrees

1. Ms. R. Galappatthi obtained an MSc from the University of Peradeniya in 2018.
   Thesis Title: Determination of aflatoxin contamination in tea brew at the time of consumption.

Development of nutritional instant porridge as a supplementary food for patients with diabetic mellitus and cholesterol

Grant No: TG 18 -138
Project Team: * Dr. (Ms.) S. Chelvendran
Dr. (Ms.) L.D.A.M. Arawwawala
Dr. (Ms.) H.M.T. Herath
Ms. M.M.U.I. Medawatta
Ms. A.W.D. Priyangani
Project Period: 2018 - 2020
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The leafy porridge (kola kanda) is a common morning diet of many Sri Lankans. Most of the leafy vegetables available in Sri Lanka are used to make mainly 'mallum' or salad and very few are used to make porridge. The leafy vegetables *Murraya koenigii* Linn. Sprengal, *Cassia auriculata*, *Vernonia cineria* (L.) Less and *Coccinia grandis* (L.) J. Voigt are used in this porridge and reported to have antioxidant and anti-diabetic effects with no toxicity. The porridge developed is also proven to have the claims of antioxidants and antidiabetic effects and is rich in nutrition. This porridge contains 61.4% available carbohydrate, 10.4% crude protein, 9.4% crude fat, 3.7% ash, 2.5% crude fiber and is rich in minerals such as Na, K, Ca, Mg, Fe, Zn, Mn, and Cu. As a value-added product, the herbal instant porridge was prepared and ready for technology transfer. The developed porridge is easy to prepare and thus saves time.

Project Achievements, Outputs/Technologies developed, Technology Transfers

- Technology development of nutritional instant herbal porridge using commonly available leafy vegetables as active ingredients.

Scientific Communications

1. Kathirgamanathar, S., Medawatta, H.M.U.I., Priyangani, A.W.D., Arawwawala, L.D.A.M., Herath, H.M.T. and Jayasinghe, G.D.D.R. (2018). Antioxidant properties and nutritional value of leafy vegetables used in herbal porridge. *Proceedings of the Asian Symposium on Medicinal Plants, Spices and other Natural Products* XVI. p.220.
2. Kathirgamanathar, S., Medawatta, H.M.U.I., Herath, H.M.T., Ransilu, P.Y., Arawwawala, L.D.A.M. and Priyangani, A.W.D. (2019). Antioxidant-rich instant herbal porridge from leafy vegetables. *Proceedings of the* 4^{th} *Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.13.
3. Kathirgamanathar, S., Herath, H.T.M., Medawatte, H.M.U.I., Arawwawala, L.D.A.M. and Priyangani, A.W.D. (2021). Development of an instant herbal porridge having functional properties and its shelf-life evaluation. *Proceedings of the* 5^{th} *Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.1.

Screening of Anti-Nutritional Factors (ANFs) and activity of bio-active proteins in locally grown edible legume varieties

Grant No: TG 18 - 147
Project Team: *Dr. (Ms.) H.M.T. Herath
Prof. (Ms.) W.K.S.M. Abeysekera
Ms. M.D.W. Samaranayake
Ms. S. Liyanage
Ms. P.Y. Ransilu
Project Period: 2018 - 2020
Funded by: Sri Lanka Treasury

Principal Investigator

Background

Grain legumes are an excellent source of protein, carbohydrates and fiber and provide many essential vitamins and minerals. The important nutritional data of edible locally grown Sri Lankan legume varieties were analyzed and the data were compiled and published as a booklet by ITI and the Department of Agriculture (DOA). Grain legumes have potent antioxidants and antioxidant activity which have not been systematically studied locally. However, they contain many anti-nutritional factors, protease inhibitors and non-anti-nutritional compound angiotensin I-converting enzyme (ACE) inhibitors. Protease inhibitors such as trypsin and chymotrypsin inhibitors have demonstrated the capability of reducing the incidence of certain cancers and have potent anti-inflammatory properties. Angiotensin I-converting enzyme (ACE) inhibitor is associated with a reduction in hypertension. Due to the unavailability of data on antioxidants, ANFs and bioactive proteins in local legume varieties, the present study developed a systematic database for the above components. Protease inhibitors are resistant to pepsin, the acidic pH of the human digestive tract and interfere with digestion by inhibiting trypsin and chymotrypsin through irreversible binding to the enzymes. Although they reduce the ability of digestive enzymes to properly hydrolyze dietary protein, the latest studies exhibit that protease inhibitors suppress carcinogenesis. Horse gram (Species: *Macrotyloma uniflorum*) is an incredible food legume that has been underutilized due to its poor cooking qualities and the presence of unflavourable compounds. This study also aimed to produce horse gram-based nutritious food products that have commercial potential.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Horse gram-based granola bar.
- Horse gram-based nutritious instant porridge.
- Horse gram-based nutritious instant powdered drink.
- Horse gram-based all-purpose flour.
- Horse gram-based nutritious drink (RTS).
- Horse gram-based nutritious flakes mix.

Publications in Refereed Journals

1. Herath, H.M.T., Samaranayake, M.D.W., Liyanage, S. and Abeysekera, W.K.S.M. (2020). Horse Gram: an incredible food grain as a potential source of functional and nutritional food ingredient. *International Journal of Food Science and Nutrition*, **5**(4), 93-101.

2. Lounge, L.L.P.S., Herath, H.M.T., Samaranayake, M.D.W., Liyanage, S.L., Ratnayake, R.H. M.K. and Abeysekera, W.K.S.M. (2020). A comparative study on potential antioxidants and antioxidant activity in raw and cooked selected locally grown legumes in Sri Lanka. *Asian Food Science Journal*, **17**(4), 14-27.
3. Abeykoon, A.M.C.N., Herath, H.M.T. and Jayasinghe, M.A. (2021). *In-vitro* analysis of trypsin and alpha-amylase inhibitory activities in selected legume varieties in Sri Lanka. *Asian Food Science Journal*, **20**(1), 1-9.

Scientific Communications

1. Lounge, L.L.P.S., Herath, H.M.T., Liyanage, S.L., Samaranayake, M.D.W., Ratnayake, R.H.M.K. and Abeysekera, W.K.S.M. (2018). Determination of antioxidant potential and polyphenol content of selected pulses in Sri Lanka. *Proceedings of the 17th Agricultural Research Symposium*, University of Wayamb. p. 290-294.
2. Hamasaki, H.N., Herath, H.M.T., Silva, M.S.W.D. and Jayawardana, T.M.D.A. (2019). Development of horse gram based ready to serve nutritious drink. *Proceedings of the Food Techno 2019, 5th Annual Session of the IFSTSL*. p.47-51.
3. Abeykoon, A.M.C.N., Gunasekara, M.A., Herath, H.M.T., Liyanage, S.L. and Jayasinghe, M. (2019). Effect of pressure cooking on trypsin inhibitor activity of locally grown legume varieties in Sri Lanka. *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.5.
4. Herath, H.M.T., Yashora R.P. and Mahanama, H.A.H.M. (2019). Horse Gram; A source of functional food ingredient. *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.11.

Post Graduate Degree

1. Ms. P. Y. Ransilu completed an MSc Degree in Food Science and Technology at the University of Peradeniya in 2020. Thesis Title: Development of horse gram-based composite flour mix and development of traditional functional food products.

Popularization Activities

- Newspaper article published on "Horse gram as a Functional Food Ingredients" in Vidya paper (2018).
- Actively participated in Sahasak Nimavum -2019 National Exhibition (20th -22nd Sep 2019).

Technological optimization and shelf-life studies of processed and refrigerated coffee milk beverage

Grant No: TG 18-148
Project Team : *Ms. A.M.C.U. Binduhewa
Eng. A.B.G.C.J. De Silva
Dr. (Ms.) D.U. Rajawardana
Project Period: 2018 - 2019
Funded by: Sri Lanka Treasury

Principal Investigator

Background

Iced coffee is a popular beverage in the present society. Iced coffee processed according to two main preservation techniques is available in the market (a) sterilized long shelf-life product presented in glass bottles/cans/tetra pack and (b) refrigerated short shelf-life product presented in polypropylene or PET cups. The correct processing techniques applied in the first type were diverted incorrectly by small-scale processors due to the high cost of production. However, this diversion was conducted without correct knowledge of food processing; thus, the quality of such products became a question, especially regarding microbiological safety. This project was conducted to develop a technologically correct process for refrigerated short shelf-life coffee milk beverages, which will be helpful for small industries. The quality of iced coffee products available in the market was also evaluated.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Pasteurized and refrigerated coffee milk drink with a shelf-life evaluated under laboratory conditions.
- Sterilized coffee milk drink with a shelf-life evaluated under laboratory conditions.

Technologies Transferred/Commercialized

- Technology was successfully transferred to a local coffee manufacturing company.

Popularization activities

- An awareness programme on “Risks of incorrect milk beverage processing” was held at the Food Technology Section, ITI, for small- to medium-scale restaurant operators.

Study on the use of sugar substitutes for food products, their detection and the development of low GI food products

Grant No: TG 18-150
Project Team : *Mr. K.V.T. Gunawardhana
Ms. P.S.F. Perera
Mr. M.M.N.P. Gunasekara
Ms. M. Pathirana
Ms. A.W.D. Priyangani
Ms. R.C. Pitipanaarachchi
Project Period: 2018 - 2021
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The use of sugar substitutes has significantly increased in Sri Lanka due to the restrictions imposed on the use of added sugar in foods. However, there is no proper study done on the type and level of sugar substitutes used in the country. This research was intended to fill this knowledge gap through market surveys and analysis of food samples with artificial sweeteners. New analytical methods were established to enhance this area's technical capabilities. Other objectives of this project were to reveal the actual situation of 'no added sugar' food products in the market with relevance to diabetes-affected people and to develop low-calorie food products focusing on the same community.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Questionnaire-based survey was conducted on "Usage of nutritive and non-nutritive sweeteners using Sri Lankan consumers" with 145 participants.
- Test methods were established for the determination of sugar substitutes such as Stevia, Sucralose, Aspartame and Asulfame K.
- Test methods were established for sugar substitutes in different food matrices.
- Development of RTS drink using Ivy gourd (Kowakka: *Coccinia grandis*) leaves. Ivy gourd leaves are known to reduce serum sugar levels. However, using sugar for developing the drink will downgrade its value as a suitable drink product for diabetes-affected people. Therefore, this RTS was developed using a suitable sugar substitute, 'Sucralose'.
- A food bar was developed using water lily seeds which is a good source of dietary fiber.

Scientific Communications

1. Gunawardhana, K.V.T., Jayammanne, J.M.N.T., Nilukshi, D.A.V., Priyangani, A.W.D., Samaranayaka, M.D.W. and Liyanage S.L. (2019). Development of Olu seed (*Nymphaea pubescens* Willd) incorporated food products and evaluation of nutritional, functional and sensory properties. *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.15.
2. Jayamanne, J.M.N.T., Gunawardhana, K.V.T., Nilukshi, D.A.V. and Edirisinghe, E.M.R.K.B. (2019). A Study on the evaluation of nutritional properties, functional properties and storage life of *Nymphaea pubescens* Willd (Olu) seed-incorporated food products. *Proceedings of the 75th Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.188.

3. Jayamanne, J.M.N.T., Samaranayake, M.D.W., Liyanage, S.L, Gunawardhane, K.V.T. and Edirisinghe, E.M.R.K.B. (2019). Evaluation of functional and nutritional properties of *Nymphaea pubescens* seeds. *Proceedings of Rajarata International Research Conference,* Rajarata University. p.216.
4. Perera, P.S.F., Somasiri, H.P.P.S. and Mahanama, K.R.R. (2020), Valuational RP- HPLC method for determination of Stevioside and Rebaudioside A in food and beverages. *Proceedings of the Annual Symposium 2020*, University of Colombo, Sri Lanka. p.12.
5. Perera, P.S.F., Gunawardene, K.V.T., Somasiri, H.P.P.S. and Mahanama, K.R.R. (2021). Development of a High-Performance Liquid Chromatographic method for the determination of sucralose in food and beverages. *Proceedings of the 5th Biennial Symposium*, Industrial Technology Institute, Sri Lanka. p.7
6. Perera, P.S.F., Gunawardene, K.V.T., Somasiri, H.P.P.S. and Mahanama, K.R.R. (2022). Study on the use of artificial sweeteners and total sugars for non-alcoholic beverages available in the Sri Lankan market. *Proceedings of the Annual Scientific Sessions*, Nutrition Society of Sri Lanka. p.62.
7. Perera, P.S.F., Somasiri, H.P.P.S. and Mahanama, K.R.R. (2022). Development of a RP-HPLC method for simultaneous determination of Acesulfame – K, Saccharin and Aspartame in nonalcoholic beverages and tabletop sweeteners. *Proceedings of the International conference on Food Research, Development and Applications,* University of Sri Jayewardenepura. p.52.

Assessment of frying conditions on safety and quality aspects of food

Grant No TG 18-151
Project Team : *Mr. M.M.N.P. Gunasekara
Ms. S. Rajapaksha
Ms. M.G.D.S. Perera
Ms. M.D.W. Samaranayake
Project Period: 2018 – 2019
Funded by: Sri Lanka Treasury

Principal Investigator

Background

The objective of this project was to evaluate the optimum frying conditions with respect to selected food matrices and selected varieties of frying oils, in order to assess the suitability of the use of frying oils repeatedly in food processing. The outcome is important to the national baseline survey data for future reference. Authentication of five branded frying oils, commonly available and used in households and industrial cooking, was selected. Three industrial oil samplings were tested, mainly obtained from export-oriented frying industries to identify the changes in frying oil quality on repeated frying cycles. Each sample of oil was tested against 10 analytical measurements including peroxide value, iodine value, moisture, free fatty acid content, saponification value/unsaponifiable matter, viscosity, Lovi bond color, anisidine value, thiobarbituric acid value, and fatty acid profile/trans- fat, based on AOAC, ISO, and AOCS methods.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Establishment of baseline data on the quality of cooking oils in repeated cycles with respect to 10 analytical parameters.
- Establishment of two new test methods in the laboratory for the assessment of cooking oil quality, P-Anisidine value based on AOCS official method Cd 18-90 (1993) SLS 313: Part 3/ Section 8 (2016) 2-thiobarbituric acid value based on IUPAC 2.531, Standard Methods for the Analysis of Oils, Fats and Derivatives1st Supplement to the 7th Revised and Enlarged Edition / AOAC Official Method Cd 19-90 (Reapproved 2009).
- Establishment of HPLC screening method at ITI for 10 synthetic antioxidants namely, *tert*-Butylhydroquinone (TBHQ), Propyl gallate, Lauryl gallate, Octylgallate, Ascorbyl palmitate, Ascorbyl stearate, 3,5-Di-tert-butyl-4-hydroxytoluene (BHT), Ethoxyquin, Dilaurylthiodipropionate and 3,5-Di-tert-butyl-4-hydroxybenzyl alcohol (Ionox -100), in par with Food Act of no 26 of 1980 Sri Lanka and CODEX.
- Establishment of GC analysis of trans-fatty acid content in oils.
- All the above methods are used for client services.

Baseline study on nutritional status of selected commonly consumed food items in Sri Lankan market with special reference to transfat status: Ω 6: ω 3

Grant No: TG 18-157
Project Team: *Dr. H.P.S. Somasiri
Prof. G.A.S. Premakumara
Mr. M.N.A. Mubarak
Ms. S. Perera
Dr. (Ms.) K. Mahatantila
Dr. C.P. Withanage
Ms. M.R.P. Dassanayake
Ms. H.P.E. De Zoysa
Dr. Lasantha Wijesekera
Dr. Palitha Karunaprema
Period covered: 2018- 2022
Funded by: Sri Lankan Treasury

**Principal Investigator*

Background

Considering the recent global health challenges and recommendations from the World Health Organization (WHO), it is important to take certain initiatives by the food authorities in Sri Lanka to regulate unhealthy nutrients and toxins present in daily diets. The American Heart Association has also recommended limiting sugar, sugar-sweetened beverages, sodium and saturated fat to eliminate the associated health problems including Non-Communicable Diseases. Apart from that Sri Lanka aimed to, actively engaged in trans-fat elimination and regulated unhealthy nutrient constituents. However, the conventional dietary behavior of Sri Lankans has changed significantly from home-cooked meals to fast food and beverages which consist of high levels of sugar, salt and fats. Therefore, this study aimed to generate baseline data by evaluating and determination of key nutritional molecules, unhealthy nutrient content and toxic compounds present in current Sri Lankan diets and their correlation to human serum composition.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Generation of comprehensive baseline data in Sri Lanka.
- New method validation was done and the accredited test methods are used for client services.

Trace elements (toxic and essential) content in selected rice varieties available in the Sri Lankan market and study on the effect of essential trace elements on uptake of toxic elements by rice in a simulated environment

Grant No: TG 18-163
Project Team: *Ms. G.U. Chandrasiri
Mr. M.N.A. Mubarak
Prof. S. Malavipathirana
Period covered: 2017- 2021
Funded by: Sri Lankan Treasury

**Principal Investigator*

Background

Being the dietary staple in most Asian countries, the concentrations of toxic and essential element content in rice are an important aspect in terms of both toxicological and nutritional standpoints. This study aimed to assess trace elements (As, Cd, Pb, Hg, Cr, Ni, Zn, Cu, Mn, Fe, and Mo) in commonly consumed rice varieties: improved, traditional and imported, available in markets of Colombo district while addressing the dietary exposure and health risk assessment. The assessment of potential health risks in terms of provisional tolerable daily intake (PTDI) is vital as the risk intensifies with the increased rate of rice consumption. Further, determining the variety effect, elemental correlations of essential trace elements in rice grains and the contribution of rice varieties to recommended daily allowances (RDA) of Fe and Zn are important in implementing efforts to alleviate the hidden hunger issues (i.e., micronutrient deficiencies) in Sri Lanka. Reliable data generated using validated test methods are important to regulate the trace element concentrations in rice available in the Sri Lankan market.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Obtained accreditation for toxic elements for cereals with validation data.
- The accredited test methods are used for client services.

Publications in Refereed Journals

1. Chandrasiri, G.U., Mubarak, M.N.A., Mahatantila, K. and Mahanama, K.R.R. (2019). Single laboratory validation of determination of 13 trace elements in rice by ICP-MS with an overview of challenges encountered. *American Journal of Analytical Chemistry*, **10**(9), 367-376.
2. Chandrasiri, G.U., Mahanama, K.R.R., Mahatantila, K. *et al.* (2022). An assessment on toxic and essential elements in rice consumed in Colombo, Sri Lanka. *Applied Biological Chemistry*, **65**, 24.

Scientific Communications

1. Chandrasiri, G.U., Mubarak, M.N.A., Mahatantila, K. and Mahanama, K.R.R. (2019). Dietary exposure assessment of trace elements in rice available in Sri Lankan market by a validated test method: health risk implications. *Proceedings of the Annual Research Symposium*, University of Colombo, Sri Lanka. p. 210.
2. Chandrasiri, G.U., Mubarak, M.N.A., Mahatantila, K., Mahanama, K.R.R. and Karunaratne, S.H.S. (2019). Effect of short-term arsenic and cadmium contamination on physicochemical properties and microbial content of paddy soil, *Proceedings of the 4th Biennial Research Symposium*, ITI, Sri Lanka. p.10.

Method development, validation and market survey of pesticide residues in tea and spices using

Grant No: TG 18 - 164
Project Team: *Mr. M.N.A. Mubarak
Dr. (Ms.) G.V.V. Liyanaarachchi
Ms. V. Priyadarshana
Project Period: 2017- 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

This project was mainly focused on method development, validation and market survey of pesticide residue in tea and spices using Liquid Chromatography with Tandem Mass Spectrometry (LC-MS/MS). Overdependence on chemical pest control methods and enormous use of pesticides can leave excessive residues of pesticides in the harvested crops like tea and spices which have high export potential. Highly selective, sensitive and accurate analytical methods such as LC-MS/MS are needed to measure the low concentrations of minimally contaminated toxic chemicals.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Establishment of analytical testing service for 23 numbers of pesticide residues in tea. including MCPA and 28 Nos of pesticide residues in spices. at ITI.
- Applied for scope expansion for the above test parameters from SLAB as per ISO 17025:2017 requirement.
- Completed survey on pesticide residues in commercially available tea and spices.

Scientific Communications

1. Liyanaarachchi, G.V.V., Weerasekara, R.A.D.S.M.R., Dayananda, P.G.K.N., Keenawinna, K.A.V.N. and Mubarak, M.N.A. (2019). Monitoring of pesticide residue contamination in the tea sold in the Sri Lankan market. *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.35.

Studies on surface sterilization of spices using non-thermal processes

Grant No: FP 125
Project Team: *Dr. P.N.R.J. Amunugoda
Ms. R.C. Pitipanaaarachchi
Eng. A.B.G.C. De Silva
Mr. B. Weerasinghe
Project Period: 2018 - 2023
Funded by: Indo-Lanka inter-governmental research cooperation via the Ministry of Science, Technology and
Research, Sri Lanka

**Principal Investigator*

Background

Non-thermal processes are an emerging trend in food processing as an alternative to thermal processes in view of the nutritional and organoleptic quality of the food product. Most of the thermal food products are preserved by subjecting to high temperatures for a few seconds or several minutes which may lead to loss of vitamins, essential nutrients, colour and flavor. To overcome or minimize these disadvantages, the concept of non-thermal processes was explored. Usually, these processes are operated at room temperature so that vitamins, essential nutrients, colour and flavour will be protected with minimal or no loss. Mostly, the non-thermal processes such as UV-C light and cold plasma are being effectively used for microbial inactivation. Spices and herbs are the substances that impart taste, flavours, aromas and colours to food. Spices are raw materials that can be used alone or as ingredients in the manufacture of processed food products. The control of microbiological spoilage of these raw materials at the ingredient stage will enable the food processor for better assurance of the production of high-quality products with an acceptable shelf life. To overcome these problems, industries have a choice of two sanitation options: ethylene oxide (EO) fumigation and irradiation processing. While both effectively kill organisms, the challenges presented by the bulk packaging of spices and herbs have made ethylene oxide fumigation and gamma processing as the methodologies of choice due to their efficient, high-density penetration. India and Sri Lanka are major producers and exporters of spices. Hence, the project undertook to establish a method of decontamination of microorganisms in spices using cold plasma with advanced UV sterilization technology for the first time in Sri Lanka and to determine its effect on the microbial inactivation and physico-chemical characterization of the selected spices in Sri Lanka and India.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A rotating drum that can treat the spice samples by UV sterilization was fabricated with three UV bulbs (27W X 3) and tested.
- UV canopy coupled to a conveyor belt was fabricated using 10 UV –C bulbs (27 W x10).
- Facility of UV dose measurements by UV- C data logging radiometer (UV photon meter-RM-22) was established.
- Atmospheric Pressure Cold Plasma Gliding Arc Discharge (APCPGAD) reactor (15 kV, 50 Hz, AC) with fixed supply voltage using atmospheric air at an airflow rate of 0.009 m^3/s was established.
- A laboratory-scale rotary-type atmospheric pressure dielectric barrier cold plasma reactor made up of glass powered by radio frequency power was fabricated.

- UV Technology has the ability to kill the microbes present in black pepper seeds, black pepper powder and cinnamon chips. Developed UV rotary drum and UV canopy-type sterilizers are cable to reduce microbial contamination to satisfactory levels. If the initial microbial counts are lower the UV treatment is much more effective in decontamination. Project activities enabled to increase the UV efficacies by a further 10- 15%; therefore, overall UV sterilization efficacy is improved to the level of 55 - 60 %.
- Cold plasma has the ability to kill the microbes present in black pepper seeds, black pepper powder and chilli powder.
- Longer treatment times can lead to changes in the surface of the spice particles and further treatment times can lead to chemical structural changes in APCPGAD.
- With the limitations of a low-pressure plasma system, a new design of a laboratory-scale reactor that uses RF power at atmospheric pressure plasma was developed.
- Laboratory scale Atmospheric Pressure (Radiofrequency) Rotary DBD Cold Plasma (APRDBDCP) was designed, fabricated & optimized for the decontamination of spices.
- Detoxification of Aflatoxins in spices using red chilli (*Capsicum anuum L.*): Atmospheric Pressure Cold Plasma Gliding Arc Discharge (APCPGAD) reactor (15 kV, 50 Hz, AC) with fixed supply voltage using atmospheric air at an airflow rate of 0.009 m^3/s was established.
- Morphological & genetic identification were carried out for microbes in selected spices.

Publications in Refereed Journals

1. Weerasinghe, W.A.B.S. and Amunugoda, P.N.R.J. (2021). UV treatment on inactivation of fungal contamination of Sri Lankan black pepper (*Piper nigrum*) seed and powder. *Frontiers Advanced Materials Research,* **3** (1),36-41.
2. Mapalagama, O.V., Amunugoda, P.N.R.J. and Ranaweera, K.K.D.S. (2021). Decontamination of pineapple (*Ananas cosmosus*) juice using ozone as a non-thermal sterilization method. *Future of Food: Journal on Food, Agriculture and Society,* **9**(5).

Scientific Communications

1. Wahalatahnthri, W.T.T.W., Amunugoda**,** P.N.R.J., Rathnayake, R.H.M.K. and Pitipanaarachchi, R. (2018). Aflatoxin contamination of selected commercialized spices in Sri Lanka. *Proceedings of the 17th Agricultural Research Symposium.*Wayamba University of Sri Lanka. p.154-158.
2. Amunugoda**,** P.N.R.J., De Silva, A.B.J.C., Weerasignhe, B. and Pitipanaarachchi, R. (2018). Dielectric barrier discharge atmospheric plasma: A review and comparison. *Proceedings of the 2nd International Conference on Food Quality, Safety and Security* (FoodQualSS 2018) Colombo, Sri Lanka. p.10.
3. Weerasignhe, B., De Silva, A.B.J.C., Amunugoda**,** P.N.R.J. and Pitipanaarachchi, R. (2018). Microbial quality assessment in selected spice brands collected from supermarkets in Sri Lanka. *Proceedings of the Asian Symposium on Medicinal Plants, Spices and Other Natural Products XVI* (ASOMPS XVI) Colombo, Sri Lanka. p.198.
4. Amunugoda, P.N.R.J. (2018). Non-thermal technology for inactivation of microorganisms in RTS Beverages & startups/ Application of UV & cold plasma treatment on spices. *Proceedings of the 8th International Food Convention* (#IFCoN2018, India). p.8.
5. Amunugoda, P.N.R.J**.,** Weerasinghe, W.A.B.S., De Silva, A.B.G.C.J. and Pitipanarachchi, R. (2019). Studies on the effectiveness of ultraviolet radiation for surface sterilization of

spices. *Proceedings of the 3rd International Conference on Food, Nutrition, Health and Lifestyle,* Bangkok. p.5.

6. Mapalagama, O.V., Amunugoda, P.N.R.J**.,** Ranaweera, K.K.D.S., Weerasinghe, W.A.B.S. and Binduhewa, A.M.C.U. (2019). Decontamination of pineapple (*Annanas comosus*) juice using ozone as a non-thermal sterilization method. *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.19.
7. De Silva, A.B.G.C.J., Weerasinghe, W.A.B.S., Pitipanarachchi, R., De Alwis, A., Gunawardana, S.H.P. and Amunugoda, P.N.R.J. (2019). Cold plasma sterilization for selected Sri Lankan spices. *Proceedings of the 4th Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.18.
8. Weerasinghe, W.A.B.S., De Silva, A.B.G.C.J., Amunugoda, P.N.R.J., Pitipanarachchi, R. and Jayawardana, T.M.D.A. (2019). Microbial contamination of selected spice brands in Sri Lanka, *Proceedings of the 75th Annual Sessions,* Sri Lanka Association for the Advancement of Science. p.158.
9. Mapalagama, O.V. and Amunugoda, P.N.R.J. (2020). Comparative study on microbial and physico-chemical properties of pineapple (*Ananas comosus*) juice under thermal pasteurization and ozone sterilization. *Proceedings of the 76th Annual Sessions,* Sri Lanka Association for the Advancement of Science. p.17.
10. Amunugoda, P.N.R.J. (2020). Decontamination of natural microbial load in Sri Lankan black pepper (*Piper nigrum*) using cold plasma - A case study. *Proceedings of the 1st International Conference on Advances in Plasma Science and Technology* (ICAPST-2020) Sri Shakthi Institute of Engineering Technology, Coimbatore, India.
11. Udeshika, S.H.D., De Silva, A.B.G.C.J., Dissanayake, T., Amarasena, S.C., Abeysundara, P. and P.N.R.J. Amunugoda (2021). Detoxification of aflatoxins in red chilies (*Capsicum annum* L.) using low-pressure cold plasma. *Proceedings of the 2nd International Conference on Advances in Plasma Science and Technology* (ICAPST 21), Department of Physics, Sri Shakthi Institute of Engineering Technology, Coimbatore, India associated with IEEE. p.14.
12. De Silva, G., Amarasena, S., Gunawardane, S., Amunugoda, N. and de Alwis, A. (2021). Effect of low-pressure cold plasma treatment on microbiological and physicochemical properties of black peppercorns. *Proceedings of FITI 2021* (From Innovation to Impact) BMICH, Colombo. p.60.
13. De Silva A.B.G.C.J., Weerathunga, H.D., Amarasena, S.C., Amunugoda, P.N.R.J. Gunawardana, S.H.P. and De Alwis, A.A.P. (2021). Evaluation of the suitability of cold plasma technology for sterilization of black pepper corns by means of essential oil content and composition. *Proceedings of the 5th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.9.
14. Gunathilake, T.A., De Silva, A.B.G.C.J., Amunugoda, P.N.R.J., Weerathunga, H.D. and Jayasinghe, M.J.K. (2021). Effect of vacuum cold plasma and atmospheric pressure gliding arc discharge cold plasma as sterilization techniques on piperine and volatile oil content of black pepper seeds (*Piper nigrum L.*) *Proceedings of the 5th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.47.
15. De Silva, A.B.G.C.J., Amarasena, S.C., Amunugoda, P.N.R.J., Gunawardena, S.H.P. and De Alwis, A.A.P. (2021). Effect of low-pressure cold plasma treatment microbiological and physicochemical properties of black peppercorns. *Proceedings of the FITI* 2021.

16. De Silva, G., Amarasena, S., Amunugoda, N., Gunawardena, S. and De Alwis, A. (2023). Positive and negative impacts of low-pressure cold plasma treatment in decontamination of black pepper (*Piper nigrum*) and red chili (*Capsicum annuum*) powders. *Proceedings of the 3rd International Conference on Advances in Plasma Science and Technology (ICAPST 23)*, Department of Physics, Sri Shakthi Institute of Engineering Technology, Coimbatore, India associated with IEEE. p.14.

Postgraduate Degrees

1. Ms. A.B.G.C.J. De Silva registered for a postgraduate degree at the University of Moratuwa (PhD Ongoing).

Awards

1. Best Project with National Significance 2021 for the project titled, "Surface Sterilization of Spices using Non-thermal Technologies (UV and Cold Plasma)" at the 5th Biennial Research Symposium, Industrial Technology Institute - P.N.R.J. Amunugoda, R. Pitipanarachchi, A.B.G.C.J. De Silva and W.A.B.S. Weerasingha.

NCBI GenBank submissions

- Sequences of eight isolated bacterial strains and fifteen isolated fungi strains from black pepper and red chili powder are deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Market basket survey to analyze pesticide residue levels in vegetables, fruits, and leafy vegetables in Sri Lanka

Grant No: TG 18-166
Project Team: *Mr. M.N.A. Mubarak
Dr. (Ms.) G.V.V. Liyanaarachchi,
Ms. D.A.T.W.K Dissanayake
Ms. R.A.D.S.M.R. Weerasekara
Project Period: 2018 - 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The average monthly consumption of fruits and vegetables by an individual in Sri Lanka approximates to 112.3 g. Hence, the investigation into whether the level of contamination in the final product is within the regulatory limits becomes crucial from the perspective of the local consumer to understand the level of exposure to these hazardous compounds. The fruits and vegetables produced and sold in Sri Lanka are regulated through the maximum residue levels (MRLs) imposed by the Office of the Registrar of Pesticides (ROP). This study investigated the pesticide residue levels in vegetables, fruits, and leafy vegetables in Sri Lankan food basket by multi-residue analysis using gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-tandem mass spectrometry (LC-MS/MS) method.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Method was validated for the analysis of twenty-eight pesticide residues in five categories of fruits and vegetables using a modified QuEChERS approach. The developed method was validated as per the international guidelines and ISO 17025 accreditation status was obtained for the method from the Sri Lanka Accreditation Board (SLAB).
- A total number of 256 fruits and vegetables sampled from different markets and the fields were included in the analysis. The analyzed commodities included tomatoes, cabbage, carrots, capsicum, leeks, long beans, okra, wing beans, bitter gourd, thibbatu, snake gourd, beans, brinjals, green chillies, cucumber, ash plantain, spinach, gotukola, kathurumurunga, mukunuwenna, sarana, kankun, agunakola, salad leaves, thampala, papaya, guava, mandarin and apples.
- Study revealed that 33.6% of the samples investigated were contaminated with at least a single pesticide residue above the detection levels, with 14.1% of the total exceeding the MRLs stipulated by the CODEX while 21.9% of the total exceeding the MRLs stipulated by the European Union (EU) for fruits, vegetables and leafy vegetables respectively.
- The analyzed samples were found to be contaminated with Tebuconazole, Azoxystrobin, Profenofos, Captan, Hexaconazole, Diazinon, Thiamethoxam, Imidacloprid, Norvaluron, Fipronil, Dimethoate, Phenthoate, Thiram and Carbofuran.
- The highest percentage of contamination above detection levels of 20.7% was observed in leafy vegetables while the percentage contamination in fruits and vegetables was 12.9% respectively.
- Moreover, out of the total fruit and vegetable samples, 4.3% exceeded the MRLs declared by the CODEX while 5.9% exceeded the MRLs declared by the EU respectively.

- The market basket survey gives Sri Lankan consumers a general awareness regarding the pesticide residue contamination in fruits and vegetables available in the Sri Lankan market.
- The farmers and/or regulatory authorities will become aware of the residue levels in food.
- The study is useful to force regulatory authorities to initiate a reliable national pesticide monitoring program and effectively implement the regulations on pesticide residues.
- The study enabled the scope expansion of ISO-17025 accreditation for test parameters of fruits and vegetables.

Scientific Communications

1. Jeevanantham, J.J., Liyanaarachchi, G.V.V., Kumarapeli, G. and Mubarak, M.N.A. (2018). Validation of a multi-residue QuEChERS method for analysis of 29 pesticide residues in fruits and vegetables using LC-MS/MS technique. *Proceedings of the 77th Annual Sessions*, Institute of Chemistry, Ceylon. p.41.

LC-MS/MS facility at ITI for Pesticide Residue Analysis

Development and scaling up of technologies of value-added products from selected underutilized fruits and investigation of their functional Properties

Grant No: TG 19-169
Project Team: *Dr H.M.T. Herath
Dr. P. Ranasinghe
Ms. A.M.C.U. Binduhewa
Ms R.C. Pitipanarachchi
Eng. A.B.G.C.J. De Silva
Ms. M.D.W. Samaranayake
Ms. S. Liyanage
Project Period: 2019 - 2021
Funded by: Sri Lanka Treasury

Principal Investigator:

Background

The importance of dietary factors on human health has long been recognized and recent clinical and epidemiological studies have proven that more attention should be given to chemical and physiological mechanisms of the effect of bioactive foods on human health. Phytochemicals play a crucial role in health promotion and disease prevention by physiological mechanisms. Free radical scavenging and metal chelation activities are the major functions of the antioxidative effect of phenolic and functional food factors. Diseases such as cancer, stroke, diabetes and degenerative processes associated with aging are propagated by significant damage to cell structure breakdown of membrane protein and DNA mutation. Antioxidants provide a vital role as a defense mechanism of living cells against oxidative damage. There are locally available seasonal underutilized native fruits in Sri Lanka with a high impact on improving the health status of people. These fruits are rich in functional bioactive ingredients of phytochemicals; polyphenols, flavonids, tannins, carotenoids, dietary fibers etc. Those phytochemicals that are naturally present in the plant constituents exhibit disease-preventive properties. Based on previous studies, native underutilized fruits with high bioactive properties such as Veralu (*Elaeocarpus serratus)*, Ambarella (*Spondius dulcis Frost*), Katu Anoda (Soursop, *Annoda muricata*), Beli (Bael, *Aegle marmelos*), Nas Narang (*Citrus madurensis*) were selected for the study. The preparations of healthy food products with high bioactive components including juices/drinks from those selected underutilized fruits, are targeted. Since the conventional pasteurization process destroys most of the nutrients and functional ingredients of the native fruits, the advantage of the proposed technology of pasteurization (High-Temperature Short Time-HTST) followed by hot filling in the preparation of juice/drink will minimize the destruction of bio-active components and nutrients and retain the quality of the product.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Ambarella fruit powder and Ambarella incorporated instant soup mix.
- Soursop fruit powder and Soursop drinking yoghurt.
- Isotonic Nas Narang sports drink.
- Veralu fruit powder, Veralu smoothies and Veralu Pudding.

Publications in Refereed Journals

1. Navoda, N.P.G.D., Samaranayake, M.D.W., Liyanage, S.L., Herath, H.M.T. and Jayasinghe, J.M.J.K. (2021). Determination of functional properties of Sri Lankan Ambarella (*Spondias dulcis* Forst. syn. *Spondias cytherea* Sonn.) fruit and development of vacuum-dried Ambarella fruit powder and incorporated soup mix. *Asian Food Science Journal*, **20**(11), 113-122.
2. Ranaweera, N.I., Pitipanarachchi, R.C., Herath, H.M.T. and Chandramali, D.V.P. (2022). Development of vacuum-dried powder and drinking yoghurt from Soursop fruit (*Annona muricata* L.) and evaluation of their physico-chemical and functional properties. *Journal of the National Science Foundation of Sri Lanka*, **50**(2), 489-502.
3. Idangodage, I.P.A., De Siva, A.B.C.G.J., Herath, H.M.T. and Jayasinghe J.M.J.K. (2023). Development and physico-chemical evaluation of an "Isotonic Nas Narang (*Citrus madurensis*) Sports Drink". *Journal of Advances in Food Science & Technology*, **10**(2), 75-85.

Scientific Communications

1. Navoda, N.P.G.D., Samaranayake, M.D.W., Liyanage, S.L., Pitipanaarachchi, R.C., Herath, H.M.T. and Jayasinghe, J.M.J.K. (2020). Determination of functional properties of Sri Lankan Ambarella (*Spondiasdulcis*Forst. syn. &*Spondiascytherea*Sonn.) fruit and development of value-added products. *Proceedings of the 76th Annual Sessions,* Sri Lanka Association for the Advancement of Science. p.11.
2. Ranaweera, N.I., Pitipanaarachchi, R.C., Herath, H.M.T. and Chandramali, D.V.P. (2020). Evaluation of physicochemical and functional properties of Soursop (*Annona muricata*) incorporated drinking yoghurt and Soursop fruit powder. *Proceedings of the 76th Annual Session,* Sri Lanka Association for the Advancement of Science. p.15.
3. Idangodage, I.P.A., De Siva, A.B.C.G.J., Herath, H.M.T. and Jayasinghe, J.M.J.K. (2021). Determination of physical, chemical and functional properties of Nas Narang fruit (*Citrus madurensis*) juice and development of an "Isotonic Nas Narang sports drink". *Proceedings of the 5th Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.2.
4. Asanka, W.G.K.L., Pitipanaarachchi, R.C., Herath, H.M.T. and Jayasinghe, J.M.J.K. (2021). Development of Veralu (*Elaeocarpus Serratus)* fruit incorporated pudding and investigation of physico-chemical and functional properties. *Proceedings of the 5th Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.3.

Awards

1. Bronze Medal in the Open category (2021) under the technical field of Food Technology for the Development of Isotonic Nas Narang Sport Drink at the awards ceremony organized by the Sri Lanka Inventors Commission - H.M.T. Herath, A.B.G.C.J. Silva, I.P.A. Idangodage and R.C. Pitipanaachchi.

Popularization Activities:

- Newspaper article published on "Nas Narang Sport drink" in Vidya paper (19.10.2022).

Enhancing the nutritional status of people by introducing healthy food products from jack, pumpkin, banana and king coconut while reducing postharvest losses of these commodities

Grant No: FP 128
Project Team: * Prof. (Ms.) I.G.N. Hewajulige
Dr. P.N.R.J. Amunugoda
Dr. (Ms.) H.M.T. Herath
Dr. (Ms.) D.M.W.D. Divisekera
Dr. (Ms.) D.U. Rajawardana
Mr. S.S.K. Madage
Mr. K.V.T. Gunawardhana
Ms. A.M.C.U. Binduhewa
Eng. A.B.G.C.J. Silva
Mr. M.M.N.P. Gunasekara
Ms. R.C. Pitipanaarchchi
Dr. (Ms). S.A.S. Jayawardena
Ms. M.D.W. Samaranayake
Ms. D.V.A. Nilukshi
Ms. M.G.D.S. Perera
Mr. W.U.D. Medis
Ms. S. Rajapaksha
Ms. A.W.D. Priyangani
Ms. T.M.D.A. Jayawardena
Ms. S. Liyanage
Ms. M.D. Jayasinghe
Project Period: 2019 - 2020
Funded by: Ministry of Science, Technology and Research, Sri Lanka

**Principal Investigator*

Background

Postharvest losses are becoming highly critical to Sri Lankan agriculture and threaten to sustainable food and environmental security of the country. The climate shocks faced by the country make the situation more crucial. Besides, noncommunicable diseases (NCDs), mainly cardiovascular diseases, chronic respiratory diseases, diabetes and cancer are identified as top killers in Sri Lanka, claiming unhealthy diet as one of the four behavioral risk factors. Therefore, the development of healthy food products/meal plans utilizing selected agricultural commodities which are proven to show high postharvest losses during the recent past would be immensely helpful to sustain the food and nutritional security of the country while providing functional food ingredients to conquer the common NCDs. Three major agricultural crops jack, banana and pumpkin which are highly nutritious but are reported to have high postharvest losses in the recent past, were identified here for value addition. Jack is available as a home garden crop, especially in rural communities and due to a lack of knowledge on postharvest management and processing it is considered an underutilized fruit crop. High economic gain throughout the year has attracted Sri Lankan farmers to banana cultivation, especially 'ambul' variety on a commercial scale. Banana is a highly perishable crop owing to high moisture content and the climacteric nature of the crop. Therefore, poor postharvest handling, improper transportation and lack of value addition in the local context could lead to high postharvest loss of this commodity during the glut period. However, there is a potential to develop new food products suitable for infants and the elderly population by considering the high fiber content

and nutritional value of this commodity. Pumpkin is the other crop that has gained attention recently. Due to the unexpected harvest, there is a potential to have excess production in the future. It is important to scale up the healthy and highly nutritious value-added products developed in a laboratory scale, utilizing pumpkin and introduce them to local and export markets. High daily wheat flour consumption which is detrimental to human health can be reduced and replaced by developing proper value-added meals/products from the above commodities. Other than that new product developments using king coconut (*Cocos nucifera* var. aurantiaca), which has high export potential and nutritional value were also considered. Therefore, technological and quality product development, guaranteeing continual market and supply chain management together with increased awareness on the importance of healthy food consumption or meal plans utilizing jack, banana, and pumpkin were targeted in this project. The innovative value-added products developed will contribute to fulfilling the nutritional gaps of the local community while increasing foreign exchange earnings through strategic marketing.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Minimally processed product technologies were successfully developed by conducting both laboratory-scale and pilot-scale trials. Cold chain management procedures for the above minimally processed products were developed. Nutritional and other quality related analysis were performed and technology transfer activities were done to SMEs.
  - Minimally Processed Mature Jack
  - Minimally Processed Ripe Jack (Waraka)
  - Minimally Processed Polos (immature Jack)
  - Minimally Processed Polos mallum
  - Minimally Processed Jack seed
  - Minimally Processed Banana blossom (Kesel muwa)
  - Minimally Processed Ash plantain (Alu Kesel) fruit
  - Minimally Processed Ash plantain peel
  - Minimally Processed Pumpkin
  - Minimally processed King coconut (shaved nuts)
- Frozen fruit and vegetable technology for the above mentioned (minimally processed) products also been developed.
- Maturity index development, quality analysis of water and meat at different stages of maturity of King coconut and minimal processing (shaved nuts) and water bottling technology with flesh were developed.
- Pumpkin/Jack/Banana/King coconut-based value-added processed food product technology development.
- **Jack – technology optimization and scaled-up**
  - Polos in brine/Polos mallum in brine (Bottled or Canned)
  - Jack fruit pieces (Bottled or Canned)
  - Polos pickle (Bottled)
  - Waraka (ripe Jack) in sugar/brine (Bottled or Canned)
  - Jack seed in brine (Bottled or Canned)
  - Kirikos (Mature Jack) - (Bottled or Canned)
  - Polos curry (Bottled or Canned)

- Polos mallum (Bottled or Canned)
- Kalupol maluwa (Jack seeds with spices and scraped coconut paste) - (Bottled or Canned)
- Dehydrated ripe Jack
- Waraka (ripe Jack) leather
- Waraka milk drink (spray-dried powdered)
- Osmotically dehydrated Waraka
- Waraka RTS/Wine
- Combination of Pumpkin flour/Jack flour and Banana flour with legumes-Complementary mix
- Jack papadam
- Jack-based burger patty/sausages
- Product development of vegetarian sausage and burger patty using a combination of Jack, immature Jack and Mushroom was also done.

- Jack seed snacks: Fried Jack seed, Mixtures – Pumpkin seeds/Jack seeds
- **Banana – new innovations**
  - Baby food from Banana puree + green leaves
  - Banana chips fried product
  - Elderly food from Banana
  - Banana flour-based baby food/elderly food
  - Spray-dried drink flour
  - Banana milk
- **Banana Blossom**
  - Bannana Blossom-Bottled / canned in brine
  - Banana Blossom Seeni sambol bottled
  - Dehydrated flour mixtures
- **Pumpkin – new innovations**: A range of pumpkin-based food products were developed with scaled-up studies;
  - Pumpkin leather
  - Pumpkin candy (osmotically dehydrated)
  - Dehydrated Pumpkin and powder
  - Pumpkin soup mixtures
  - Jack/Banana/Pumpkin powder mix
  - Seed snack
  - Pumpkin flour/seed flour
  - Pumpkin puree/paste
  - Pumpkin butter
  - Pumpkin ready to serve drink
    - Alternative flour-based (Banana/Pumpkin/Jack flour) sandwich snack with mushroom filling

- **King coconut**
  - Bottled King coconut water with meat particles (King coconut flesh)
  - King coconut export protocol

- **Technologies Commercialized**
  - Canned Kirikos curry for the export market
  - Osmotically dehydrated Jack
  - Minimally processed Jack fruit
  - Minimally processing of fresh-cut ripe Jack fruit (Waraka)
  - Frozen vegetables and fruits including Jack (immature, mature and ripe, Banana, Banana flower, Pumpkin etc.).
  - Jack and Mushroom-based Vegetarian Burger patty technology transfer.
  - Banana export protocol.
  - Fruits and Vegetables dehydration technology transfer including Jack and Jack flour.
  - King coconut export protocols/King coconut bottling technology.
  - Technology of Pumpkin flour.
  - Young Jack fruit canning technology.

Publications in Refereed Journals

1. Jayasinghe, M.D. and Hewajulige, I.G.N. (2021). King coconut - The golden nut of Sri Lanka, *Sri Lanka Journal of Food and Agriculture*, **7**(1), 9-12 – Review Article
2. Jayasinghe, M.D., Gunasekara, M.M.N.P., Perera, M.G.D.S., Karunarathna, K.D.S.M. Chandrasiri, G.U. and Hewajulige, I.G.N. (2023). Study on compositional changes of king coconut (*Cocos nucifera* var. *aurantiaca)* water and kernel during maturation and evaluation of optimum quality characteristics targeting commercial applications. *Journal of the National Science Foundation of Sri Lanka*, **51**(2), 273-285.

Scientific Communications

1. Jayasinghe, M.D., Gunasekara, M.M.N.P., Perera, M.G.D.S., Chandrasiri, G.U. Karunarathna, K.D.S.M. and Hewajulige, I.G.N. (2021). Compositional changes of king coconut (*Cocos nucifera* var. *aurantiaca*) water and kernel during maturation. *Proceedings of the 41st Annual Sessions*, Institute of Biology, Sri Lanka. p.72.
2. Ruparathna, K.A.M., Amunugoda, P.N.R.J. and Jayasinghe, J.M.J.K. (2021). Comparative study of the nutritional properties of flours from banana, jackfruit, pumpkin and wheat. *Proceedings of the International Research Conference* (VUIRC-2021), Vavuniya University. p.30-33.
3. Ruparathna, K.A.M., Amunugoda, P.N.R.J. and Jayasinghe, J.M.J.K. (2021). Development of an alternative flour-based sandwich snack with mushroom filling. *Proceedings of the International Conference on Applied and Pure Sciences*, Faculty of Science, University of Kelaniya, Sri Lanka. p.203.

Popularization Activities

- Showcased the products at Shilpa Sena Exposition 2019: exhibitions held in BMICH and Pollonnaruwa.
- ITI Open Day in 2019-FTS participated to showcase the newly developed products.
- Awareness and feasibility workshop on fruits and vegetable processing for Bogawanthalawa Plantation Community workers.
- INNO-TECH Exhibition at NSBM, Pitipana, Homagama (12.03.2020).
- Investor's forums conducted after the COVID-19 pandemic situation to popularize ITI products on 27th May 2021 at Gangarama Temple.
- Investor's forums conducted after the COVID-19 pandemic situation to popularize ITI

products on 1st July 2021 at Gangarama Temple.

- Awareness programme on services done by the Food Technology Section to uplift the SMEs at Pollonnaruwa from 10th to 11th September 2019.
- Awareness presentation on "Business opportunities for SMEs with the Industrial Technology Institute" at the Organizations for Professional Association (OPA) on 23rd September 2020.
- Webinar on minimally processed or fresh-cut fruits and vegetable products industry: overview and challenges – organized by the Institute of Food Science and Technology Sri Lanka on 18th July 2020.
- International Webinar on the challenge of reducing food loss and waste to improve food security in the global south. Organized by COMSATS. 30th November 2020.
- International Webinar on the Export of fruits and vegetables in reefer containers to Middle Eastern countries. Funded by the European Union. 15th December 2020.
- International Webinar on Boundless opportunities in agriculture during post-COVID-19 – Organized by JASTECA Institute of Management on 24th May 2020.
- Webinar on Impact of COVID-19 on Agriculture– For farmers/ cultivators in the Jaffna peninsula – on 31st May 2020.
- Webinar on great opportunities in agriculture - Discussion on benefits needed by stakeholders in agriculture. Organized by The Chamber of Commerce on 16th May 2020.

HERBAL TECHNOLOGY

The Industrial Technology Institute plays a key role in supporting Sri Lanka's growing natural products sector through advanced herbal technology research and innovation. Our multidisciplinary expertise drives the development of high-quality herbal drugs, cosmetics, and wellness products, combining traditional knowledge with modern science.

Through demand-driven research, technology transfers, consultancy services, and industry-focused training, ITI helps to strengthen local and export markets. State-of-the-art facilities enable comprehensive testing for safety, quality, and compliance, ensuring herbal products meet national and international standards.

Research and development for scientific validation of health benefits of Ceylon Cinnamon

Grant Nos: TG 11 -47, TG 11-48, TG 11-60, TG 15-107
Project Team: *Prof. G.A.S. Premakumara
Mr. K.R. Dayananda
Dr. H.D. Weeratunge
Dr. (Ms.) W.P.K.M Abeysekera
Dr. S. K. Ganegamage
Dr. P. Ranasinghe
Project Period: 2011 - 2015
Funded by: Sri Lanka Treasury

Branding Ceylon Cinnamon

Grant No: TG -11 - 47A
Project Team : *Dr. (Ms.) S. Senaratne
Mr. V. Weerasekera
Project Period: 2011-2013
Funded by: Sri Lanka Treasury

Development of skin whitening & anti-aging cream & moisturizer from Ceylon Cinnamon

Grant No: TG 14-0-01
Project Team : *Dr. (Ms.) W.P.K.M. Abeysekara
Prof. G.A.S. Premakumara
Ms. P.I.P.K. Fernando
Project Period: 2014 - 2015
Funded by: Sri Lanka Treasury

**Principal Investigators*

Background

Cinnamon is one of the first traded, most popular and useful spices worldwide. Among several species of cinnamon, Ceylon Cinnamon (*Cinnamomum zeylanicum* Blume) is the true Cinnamon and has gained a high reputation and demand in international trade since ancient times. ITI has been engaged in R&D and value addition to Cinnamon since 1955, the establishment of the institute. Research on the establishment of genetic barcoding information in the name of *Cinnamomum zeylanicum* was done from 2011 to 2015. Since there is a synonym as *Cinnamomum verum*, it was beneficial to Sri Lanka to establish the scientific authenticity of *Cinnamomum zeylanicum* as the name implies Cinnamon's unique inheritance to Ceylon. This was the initial study conducted towards obtaining Geographical Indication (GI) for Ceylon Cinnamon, by upholding scientific and genetic authenticity over other competitors under the name "zeylanicum".

Besides being a spice in nature, Ceylon Cinnamon has been used as a medicine in the Sri Lankan traditional system of medicine. Some of the traditional medicinal claims of Ceylon Cinnamon have been scientifically validated in several research studies, particularly at the international level. However, reported health benefits are doubtful since the experimental Cinnamon samples are not properly authenticated. Further, some reported findings are available even without mentioning the *Cinnamomum* species used. On the other hand, within the country, there are no in-depth studies on the health benefits of authenticated Ceylon Cinnamon, even

though it is the most economical minor agricultural crop in Sri Lanka. Moreover, reported health benefits are mostly for the bark of Ceylon Cinnamon and scientific validation on the health benefits of the leaf of Ceylon Cinnamon remains obscure even though the leaf is also reported to possess a number of health benefits in Sri Lankan traditional medicine and in folklore. In this connection, this study was undertaken for a comprehensive and comparative investigation and scientific validation of the medicinal properties of both bark and leaf of Ceylon Cinnamon using a range of biological activities. Ceylon Cinnamon-related research and development activities were conducted at ITI to;

- Enhance the International Image for Ceylon Cinnamon
- Establishment of the latest GC fingerprint for Ceylon Cinnamon bark oil
- Establishment of the latest LC-MS fingerprints for water, ethanol and acetone extracts of Ceylon Cinnamon bark
- Establishment of the database for Ceylon Cinnamon bark oils to establish a geographical indication of Ceylon Cinnamon.

Cinnamon bark as well as other Cinnamon products have wide applications in perfumery, pharmaceutical and essence industries other than the food industry. However, it is not well investigated worldwide in the cosmetic industry as skin whitening and anti-aging creams, moisturizers and lotions etc. Evaluation of the bioactivities of Ceylon Cinnamon was commenced at ITI in 2012 under TG 11-60. Ceylon Cinnamon bark and leaf extracts were evaluated for anti-tyrosinase, anti-elastase, anti-collagenase, anti-hyaluronidase and sun protection ability under TG-14-0-01. Based on the research findings, Cinnamon-based cosmetic products were developed.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Barcoding of six species of Cinnamon native to Sri Lanka.
- Publishing all the barcoded species in the National Center for Biotechnology Information (NCBI), USA webpage;

  Cinnamomum sp. matK gene - GenBank Accession number: JN988465
  Cinnamomum dubium matK gene - GenBank Accession number: JQ843683
  Cinnamomum rivulorum matK gene - GenBank Accession number: JQ843684
  Cinnamomum sinharajaense matK gene - GenBank Accession number: JQ843685
  Cinnamomum citriodorum matK gene - GenBank Accession number: JQ843686
  Cinnamomum cappara-coronde matK gene - GenBank Accession number: JQ843688
  Cinnamomum sp. rbcL gene - GenBank Accession number: JN988468
  Cinnamomum dubium rbcL gene - GenBank Accession number: JQ843678
  Cinnamomum rivulorum rbcL gene - GenBank Accession number: JQ843679;
  Cinnamomum sinharajaense rbcL gene - GenBank Accession number: JQ843680
  Cinnamomum citriodorum rbcL gene - GenBank Accession number: JQ843681
  Cinnamomum cappara-coronde rbcL gene - GenBank Accession number: JQ843682
- Contribution to enhancing the international image of Ceylon Cinnamon bark oil by providing the technology for exporting better quality Cinnamon bark oil to the international market.
- Contribution to increase Cinnamon exports including Cinnamon quills and bark oil.
- Publications on Ceylon Cinnamon bark oil analysis results with a geographical indication which unique to Sri Lanka.

- GC-MS database of Ceylon Cinnamon bark oils extracted from different districts as well as different forms of Cinnamon.
- Authentic Ceylon Cinnamon bark oil bank as a reference material.
- Capacity building in GC and GC-MS analysis.
- Scientific validation of traditional claims on medicinal properties of the bark of Ceylon Cinnamon.
- Scientific validation of traditional claims on medicinal properties of the leaf of Ceylon Cinnamon.
- Bioactivity research results showed potent anti-elastase, anti-collagenase and moderate anti-tyrosinase and anti-hyaluronidase activities and sun protection ability of Ceylon Cinnamon. Those were the first reports on whitening and skin anti-aging properties of Ceylon Cinnamon worldwide.
- Moreover, these novel findings indicated the potential for developing skin whitening and anti-aging products from the bark and leaf of Ceylon Cinnamon.

Products Developed or Commercialized

- Technology was established to distill different grades of Ceylon Cinnamon bark oil as per the international requirement by varying the composition of Cinnamon raw material.
- Cinnamon-based cosmetics (body wash, shampoo etc.).
- Skin whitening and anti-aging cream.
- Skin whitening and anti-aging moisturizer.
- Cinnamon nutraceutical capsule with clinical trial data.
- Cinnamon tea.
- Cinnamon drink- carbonated.
- Cinnamon nano silver incorporated body wash.

Cinnamon Based Products

Publications in Refereed Journals

1. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2013). *In vitro* antioxidant properties of bark and leaf extracts of Ceylon Cinnamon (*Cinnamomum zeylanicum* Blume). *Tropical Agricultural Research*, **24** (2), 128-138.
2. Ranasinghe, P., Pigera, S., Premakumara, G.A.S., Galappaththy, P., Constantine, G.R. and Katulanda, P. (2013). Medical properties of 'true cinnamon' (*Cinnamomum zeylanicum*): a systematic review. *BMC Complementary and Alternative Medicine*, **13**, 275.
3. Arachchige, S.P.G., Abeysekera, W.P.K.M. and Ratnasooriya, W.D. (2017). Anti-amylase, anti-cholinesterases, anti-glycation and glycation reversing potential of bark and leaf of Ceylon Cinnamon (*Cinnamomum zeylanicum* Blume) *in vitro. Evidence Based Complementary and Alternative Medicine,* Article ID 5076029.
4. Abeysekera, W.P.K.M., Arachchige, S.P.G. and Ratnasooriya, W.D. (2017). Bark extracts of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) possess antilipidemic activities and bind bile acids *in vitro. Evidence Based Complementary and Alternative Medicine,* Article ID 7347219.
5. Ranasinghe, P., Jayawardena, R., Pigera, S., Wathurapatha, W.S., Weeratunge, H.D. *et. al.* (2017). Evaluation of pharmacodynamic properties and safety of *Cinnamomum zeylanicum* (Ceylon cinnamon) in healthy adults: a phase I clinical trial, *BMC Complementary and Alternative Medicine*, **17**(1), 550.
6. Ranasinghe, P., Galappaththy, P., Constantine, G.R., Jayawardena, R., Weeratunge, H.D., Premakumara, S. and Katulanda, P. (2017). *Cinnamomum zeylanicum* (Ceylon cinnamon) as a potential pharmaceutical agent for type-2 diabetes mellitus: study protocol for a randomized controlled trial. *Trials*, **18** (1), 446.
7. Ranasinghe, P., Jayawardena, R., Premakumara, G.A.S., Katulanda, P.,Constantine, G.R. and Galappaththy, P. (2017). Evaluation of pharmacodynamic properties and safety of *Cinnamomum zeylanicum* (Ceylon Cinnamon) in healthy adults: Study protocol for a phase I clinical trial. *MOJ Bioequivalence & Bioavailability*, **3**(2), 28-32.
8. Abeysekera, W.P.K.M., Arachchige, S.P.G., Abeysekera, W.K.S.M., Ratnasooriya, W.D. and Medawatta, H.M.U.I. (2019). Antioxidant and Glycemic Regulatory Properties Potential of different maturity stages of leaf of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) *in vitro*. *Evidence-Based Complementary and Alternative Medicine*, Article ID 2693795.
9. Abeysekera, W.P.K.M., Premakumara, G.A.S., Ratnasooriya, W.D. and Abeysekera, W.K.S.M. (2022). Anti-inflammatory, cytotoxicity and antilipidemic properties: novel bioactivities of true cinnamon (*Cinnamomum zeylanicum* Blume) leaf. *BMC Complementary Medicine and Therapies*, **22**, 259.

Scientific Communications

1. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2012). *In vitro* antioxidant properties of bark and leaf extracts of Ceylon Cinnamon (*Cinnamomum zeylanicum* Blume). *Proceedings of the 24th Annual Congress*, Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka. p.13.
2. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2012). *In vitro* antioxidant properties of bark and leaf extracts of Ceylon Cinnamon (*Cinnamomum zeylanicum* Blume). *Proceedings of the 3rd International Conference*, South Asian Association of Physiologists (SAAP-3), Sri Lanka. p.69.

3. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2013). Anti-elastase activity of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume): A novel skin anti-aging property. *Proceedings of the 69th Annual Sessions*, Sri Lanka Association for the Advancement of Science, Sri Lanka. p.92.
4. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2013). Glutathione S –Transferase enzyme inhibitory activity of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume). *Proceedings of the Annual Research Symposium*, University of Colombo, Sri Lanka. p.185.
5. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2013). *In vitro* anti-diabetic properties of bark and leaf of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume), *Proceedings of the Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.92.
6. Abeysekera, W.P.K.M., Ranasinghe, P. and Premakumara, G.A.S. (2013). Anti-genotoxic potential of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume), *Proceedings of the Annual Sessions*, Young Scientists Forum, Sri Lanka. p.2.
7. Weeratunge, H.D., Premakumara, G.A.S. and Dayananda, K.R. (2013). Investigation of coumarin levels in different grades of Ceylon cinnamon. *Proceedings of the 42nd Annual Sessions*, Institute of Chemistry Ceylon, *Chemistry in Sri Lanka.* **30** (2), p.22.
8. Weeratunge, H.D. and Premakumara, G.A.S. (2013). Comparative study of coumarin levels in Ceylon cinnamon (*Cinnamomum zeylanicum*) and Cassia (*Cinnmomum cassia*). *Proceedings of the World Congress on Pharmaceutical Science & Chemical Technology*. p. 35.
9. Weeratunga, H.D., Ganegamage, S.K. and Premakumara, G.A.S. (2014). Comparative Study of Ceylom Cinnamon (*Cinnamomum zeylanicum*) bark oils extracted from different foams of Ceylon cinnamon bark. *Proceedings of the Annual Sessions*, Institute of Biology, Sri Lanka.p.31.
10. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2014). *In vitro* lipase, cholesterol esterase and cholesterol micellization inhibitory activities of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume*). Proceedings of the 7th International Research Conference*, General Sir John Kotelawala Defence University, Sri Lanka. p.53.
11. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2014). Methylglyoxal mediated protein glycation inhibitory activity of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume). *Proceedings of the 70th Annual Sessions*, Sri Lanka Association for the Advancement of Science, Sri Lanka. p.31.
12. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2014). *In vitro* lipase, cholesterol esterase and cholesterol micellization inhibitory activities of leaf and bark of *Cinnamomum zeylanicum* Blume (Ceylon cinnamon). *Proceedings of the Annual Sessions*, Young Scientists Forum, Sri Lanka. p.1.
13. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2015). Glycemic regulatory properties of stem bark and leaf of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) *in vitro*. *Proceedings of the 8th International Research Conference*, General Sir John Kotelawala Defence University, Sri Lanka. p.157.
14. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2015). Anti-cholinesterase activity of bark and leaf of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) *in vitro. Proceedings of the 71st Annual Sessions*, Sri Lanka Association for the Advancement of Science, Sri Lanka. p.46.

15. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2015). Nitric oxide and superoxide radical scavenging activity of bark and leaf of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) *in vitro*. *Proceedings of the 35th Annual Sessions*, Institute of Biology, Sri Lanka. p.50.
16. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2016). Bark of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume): A potential natural product for novel hypolipidemic functional foods and nutraceuticals. *Research Summit*, National Science Foundation, Sri Lanka. p.81.
17. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2016). Proanthocyanidins and selected phenolic and non phenolic compounds in bark and leaf of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume). *Proceedings of the 72nd Annual Sessions*, Sri Lanka Association for the Advancement of Science, Sri Lanka. p.96.
18. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2016). Growth inhibition and cytotoxicity of leaf extracts of Ceylon cinnamon (*Cinnamomum zeylanicum*) on human breast carcinoma (MCF 7) and hepatocarcinoma ($HepG_2$) cell lines, *Proceedings of the Annual Research Symposium*, University of Colombo, Sri Lanka. p.257.
19. Gayanthika, M.R.U., Godakumbura, P.I., Weerathunga, H.D. and Abeysekera, W.P.K.M. (2016). Investigation of Ceylon cinnamon bark extracts for health promoting properties as nutraceutical agent. *Proceedings of the 2nd Symposium of BSc. [Honors] Degree in Applied Sciences, Symposium*, University of Sri Jayewardenepura, Sri Lanka. p.42.
20. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2016). Anti-inflammatory activity of bark of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume). *Proceedings of the 9th International Research Conference*, General Sir John Kotelawala Defence University, Sri Lanka. p.260.
21. Medawatta, H.M.U.I., Abeysekera, W.P.K.M., Premakumara, G.A.S., Peiris, M.D.P.M. and Abeysekera, W.K.S.M. (2017). Antioxidants and antioxidant activity of different maturity stages of leaf of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) *in vitro*. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.15-16.
22. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2018). Bark extracts of Ceylon cinnamon potentiate growth inhibition and cytotoxicity in human breast carcinoma (MCF 7), hepatocarcinoma ($HepG_2$) and endometrial carcinoma (AN3CA) cell line. *Proceedings of the Annual Research Symposium*, Faculty of Nursing, University of Colombo, Sri Lanka. p.200.
23. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2019). Skin whitening and anti-aging potential of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume), *Proceedings of the Annual Research Symposium*, Faculty of Nursing, University of Colombo, Sri Lanka.p.194.
24. Binuwangi, A.K.D.M., Abeysekera, W.P.K.M., Abeysekera, W.K.S.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2019). *In vitro* anti-diabetic potential of bark of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) using yeast cells glucose uptake assay, *Proceedings of the 39th Annual Sessions*, Institute of Biology, Sri Lanka. p.59.
25. Medawatta, H.M.U.I., Ranasinghe, P., Weerathunga, H.D., Abeysekera, W.P.K.M., Premakumara, G.A.S., Samaraweera, D.N. and Jayasinghe, G.G. (2021). Antioxidant properties of Sri Gamunu bark (*Cinnamomum zeylanicum* Blume) high yielding Cinnamon variety developed in Sri Lanka: an *in vitro* study. *Proceedings of the 5th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.6.

26. Medawatta, H.M.U.I., Ranasinghe, P., Weerathunga, H.D., Abeysekera, W.P.K.M., Premakumara, G.A.S., Samaraweera, D.N. and Jayasinghe, G.G. (2021). Antioxidants and antioxidant activity of leaf of Sri Gemunu and Sri Wijeya (*Cinnamomum zeylanicum* Blume) high yielding cinnamon varieties in Sri Lanka. *Proceedings of the International Conference on Innovation and Emerging Technologies* (ICIET), University of Sri Jayewardenepura, Sri Lanka. p.119.
27. Weeratunge, H.D., Senevirathne, I.G.N.H., Abeysekera, W.P.K.M., Premakumara, G.A.S. and W.K.S.M. Abeysekera (2021). Antioxidants and antioxidant activity of H grade bark of Ceylon Cinnamon (*Cinnamomum zeylanicum* Blume), *Proceedings of the 41st Annual Sessions*, Institute of Biology, Sri Lanka. p.54.
28. Alagiyawanna, A.M.A.D.S., Ranasinghe, P., Abeysekera, W.P.K.M., Medawatta, H.M.U.I., Premakumara, G.A.S., Jayasinghe, G.G. and Samaraweera, D.N. (2022). Antioxidants and antioxidant activity of stem bark and leaf of Sri Gemunu and Sri Wijeya cinnamon varieties in Sri Lanka. *Proceedings of the International Conference on Innovation and Emerging Technologies*, (ICIET), Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka. p.75.
29. Nethsharaa, H.A.D., Weerathunga, H.D. and Abeysekera, W.P.K.M. (2022). Method validation and quantification of coumarin content in different grades of quills of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume). *Proceedings of the International Conference on Innovation and Emerging Technologies*, (ICIET), Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka. p.76.

Book chapters

1. Premakumara, G.A.S. and Abeysekera, W.P.K.M. (2020), Chapter 12: Pharmacological properties of Ceylon cinnamon. In: *Cinnamon: Botany, Agronomy, Chemistry and Industrial Applications*. Springer Nature Switzerland AG Gewerbestrasse 11, 6330 Cham, Switzerland.
2. Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2018). Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) In: *Nutritional and Health Benefits of Selected Food Crops of Sri Lanka: A Concise Compilation of Scientific Findings*. Institute of Biology, Sri Lanka, p.41-62.

Postgraduate Degree

1. Ms. W.P.K.M Abeysekera, obtained a PhD from the University of Colombo in 2018.
   Thesis title: Assessment of some potential health benefits of Sri Lankan cinnamon, *Cinnamomum zeylanicum* Blume (*Cinnamomum verum* Presl) by studying selected bioactivities.

Awards

1. Best Oral Presentation at 24th Annual Congress of Postgraduate Institute of Agriculture, University of Peradeniya for the paper: Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2012). *In vitro* antioxidant properties of bark and leaf extracts of Ceylon Cinnamon (*Cinnamomum zeylanicum* Blume).
2. Best Oral Presentation at Biennial Research Symposium of Industrial Technology Institute for the abstract: Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2013). *In vitro* anti-diabetic properties of bark and leaf of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume).

3. Merit Certificate for Oral Presentation at Young Scientist Forum for the extended abstract: Abeysekera, W.P.K.M., Premakumara, G.A.S. and Ratnasooriya, W.D. (2014). *In vitro* lipase, cholesterol esterase and cholesterol micellization inhibitory activities of leaf and bark of *Cinnamomum zeylanicum Blume* (Ceylon cinnamon).
4. Prize for Excellence in Agricultural Research 2019, 1st prize in the plantation sector in consideration of the research on "Bioactivity of Ceylon Cinnamon" organized by the Council for Agricultural Research Policy (CARP) - W.P.K.M. Abeysekera and G.A.S Premakumara.
5. GRC Post Graduate Research Award 2020 presented by the Sri Lanka Association for Advancement of Science (SLAAS) – W.P.K.M. Abeysekara.

Popularization Activities

- Health benefits of 'True cinnamon' Ceylon cinnamon in Vidya magazine of Daily News paper (31.01.2018).
- Medicinal properties of Ceylon cinnamon in Silumina newspaper (09.09.2018).
- W.P.K.M. Abeysekera, *Cinnamomum zeylanicum* Blume (Ceylon cinnamon): A multifaceted Medicinal Spice, Institute of Biology (IOB), Bio news. 1(2), 2021.

NCBI GenBank submissions

- Twelve sequences are deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Development of *Bacillus thuringiensis* (Bt) microbial pesticide series to control pests in Sri Lanka

Biological control of Strawberry and vegetable pests

Grant No: FP 98, TG 11-46
Project team: *Prof. (Ms.) J.K.R.R. Samarasekara
Dr. D.A.S. Siriwardena
Project Period: 2011 -2012
Funded by: Bio Power Lanka (Pvt) Ltd, Sri Lanka
Sri Lanka Treasury

Development of *Bacillus thuringiensis* (Bt) microbial pesticide with enhanced and broad spectrum activity to control rice and vegetable pests

Grant No: FP 99
Project team: *Prof. (Ms.) J.K.R.R. Samarasekara
Prof. O.V.D.S.J. Weerasena
Project Period: 2012 -2016
Funded by: National Science Foundation, Sri Lanka

Molecular and biochemical characterization of *Bacillus thuringiensis* isolates with insecticidal activity

Grant No: FP 124
Project team: *Prof. (Ms.) J.K.R.R. Samarasekara
Prof. O.V.D.S.J. Weerasena
Dr. (Ms.) R.Y. Baragamaarachchi
Project Period: 2017 -2019
Funded by: National Science Foundation, Sri Lanka

Development of *Bacillus thuringiensis* (Bt) microbial pesticide to control rice pests

Grant No: TG 16-121
Project team: *Prof. (Ms.) J.K.R.R. Samarasekara
Dr. A.P. Benthota
Dr. Sarathchandra Perera
Project Period: 2016 -2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The bio-pesticide formulations were developed from the bacteria *Bacillus thuringiensis kurstaki* (*Btk*) and *Bacillus thuringiensis jegathesan* (*Btj*) strains to be used against lepidopteran pests that harm rice and vegetable cultivations in Sri Lanka. *Bacillus thuringiensis*, a gram-positive spore-forming bacterium, produces insecticidal crystalline proteins (cry), cytolytic proteins (cyt) and vegetative proteins (vip) which contribute to its pathogenicity to lepidopteron pests. The products contain 5-20% biological components i.e., *Btk*or *Btj* primary powder. This is a viable alternative to hazardous chemical pesticides.

Project Achievements/Outcomes
Technologies/Processes/Methods Developed

- Eighteen indigenous insecticidal *Bt* strains containing insecticidal parasporal crystals were isolated and identified.
- This study introduced a novel, rapid and efficient isolation technique of *Bt* strains from environment samples followed by chromogenic identification.
- Gyrase B gene sequencing characterized that 18 *Bt* strains belong to subspecies, *kurstaki*, *graciosensis, konkukian, jegathesan, morisoni*, *aizawai, poloniensis, kenyae*, and is the first report of isolating these *Bt* subspecies from Sri Lanka.
- Identified *Bt kurstaki* and one *Bt jegathesan* strain with higher insecticidal activity against rice leaf folder at the laboratory and field level.
- Most of the *Bt* strains were identified as chitinase producers through qualitative and quantitative detection assays and strain *B. kurstaki* as the highest chitinase producer. These strains also showed fungicidal activity against *F. oxysporum* and *A. alternate*.
- Insecticidal bioassays showed that *Bt* strains, *B.kurstaki* and *B. jegathesan* are insecticidal against rice leaf folder and strain *B. kurstaki* showed the highest insecticidal activity.
- Preliminary field bioassay of inverted oil formulations of *B. kurstaki* and *B. jegathesan* showed the highest population reduction against rice leaf folder after 18 days of treatment. None of the tested *Bt* strains showed insecticidal activity against hemipteran pests *N. lugens* and *L. oratorius*.
- Identified indigenous *Bt kurstaki* and one *Bt jegathesan* Sri Lankan strain with higher insecticidal activity against the lepidopteran pest, Rice Leaf Folder.
- These *Bt* strains showed good insecticidal activity at the laboratory and field level against Rice Leaf Folder.
- This is the first report of insecticidal activity of Sri Lankan *Bt* strains for rice and vegetable lepidopteron pests.

Technology Developed

- The microbial bio-pesticide products containing bacteria *Bacillus thuringiensis kurstaki* (*Btk*) and *Bacillus thuringiensis jegathesan* (*Btj*) for rice pests.

Publications in Refereed journals

1. Baragamaarachchi, R.Y., Samarasekera, J.K.R.R., Weerasena, O.V.D.S.J., Lamour, K. and Jurat-Fuentes, J. (2019). Identification of a native *Bacillus thuringiensis* strain from Sri Lanka active against Dipel-resistant *Plutella xylostella*. *PeerJ*, DOI 10.7717/peerj.7535.

Scientific Communications

1. Baragamaarachchi R.Y., Weerasena O.V.D.S.J. and Samarasekera, R. (2016). Evaluation of insecticidal activity of Sri Lankan *Bacillus thuringiensis kurstaki* against *Plutella xylostella* and *Cnaphalocrocis medinalis*. *Proceedings of the 72nd Annual Sessions,* Sri Lanka Association for the Advancement of Science. p.15.
2. Baragamaarachchi, R.Y., Weerasena, O.V.D.S.J. and Samarasekera, R. (2016). Screening of novel chitinolytic *Bacillus thuringiensis* strains isolated from Sri Lankan soil. *Proceedings of the 8th Annual Scientific Sessions,* Institute of Biochemistry, Molecular Biology & Biotechnology, University of Colombo. p.25.

3. Baragamaarachchi, R.Y., Vidanapathirana, A.C., Weerasena, O.V.D.S.J., Samarasekara, R. and Nishantha, K.M.D.W.P. (2016). Sri Lankan *Bacillus thuringiensis* isolates with insecticidal and chitinase activity, *NSF Research Summit 2016, "Empowered by Research & Innovation"*. p.88.
4. Baragamaarachchi, R.Y., Samarasekara, R., Sarathchandra, S.R. and Weerasena, O.V.D.S.J. (2017). Entomocidal activity of native strains of *Bacillus thuringiensis kurstaki* against rice pest *Cnaphalocrocis medinalis*. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.26-27.
5. Baragamaarachchi, R.Y., Samarasekara, R. and Weerasena, O.V.D.S.J. (2017). Evaluation of chitinase activity of Sri Lankan *Bacillus thuringiensis* strains. *Proceedings of the 73rd Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.38.
6. Samarasekera, R., Baragamaarachchi, R.Y., Weerasena O.V.D.S.J., Nishantha, P. and Bentota, A. (2017). Insecticidal *Bacillus thuringiensis* Sri Lankan strains and its applications in controlling vegetable and rice pests. *Proceedings of the 3rd International Conference on Agriculture, Food Security and Biotechnology*, organized COMSATS, Islamabad, Pakistan. p.13-14.
7. Pathmanathan, N., Samarasekara, R., Baragamaarachchi, R.Y. and Weerasena, O.V.S.J. (2018). Conjugative plasmid transfers between insecticidal strains of *Bacillus thuringiensis*: Use of antibiotic resistance traits to detect transconjugants, *Proceedings of the 5th International Conference on Multidisciplinary Approaches*. p.173.
8. Baragamaarachchi, R.Y., Samarasekara, J.K.R.R., Weerasena, O.V.D.S.J. and Jurat-Fuentes, J.L. (2019). *Bacillus thuringiensis* strain from Sri Lanka with insecticidal activity against *Plutella xylostella* and *Cnaphalocrocis medinalis*. *Proceedings of the International Conference*, Sri Lanka Academy of Young Scientists (SLAYS), Sri Lanka. p.14.

Postgraduate Degrees

1. Mr. D.A.S. Siriwardena obtained a PhD from the University of Peradeniya in 2011.
   Thesis Title: Microbial Insecticides from *Bacillus thuringiensis* and Fungal Metabolites from *Hirsutella thompsonii.*
2. Ms. Rashini Baragamaarachchi obtained a PhD from the University of Colombo in 2020.
   Thesis Title: Molecular characterization of *Bacillus thuringiensis* isolates from Sri Lanka with insecticidal activity against *Plutella xylostella* and *Cnaphalocrocis medinalis*.

Awards

1. Best Poster Award 2016– for the poster "*Bacillus thuringiensis* isolates with insecticidal and chitinase activity" at the National Science Foundation Research Summit 2016 - J.K.R.R. Samarasekara.

Establishment of quality control and standardization parameters for Asamodagam spirit

Grant No: FP 92
Project Team: *Prof. G.A.S. Premakumara
Dr. (Ms.) L.D.A.M. Arawwawala
Dr. (Ms.) S. Chelvendran
Project Period: 2011 – 2013
Funded by: Department of Ayurveda, Sri Lanka

**Principal Investigator*

Background

"Asamodagam spirit" is an herbal preparation that is given to children as a remedy for gastrointestinal problems. The water distillate of *Trachyspermum ammi* (Family: Apiaceae; Sinhala name: Asamodagam; Sanskrit name: Ajamoda) fruits is used to prepare "Asamodagam spirit". Thymol (39.1%) was found to be the major component in the essential oil of *T. ammi* fruits, along with *p*-cymene (30.8%), γ-terpinene (23.2%), β-pinene (1.7%), and terpinene-4-ol (0.8%). Therefore, some of these compounds, including thymol may be present in the water distillate of *T. ammi* fruits. However, some drug manufacturers dissolve thymol crystals in water and market the formulation as "Asamodagam spirit", without proper quality control and other standardized practices. Although thymol has antimicrobial and antiseptic properties, it also causes irritation to the skin, eyes and respiratory tract and affects the central nervous system, when recommended concentrations are exceeded. This issue has been brought to the notice at several forums as a serious health issue. However, it has not surfaced so far because "Asamodagam spirit" is given to children, thus the consequences have not properly surfaced. Moreover, since these preparations are freely available as shelf-top, over-the-counter, and non-prescription medication for children, it is given to children without proper medical advice. Therefore, it is a timely need to develop quality control and standardization parameters for this pediatric medication.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Established standardization techniques for Asamodagam spirit.
- Designed a lab-scale distillation unit to prepare natural Asamodagam spirit.

Publications in Refereed Journals

1. Premakumara, G.A.S., Kathirgamanathar, S., Thayalini, T., Bandara, V.S., Thevanesam, V. and Arawwawala, L.D.A.M. (2016). Antibacterial activity and chemical analysis of fruit oil of *Trachyspermum ammi* Linn. Sprague. *Journal of Ayurvedic and Herbal Medicine,* **2**, 117-119.

Scientific Communications

1. Premakumara, G.A.S., Kathirgamanathar, S., Arawwawala, L.D.A.M. and Bandara, V.S. (2013). Standardization of Asamodagam spirit from *Trachyspermum ammi. Proceedings of the Annual Research Symposium,* Industrial Technology Institute, Sri Lanka. p.28.

Establishment of quality standards for the authentication of controversial endemic/rare herbal plants of *Rauvolfia serpentina*, *Rauvolfia densiflora*, *Munronia pinnata, Andrographis paniculata,Withania somnifera* and *Ruelia tuberosa*

Grant No: FP 94
Project Team: *Prof. R.M. Dharmadasa
Prof. G.A.S. Premakumara
Dr. (Ms.) D. Senasekera
Project Period: 2013-2016
Funded by: Department of Ayurveda, Sri Lanka

**Principal Investigator*

Background

Adulteration and substitution are mainly practiced with the intention of enhancing profit. However, the process of substitution or adulteration may adversely affect the quality, safety, and efficacy of herbal drugs and subsequently their therapeutic properties. Therefore, the present study was undertaken to establish a comparative quality standard based on morphological, anatomical, powder microscopical, phytochemical, physicochemical and bioactivity of selected controversial medicinal plants in order to streamline the proper use of raw materials in herbal drug preparation. All protocols were adopted from classical texts published. Systematic quality standards were prepared for *Munronia pinnata* (Wall.) Theob. (Meliaceae) with *Andrographis paniculate* (Burm.f.) Wall. Ex Nees (Acanthaceae), *Withania somnifera* (L.) Dunal (Solanaceae) with *Ruellia tuberosa* L. (Acanthaceae), *Rauvolfia serpentina (*L.) Benth. Ex Kurz (Apocyanaceae), *Rauvolfia densiflora* (Wall.) Benth. Ex Hook.f. (Apocyanaceae), *Plectranthus hadiensis* (Forssk.) Schweinf. Ex Sprenger and *Coleus amboinicus* Lour. (Lamiaceae), *Salacia reticulata* Thw. (Celastraceae) with *Salacia chinensis* L. (Celastraceae) by using available published protocols.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Systematic survey on commonly adulterated/substituted materials and selected the most commonly adulterated critically needed species.
- Established protocols for agronomic practices, taxonomic characterization, and phytochemical screenings for all species.

Publications in Refereed Journals

1. Lenora, R.D.K., Dharmadasa, R.M., Abeysinghe, D.C. and Arawwawala, L.D.A.M. (2012). Comparison of chemical profiles and plumbagin contents under different growing systems. *Pharmacologia,* **3**(2), 57-60.
2. Fernando, I.D.N.S., Dharmadasa, R.M. and Abeysinghe, D.C. (2013). Determination of phenolic contents and antioxidant capacity of different parts of *Withania somnifera* (L.) Dunal. from three different growth stages. *Industrial Crops & Products,* **50**, 537-539.
3. Dharmadasa, R.M., Samarasinghe, K., Adhihetty, P. and Hettiarachchi. P.L. (2013). Comparative pharmacognostic evaluation of *Munronia Pinnata* (Wall.) Theob. (Meliaceae) and its Substitute *Andrographis paniculata* (Burm.f.) Wall. Ex Nees (Acanthaceae). *World Journal of Agricultural Research,* **1**(5), 77-81.

4. Siriwardane, D.A.S., Dharmadasa, R.M. and Samarasinghe, K. (2013). Distribution of withaferin A, an anticancer potential agent, in different parts of two verities of *Withania somnifera* (L.) Dunal. grown in Sri Lanka. *Pakistan Journal of Biological Sciences*, **16**(3), 141-144.
5. Muthukumarana, R. and Dharmadasa, R.M. (2014). Pharmacognostical investigation of *Plectranthus hadiensis* (Forssk.) Schweinf. ex Sprenger. and *Plectranthus amboinicus* (Lour.) Spreng. *World Journal of Agricultural Research*, **2**(5), 240-246.
6. Luxmini, K.P.A.M.K., Dharmadasa, R.M., Samarasinghe, K. and Muthukumarana, P.R.M. (2015). Comparative pharmacognostic study of different parts of *Withania somnifera* and its substitute *Ruellia tuberosa*. *World Journal of Agricultural Research*, **3**(1), 28-33.
7. Keeragalaarachchi, K.A.G.P., Dharmadasa, R.M, Wijesekara, R.G.S. and Kudavidanage, E.P. (2016). Natural antidiabetic potential of *Salacia chinensis* L. (Celastraceae) based on morphological, phytochemical, physico-chemical and bioactivity: A promising alternative for *Salacia reticulata* Thw. *World Journal of Agricultural Research*, **4**(2), 49-55.

Scientific Communications

1. Dharmadasa, R.M., Hettiarachchi, P.L. and Premakumara, G.A.S. (2011). Comparative pharmacognostic studies of *Munronia pinnata* (Wall.) Theob. (Meliaceae) and its substitute/ adulterant *Andrographis panniculata* (Burm.f.) Wall. ex Nees (Acanthaceae). *Proceedings of the 3rd International Conference on Medicinal Plants and Herbal Products.* p.60.
2. Luxmini, K.P.A.M.K., Dharmadasa, R.M. and Samarasinghe, K. (2013). Comparative pharmacognostic aspects of *Withania somnifera* and *Ruellia tuberosa. Proceedings of the 1st International Conference on Unani, Ayurveda, Siddha and Traditional Medicine*. p.36.
3. Fernando, I.D.N.S., Dharmadasa, R.M. and Abeysinghe, D.C. (2013). Phenolic contents and antioxidant capacities of different parts of *Withania somnifera* (L.) Dunal. from three different growth stages. *Proceedings of the 12th Agricultural Research Symposium.* p.160-164.
4. Adhihetty, P., Dharmadasa, R.M., Samarasinghe, K. and Hettiarachchi, P.L. (2013). Phytochemical, physicochemical and antioxidant activity of *Munronia pinnata* (Wall.) Theob. (Meliaceae) and *Andrographis paniculata* (Burm.f.) Wall. Ex Nees (Acanthaceae). *Proceedings of the 69th Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.269.
5. Arachchi, K.A.P.G.K., Kudawidhanage, E.P., Dharmadasa, R.M. (2015). Comparative phytochemical, physicochemical characters, and bioactivity of *Salacia reticulata* Thw. and *Salacia chinensis* L. (Celestraceae). *Proceedings of the Student Research Symposium*, Sabaragamuwa University of Sri Lanka. p.1.
6. Dharmadasa, R.M., Fernando, S.N. and Abeysinghe, D.C. (2017). Effect of different fertilizer levels on physical yield, phenolic content and antioxidant capacity of different parts of *Withania somnifera* from 3 different growth stages. *Proceedings of the 5th ICAUST International Conference*, Colombo, Sri Lanka. p.65.

Award

1. Presidential Award for Scientific Publication -2013 for the paper titled, Determination of phenolic contents and antioxidant capacity of different parts of *Withania somnifera* (L.) Dunal. from three different growth stages. *Ind. Crops Prod.*, **50**, 537-539 - I.D.N.S. Fernando, R.M. Dharmadasa and D.C. Abeysinghe.

Popularization Activities

- Distributed the information gathered from the project to several Ayurveda and Traditional practitioners through ITI workshops.

Phytochemical analysis and antimicrobial activities of Parankipaddai Kudineer (decoction) used in skin diseases

Grant No: FP 97
Project Team: *Dr. (Ms.) S. Chelvendran
Prof. (Ms.) V. Thevanesam
Dr. (Ms.) T. Thileepan
Project Period: 2011 – 2015
Funded by: HTEC Grant, University of Jaffna, Sri Lanka

**Principal Investigator*

Background

The indigenous system of medicine in Sri Lanka consists of Ayurveda, Siddha and Unani. In these systems, the use of most of the plants has been identified and well-documented. However, the efficacy of these plants has still not been fully explored using scientific methods. Parankipaddai decoction is a Siddha Ayurvedic drug, which consists of 13 medicinal plant parts (*Indigofera aspalathoides, Enicostemma littorale, Cassia angustifolia, Azima tetracantha, Zingiber officinale, Piper nigrum, Piper longum, Myristica fragrans, Syzygium aromaticus, Smilax chinensis, Embelia ribes* and *Hyoscyamus niger*) out of which, 7 plants are commonly used to treat all the skin diseases in the Siddha medical system. In order to evaluate the efficacy, the extracts and essential oils of 13 plant parts were screened against 50 spectrum of organisms, sensitive standard organisms (*Staphylococcus aureus* – NCTC 6571, *E coli* – NCTC -10418, *P aeruginosa* – NCTC – 10662); Gram positive cocci (5 clinical Methicillin Resistant *S aureus* (MRSA) MRSA 19, MRSA 18, MRSA 15, MRSA 21, MRSA 16, Vancomycin Resistant *Enterococcus* (VRE 286) and Group A beta – hemolytic *Streptococci*); Gram negative bacilli (Multi Drug Resistant {MDR} *Klebsiella pneumonia* and extended spectrum *β*-lactamase {ESBL} positive *Klebsiella pneumonia, Proteus* spp., *Enterobactor clocae* & *Acinetobactor* spp.) and *Candida* spp (*C tropicalis*ATCC 13803, *C krusei*ATCC 6258, *C albicans* ATCC 90028, *C glabrata*ATCC90030, *C parapsiolsis*ATCC22019, 3 clinical isolates of *C albicans*), which were isolated from the clinics in Peradeniya teaching hospital.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The results revealed that the essential oils obtained from *Syzygium aromaticus* and *Myristica fragrans* showed activity for all the pathogens tested.
- The active ingredients were used to develop a dermal ointment.
- The spectrum of screening of more than 50 pathogens was successfully deposited in the Faculty of Medicine, University of Peradeniya.

Publications in Refereed Journals

1. Thevanesam, T.T.V., Kathirgamanathar, S. and Gamage. T. (2012). Antibacterial activity and preliminary screening of phytochemicals of whole plant of *Enicostemma littorale. Tropical Agricultural Research,* **24**(1), 99-105.
2 Thileepan, T., Thevanesam, V. and Kathirgamanathar, S. (2017). Antimicrobial activity of seeds and leaves of *Myristica fragrans* against multi-resistant microorganisms. *Journal of Agricultural Science and Technology,* A **7**, 302-308.
3 Thileepan, T., Thevanesam, V. and Kathirgamanathar, S. (2018). Anticandidal activity of essential oils of *Myristica fragrans* and *Syzygium aromaticum. Journal of Innovations in Pharmaceutical and Biological Sciences,* **5**(3), 35-38.

Scientific Communications

1. Thayalini. T., Thevanesam, V., Kathirgamanathar, S. and Gamage. T. (2012). Antibacterial activity and preliminary screening of phytochemicals of whole plant of *Enicostimma littorale*. *Proceedings of the 24th Annual Congress of Postgraduate Institute of Agriculture*, University of Peradeniya. p.35.
2. Kathirgamanathar, S., Thayalini, T., Thevanesam, V. and Gamage, T. (2013). Antibacterial activity and preliminary phytochemical screening of decoction of *Indigofera aspalathoides* whole plant. *Chemistry in Sri Lanka*. **30**(2),21.
3. Thayalini, T., Thevanesam, V., Kathirgamanathar, S. and Gamage, T. (2013). Antibacterial activity of decoction and methanolic extract of leaf of *Myristica fragrans* against MRSA. *Proceedings of the Annual Research Symposium*, Industrial Technology Institute. p.22.
4. Thayalini, T., Thevanesam, V., Kathirgamanathar, S. and Gamage, T. (2013). Antibacterial activity of leaf of *Cassia angustifolia* against skin pathogens. *Proceedings of World Congress on Pharmaceutical Sciences & Chemical Technology*, Colombo. p.37.
5. Thayalini, T., Thevanesam, V., Kathirgamanathar, S. and Gamage, T. (2013). Antibacterial activity of the fruit of *Embelia ribes* against skin pathogens. *Proceedings of the Annual Scientific Sessions of the Sri Lankan Society for Microbiology (SSM)*, University of Peradeniya. p.12.
6. Thayalini, T., Thevanesam, V., Kathirgamanathar, S. and Gamage, T. (2013). Comparative study of antibacterial activity and preliminary phytochemical screening of leaves and seeds of *Myristica fragrans. Proceedings of the 1st International Conference of Unani, Ayurveda, Siddha and Traditional Medicine*, University of Colombo. p.28.
8. Thayalini, T., Thevanesam, V., Kathirgamanathar, S. and Gamage, T. (2014). Screening of antimicrobial activity of oil of *Syzygium aromaticum*, IPURSE. *Proceedings of the International Research Sessions*, University of Peradeniya. p.584.
9. Thileepan, T., Thevanesam, V., Kathirgamanathar, S. and Gamage, T. (2014), Determination of Minimum Inhibitory Concentration (MIC) of *Syzygium aromaticum* oil against multi-resistant bacteria and *Candida* using microtiter plate assay. "*National Development through Research and Innovation", Proceedings of the HETC Symposium.* p.65.
10. Thayalini, T., Thevanesam, V., Kathirgamanathar, S., Liyanapathirana, V. and Gamage, T. (2015). Antibacterial activity of decoction and methanolic extracts of the fruit of *Piper longum* against selected pathogens. *Proceedings of the 4th Annual Conference and Scientific Sessions*, Sri Lanka Society for Microbiology (SSM). p.9.
11. Thileepan, T., Thevanesam, T. and Kathirgamanathar, S. (2017) Antibacterial activity of *Parankipaddai Kudineer* (decoction) and its component plants. *Proceedings of the International Symposium on Traditional Medicine and Complementary Medicine*. p.103.

Postgraduate Degrees

1. Ms. Thayalini Thileepan obtained a PhD from the University of Jaffna in 2015.
   Thesis title: Evaluation of Phytochemical analysis and antimicrobial activities of Parankipaddai Kudineer (decoction) used in skin diseases.

Development of a natural gastroprotective agent from *Trichosanthes cucumerina* Linn

Grant No: FP-104
Project team: *Dr. (Ms.) L.D.A.M. Arawwawala
Prof. (Ms.) I. Thabrew
Dr. (Ms.) M. Thammitiyagodage
Dr. (Ms.) R. Karunakaran
Project Period: 2013 – 2016
Funded by: National Research Council, Sri Lanka

**Principal Investigator*

Background

Trichosanthes cucumerina Linn (Family: Cucurbitaceae), locally known as Dummella is commonly found in Asian countries including Sri Lanka. The aerial parts of *T. cucumerina* (T.C) are used as a remedy for gastric ulcers in Sri Lanka. In a previous study, it was found that hot water extract of T.C aerial parts possesses marked gastroprotective properties as evidenced by its potential to inhibit the formation of gastric lesions induced by absolute ethanol in rats. Therefore, the aim of the study was to scientifically evaluate the gastroprotective activity of fractions of the hot water extract of T.C. aerial parts with a view to (a) identifying the fraction with the best gastroprotective activity and the possible mechanism/s by which this fraction exerts gastroprotection, (b) evaluate the safety profile of the fraction and (c) development of a nutraceutical.

Project Achievements/Outcomes

- Gastroprotective activity of hexane fraction (HF), ethyl acetate fraction (EF), butanol fraction (BF) and aqueous fraction (AF) of *Trichosanthes cucumerina* hot water extract was evaluated.
- EF showed the maximum gastroprotection effect, followed by BF and AF. Further, EF (75 mg/kg) exhibited a significantly higher gastroprotection compared to the reference drugs.
- Further investigations with lower doses of EF confirmed that EF can mediate a significant and dose-dependent gastroprotection.
- The rats treated with the EF showed a significant reduction in free acidity (by 45%), total acidity (by 48%) in the gastric juice and an increased the amount of mucus produced by the rat gastro mucosa and potent antihistamine activity (by 25.6%).
- *In vitro* and *in vivo* antioxidant assays confirmed EF was rich in antioxidant components.
- Developed two marketable value-added products (Jelly and Ready to Serve Drink) from *Trichosanthes cucumerina* hot water extract.

Publications in Refereed Journals

1. Karunakaran, R., Thabrew, M.I., Thammitiyagodage, G.M., Galhena, B.P. and Arawwawala, L.D.A.M. (2017). The gastroprotective effect of ethyl acetate fraction of hot water extract of *Trichosanthes cucumerina* Linn and its underlying mechanisms. *BMC Complementary and Alternative Medicine,* 17:312.
2. Thabrew, M.I. and Arawwawala, L.D.A.M. (2016). An overview of *in vivo* and in *vitro* models that can be used for evaluating anti-gastric ulcer potential of medicinal plants. *Austin Biology,* ID. 1007.

Scientific Communications

1. Arawwawala, L.D.A.M., Ramani, K., Thabrew, M.I., Thammitiyagodage, M.G. and Galhena, B.P. (2017). Long term toxicity study of ethyl acetate fraction of *Trichosanthes cucumerina*. Linn in rats. *Proceedings of the National Research Conference and Exhibition on Indigenous Medicine.* p.67.
2. Karunakaran, R., Arawwawala, L.D.A.M., Thammitiyagodage, M.G., Thabrew, M.I. and Galhena B.P. (2015). Acute oral toxicity study and antihistamine activity of ethyl acetate fraction of hot water extract of *Trichosanthes cucumerina* Linn in Wistar Rats. *Proceedings of the* 67th Annual Convention of the Sri Lanka Veterinary Association. p.58.
3. Karunakaran, R., Arawwawala, L.D.A.M., Thammitiyagodage, M.G., Thabrew, M.I. and Galhena, B.P. (2015). Gastroprotective effect of fractions of the hot water extract of *Trichosanthes cucumerina* Linn against ethanol-induced gastric ulcers in Wistar rats. *Proceedings of the* 2nd Scientific Sessions of Sri Lanka Association for Laboratory Animal Science (SLALAS). p.50.
4. Karunakaran, R, Arawwawala, L.D.A.M., Thammitiyagodage, M.G., Thabrew, M.I. and Galhena, B.P. (2015). Mechanism of gastroprotection by ethyl acetate fractions of *Trichosanthes cucumerina* Linn. *Proceedings of the 71st Annual Sessions,* Sri Lanka Association for the Advancement of Science. p.4.
5. Karunakaran, R., Arawwawala, L.D.A.M., Thammitiyagodage, M.G., Liyanage, S.K., Kumara, W.G.S.S., Thabrew, M.I. and Galhena, B.P. (2019). Toxicity study of the ethyl acetate fraction of hot water extract from *Trichosanthes cucumerina* Linn in Wistar rats. *Proceedings of the 6th Scientific Sessions,* Sri Lanka Association for Laboratory Animal Science (SLALAS). p.42.

Cosmetically active herbal ingredients for development of personal care products

Grant No: TG 13-69
Project team: *Prof. (Ms.) J.K.R.R. Samarasekara
Dr. (Ms.) G.D. Liyanaarachchi
Ms. P.I.P.K. Fernando
Project Period: 2013 - 2016
Funded by: Sri Lanka Treasury

Antioxidant and enzyme inhibitory phytoceuticals for cosmetic Applications

Grant No: FP 123
Project team: *Prof. (Ms.) J.K.R.R. Samarasekara
Dr. (Ms.) G.D. Liyanaarachchi
Prof. K.R. Mahanama
Dr. K.D.P. Hemalal
Project Period: 2017 - 2019
Funded by: National Science Foundation, Sri Lanka

**Principal Investigator*

Background

Medicinal plants have been extensively used as active ingredients in cosmetics and therapeutics, as beautifying agents and also as a remedy for dermatological disorders such as eczema, acne, hyperpigmentation, and photoaging for centuries. These plants provide a largely unexplored source for the potential development of active ingredients for cosmetic formulations. Hence, cosmeceuticals are a growing market segment, driven by the rising need of people to maintain healthy skin without using synthetic chemicals. This rising demand for herbal cosmetics due to its fewer side effects, safety, and compatibility with all skin types prompts the leading manufacturers to launch new herbal cosmetic products. Plant sources contain numerous natural compounds that can be used as whitening, anti-aging, and anti-wrinkle ingredients and also for the treatment of dermatological disorders.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Protocols were optimized to evaluate elastase, tyrosinase and hyaluronidase inhibitory activities.
- Identified medicinal plants with tyrosinase, elastase, and hyaluronidase inhibitory activities that can be incorporated in cosmetics as whitening, moisturizing and anti-ageing ingredients.
- Isolated bioactive compounds from Sri Lankan medicinal plants that possessed promising whitening and anti-inflammatory properties.
- Established stability tests for cosmetics.

Technology Developed

- Whitening cream, whitening gel and herbal hand sanitizers were developed according to SLS standards, incorporating medicinal plants.

Publications in Refereed Journals

1. Liyanaarachchi, G.D., Samarasekara J.K.R.R., Mahanama, K.R.R. and Hemalal K.D.P. (2018). Tyrosinase, elastase, hyaluronidase inhibitory, and antioxidant activity of Sri Lankan medicinal plants for novel cosmeceuticals. *Industrial Crops & Products*, **111,** 597-605. https://doi.org/10.1016/j.indcrop.2017.11.019.
2. Liyanaarachchi, G.D., Perera S., Samarasekera, J.K.R.R., Mahanama, K.R.R., Hemalal, K.D.P., Dlamini, S., Perera, H.D.S.M., Alhadidi, Q., Shah, Z.A. and Tillekeratne, L.M.V. (2022). Bioactive constituents isolated from the Sri Lankan endemic plant *Artocarpus Nobilis* and their potential to use in novel cosmeceuticals, *Industrial Crops & Products*, **184**, 115076. https://doi.org/10.1016/j.indcrop.2022.115076.

Scientific Communications

1. Liyanaarachchi, G., Samarasekara, R., Mahanama, K.R.R. and Hemalal, K.D.P. (2015). *In vitro* elastase, tyrosinase, hyaluronidase inhibitory and antioxidant activities of *Curcuma aromatica* from Sri Lanka. *Proceedings of the Graduate Research Symposium*), University of Colombo. p.35.
2. Liyanaarachchi, G., Samarasekara, R., Mahanama, K.R.R. and Hemalal, K.D.P. (2015). *In vitro* elastase, tyrosinase inhibitory and antioxidant activity of *Vetiveria zizanioides. Proceedings of the 8th International Research Conference*, General Sir John Kotelawala Defense University. p.163.
3. Liyanaarachchi, G., Samarasekara, R., Mahanama, K.R.R. and Hemalal, K.D.P. (2015). *In vitro* tyrosinase inhibitory activity of some selected Sri Lankan medicinal plants. *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.28-29.
4. Liyanaarachchi, G., Samarasekara, R., Mahanama, K.R.R. and Hemalal, K.D.P. (2016). Evaluating the tyrosinase, elastase, hyaluronidase inhibitory and antioxidant properties of the ethanol extract of Camellia sinensis as refuse tea, a potential cosmetic ingredient, *Proceedings of the NSF Research Summit 2016, "Empowered by Research & Innovation.* p.84.
5. Liyanaarachchi, G., Samarasekara, R., Mahanama, K.R.R. and Hemalal, K.D.P. (2017). Evaluating the tyrosinase, hyaluronidase inhibitory and antioxidant activities of *Artocarpus heterophyllus, Proceedings of the Annual Research Symposium*, University of Colombo. p. 239.
6. Liyanaarachchi, G., Samarasekara, R., Mahanama, K.R.R. and Hemalal, K.D.P. (2017). Evaluating the tyrosinase, elastase hyaluronidase inhibitory and antioxidant activities of *Artocarpus altilis* (*Artocarpus incisus*), *Proceedings of the 3rd Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.12.
7. Liyanaarachchi, G., Samarasekara, R., Mahanama, K.R.R. and Hemalal, K.D.P. (2018). A bioactive pyranoxanthone from the stem bark of the Sri Lankan endemic plant *Artocarpus nobilis*. *Proceedings of the Asian Symposium on Medicinal Plants, Spices and other Natural Products.* p.194.
8. Liyanaarachchi, G., Samarasekara, R., Mahanama, K.R.R. and Hemalal, K.D.P. (2018). *In vitro* pro-inflammatory enzyme inhibitory activities of Artocarpus heterophyllus. *Proceedings of the* 5th *International Conference on Multidisciplinary Approaches*. p.146.
9. Liyanaarachchi, G., Samarasekara, R., Mahanama, K.R.R. and Hemalal, K.D.P. (2018). *In vitro* pro-inflammatory enzyme inhibitory activities of *Artocarpus altilis, Proceedings of the 38th Annual Sessions*, Institute of Biology. p.46.

Postgraduate Degrees

1. Ms. Gavini Liyanaarachchi obtained a PhD from the University of Colombo in 2020.
   Thesis Title: Antioxidant and enzyme inhibitory activities of selected medicinal plants and chemical characterization of phytochemicals of *Artocarpus nobilis* and its topical applications.

Awards

1. Award for the Best Innovation Project 2018 for the project titled "Antioxidant and enzyme inhibitory phytoceuticals for cosmetic application" at the 4th Biennial Research Symposium (2019), Industrial Technology Institute – G. Liyanaarchchi and R. Samarasekara.

NCBI GenBank Submission

- One isolate was deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Collaborations

- The Department of Medicinal and Biological Chemistry and the Department of Biological Sciences, University of Toledo provided facilities to conduct compound isolation and spectroscopy studies, anti-cancer, anti-inflammatory and neuroprotective studies.

Investigation on natural fragrances and other volatiles from Sri Lanka flora and their industrial applications

Grant No: TG 13-71
Project Team : *Dr. H.D. Weerathunga
Prof. G.A.S. Premakumara
Prof. E.D. de Silva
Project Period: 2013 - 2018
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Spices and essential oil-bearing plants grow abundantly in Sri Lanka and represent one of the Island's oldest export ventures. Furthermore, much research has been conducted on essential oils, particularly on applications in pharmacology, medical microbiology, phytopathology and food preservation, from the time of its evolution as an industry. However, except for already known major essential oils such as cinnamon, clove, pepper, nutmeg, citronella, betel and cardamom, there is no evidence for research carried out on Sri Lankan fragrance plants and lesser-known essential oils for potential economic applications. Therefore, this research was scientifically designed to investigate the Sri Lankan flora with aromas to be incorporated into value-added products in the cosmetic industry based on different biological activities. The research output will enhance the use of fragrances found in Sri Lankan trees, herbs and flowers which will automatically increase the value of Sri Lankan wealth and will therefore, through new innovations using those materials will bring more attention to foreign market leaders in the aroma industry. An exploration of novel essential oils was carried out for the selected four forests in Sri Lanka including Sinharaja, Kanneliya, Nilgala and Ritigala forests.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- More than 73 plant species from Sinharaja, Kanneliya, Ritigala and Nilagala forests were investigated for essential oils and over 230 types of essential oils (including leaf, bark, root, stem, heartwood and resins) were extracted from the collected plant species.
- Five species each from wild ginger, wild cardamom, and wild cinnamon and twelve endemic Dipterocarpaceae species were selected for perfumery formulations.
- Five perfumes were developed, and the technology is ready to be transferred with unique fragrance properties.
- Four compounds were isolated, and chemical characterization was done by NMR and GC-MS analysis.
- Musk-type base note fragrance was prepared from the isolated compound.
- Floral-type top note was prepared from the endemic cinnamon.
- Zurumbone was isolated as a highly bioactive substance from wild ginger.
- β-Santaool, containing essential oil was extracted from wild ginger which can be used as a base note in perfumes.

Scientific Communications

1. Weeratunge, H.D., Premakumara, G.A.S. and de Silva, E.D. (2017). Analysis of volatile constituents of leaf, stem bark and root bark oils of *Cinnamomum capparu-coronde* Bl. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.17.

2. Weeratunge, H.D., Premakumara, G.A.S. and de Silva, E.D. (2018). Analysis of volatile constituents of wild variety of *Cymbopogon nardus* (L.) Rendle found in Nilgala forest reserve. *Proceedings of the Annual Symposium,* University of Colombo. p.30.
3. Weeratunge, H.D., Premakumara, G.A.S. and de Silva., E.D. (2019). Analysis of volatile constituents of leaf, stem bark and root bark oils of *Cinnamomum dubium* Nees (Sewel kurundu) found in Kanneliya forest reserve. *Proceedings of the 4th Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.23.
4. Weeratunga, H.D., Premakumara, G.A.S. and de Silva, E.D. (2020). Analysis of volatile constituents of *Gyrinops walla* Gaertn found in Sinharaja forest reserve. *Proceedings of the Postgraduate Research Symposium,* University of Colombo. p.21.
5. Weeratunge, H.D., Premakumara, G.A.S. and de Silva., E.D. (2020). Isolation and characterization of potential fragrance compounds from *Cinnamomum dubium* Nees. (Sewel kurundu) found in Sri Lanka. *Proceedings of the International Conference on Frontiers in Chemical Technology,* Institute of Chemistry Ceylon. p.18.

Postgraduate Degrees

1. Mr. H.D. Weeratunga obtained a PhD from the University of Colombo in 2022.
   Thesis Title: Investigation on natural fragrances and other volatiles from Sri Lankan flora and their industrial applications.

Awards

1. Best oral presentation at Postgraduate Research Symposium of the University of Colombo for the abstract: Weeratunga, H.D., Premakumara, G.A.S., de Silva, E.D. (2020). Analysis of volatile constituents of *Gyrinops walla* Gaertn found in Sinharaja forest reserve.

NCBI GenBank submissions

- Sequences of twelve new isolates were deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Investigation of *Gyrinops walla* Gaertn

Grant No: TG 13-73
Project Team: *Dr. T.D.C.M.K. Wijayasiriwardena
Prof. (Ms.) J.K.R.R. Samarasekara
Prof. G.A.S. Premakumara
Dr. H.D. Weerathunga
Project Period: 2013 – 2015
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Wallapatta, botanically known as *Gyrinops walla* Gartn, is a valuable tree due to the resin and agarwood that it produces. It has been harvested in the wild due to its high economic value and smuggled out of the country. Since there was no scientific method to identify the wood, especially when exported as wood powder, the project was initiated to develop a *Gyrinops walla* wood identification technique based on microscopic characteristics.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Microscopical data were generated for the identification of Wallapatta wood in the form of powder.
- Non-alcoholic cologne/aftershave developed.

Scientific Communications

1. Rajapaksha, R.M.V.H.C., Wijayasiriwardena, C., Weeratunge, H.D., Samarasekera, R. and Premakumara, G.A.S. (2013). Chemical and biological investigation of *Gyrinopswalla* Gartn. *Proceedings of the World Congress on Pharmaceutical Sciences & Chemical Technology*. p. 36-37.

Data mining on Sri Lankan natural products research to develop a database and in silico experiments for drugs leads

Grant No: TG 13 -88
Project Team: *Ms. P. Jayasinha
Prof. G.A.S. Premakumara
Project Period: 2013 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The natural product research is one of the key areas of research in Sri Lanka. Many medicinal plants have been investigated by scientists at different levels in academic institutions for their biological activities and chemical properties for many decades. In many cases, constituents, chemical properties and bioactivity of natural products have been investigated and published. However, information about these publications is scattered among the institutions. Further, studies on bioactive compounds, including drug development based on the identified bioactive compounds, are sporadic or scarce. Due to the difficulty in accessing information increases the possibility of repetition of work. In addition, there are instances where endemic Sri Lankan medicinal plants have been investigated in other countries and findings published and even patented, which results in losing the 'ownership' of the plant/compound. This study mainly addressed the inadequacy of the above-mentioned further studies. During the first stage, information on natural product research carried out in Sri Lanka was gathered and reviewed. In the second stage a few bioactive molecules selected while reviewing literature were used in *in silico* techniques to identify their potential as leads for drug discovery.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A bibliography of Natural Product Research in Sri Lanka was compiled. A database with the details of Natural Product Research carried out in Sri Lanka has been developed.
- The secondary metabolites with promising results against Angiotensin converting enzymes, Renin, Acetylcholine Esterase and Butrylcholine Esterase were identified for further studies.

Scientific Communications

1. Abdulla, S.M., Premakumara, G.A.S., Ranasinghe, P. and Jayasinha, P. (2017). Computational study on binding interaction of Renin with Phoenicanthusine. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.18.
2. Perera, A.S., Premakumara, G.A.S., Ranasinghe, P., Jayasinha, P. and Ratnaweera, C.N. (2017). *In silico* study of acetylcholinesterase inhibitors from Xanthone derivatives from natural products found in Sri Lanka. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.20.

Awards

1. Best Oral Presentation at the International Conference on Drug Discovery and Development, Sri Lanka 2017.

Activity guided separation of anti-inflammatory compounds from *Alpinia calcarata* rhizome & leaf

Grant No : FP 106
Project Team: *Dr. (Ms.) S. Chelvendran
Prof. G.A.S. Premakumara
Prof. S.M. Handunnetti
Project Period: 2013 – 2016
Funded by: National Research Council, Sri Lanka

**Principal Investigator*

Background

In traditional medicine, *Alpinia calcarata* (Sinhala: Heenaraththa; Tamil: Chitharaththa) rhizome is used in polyherbal formulations in the treatment of rheumatoid arthritis. The water and ethanolic extracts were proven to have anti-inflammatory, gastroprotective, antinociceptive, antifungal, and antimicrobial activities. The present project focused on the anti-inflammatory activity of essential oils of rhizome and leaf of *A. calcarata.* The anti-inflammatory active compounds were isolated based on *in vitro* and *in vivo* studies and a formulation was developed for topical applications using the active fraction and the essential oils from rhizome and leaf.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Isolation of anti-inflammatory active compounds.
- Development of a standardized anti-inflammatory formulation with scientific evidence.

Publications in Refereed Journals

1. Chandrakanthan, M., Handunnetti, S.M., Premakumara, G.A.S. and Kathirgamanathar, S. (2020). Topical anti-inflammatory activity of essential oils of *Alpinia calcarata* Rosc., its main constituents, and possible mechanism of action. *Evidence-Based Complementary and Alternative Medicine,* Article ID 2035671.

Scientific Communications

1. Chandhrakanthan, M., Kathirgamanathar, S., Handunnetti, S.M. and Premakumara, G.A.S. (2015). Extracts of *Alpinia calcarata* (Lesser galangal) inhibits production of inflammatory mediator - Nitric oxide in RAW 264.7 Murine macrophage. *Proceedings of the Young Scientist Forum Symposium.* p.37-40.
2. Chandhrakanthan, M., Kathirgamanathar, S., Handunnetti, S.M. and Premakumara, G.A.S. (2015). Evaluation of anti-inflammatory activity of *Alpinia calcarata* leaf extracts: An *in vitro* study. *Proceedings of the 7th Annual Scientific Sessions,* IBMBB. p.16.
3. Chandhrakanthan, M., Kathirgamanathar, S., Handunnetti, S.M. and Premakumara, G.A.S. (2015). *Alpinia calcarata* Rosc. rhizome extracts: A prospective inhibitor of inflammatory mediators. *Proceedings of the 8th International Research Conference*, General Sir John Kotelawala Defence University, Sri Lanka. p.162.
4. Chandhrakanthan, M., Kathirgamanathar, S., Handunnetti, S.M. and Premakumara, G.A.S. (2015). Essential oils of *Alpinia calcarata* Rosc. inhibits the *in vitro* generation of reactive oxygen species in mouse macrophages. *Proceedings of the 2nd International Conference on*

Multidisciplinary Approaches. Faculty of Graduate Studies, University of Sri Jayewardenepura. p.19.

5. Chandhrakanthan, M., Kathirgamanathar, S., Handunnetti, S.M. and Premakumara, G.A.S. (2015). Anti-inflammatory volatile constituents from rhizomes and leaves of *Alpinia calcarata. Proceedings of the 2nd Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.21.
6. Chandhrakanthan, M., Kathirgamanathar, S., Maurya, A.K., Pal, A., Handunnetti, S.M. and Premakumara, G.A.S. (2018). *In vivo* and *in vitro* studies on anti-inflammatory potential of *Alpinia calcarata* Rosc. Rhizome and leaf essential oils. *Proceedings of the XVI Asian Symposium on Medicinal Plants, Spices and other Natural Products.* p.92.

Postgraduate Degrees

1. Ms. Madhuvanthi Chandrakanthan obtained a PhD from the University of Colombo in 2021. Thesis Title: Activity-guided separation of anti-inflammatory compounds from *Alpinia calcarata* rhizome & leaf and its industrial product development.

Validation and value addition of bio-active natural ingredients for industrial applications

Grant No: FP 107
Project team: *Prof. (Ms.) J.K.R.R. Samarasekara
Dr. (Ms.) H.D.S.M. Perera
Dr. (Ms.) S. Samaradivakara
Project Period: 2013 - 2019
Funded by: National Research Council, Sri Lanka

**Principal Investigator*

Background

The research was carried out to search and identify bioactive medicinal plant extracts and compounds and introduce them to the industry through validation and value addition. For that, twenty-four extracts of twenty medicinal plants including endemic plants to Sri Lanka were selected based on ethnobotanical information, reported bioactivities and previous studies conducted. Total ethanol extracts were prepared from each plant to carry out *in vitro* bio-activity studies. Antioxidant, anti-inflammatory, anti-microbial and anti-cancer properties of the total ethanol extracts of the medicinal plants were investigated using standardized *in vitro* assay models.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- New bioassays were optimized and developed.
- Bioactivity profiles of twenty-five plant extracts including endemic plants were developed.
- Compound isolation methods were developed, bioactive compounds including a novel compound were isolated and bioactivity profiles of the isolated compounds were established.

Technology Developed

- Development of herbal formulations with anti-inflammatory activities.

Collaborations

- HEJ Research Institute of Chemistry and Dr. Panjwani Center for Molecular Medicine and Drug Research (PCMD) of The International Center for Chemical and Biological Sciences (ICCBS) provided facilities to conduct spectroscopy studies of compounds, anti-cancer, anti-inflammatory, anti-microbial and enzyme inhibitory assays.
- The Institute of Biochemistry, Molecular Biology and Biotechnology (IBMBB) of the University of Colombo provided facilities to conduct anti-inflammatory and DNA barcoding studies.
- The Department of Medicinal and Biological Chemistry and Department of Biological Sciences, University of Toledo provided facilities to conduct compound isolation and spectroscopy studies, anti-cancer, anti-inflammatory and neuroprotective studies.

Formulation of a para-pheromone from local varieties of *Ocimum sanctum* for the control of fruit & melon flies

Grant No: FP 109
Project Team: *Prof. R.M. Dharmadasa
Dr. C.H. Manoratne
Project Period: 2013 – 2016
Funded by: National Research Council, Sri Lanka
& CIC Holdings (Pvt) Ltd., Sri Lanka

**Principal Investigator*

Background

Fruit flies cause considerable damage to fruit and vegetables which can lead up to 90-100% yield loss, depending on fruit fly population, locality, variety and season. The use of chemical pesticides is not practical due to the difficulty in handling and the negative environmental impact. On the other hand, the importation of synthesized chemicals is restricted due to their toxic nature. Therefore, the development of an effective, plant-based insect attractant at an affordable price, was an urgent national need. A systematic survey conducted in all agro-ecological regions of Sri Lanka found that 44 different *Ocimum* species/morphotypes are available throughout the country. All *Ocimum* species were screened for chemical profiles and the most potent 12 species/morphotypes were selected for the study. Agronomic protocols were developed for the selected species. Plant extracts were prepared under laboratory, pilot scale and commercial scale. A formulated fruit fly attractant product named as *Bactocera* species controlling agent 'BASCA' was evaluated for insect attracting ability at research centers of the Department of Agriculture and found that the product is highly effective in controlling the fruit flies and melon flies. After a successful evaluation, the technology of 'BASCA' was transferred to a private partner.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Systematic survey on available *Ocimum* species in Sri Lanka.
- Established protocols for agronomic practices, taxonomic characterization, and phytochemical screenings were completed for all species.
- Developed an economical and highly effective commercial product called 'BASCA'.

Technologies Commercialized

- 'BASCA', the technology developed was commercialized through CIC Holdings Pvt. Ltd.

Patents

- Environmentally friendly, controlled release fruit and melon flies' attractive product based on *Ocimum* extracts and natural nano-composite substrate (Sri Lanka Patent No: 18249).

Publications in Refereed Journals

1. Abeywardhana, K.W., Abeysinghe, D.C., Dharmadasa, R.M. and Aththanayake, A.M.L. (2014). Determination of optimum maturity stage for *Ocimum sanctum* L. grown under

different growing systems in terms of therapeutically active secondary metabolites. *World Journal of Agricultural Research*, **2**(4), 159-162.
2. Dharmadasa, R.M., Abeywardhana, K.W., Abeysinghe, D.C., Aththanayake, A.M.L. Bandara, J. and Bandara, V.S. (2015). Determination of suitable agro-climatic region and optimum harvesting stage by means of total phenolic content, total flavonoid content and total antioxidant capacity of *Ocimum tenuiflorum* L. (Lamiaceae) grown in Sri Lanka. *World Journal of Agricultural Research*, **3**(5), 148-152.
3. Dharmadasa, R.M., Siriwardhane, D.A.S., Samarasinghe, K., Rangana, S.H.C.S., Nugaliyadda, L., Gunawardane, I. and Aththanayake, A.M.L. (2015). Screening of two *Ocimum tenuiflorum* L. (Lamiaceae) morphotypes for their morphological characters, essential oil composition and fruit fly attractant ability. *World Journal of Agricultural Research*, **3**(1), 1-4.

Scientific Communications

1. Abeywardhana, K.W., Abeysinghe, D.C. and Dharmadasa, R.M. (2014). Determination of optimum maturity stage for *Ocimum sanctum* L. grown under two different growing systems in terms of therapeutically active secondary metabolites. *Proceedings of the 13th Agricultural Research Symposium.* Wayamba University of Sri Lanka. p.412-416.
2. Ranchigoda, R.K.S.S., Dharmadasa, R.M. and Fonseka, D.L.C.K. (2014). Comparative pharmacogenetic study of seven *Ocimum* morphotypes. *Proceedings of the International Symposium on Agriculture and Environment*, University of Ruhuna. p.11.
3. Abeywardhana, K., Abeysinghe, D.C. and Dharmadasa, R.M. (2014). Comparison of antioxidant, polyphenol and flavonoid contents of different parts of *Ocimum sanctum* grown under different growing systems at three different maturity stages. *Proceedings of the 70th Annual Sessions*, Sri Lanka Association for the Advancement of Science.p.12.
4. Shiromala, M.A.N., Abeysinghe, D.C. and Dharmadasa, R.M. (2015). Screening of existing *Ocimum* morphotypes for total phenolic content total flavonoid content, total antioxidant capacity and brine shrimp toxicity assay. *Proceedings of the 14th Agricultural Research Symposium*, Wayamba University of Sri Lanka. p.307.
5. Jayampathi, B.P.S., Abeysinghe, D.C. and Dharmadasa, R.M. (2015). Diurnal variation patterns of total antioxidant capacity and bioactive compounds of leaves of *Ocimum tenuiflorum* L. (Lamiaceae). *Proceedings of the 14th Agricultural Research Symposium*, Wayamba University of Sri Lanka. p.297-301.

Books/Book Chapters/Book published

1. Dharmadasa, R.M. and Abeywardena, K. (2018). Cultivation and processing of *Ocimum tenuiflorum* L. Industrial Technology Institute. ISBN Number: 978-955-8394-25-0.

Awards

1. DASIS Award 2018 (Open Category) for BASCA - Environment-friendly, 100% natural, non-hazardous fruit and melon flies controlling product at the awards ceremony organized by the Sri Lanka Inventors Commission – R.M. Dharmadasa and C.H. Manoratne.
2. Gold Medal 2018 in the Open category under the technical field of Agriculture for the Formulation of BASCA - Environment-friendly, 100% natural, non-hazardous fruit and

melon flies controlling product at the awards ceremony organized by the Sri Lanka Inventors Commission - R.M. Dharmadasa and C.H. Manoratne.

3. SLCARP Award for Excellence in Agricultural Research 2019 – Certificate of Commendation in the non-plantation sector in consideration of the research project on "Formation of a para-pheromone from local varieties of *Ocimum sanctum* L. for the control of local fruit and melon flies" - R.M. Dharmadasa and C.H. Manoratne.
4. Best project with nationally significant output awarded (2017) at the 3rd Biennial Research Symposium, Industrial Technology Institute, Sri Lanka. - R.M. Dharmadasa and C.H. Manoratne.

Popularization Activities

- Workshops on the effect of BASCA were conducted, targeting extension officers and potential fruit and vegetable growers.

Basic Concept of BASCA Production

Problem Identification

Stratratergic Planing

Final outcome

Investigation of Sri Lankan marine algae

Grant No: FP 117
Project Team: *Prof. K.W. Samarakoon
Prof. G.A.S. Premakumara
Dr. P. Ranasinghe
Project Period: 2015 - 2016
Funded by: Korea Institute of Ocean Science and Technology (KIOST), Korea

**Principal Investigator*

Background

The ocean which covers more than 70% of the Earth's surface, is a magnificent creation of nature, cherished with a wide diversity of marine organisms that offer a rich source of natural products. According to recent findings, Marine organisms are rich in bioactive compounds including polysaccharides, polyunsaturated fatty acids (PUFA), polyphenolic compounds, antioxidants, peptides, essential vitamins and minerals. However, marine fauna and flora that inhabit the coastal areas of Sri Lanka represent an underexplored natural resource. The bioactive potentials and medicinal values of these organisms have not been explored widely, except for a few biochemical and taxonomical studies. These natural products or functional ingredients from marine organisms can be used for food, cosmetics and the pharmaceutical industry due to their broad spectrum of bioactivity with reduced toxicity.

Project Achievements/Outcomes:

Technologies/Processes/Methods Developed

- More than 15 algae species were collected, identified and screened for different bioactive properties. Information on bioactive potential, nutritional value and habitat will be useful for future projects targeting product development using marine algae.

Publications in Refereed Journals

1. Fernando, I.P.S., Sanjeewa, K.K.A., Samarakoon, K.W., Lee, W.W., Kim, H.S., Kang, N., Ranasinghe, P., Lee, H.S. and Jeon, Y.J. (2017). A fucoidan fraction purified from *Chnoospora minima*; a potential inhibitor of LPS-induced inflammatory responses. *International Journal of Biological Macromolecules*, **104**, 1185–1193.
2. Fernando, I.P.S., Sanjeewa, K.K.A., Samarakoon, K.W., Lee, W.W., Kim, H-S., Ranasinghe, P., Gunasekara, U.K.D.S.S. and Jeon, Y.J. (2018). Antioxidant and anti-inflammatory functionality of ten Sri Lankan seaweed extracts obtained by carbohydrase assisted extraction. *Food Science and Biotechnology*, **27**(6), 1761-1769.
3. Fernando, I.P.S., Sanjeewa, K.K.A., Samarakoon, K.W., Lee, W.W., Kim, H-S., Kim, E-A., Ranasinghe, P., Gunasekara, U.K.D.S.S., Premakumara, G.A.S. and Jeon, Y.J. (2018). Preliminary screening of two marine algae and sea grass harvested from Sri Lankan waters against the LPS-induced inflammatory responses in RAW 264.7 macrophages and in vivo zebrafish embryo model. *Journal of the National Science Foundation of Sri Lanka*, **46**(2), 117-124.

Scientific Communications

1. Batugedara, G.A., Samarakoon, K.W., Gunasekara, U.K.D.S.S. and Ranasinghe, P. (2016). Antioxidant activity, proximate analysis and metal ion analysis of some selected Sri Lankan marine algae. *Proceedings of the 72nd Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.55.
2. Samarakoon, K.W., Fernando, I.P.S., Gunesekara, U.K.D.S.S., Premakumara, G.A.S., Ranasinghe, P. and Jeon, Y.J. (2016). *In vitro* antioxidant, anticancer and anti-inflammatory properties of the solvent fractions of three intertidal marine florae harvested from Kalpitiya, Sri Lanka. *Proceedings of the 9th International Research Conference*, General Sir John Kotelawala Defence University, Sri Lanka. p.186.
3. Samarakoon, K.W., Fernando, I.P.S., Gunesekara, U.K.D.S.S., Ranasinghe, P., Premakumara, G.A.S. and Jeon, Y.J. (2016). Investigation of *in vitro* bioactivities, targeted isolation of bioactive compounds from Sri Lankan sea grapes, *Caulepa racemosa*. *Proceeding of the 36th Annual Sessions*, Institute of Biology, Sri Lanka. p.23.
4. Samarakoon, K.W., Fernando, I.P.S., Gunesekara, U.K.D.S.S., Premakumara, G.A.S., Ranasinghe, P., Jayarathne, L., De Silva, R.C.L. and Jeon, Y.J. (2016). FTIR spectroscopic analysis and antioxidant activities of crude polysaccharides from Sri Lankan marine algae. *Proceeding of the 72nd Annual Sessions*. Sri Lanka Association for the Advancement of Science (SLAAS). p.54.
5. Sathiyakumar, S., Samarakoon, K.W., Jayasekera, S.J.B.A., Ranasinghe, P. and Dharmadasa, R.M. (2016). Sterilization protocol for the Sri Lankan green algae *Caulerpa racemosa* and its antioxidant activity. *Proceedings of the 15th Agricultural Research Symposium*, Wayamba University of Sri Lanka. p.254-258.

Programme on identification, uses, conservation and sustainable use of medicinal plants organized by the Ministry of Technology and Research with the assistance of Sri Lanka Association for the Advancement of Science (SLAAS) and Ministry of Education (MoE)

Grant No: TG 14 - 91
Project Team : *Prof. R.M. Dharmadasa
Mr. K. Samarasinghe
Project Period: 2014 – 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Sri Lanka is enriched with high biodiversity and has been identified as one of the world's biodiversity hot spots. About 4750 flowering plant species have been identified and 27% of them are endemic; the medicinal value of over 50% of plant species have been recorded. However, existing forest cover is decreasing day by day due to deforestation to fulfill the demands of the increasing population. As a direct consequence of deforestation, existing habitats of invaluable medicinal plants which are heavily used in Traditional and Ayurveda systems of medicine, are also diminishing rapidly. Moreover, a lack of awareness among the younger generation on the value and uses of medicinal plants and their wider usage in different systems of medicine has been identified as a major threat to the conservation of medicinal plants. Therefore, these valuable medicinal plants should be protected by implementing well-designed conservation measures in order to ensure the conservation and sustainable use of medicinal plants for future generations. It has become a timely important issue to popularize medicinal plants among school children by conducting awareness programmes, familiarizing them with their uses and stepping into conservation by establishing herbal gardens in schools. Having realized this critical issue, this program was initiated not only to widen the breadth and depth of knowledge of school children but also to change their attitude positively towards valuing national heritage. This is expected to contribute directly to the biodiversity conservation and sustainable development of the country leading to a green economy.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The program was successfully conducted in 11 schools selected from different education zones.
- More than 5000 students actively participated and were made aware of the importance of medicinal plants, their uses, the importance of conservation, how to establish medicinal plants as well as future prospects.
- One program was conducted for all officers of the research staff of MahaIlluppallama research station.
- Model demonstrative and scientifically labeled medicinal plant gardens were successfully established and handed over to the schools.

Establishment of animal and human cell culture facility at ITI for pharmacological and nutraceutical research

Grant No: TG 15- 106, TG 18-167
Project Team : *Dr. P. Ranasinghe
Prof. K.W. Samarakoon
Dr. (Ms.) G.D. Liyanaarachchi
Prof. (Ms.) L.D.C. Peiris
Project Period: 2015 - 2021
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

In vitro biochemical assays for the study of functional properties of natural products and functional food are well established at the Industrial Technology Institute, particularly at the Bioactivity Laboratory of Herbal Technology Section (HTS). However, in the full path of development of supplements or drug leads, there is a need for more in-depth and specific studies on their mode of action and cytotoxicity before demanding clinical trials. Therefore, these projects aimed to develop a small-scale cell culture research facility at ITI. At present ITI is equipped with a fully functional small laboratory for human and animal cell-based assays.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The Herbal Technology Section offers cell-based cytotoxicity assay as a Customized Test Service (CTS) from year 2022.

Publications in Refereed Journals

1. Gunathilaka, T.L., Samarakoon, K., Ranasinghe, P. and Peiris, L.D.C. (2020). Antidiabetic potential of marine brown algae - a Mini Review. *Journal of Diabetes Research*, Article ID 1230218.

Scientific Communications

1. Gunathilaka, M.D.T.L., Samarakoon, K.W., Ranasinghe, P. and Peiris, L.D.C. (2020). *In-vitro* cytotoxic activity of crude methanol extract and its fractions of Sri Lankan marine brown algae *Choonospora minima. Proceedings of the* 7th *International Conference on Multidisciplinary Approaches*, University of Sri Jayewardenepura.p.115.
2. Gunathilaka, M.D.T.L., Keerthirathna, W.L.R., Samarakoon, K.W., Ranasinghe, P. and Peiris, L.D.C. (2020). Anti-proliferative and apoptotic activity of polyphenol-rich crude methanol extract of *Gracillaria edulis* against human Rhabdomyosarcoma (RD) and breast adenocarcinoma (MCF-7) cell lines. *Proceedings of the 1*st *International Electronic Conference on Biomolecules: Natural and Bio-Inspired Therapeutics for Human Diseases.* www./mdpi.com/journal/proceedings.
3. Gunathilaka, M.D.T.L., Samarakoon, K.W., Ranasinghe, P. and Peiris, L.D.C. (2021). Caspase cascade activation during apoptotic cell death of human rhabdomyosarcoma (RMS) and breast adenocarcinoma (MCF-7) cells induced by different fractions of *Chnoospora minima*. *International Conference on Applied and Pure Sciences*, University of Kelaniya. p.16.

4. Gunathilaka, M.D.T.L., Samarakoon, K.W., Ranasinghe, P. and Peiris, L.D.C. (2021). A study on cytotoxicity and apoptotic potential of different fractions of *Gracillaria edulis* (Gmelin) Silva against human breast adenocarcinoma (MCF-7) cells. *Proceedings of the International Conferences in Multidisciplinary Approach*, University of Colombo. p.67.
5. Gunathilaka, M.D.T.L., Samarakoon, K.W., Ranasinghe, P. and Peiris, L.D.C. (2021). Gene Expression Analysis of Human breast adenocarcinoma (MCF-7) Cells Treated with a Sri Lankan Red Seaweed *Gracillaria edulis* (Gmelin) Silva. *Proceedings of the 14th International. Research Conference*, General Sir John Kotelawala Defense University, Sri Lanka. p.2.
6. Gunathilaka, M.D.T.L., Samarakoon, K.W., Ranasinghe, P. and Peiris, L.D.C. (2021). Apoptogenic potential of different fractions of Sri Lankan brown seaweed *Chnoospora minima* against human breast adenocarcinoma (MCF-7) cell line. *Proceedings of the Research Sessions*, Open University of Sri Lanka. p.1-6.
7. Gunathilaka, M.D.T.L., Samarakoon, K.W., Ranasinghe, P. and Peiris, L.D.C. (2021). Assessment of cytotoxicity and apoptotic activity of different fractions of *Gracillaria edulis* against human rhabdomyosarcoma (RMS) cell line. *College of Biochemists Sri Lanka*. p.23.
8. Abeysiriwardhana, H.N.I., Ranasinghe, P., Jayasooriya, R.J.P.T. and Samarakoon, K.W. (2022). Evaluation of Sri Lankan Wild Fruits Based on Free Radical Scavenging Activity, Polyphenolic Content and Cytotoxic Activity. *15th International Research Conference*, General Sir John Kotelawala Defence University. p.34.

Development of organoleptic, microscopic, physico-chemical and chemical methods to detect bee honey adulteration

Grant No: TG 14-104
Project Team : *Dr. T.D.C.M.K. Wijayasiriwadane
Ms. W.A.D.D. Wasalamuni
Project Period: 2015 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Bee honey is an important raw material used in the herbal, food and pharmaceutical industries in Sri Lanka. The quality of bee honey is detected as per SLS 464:1979. According to the standard, seven parameters such as organoleptic, physico-chemical and chemical are used to detect the quality of honey. However, it is difficult to identify the quality, when the honey is adulterated with manmade honey and also with wasp honey (Bambara peni in Sinhala), or dorsata honey. The project was aimed at developing standards for dorsata honey as well as to identify honey adulterated with pollen, wax chunks, powdered plant flowers and starch.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- SLS standard for Bees Honey was revised as SLS 464:2016.
- Identification of dorsata honey based on the revised standard.
- Ability to detect adulteration more scientifically.

Scientific Communications

1. Wijayasiriwardena, T.D.C.M.K. (2018). Identification of adulteration of herbal raw materials. *Proceedings of the International Conference on Ayurveda & Herbal Drugs*, Ahmedabad, India. p.6-7.

Popularization Activities

- ITI to identify adulteration in the Herbal & Food industries, Vidya magazine, Ministry of Science, Technology and Research. (28.03.2018.)
- ITI to identify genuine bee honey, Vidya magazine, Ministry of Science, Technology and Research (25.04.2018).

Formulation of herbal drink & herbal lozenger from *Aporosa lindleyana* Baill young leaves & bioactivity studies

Grant No: TG 15 - 103
Project Team: *Dr. (Ms.) S. Chelvendran
Dr. P. Ranasinghe
Dr. (Ms.) W.P.K.M. Abeysekera
Ms. A.M.C.U. Binduhewa
Project Period: 2015 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The young leaves of *Aporosa lindleyana* Baill named as 'Kebella' in Sinhala, are consumed as a leafy vegetable in Sri Lanka and extensively used in India for medicinal purposes. A decoction of the Kebella root is used traditionally to treat jaundice, headache, insanity, seminal loss and for excessive thirst. The bark and root of this plant are reported to have antioxidant, antimicrobial and analgesic effects. In Sri Lanka, the medicinal properties of these leaves are less known by researchers, except in the preparation of a formulation for diabetes, which has these leaves as one of the ingredients. The leaves showed a high antioxidant potential (via DPPH, ABTS, FRAP and ORAC analysis), high α-amylase activity and marked anti-lipidemic activities in terms of anti-lipase, anti-cholesterol esterase and bile acid binding. Hence, the objective of the research was to formulate a herbal drink and a lozenge from *Aporosa lindleyana* Baill young leaves and to study the bioactivity of processed food products.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Antioxidant-rich Kebella tea
- Ready to serve Kebella drink

Publications in Refereed Journals

- Kathirgamanathar, S., Abeysekera, W.P.K.M., Weerasinghe, D.M.K.P., Ranasinghe, P. and Binduhewa, A.M.C.U. (2018). Antioxidant, anti-amylase and lipid-lowering potential of leaves of *Aporosa lindleyana* Baill. (Kebella). *Sri Lankan Journal of Biology*, **3**(1), 1-10.

Scientific Communications

1. Kathirgamanathar, S., Weerasinghe, D.M.K.P., Abeysekera, W.P.K.M., Ranasinghe, P. and Binduhewa, A.M.C.U.(2015). Antioxidant properties of leaves of *Aporosa lindleyana* Baill. (Kebella). *Proceedings of the 35th Annual Sessions*, IOB, Sri Lanka. p.62.
2. Kathirgamanathar, S., Weerasinghe, D.M.K.P., Abeysekera, W.P.K.M., Ranasinghe, P. and Binduhewa, A.M.C.U. (2016). Anti-lipase and anti-cholesterol esterase activities and binding of bile acids by leaf extracts of *Aporosa lindleyana* Baill. (Kebella). *Proceedings of the 36th Annual Sessions*, Institute of Biology, Sri Lanka. p.24.
3. Kathirgamanathar, S., Abeysekera, W.P.K.M., Weerasinghe, D.M.K.P., Ranasinghe, P. and Binduhewa, A.M.C.U. (2016). Anti-amylase potential and phytochemical analysis of leaf

extracts of *Aporosa lindleyana* Baill. (Kebella). *Proceedings of the 4th International Conference on Ayurveda, Unani, Siddha & Traditional Medicine*. p.135.

4. Kathirgamanathar, S., Abeysekera, W.P.K.M., Weerasinghe, D.M.K.P., Ranasinghe, P., Binduhewa, A.M.C.U. and Peiris, M.D.P.M. (2017). *Aporosa lindleyana* Baill. (Kebella) tea: An alternative to green tea. *Proceedings of the 73rd Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.72.
5. Kathirgamanathar, S., Abeysekera, W.P.K.M., Binduhewa, A.M.C.U., Ranasinghe, P. and Peiris, M.D.P.M. (2017). Development of an antioxidant rich ready to serve drink from *Aporosa lindleyana* Baill. (Kebella), *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.47.

Development of *in-vitro* propagation technology for commercial cultivation of *Stevia rebaudiana* Bertoni (Asteraceae) - A non-caloric, natural sweetener

Grant No: TG 16-118
Project Team: *Prof. R.M. Dharmadasa
Dr. P. Ranasinghe
Project Period: 2017 - 2018
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Stevia rebaudiana (Bertoni) is mainly known for the accumulation of high sweet-taste mixture of diterpene glycosides and steviol glycosides in its leaves. Stevia mainly grows at altitudes of 500-3000 m in semidry mountain areas but also can grow in grasslands and scrub forests. The major sweet component present in the leaves is a zero-calorie diterpene glycoside which acts as a natural, non-nutritive sweetener, used as a substitute for sucrose. Moreover, the Stevioside present in Stevia tastes about 300 times sweeter than sucrose (0.4% solution) and hence there is a strong possibility to use it as the best alternative to table sugar in the years to come. Furthermore, it is an alternative sweetener source for diabetes patients. The increasing global demand for low-calorie sweeteners, produced from natural sources has stimulated the current demand for additional sources of low-calorie sweeteners.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Developed *in-vitro* propagation technology for *Stevia rebaudiana.*

Scientific Communications

1. Dharmadasa, R.M., Senevirathna, L.P.J. and De Silva, V. (2018). *In vitro* propagation of *Stevia rebaudiana* (Bertoni) Bertoni. *Proceedings of the IASTEM International Conference*, Melbourne, Australia. p.17-19.
2. Dharmadasa, R.M., De Silva, G.B.V.U., Fonseka, D.L.C.K., Lintha, A. and Ranasinghe, P. (2018). *In vitro* propagation of *Stevia rebaudiana* (Bertoni) Bertoni (Asteraceae). *Proceedings of the 74th Annual Session*, Sri Lanka Association for the Advancement of Science. p.111

Rapid extraction of medicinal & aromatic plants and flowers & selective isolation of compounds by microwaves

Grant No: TG 15- 108
Project Team : *Prof. J.K.R.R. Samarasekara
Dr. (Ms.) H.D.S.M. Perera
Dr. (Ms.) G.D. Liyanaarachchi
Ms. V.S. Bandara
Project Period: 2016 - 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Microwave extraction of medicinal and aromatic plants has emerged as a promising technique over other extraction techniques mainly from an economical point of view, being inexpensive, simple and efficient. Microwave Hydrodiffusion and Gravity (MHG) is a new technique for the extraction of essential oil and secondary metabolites, especially flavors and fragrances. MHG is a combination of microwaves and Earth's gravity to extract secondary metabolites from biological materials. Essential oils and extracts produced using MHG have a competitive advantage for research in product development and identification of new bioactive ingredients for industrial applications in cosmetic, food and health care sectors.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Technologies were developed for the extraction of total extracts enriched with flavors, pigments, fragrances and oils using MHG technique; Strawberry fruit extract, Watermelon fruit extract, Tomato extract, Pineapple fruit extract, Ginger extract, Vanilla, Sweet Jack fruit extract, Anoda fruit extract, Jamson fruit extract, Onion extract, mushroom extract, Catechin rich tea extract from fresh tea leaves, Banana fruit extract, Fragrant extracts from Lime, Orange and Pineapple.
- Technologies were developed for solvent-free extraction of essential oils and aromas using MHG technique for;
  Cinnamon bark and leaf oil, Betel leaf oil, Holy Basil leaf oil, Allspice leaf oil, Citrus oils, Ginger oil, clove oil, Coriander oil, Pepper oil, Tea aroma from black tea, Sweet jack fruit fragrance from sweet jack fruit.

Scientific Communications

1. Hansika, S.A.T., Sirimuthu, N.M.S., Bandara, V.S., Perera, H.D.S.M. and Samarasekara, R. (2016). Microwave extraction of essential oils from bark and leaf of *Cinnamomum*

zeylanicum: A comparison with conventional hydrodistillation technique. *Proceeding of the 3rd Uni-In Alliance Symposium*, University of Sri Jayawardanapura, Sri Lanka. p.56.
2. Ranatunga, R.A.G.N., Samarasekara, R., Bandara, V.S., Perera, H.D.S.M., Weeratunga, H.D. and Gimhani, D.R. (2017). Comparison of solvent-free microwave extraction and conventional hydro-distillation of essential oil from local ginger (*Zingiber officinale* Roscoe). *Proceedings of the 16th Agricultural Research Symposium*, Wayaba University of Sri Lanka. p.56-60.
3. Ranatunga, R.A.G.N., Perera, H.D.S.M., Bandara, V.S. and Samarasekara, R. (2018). Solvent-free microwave extraction of essential oil from leaves of *Ocimum tenuiflorum*. *Proceedings of the 5th International Conference on Multidisciplinary Approaches*, University of Sri Jayewardenepura. p.149.
4. Ranatunga, R.A.G.N., Perera, H.D.S.M., Bandara, V.S. and Samarasekara, R. (2018). Solvent-free microwave extraction of essential oil from leaves of *Cinnamomum zeylanicum* Blume. *Proceedings of the 38th Annual Sessions*, Institute of Biology, Sri Lanka. p.45.
5. Ranatunga, R.A.G.N., Perera, H.D.S.M., Bandara, V.S. and Samarasekara, R. (2018). Solvent-free microwave extraction of essential oil from bark of *Cinnamomum zeylanicum* Blume. *Proceedings of the 11th International Research Conference*, General Sir John Kotelawala Defense University. p.14.

Awards

1. Gold Medal for Oral Presentation at the 3MT Competition (2018) organized jointly by Sri Lankan Academy of Young Scientists (SLAYS) and National Science Foundation of Sri Lanka (NSF) in collaboration with Coordinating Secretariat for Science, Technology and Innovation (COSTI) for the presentation on Chemical and Biological Characterisation of selected Sri Lankan medicinal plants for value-added industrial applications - H.D.S.M. Perera.

Popularization Activities

- Demonstrated the MHG technique.
- Displayed the products/extracts prepared by MHG technique at exhibitions.

Value addition to coconut oil

Grant No: TG 16 - 119
Project Team: *Dr. T.D.C.M.K. Wijayasiriwardena
Ms. W.A.D.D. Wasalamuni
Ms. D.L.S.M. Jayarathne
Project Period: 2016 - 2018
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Coconut oil is available abundantly in Sri Lanka. However, it has not been utilized to its full potential due to various reasons such as stickiness, rancidity, poor shelf life, technology gap etc. Coconut oil has various physical forms such as ordinary Coconut oil, Virgin coconut oil, King coconut oil or RBD oil. Each of them has specific characteristics, physical properties, chemical properties, and therapeutic properties. Value addition to naturally available Coconut oil may have a potential market in the herbal and cosmetic industry in the future.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Standardized herbal and cosmetic products based on Coconut oil with improved process technology were transferred to the industry.

Scientific Communications

1. Zeeniya, M.F.F., Wasalamuni, W.A.D.D., Jayarathne, D.L.S.M. and Wijayasiriwardena, T.D.C.M.K. (2017). Investigation of physico-chemical properties of various types of Coconut oil. *Proceedings of the 3rd Symposium Uni-In Alliance*, University of Sri Jayewardenepura. p. 62.

Popularization Activities

- A technology training workshop was conducted in 2018 to elevate the technology skills of S&T officers of the Ministry of Science, Technology and Research and other industry representatives.

Development of technologies for sustainable raw material production for cosmetic industry using endemic *Gyrinops walla gaertn* (Sin. Walla Patta) – an endemic, industrial potential, lucrative fragrance plant grown in Sri Lanka

Grant No: TG 16 - 120
Project Team : *Dr. P. Ranasinghe
Prof. R.M. Dharmadasa
Mr. S. Gunasekera
Mr. A. Satharasinghe
Project Period: 2016 - 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Agarwood is a fragrant resinous heartwood product produced by natural microbial infection in the plant. *Gyrinops walla*, locally known as "Walla Patta" is considered as the only agarwood-forming tree that is endemic to Sri Lanka. The fungal infection on the wounded stem of *G. walla* trees induces the formation of agarwood. The resin is secreted as a defense mechanism by the trees. The resin is deposited around the wounds over the years eventually forming agarwood. This aromatic resin is used for the production of the world's most expensive perfumes due to its unique fragrance and has a high demand globally. Hence, illegal harvesting and smuggling of this plant out of the country have been reported over the last few decades. The seeds are the most commonly used method to propagate *G. walla* but the seedling supply is inadequate to meet the demand. Also, this plant takes a long time to produce the resin within its stem. Therefore, considering all the above situations the project was initiated to develop an *in vitro* micropropagation technique that can ensure a rapid rate of multiplication of plantlets and aggrandized production of bioactive molecules in tissues.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A new test method was developed to test total terpenoid content in plant material. This method is now used for bioactive phytochemical testing at ITI.
- The callus and microorganism co-culture method tested in this study, is capable of inducing some important sesquiterpenes such as in *G. walla* callus.
- The knowledge generated on *G. walla* analysis supported a new contract project on the development of a chemometric method for differentiation of extracts of local *G. walla* and imported agarwood extracts with Asian plantation.

Scientific Communications

1. Kandapolaarachchi, O.K., Weerathunga, H.D., Somadasa, C.T., Dharmadasa, R.M. and Ranasinghe, P. (2018). Estimation of terpenoid contents in different parts of *Gyrinops walla* (Walla patta). *Proceeding of the Asian Symposium on Medicinal Plants, Spices and Other Natural Products XVI* (ASOMPS XVI), 12 -14th December 2018, Colombo. p.2.

Development of an anti-glycation and glycation reversing assay kit addressing all stages of glycation process

Grant No: TG 16-123
Project Team: *Prof. G.A.S. Premakumara
Dr. P. Ranasinghe
Dr. (Ms.) W.P.K.M. Abeysekera
Prof. (Ms.) W.K.S.M. Abeysekera
Project Period: 2016 - 2018
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

There are an extremely limited number of anti-glycation kits available worldwide. Even those available kits address only some known glycated products which have been identified *in vivo*. Further, none of these available kits addresses the glycation-reversing process. Therefore, the objective of this research was to develop an anti-glycation and glycation-reversing assay kit addressing all stages of the glycation process.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Early and middle-stage anti-glycation and glycation reversing assays.
- Anti-glycation assay kit.
- Glycation reversing assay kit.

Technologies Transferred/Commercialized

- Developed KIT is available for technology transfer.

Publications in Refereed Journals

1. Arachchige, S.P.G., Abeysekera, W.P.K.M. and Ratnasooriya, W.D. (2017). Anti-amylase, anti-cholinesterases, anti-glycation and glycation reversing potential of bark and leaf of Ceylon cinnamon (*Cinnamomum zeylanicum* Blume) *in vitro*. *Evidence-Based Complementary and Alternative Medicine*, Article ID 5076029.
2. Abeysekera, W.K.S.M., Abayarathna, U.P.T.C., Premakumara, G.A.S., Jayasooriya, M.C.N. and Abeysekera, W.P.K.M. (2018). Anti-glycation and glycation-reversing potential of fenugreek (*Trigonella foenum-graecum*) seed extract. *Biomedical Journal of Scientific & Technical Research*, **3**(1), 3138-3142.

Investigation of Sri Lankan natural compounds as drug leads for inflammatory diseases and management of dyslipidemia: *in-silico* and *in-vitro* approach

Grant No: TG 16-136
Project Team: *Dr. P. Ranasignhe
Ms. S.M. Abdulla
Dr. C. Rathnaweera
Dr. S. Weerasinghe
Dr. C. Udawatte
Project Period: 2016 - 2018
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Natural products remain the best and most productive sources of drugs and drug leads. They possess enormous structural and chemical diversity that is unsurpassed by any synthetic library. About 40% of the chemical scaffolds found in natural products are absent in today's medicinal chemistry collection. This Study involves the use of natural products to identify suitable probes with anti-inflammatory properties. *In silico* models provide high throughput and are used in the very early stages of the drug development process. Many drug discovery programs include computational methods as an important part. For this study, natural compounds published from plant species found in Sri Lanka, obtained from reviewing published information in reputed peer-reviewed journals during the period 1970-2014, were used. To further validate their uses, this research study uses these natural products as ligands in molecular modeling studies with selected enzymes. The following enzymes were chosen to be targeted, considering their ability to cure dyslipidemia and anti-inflammatory diseases, if their action was inhibited; Angiotensin-converting enzyme (ACE), Renin, HMG Co-A reductase, Aldose Reductase, COX1, COX2, Acetylcholine esterase and Butyrylcholine esterase.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Established a Computer-Aid Drug Design (CADD) system at the Herbal Technology Section.
- Promising inhibitors of Angiotensin Converting Enzyme, Renin, HMG Co-A Reductase, Aldose Reductase, Acetyl Choline Esterase, Butyl Choline esterase, COX-1 and COX-2 have been identified using computer-aided drug designing;
  Angiotensin Converting Enzyme: Morelloflavone (*Garcinia spicata*), Mangiferin (*Salacia oblongata*), Linarin (*Exacum macranthus*), Nectandrin B and Malabaricone C (*Myristica fragrans*), Stemonoporol and Resveratrol (*Vateria copalliferol*), Balanocarpol (*Balanocarpus zeylanicus* and *Hopea jucunda*), Cordatolide B and C (*Calophyllum cordato-oblongum*).

Scientific Communications

1. Abdulla, S.M., Premakumara, G.A.S. and Udawatte, C. (2017). Binding properties of Angiotensin-converting enzyme binding properties with selected Sri Lankan natural products: *in-silico* study. Chemistry in Sri Lanka. **34**(2),17-18.

2. Perera, A.S., Ranasinghe, P., Ratnaweera, C.N. and Udawatte, C.S. (2017). Xanthones derivatives from natural products found in Sri Lanka as acetylcholinesterase inhibitors: *in-silico* approach. Chemistry in Sri Lanka. **34**(2),15-16.
3. Abdulla, S.M., Premakumara, G.A.S. and Ranasinghe, P. (2017). *In-silico* study of the binding properties of Renin with Phoenicanthusin. *Proceedings of the International Conference on Drug Discovery and Development*, Colombo. p.12.
4. Abdulla, S.M., Premakumara, G.A.S. and Ranasinghe, P. (2017). Computational study of Angiotensin-converting enzyme and Renin with Phoenicanthusin. *Proceedings of the 10th International Research Conference*, General Sir John Kotelawala Defence University. p.50.
5. Abdulla, S.M., Premakumara, G.A.S., Ranasinghe, P. and Jayasinha, P. (2017). Computational study on binding interaction of Renin with Phoenicanthusine. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.18.
6. Perera, A.S., Ranasinghe, P., Ratnaweera, C.N. and Udawatte, C.S. (2017). *In-silico* screening of xanthones derivatives from Sri Lankan natural products against acetylcholinesterase. *Proceedings of the International Conference on Drug Discovery and Development*, Colombo.p.10.
7. Perera, A.S., Premakumara, G.A.S., Ranasinghe, P., Jayasinha, P. and Ratnaweera, C.N. (2017). *In-silico* study of acetylcholinesterase inhibitors from Xanthone derivatives from natural products found in Sri Lanka. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.20.
8. Abdulla, S.M., Premakumara, G.A.S., Ranasinghe, P. and Udawatte, C. (2018). Novel drugs for the management of hypertension: Molecular dynamic study of Renin bound to selected Sri Lankan natural products. *Proceedings of the Asian Symposium on Medicinal Plants, Spices and Other Natural Products, XVI.* p.146.
9. Abdulla, S.M., Premakumara, G.A.S., Ranasinghe, P. and Udawatte, C. (2018). Molecular dynamic simulation of angiotensin-converting enzyme with Malabaricane C. *Proceedings of the University of Colombo Research Symposium*. p.198.

Popularization Activities

- A workshop was carried out on Molecular docking and basics of Computer-Aided drug design for natural product research at the Herbal Technology Section, ITI on March 2018 to all staff members of ITI with the idea of transferring the basic docking methodology.

Formulation of cost effective, high efficacy, natural agricultural pests controlling agent (NAPCA- 90% EC)

Grant No : FP 122
Project Team: *Prof. R.M. Dharmadasa
Mr. K. Kannangara
Project Period: 2017- 2020
Funded by: National Research Council, Sri Lanka

Principal Investigator

Background

Herbivorous insects are said to be responsible for destroying approximately one-fifth of the world's total crop production annually. The sap-sucking insects including planthoppers, leafhoppers, mealy bugs, aphids, whiteflies and thrips are a major threat to many agricultural crops such as fruit and vegetables, plantation crops, spices as well as ornamental crops. Infested plants become wilted, yellow, deformed, or stunted, and may eventually die. Even though controlling insect pests using chemicals is an effective option, continuous application of chemical pesticides builds up resistance in insect pests. Further, causes deleterious effects on beneficial organisms, and has negative impacts on the environment. Therefore, the investigation of environment-friendly, safer, cost-effective herbal-based green product/s is an urgent need to minimize these negative impacts and to promote organic agriculture in Sri Lanka. This project was aimed at formulating plant protection products (PPP) from locally available medicinal plants that can be used as cheap and safer alternatives to synthetic insecticides to protect crops from pests, especially sap-sucking insects. A PPP was prepared by adding essential oils as well as plant extracts of selected plants.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Developed an economically viable, highly effective, commercial product called NAPCA for sap-sucking and other insects. The product has a shelf life of up to 3 years.
- An inventory of plant species was prepared including insect repellent and insecticidal plants available in Sri Lanka.
- Established protocols for agronomic practices, taxonomic characterization and phytochemical screenings for selected plant species.

Publications in Refereed Journals

1. Dharmadasa, R.M., Rathnayake, R.M.D.H., Abeysinghe, D.C., Rashani, S.A.N., Samarasinghe, K. and Attanayake, A.L.M. (2016). Screening of local and introduced varieties of *Pogostemon heyneanus* benth. (Lamiaceae), for superior quality physical, chemical and biological parameters. *World Journal of Agricultural Research,* **2**(6), 261-266.
2. Premathilake, U.G.A.T., Wathugala, D.L. and Dharmadasa, R.M. (2018). Effect of different fertilizers on crop growth, oil yield and chemical composition of lemongrass (*Cymbopogon citrates* (DC.) Stapf). *The Journal of Agricultural Sciences Sri Lanka*, **13**(3), 254-262.

3. Premathilake, U.G.A.T., Wathugala, D.L. and Dharmadasa, R.M. (2018). Evaluation of chemical composition and assessment of antimicrobial activities of essential oil of lemongrass (*Cymbopogon citratus* (dc.) stapf). *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, **4**(1), 13-19.
4. Rathnayake, R.M.D.H., Dharmadasa, R.M. and Abeysinghe, D.C. (2019). Effect of different spacing and fertilizer levels on physical and chemical yield of different parts of *Pogostemon heyneanus* Benth. (Lamiaceae). *World Journal of Agricultural Research*, **7**(2), 49-51.
5. De Silva, G.B.V.U., Dharmadasa, R.M., Senanayake, R.A.S.P., Lintha, A. and Sewwandi, S.K.U. (2020). Comparison of essential oil content and composition of different parts of *Cymbopogon citratus* (DC.) Stapf (Poaceae) grown in Sri Lanka. *World Journal of Agricultural Research*, **8**(1), 1-5.
6. Dharmadasa, R.M., Jayasinghe, J.A.T.U., Arawwawala, L.D.A.M. and Fonseka D.L.C.K. (2020). Compositional analysis of volatile compounds of Paspangiri - a mixture of leaves of five rutaceae plants used as an effective remedy for respiratory system microbial infections in traditional systems of medicine. *World Journal of Agricultural Research*, **8**(3), 84-88.
7. De Silva, G.B.V.U., Dharmadasa, R.M., Senanayake, R.A.S.P. and Lintha A. (2021). Selection of superior quality *Cymbopogon nardus* (L.) Rendle (Poaceae) populations by means of quantity and quality of essential oils. *World Journal of Agricultural Research*, **9**(1), 1-8.

Scientific Communications

1. Lakshmi, J.W.P.H., Abeysinghe, D.C. and Dharmadasa, R.M. (2016). Comparison of growth parameters, bioactive compounds and antioxidant capacity of two pogostemon species under two different growing systems. *Proceedings of the 14th Agricultural Research Symposium,* Wayambe University of Sri Lanka. p.288-291.
2. Dharmadasa, R.M., Rathnayake, R.M.D.M. and Abeysinghe, D.C, (2017). Effect of different spacing, fertilizer treatments on physical and chemical yield of different parts of *Pogostemon heyneanus* Benth. (Lamiaceae). *Proceedings of the 73rd Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.142.
3. Dharmadasa, R.M., Amadoru, I.J. and Abeysinghe, D.C. (2018). Effect of different mulches on yield, antioxidant capacity, bioactive compounds oil contents and composition of *Pogostemon heyneanus* Benth. (Lamiaceae). *Proceedings of the 6th ICAUST (2018) International Conference*, Sri Lanka. p.102.
4. Amadoru, I.J., Abeysinghe, D.C. and Dharmadasa, R.M. (2018). Effect of irrigation and natural shade under coconut palms on yield, antioxidant capacity, bioactive compounds, oil yield and composition of *Pogostemon heyneanus* Benth. (Lamiaceae). *Proc. Win C 2018.*
5. Dharmadasa, R.M., Lintha, A., Gunasekara, G.Y.M., De Silva, G.B.V.U. and Sewwandi, S.K.U. (2018). Essential oil content and composition of different parts of *Cymbopogon citratus* Stapf. (Gramineae) grown in Sri Lanka. *Proceedings of the 74th Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.14.
6. Dharmadasa, R.M., Gunasekara, Y., Lintha, A. and De Silva, G.B.V.U. (2018). Comparison of essential oil content and composition of different parts of locally grown *Trachyspermum ammi* (L.) Sprague species with market samples. *Proceedings of the 74th Annual Sessions,* Sri Lanka Association for the Advancement of Science. p.15.
7. Dharmadasa, R.M., Lintha, A., Gunasekara, G.Y.M., De Silva, G.B.V.U. and Sewwandi, S.K.U. (2018). Comparative study on essential oil content and composition of two varieties

of *Cymbopogan nardus* populations in Sri Lanka. *Proceedings of the 74th Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.110.

8. Dharmadasa, R.M., Lintha, A., Gunasekara, G.Y.M., De Silva, G.B.V.U. and Sewwandi, S.K.U. (2018). Comparison of essential oil content and composition of different parts of *Cymbopogan citrates* STAPF and *Cymbopogan nardus* (L.Rendle) grown in Sri Lanka. *Proceedings of 6th International Conference on Ayurveda, Unani, Siddha and Traditional Medicine.*
9. Amadoru, I.J., Abeysinghe, D.C. and Dharmadasa, R.M. (2018). Effect of irrigation and natural shade under coconut palms on yield, antioxidant capacity, bioactive compounds, oil yield and composition of *Pogostemon heyneanus* Benth. (Lamiaceae). *Proc. WinC 2018.*
10. Senarathne, M.A.H., Dharmadasa, R.M., Abeysinghe, D.C., Mewan, K.M. and Gunarathne, H.D.M.D.P. (2019). Screening of leaves of *Citrus* varieties for their phenolic, flavonoid and essential oil contents and total antioxidant capacity, *Proceedings of the 18th Agricultural Research Symposium*, Wayamba University of Sri Lanka. p.627-631.

Awards

1. Gold Medal 2020 in the Open Category under the technical field of Agriculture for the development of Natural Agricultural Pest Control Agents (NAPCA) by using Sri Lankan-grown medicinal and aromatic plant extracts for the control of sucking agricultural pests at the award ceremony organized by the Sri Lanka Inventors Commission - R.M. Dharmadasa.
2. DASIS award 2021 (open category) under the technical field of Agriculture for the development of a natural agricultural pest control agent (NAPCA) by using Sri Lankan-grown medicinal and aromatic plant extracts for the control of sucking agricultural pests at the awards ceremony organized by the Sri Lanka Inventors Commission - R.M. Dharmadasa.

Popularization Activities

- Workshops on the effect of NAPCA were conducted targeting extension officers and potential fruit and vegetable growers.

Establishment of biologically relevant antioxidant bio-assays covering different modes of action: applications in R&D and commercialization

Grant No: TG 18 -139
Project Team: *Dr. (Ms.) W.P.K.M. Abeysekara
Prof. G.A.S. Premakumara
Dr. P. Ranasinghe
Prof. (Ms.) W.K.S.M. Abeysekara
Project Period: 2018 - 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Antioxidant activity of a test sample cannot be concluded based on a single test method. Each method varies in different respects. The antioxidants in a test sample may act by multiple mechanisms in a single system or different single mechanisms depending on each test method. The biological relevance of each method is also different. Therefore, to date, various methods are used in the investigation of the antioxidant activity of test samples (foods, plant extracts, commercial antioxidants etc.). Currently, a range of antioxidant bioassay methods has been established and used in both R&D activities and as a commercialized service at ITI. However, most of the available methods are based on non-physiological radical sources since the biological relevance is limited. To date, there are no established antioxidant bioassays to evaluate the lipid peroxidation of biological materials including foods and serum samples at ITI. Therefore, the objective of this project was to establish biologically relevant antioxidant bioassays covering different modes of action.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Hydrogen peroxide radical scavenging (H_2O_2) antioxidant bioassay.
- Hydroxyl radical scavenging antioxidant bioassay.
- Thiobarbituric acid (TBA) antioxidant bioassay.
- Widen the area of antioxidant bioassays at ITI.
- Evaluation of antioxidant activity of foods and natural products through different modes of action.

Scientific Communications

1. Weerakkody, R., Abeysekera, W.P.K.M., Abeysekera, W.K.S.M., Ranasinghe, P., Premakumara, G.A.S. and Ratnasooriya, W.D. (2019). Antioxidants and antioxidant activity of root and stem bark of *Moringa oleifera* Lam. (Murunga), *Proceedings of the 39th Annual Sessions,* Institute of Biology, Sri Lanka. p.60.

Value addition to essential oils by fractional distillation under vacuum

Grant No: TG 18 -140
Project Team: *Prof. G.A.S. Premakumara
Dr. H.D. Weeratunga
Dr. P. Ranasinghe
Dr. H.P.P.S. Somasiri
Project Period: 2018 - 2021
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Presently, no value additions are taking place for essential oils produced in Sri Lanka by fractional distillation. Moreover, Sri Lanka does not produce any natural isolates or fragrance compounds for the world market which are highly demanded in the pharmaceutical, flavor and fragrance industries. Further, the essential oils readily available in Sri Lanka can be fractionated to aroma compounds or fractionated compounds can be chemically transformed as top notes in perfumes. The essential oils produced in Sri Lanka are mainly exported to France, Germany, the United Kingdom and the USA as ingredients for the perfume industry. Those countries are only producing top notes such as Lavender, Jasmine and Rose. The middle notes and the bottom notes are imported from Asian countries including Sri Lanka and formulate the fragrance. However, Sri Lanka produces both bottom and top notes required for the perfumery production, though we are still unable to succeed in the perfumery industry. Therefore, the project was conducted to add value to essential oils readily available in Sri Lanka by fractionating them into expensive and highly demanded natural isolates. Some of those fractionated natural isolates can be transformed into expensive top notes such as Ionone. In addition, fractionated essential oil fractions such as citronelal, citronellol and geraniol can be used to manufacture natural rose fragrances. Further, fractionated natural isolates such as eugenol, citral and caryophyllene can be exported as precursors to synthesize expensive and highly demanded compounds in the pharmaceutical, flavor and fragrance industries.

- The study contributes towards the improvement of the essential oils manufacturing industry and contributes to uplifting the economy of the country.
- The findings of the study encourage the production of natural isolates, high-quality natural essential oils, perfumery, effective air fresheners as mosquito repellent activity and top notes including rose oil substitutes.
- The findings of the present study would have a considerable impact on the personal care products, household products, flavor and fragrance industry and pharmaceutical industry of the country as it will contribute towards improvement in the social and economical disciplines.
- These findings would encourage cultivators to grow Cinnamon, Clove, Citronella and Lemongrass and hence have a direct impact on improving the national agro-industry.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Technology was established for fractioning volatile oils including Cinnamon leaf,

Cinnamon bark, Ceylon Citronella, Lemongrass, Clove stem and Clove bud under reduced pressure as per the guidelines given by the Operation Manual. The fractionation protocols can be transferred as technologies in each case.

- Technology was developed to upgrade Cinnamon chip oil to higher grade aromatherapy grade Cinnamon bark oil with 60% cinnamaldehyde level (Fractionated oil was used for formulation).
- Natural isolates including Eugenol (98%), Linalool (70%), Citral (95%), D-Limonene (68%), Geraniol (68%) & Camphene (68%) were developed.
- Ladies' perfume with rose fragrance.
- Mosquito repellent lotion for children and adults (Fractionated Citronella oil was used).

Scientific Communications

1. Lokuge, C.M., Weerathunge, H.D., Premakumara, G.A.S. and Chandrathilake G.G.T. (2019). Evaluation of essential oil yield and chemical compositions of Lemongrass (*Cymbopogon spp*.) cultivars grown in different locations Sri Lanka. *Proceedings of the 24th International Forestry and Environment Symposium*, University of Sri Jayewardenepura.p.60.
2. Lokuge, C.M., Chandrathilake, G.G.T. and Weerathunge, H.D. (2019). Study on chemical composition of the essential oils obtained from selective oil-bearing plants in Sri Lanka. *Proceedings of the 5th UNI-IN ALLIANCE 2019 Symposium of the B.Sc. (Honours) Degree in Applied Sciences*, University of Sri Jayewardenepura. p.7.
3. Lokuge, C.M., Ranasinghe, P., Weerathunge, H.D., Premakumara, G.A.S. and De Silva, H. (2022). Fractionating of Ceylon citronella (*Cymbopogon nardus* L Rendle) essential oils by fractional distillation under reduced pressure. *Proceedings of the 6th International Conference on Medicinal Plants, Herbal Products & Hydroponics*, University of Colombo. p. 52.

Comprehensive utilization of Sri Lankan grown of *Moringa oleifera* Lam. in developing health food and herbal medicinal products to startup the *Moringa oleifera* Lam. industry in Sri Lanka

Grant No: TG 18-141
Project team: *Prof. (Ms.) J.K.R R. Samarasekara
Dr. T.D.C.M.K. Wijesiriwardena
Dr. (Ms.) H.D.S.M. Perera
Dr. (Ms.) D.M.W.D. Divisekera
Dr. (Ms.) S.A.S. Jayawardana
Project Period: 2018-2021
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Moringa is considered as one of the world's most beneficial trees. Almost all parts of the tree have been consumed by humans or have been utilized in Ayurvedic and Traditional systems of medicine since ancient times. Although bioactive properties of different Moringa varieties were reported, limited studies have been conducted on the Moringa varieties that are grown in Sri Lanka. This project was focused on investigating antioxidant, antidiabetic, anti-inflammatory and antimicrobial potential of leaves, barks, pods and flowers of Sri Lankan-grown Moringa varieties. A range of Moringa-based food and herbal medicinal products was developed targeting health-conscious consumers.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Antioxidant, anti-inflammatory, antidiabetic and antimicrobial properties of Moringa leaves, bark, pods and flowers were identified.
- A method to extract Moringa seed oil was developed.

Technologies Developed

- A chewable Moringa tablet was formulated incorporating Moringa leaves.
- A standardized herbal tea was formulated incorporating Moringa leaves.
- A moisturizer, a body cream, a body lotion, a soap, a shower gel and a shampoo were developed as Moringa-based skin care and hair care cosmetics.
- A laxative mixture was formulated incorporating Moringa leaf powder
- A toothpaste was formulated incorporating Moringa leaf powder.
- A hand sanitizing gel was formulated incorporating Moringa leaf extract.
- A wound healing cream was formulated incorporating Moringa leaf extract.
- A burn cream was formulated incorporating Moringa seed oil.
- A pain relieving herbal spray was formulated incorporating Moringa seed oil.
- An ointment was formulated incorporating Moringa seed oil.

Scientific Communications

1. Ranatunga, R.A.G.N., Perera, H.D.S.M., Samarasekara, J.K.R.R., Wijayasiriwardena, T.D.C.M.K. and Mahanama, K.R.R. (2019). *In vitro* antioxidant properties of leaves from Sri Lanka-grown *Moringa oleifera* Lam. morphotypes. *Proceedings of the 12th International Research Conference*, General Sir John Kotelawala Defense University. p.186.
2. Hemathilaka, D.M.K.S., Samarasekera, J.K.R.R., Perera, H.D.S.M. and Kottearachchi, N.S. (2019). Development of Moringa (*Moringa oleifera*) based formulations for industrial application. *Proceedings of the 18th Agricultural Research Symposium*, Wayamba University of Sri Lanka. p.246-249.
3. Dissanayaka, D.M.D.C., Divisekera, D.M.W.D. and Hettiarachchi, S. (2019). Investigation of anti-bacterial activity of *Moringa oleifera (drumstick)* and assessing as a potential ingredient to increase the shelf life of minimally processed *Alternanthera sessilis* (Mukunuwenna). *Proceedings of the Rajarata International Research Conference*, Rajarata University of Sri Lanka. p.214.
4. Bamunuarachchi, B.A.S.U., Dasanayaka, P.N., Liyanarachchi, G.D., Perera, H.D.S.M. and Samarasekara, R. (2021). Preparation and standardization of toothpaste incorporating *Moringa oleifera* leaves. *Proceedings of the 5th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.16.
5. Bamunuarachchi, B.A.S.U., Samarasekara, R., Dasanayaka, P.N., Liyanarachchi, G.D. and Perera, H.D.S.M. (2021). Preparation, evaluation and comparison of *Moringa oleifera* incorporated toothpaste with commercial toothpaste. *Proceedings of the Young Scientists' International Conference on Multidisciplinary Research*, National Institute of Fundamental Studies. p.27.
6. Bamunuarachchi, B.A.S.U., Samarasekara, R., Dasanayaka, P.N., Liyanarachchi, G.D. and Perera, H.D.S.M. (2021). In-vitro antibacterial activity of developed toothpaste incorporating *Moringa oleifera* leaves against Staphylococcus aureus, Proceedings of Uni-in-alliance, Faculty of Applied Sciences, University of Sri Jayewardenepura. p.45.

Awards

1. Best Oral Presentation Award at Young Scientists' International Conference on Multidisciplinary Research, National Institute of Fundamental Studies, Kandy.2021. Paper: Bamunuarachchi, B.A.S.U., Samarasekara, R., Dasanayaka, P.N., Liyanarachchi, G.D. and Perera, H.D.S.M. (2021). Preparation, evaluation and comparison of *Moringa oleifera* incorporated toothpaste with commercial toothpaste.

Pharmacognostical investigation of *Curcuma albiflora* Thw.(Harankaha)

Grant No: FP 127
Project Team: *Dr. T.D.C.M.K. Wijayasiriwardene
Prof. G.A.S. Premakumara
Dr. H.M.I.C. Herath
Project Period: 2018 - 2020
Funded by: National Science Foundation, Sri Lanka

**Principal Investigator*

Background

Curcuma albiflora Thw. vernacularly known as "Harankaha" is used in Traditional Sri Lankan medicine as an anti-inflammatory drug, as a poultice, paste or oil made with the rhizome or as a herbal oil to mitigate arthritic joint problems. Although the raw material is adequately available, no commercial products are yet available in the market. Therefore, it was thought to investigate with scientific evidence on the value-added product and consumer satisfaction survey of the ointment produced from "Harankaha".

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Anti-inflammatory ointment, validated by the community as post post-marketing surveillance study which can be considered as a preliminary clinical study to find the effectiveness on the use of the product.
- A perfume was developed using the volatile fraction of "Harankaha" which can be used as an import substitute in the fragrance industry.

Publications in Refereed Journals

1. Herath, H.M.I.C., Wijayasiriwarderna, T.D.C.M.K. and Premakumara, G.A.S. (2017). Comparative GC-MS analysis of all *Curcuma* species grown in Sri Lanka by multivariate test. *Ruhuna Journal of Science,* **8**, 103-111.
2. Herath, H.M.I.C., Wijayasiriwarderna, T.D.C.M.K. and Premakumara, G.A.S. (2017). Anti-inflammatory activity of *Curcuma albiflora* Thw. species grown in Sri Lanka. *Journal of Ayurveda Medical Science,* **2**(4), 290 - 293.
3. Herath, H.M.I.C., Wijayasiriwarderna, T.D.C.M.K. and Premakumara, G.A.S. (2017). Morphological and microscopical analysis of five *Curcuma* species grown in Sri Lanka using multivariate test. *International Journal of Pharmacognosy*, **4**(7), 224 - 231.
4. Herath, I., Wijayasiriwardena, C., Joshi, R. and Premakumara, S. (2018). Pharmacognostical investigation of *Curcuma albiflora* Thw.: A review. *American Journal of Essential oil & Natural Products,* 6(4), 18-26.
5. Herath, I., Wijayasiriwardena, C., Joshi, R. and Premakumara, S. (2018). Identification and volatile composition of *Curcuma oligantha* Trimen. *American Journal of Essential oil & Natural Products,* 6(2), 11-14.
6. Herath, H.M.I.C., Wijayasiriwarderna, T.D.C.M.K., Karunagoda, L.M., Premakumara, G.A.S. (2018) Study on effectiveness and user satisfaction of anti-inflammatory ointment of *Curcuma albiflora* Thw. in Bentota Divisional Secretariat, Southern Sri Lanka. *Ruhuna Journal of Science,* 9(2), 140-149.

7. Herath, H.M.I.C., Wijayasiriwarderna, T.D.C.M.K. and Premakumara, G.A.S. (2018). In vitro antioxidant and in vivo anti-inflammatory activity of *Curcuma albiflora* THW. *Sri Lanka Journal of Biology,* 3(1), 24-33.
8. Herath, I., Wijayasiriwardena, C., Joshi, R. and Premakumara, S. (2018). Pharmacognostical investigation of Curcuma albiflora Thw.: A review. *American Journal of Essential oil & Natural Products*, 6(4), 18-26.

Scientific Communications

1. Herath, H.M.I.C., Wijayasiriwarderna, T.D.C.M.K., Karunagoda, L.M. and Premakumara, G.A.S. (2018). Study on the effectiveness and user satisfaction of anti-inflammatory ointment of *Curcuma albiflora* THW. in two community-based centers in Southern Sri Lanka. *Proceedings of the Annual Research Symposium*, University of Colombo.
2. Herath, H.M.I.C., Wijayasiriwarderna, T.D.C.M.K. and Premakumara, G.A.S. (2017). Anti-inflammatory activity of *Curcuma albiflora* on cotton pellet induced granuloma in rats. Proceedings of *the 3rd Biannual Research Symposium,* Industrial Technology Institute, Sri Lanka. p.28-29.

Post Graduate Degree

1. Mr. H.M.I.C. Herath obtained a PhD degree from the University of Colombo in 2017.
   Thesis Title: Pharmacognostical investigation of *Curcuma albiflora* Thw. (Harankaha).

Development of an adulteration detection kit for bee honey for industries

Grant No: TG 19 -179
Project Team: *Dr. T.D.C.M.K. Wijayasiriwardene
Ms. M.K. Kumarapeli
Project Period: 2019 - 2020
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Bee honey is a high-demand nutraceutical that has an annual demand of over 20,000 metric tons. However, local production is less than half and adulterated honey has been reported over the years. Since obtaining a report from a third-party laboratory would take a few days and was considered a burden to industries, it was decided to develop a tailor-made solution for industries, vendors and the public.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A tailor-made field adulteration detection kit for bee honey identification was developed.

Technologies Transferred/Commercialized

- Group technology transfer was done for 24 public health inspectors of the Colombo Municipal Council in 2020.
- More than 30 test kits have been delivered to the industry stakeholders by 2020.

Awards

1. Award for the Best Innovation Project 2019 for the project titled "Development of an adulteration detection kit for bee honey for industries" at the 4th Biennial Research Symposium, Industrial Technology Institute - T.D.C.M.K. Wijayasiriwrdena and Madushika Kumarapeli.

Popularization Activities

- Awareness programme to Astron Pharmaceuticals Ltd. on adulteration detection of bee honey.
- Awareness given through various marketing events conducted by MBD of ITI.
- New device to determine the quality of bee honey, Daily Mirror Newspaper (14.11.2019).

The Industrial Technology Institute (ITI) conducts cutting-edge research, testing services, and collaborative projects in molecular biology and biotechnology to support the advancement of agriculture, health, environment, and industry in Sri Lanka.

With expertise in modern biotechnological techniques, ITI engages in product development, problem-solving research, and technology-driven solutions for national needs. We also provide specialized training programs and educational opportunities, fostering knowledge transfer to students, professionals, and industry partners.

Iron fortification of rice seeds using soya bean ferritin

Grant No: TG 11- 52
Project Team: *Dr. (Ms.) S.G. Senaratne
*Dr. (Ms.) W.W.P. Rodrigo
Ms. H.H.K. Achala
Project Period: 2011 - 2015
Funded by: Sri Lanka Treasury

**Principal Investigators*

Background

Iron deficiency is one of the most widespread nutritional disorders in the world. Several approaches have been taken to solve this issue, but none of them are able to fully address this problem. In this context, the development of rice plants with high iron content by genetic engineering methods is a promising approach. Therefore, the overall objective of this research was to increase iron content in rice seeds by introducing a soybean (*Glycine max* (L).) ferritin gene into rice (*Oryza sativa* ssp *indica*) seeds under the control of rice seed-specific globulin promoter.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Establishment of a simple and efficient transformation method to transform foreign genes into rice plants called "in plant transformation method".

Scientific Communications

1. Perera, M.D.H., Govindaraj, N., Bandara, K.G.W.W., Chandrasekharan, N.V. and Senaratne, S.G. (2012). Cloning of soybean ferritin gene towards iron-fortification of rice. *Proceedings of the 68th Annual Session*, Sri Lanka Association for Advancement of Science. p.100.
2. Perera, M.D.H., Govindaraj, N., Bandara, K.G.W.W., Chandrasekharan, N.V. and Senaratne, S.G. (2013). Cloning of soybean ferritin gene towards iron-fortification of rice. *Proceedings of Annual Research Symposium*, Industrial Technology Institute. p.2.
3. Rodrigo, W.W.P., Achala, H.H.K., Bandara, K.G.W.W., Rathnayaka, N.R.M.K.N.D., Withana, W.T.G.S.L., Chandrasekharan, N.V. and Senaratne, S.G. (2015). Studies towards the development of transgenic rice expressing ferritin. *Proceedings of the 7th Annual Scientific Sessions*, Institute of Biochemistry, Molecular Biology and Biotechnology, University of Colombo. p.23.
4. Delpachithra, H.D., Rodrigo, W.W.P. and Withana, W.T.G.S.L. (2017). Regeneration of ferritin-rich transgenic rice plants using in-planta transformation method. *Proceedings of the Postgraduate Institute of Science Research Congress 2017 (RESCON 2017)*, University of Peradeniya. p.74.
5. Fonseka, W.N.T. and Rodrigo, W.W.P. (2019). Detection of endosperm-specific gene expression in ferritin rich transgenic rice seeds. *Proceedings of the International Research Conference 2019 (IRCUWU 2019)*, Uva Wellassa University of Sri Lanka. p.296.

NCBI GenBank Submissions

- One isolate was deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA

Expression of lysine-rich protein SBgLR gene in rice seeds

Grant No: TG 11- 53
Project Team: *Dr. (Ms.) S.G. Senaratne
*Dr. (Ms.) W.W.P. Rodrigo
Ms. W.T.G.S.L. Withana
Project Period: 2011 - 2015
Funded by: Sri Lanka Treasury

Principal Investigators

Background

Rice (*Oryza sativa* spp *indica*), a major staple crop worldwide, has limited levels of essential amino acids, especially lysine, which leads to many health effects. Genetic Engineering is one of the techniques that can be used to resolve this nutritional problem, by improving the content of amino acids. Therefore, the overall objective of this research was to increase both lysine and total protein content in rice seeds by introducing the pollen-specific lysine-rich protein-encoding gene (SBgLR) from potato (*Solanum tuberosum*) into rice (*Oryza sativa* spp *indica*) seed under the control of the rice seed-specific globulin promoter.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Establishment of a simple and efficient transformation method to transform foreign genes into rice plants called "in-plant transformation method".

Scientific Communications

1. Chandrikah, G., Kapuruge, E.P., Perera, M.D.H., De Silva, D.P.D.C., Chandrasekharan, N.V. and Senaratne, S.G. (2012). Cloning of the potato SBgLR gene and rice Glb promoter to produce lysine-rich rice. *Proceedings of the 68th Annual Sessions,* Sri Lanka Association for the Advancement of Science. p.62.
2. Rodrigo, W.W.P., Chandrasekharan, N.V. and Senaratne, S.G. (2015). Construction of a fusion cassette for the introduction of a lysine-rich gene into rice (*Oryza sativa* L.) genome. *Proceedings of the 2nd Ruhuna International Science and Technology Conference* (RISTCON), University of Ruhuna. p.87.
3. Rodrigo W.W.P., Achala, H.H.K., Bandara, K.G.W.W., Withana, W.T.G.S.L., Chandrasekharan, N.V. and Senaratne, S.G. (2015). Development of transgenic rice plants with lysine rich protein coding gene, *Proceedings of the 71st Annual Scientific Sessions,* Sri Lanka Association for the Advancement of Science. p.80.
4. Delpachithra, H.D., Munasinghe, M., Withana, W.T.G.S.L. and Rodrigo, W.W.P. (2017). Transformation and screening of lysine rich transgenic rice plants. *Proceedings of the 3rd Symposium of Uni-In Alliance,* University of Sri Jayewardenepura. p.92.

NCBI GenBank Submissions

- Twenty-one isolates were deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Estimation of rice percentage in wheat and rice bread

Grant No: TG 12- 00-02
Project Team: *Dr. (Ms.) S.G. Senaratne
*Dr. (Ms.) W.W.P. Rodrigo
Dr. (Ms.) A.M.M.H. Athapaththu
Project Period: 2012 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigators*

Background

Rice flour lacks an important protein called gluten, which strengthens the dough and holds in gases produced during fermentation in bakery food production. The use of rice flour is limited to unfermented baked products since rice proteins are unable to hold gases produced during fermentation. Hence, a mixture of rice flour with other flour types would give a higher nutritional value and a good quality for fermented processed food rather than the rice itself. Therefore, these rice-incorporated processed food items would be a promising substitute for all wheat-based foods. As a result, manufacturers tend to incorporate rice and wheat in different percentages and produce bakery items in order to attract consumers to rice-based products. Cereal composition is always a key factor in the quality and safety of food and feed. Therefore, correct labeling is very important. However, when it comes to rice-based food, in order to attract more consumers, manufacturers falsify the rice percentage of processed food items. Thus, the establishment of an analytical tool to detect rice adulteration and mislabeling is essential. This study was conducted to develop a molecular-based method to quantify the rice percentage in rice-incorporated processed food items.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Different DNA extraction methods were optimized for baked products. Semi-quantitative methods were practiced as a real-time PCR facility was not available during the time period.

Scientific Communication

1. Somatilaka, B.G.N.D.K., Nanayakkara, A.K., Rajapakse, D., Senaratne, S.G. and Chandasekharan, N.V. (2013). Development of molecular methods for the estimation of rice percentage in wheat/rice incorporated bakery products. *Proceedings of the Annual Research Symposium*, Young Scientist Forum, Sri Lanka. p.48.

Lactide biopolymer synthesis for healthcare industry

Grant No: TG 13-00/03
Project Team: *Dr. (Ms.) A.M.M.H. Athapaththu
Dr. (Ms.) W.W.P. Rodrigo
Dr. P.A.D.H.N. Gunathilake
Project Period: 2013 – 2015
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The commercial production of lactic acid using fermentation technology mainly depends on the cost of raw materials used. Therefore, it is essential to select a raw material for industrial production of lactic acid with a number of characteristics such as low cost, rapid rate of fermentation, lowest amount of contaminants, high yields of lactic acid production, little or no formation of by-products and availability throughout the year. Cassava (*Manihot esculenta*), also commonly called as manioc, tapioca or yuca, is one of the most important food crops especially in humid tropics. It is grown even in low nutrient availability and is able to resist drought. The study was conducted with cassava, which is used as a low-cost substrate in the fermentation to produce L-(+)-lactic acid. The current research was conducted through microbial fermentation using *Lactobacillus* species. The two species used were *Lactobacillus casei* (ATCC No: 393) and *Lactobacillus delbrueckii* (ATCC No: 15808). These organisms are used particularly for the production of L-(+)-lactic Acid.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The methods and compositions were optimized for large-scale media, in order to process large-scale fermentation.

Scientific Communications

1. Selvaraj, S., Gunesekera, N., Gunathilaka, P.A.D.H.N. and Athapaththu, A.M.M.H. (2017). Production and detection of L-(+)-lactic acid using cassava as the low-cost fermentation medium for the synthesis of biodegradable polymers as orthopedic devices. *Proceeding of the 2nd International Conference on Bioscience and Biotechnology*. p.54-64.
2. Selvaraj, S., Gunesekera, N., Athapaththu, A.M.M.H., Gunathilaka, P.A.D.H.N., Achala, H.H.K. and Rodrigo, W.W.P. (2016). Production of L-(+)-lactic acid for the health-care industry using *Lactobacillus casei* & *Lactobacillus delbrueckii* with cassava as the raw material. *Proceedings of the Annual Research Symposium*, Young Scientist Forum, Sri Lanka. p.96.

Postgraduate Degrees

1. Ms. Saranya Selvaraj obtained an MSc degree from the Postgraduate Institute of Agriculture, University of Peradeniya in 2015/2016.
   Thesis Title: Production and detection of L-(+)-lactic acid using cassava as the low-cost fermentation media for health and industry.

Development of a DNA rabies vaccine for dogs

Grant No: TG 13 -87
Project Team: * Dr. (Ms.) S.G. Senaratne
* Mr. K.G.W.W. Bandara
Dr. (Ms.) A.M.M.H. Athapaththu
Project Period: 2013 – 2017
Funded by: Sri Lanka Treasury

**Principal Investigators*

Background

Rabies is a zoonotic disease that is caused by the rabies virus. In Sri Lanka 50 to 60 deaths occur annually due to bites from rabies-infected dogs. Rabies is 100% fatal once symptoms have appeared. The most cost-effective way to prevent rabies in people is to eliminate rabies in dogs through effective mass rabies immunization campaigns since the dog is the main reservoir as well as the transmitter of rabies in the country. Sri Lanka spends around Rs. 500 million per year for the treatment of rabies patients and rabies control. Currently, the dog rabies vaccine is imported by the country because there is no local rabies vaccine production. This may be due to complications of the rabies vaccine production process that require mammalian cell culture and other complicated downstream processes. Furthermore, the inability of currently used vaccination strategies to provide highly potent, cost-effective, safe and sustained protection, preferably after a single dose therapy, indicates the need for an improved rabies vaccine. Recent discoveries show that DNA vaccines can elicit strong, antigen-specific immune responses in dogs. The objective of this study was to develop a DNA rabies vaccine by cloning the rabies virus glycoprotein gene in the pcDNA 3.1 expression vector and analyze the immunogenicity of the DNA vaccine by vaccinating dogs with the DNA vaccine supplemented with suitable adjutants.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The rabies virus glycoprotein gene was selected from the rabies virus isolated in Sri Lanka.
- Codon optimization was carried out to increase the expression of rabies virus glycoprotein gene in dogs.
- Synthesized Sri Lankan rabies virus glycoprotein gene containing PstI restriction site at 5' end and BamHI site at 3' end.
- Rabies virus glycoprotein gene was cloned in pcDNA 3.1 expression vector.
- Recombinant pcDNA 3.1 plasmid vector will be used as the DNA vaccine.

Scientific Communications

1. Bandara, K.G.W.W., Withanage, G.P.W.K., Athapaththu, A.M.M.H., Withana, W.T.G.S.L., Chandrasekharan, N.V. and Senaratne, S.G. (2015). Development of a DNA rabies vaccine for dogs using glycoprotein gene of Rabies Virus. *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology, Sri Lanka. p.2.
2. Bandara, K.G.W.W., Withanage, G.P.W.K., Rajapakse, R.P.V.J., Withana, W.T.G.S.L., Chandrasekharan, N.V., Senaratne, S.G. and Athapaththu, A.M.M.H. (2018). Development of a DNA rabies vaccine for dogs. *Proceedings of the International Workshop on Modern and Emerging Trends in Vaccine Development*, Nigeria. p.50.

Comprehensive research proposal on an operation model to control dengue in Sri Lanka using multiple vector control interventions, new product development and community engagement

Grant No: FP 115
Project Team: *Prof. W. Abeyewickreme
Dr. P.A.D.H.N. Gunathilleke
Dr. (Ms.) A.M.M.H. Athapaththu
Dr. (Ms.) W.W. Rodrigo
Dr. I.P.L. Jayarathne
Project Period: 2014 – 2021
Funded by: National Research Council, Sri Lanka

Capacity building for the development of monoclonal antibodies against Dengue virus and to determine the feasibility of a nanomaterial to anchor the developed antibodies

Grant No: TG 15 -96
Project Team: *Dr. (Ms.) A.M.M.H. Athapaththu
Ms. H.H.K. Achala
Prof. (Ms.) P. Udagama
Project Period: 2015 – 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

"A novel diagnostic kit based on nanobiotechnology for early, rapid and definitive diagnosis of DENV" was a component of the project on "Comprehensive research proposal on an operation model to control dengue in Sri Lanka using multiple vector control intervention, new product development and community engagement "(funded by NRC -TO 14-04) which was performed in the Biotechnology Section of ITI. This project funded a Real-Time PCR machine worth 5 million rupees for the Biotechnology Section of ITI. The funding for the reagents and the consumables was from the parallel TG project 15/96 was for capacity building for the development of monoclonal antibodies against the Dengue virus and to determine the feasibility of a nanomaterial to anchor the developed antibodies of ITI. In this study, a portable, user-friendly, and cheap kit that could be used as a home appliance or in any field setting for the detection of DENV in blood at a single cell level was targeted to develop by combining biotechnology and nanotechnology. Therefore, the intention was to determine the feasibility of developing a rapid diagnostic kit to the extent that the public could purchase the test strips over the counter from any pharmacy. The study also focused on developing antibodies against DENV, by formulating a nanomaterial that can anchor those antibodies and thereby facilitate with a highly sensitive, portable and cheap diagnostic kit to detect dengue virus from blood, at the early viremic phase. Finally, the results of the research would lead to a nanotechnology-based kit for the detection of DENV, thereby preventing dengue epidemics through early diagnosis, proper treatment and patient management to safeguard human and economic wellness.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Anti-DENV NS1 monoclonal antibodies using synthetic peptides were developed.
- Out of all the antibodies, one antibody was selected that can be used to detect all four serotypes of DENV.
- Water-soluble L-cysteine capped CdTe Quantum Dots were successfully fabricated in zeolite under atmospheric conditions.
- These highly fluorescent CdTe Quantum Dots together with the produced monoclonal antibodies were used to develop a preliminary structure of the Lateral Flow Immuno Assay (LFIA) for the rapid detection of DENV in urine.
- Monoclonal antibodies were developed.
- Nanoparticles for the development of diagnostic kits were developed.
- Antibody immobilization on nanoparticles is ongoing.
- Development of a nano-based user-friendly diagnostic kit for the detection of Dengue virus at home is still ongoing.

Publications in Refereed Journals

1. Munasinghe, E., Jayawardane, Y., Rajapaksha, A., Bandara, A., Weerasooriya, R. and Jayarathne, L. (2021). Fabrication of water soluble L-cysteine capped Cd Te quantum dots in zeolite confinement. *Exploratory Materials Science Research*, E-ISSN: 2582.
2. Munasinghe, E., Athapaththu, M. and Abeyewickreme, W. (2022), Immuno-dominant dengue NS1 peptides as antigens for production of monoclonal antibodies. *Frontiers in Molecular Biosciences*, **9**, 935456.

Scientific Communications

1. Munasinghe, M.M.E., Athapaththu, A.M.M.H., Gunathilaka, P.A.D.H.N. and Abeywickreme, W. (2015). Optimization of the cell culture media to obtain the most effective nutrient concentrations in the medium for the growth and maintenance of the myeloma cells. *Proceedings of the International Research Sessions*, University of Peradeniya. p.234.
2. Munasinghe, M.M.E., Chandrasekharan, N.V., Korbakis, D., Soosaipillai, A., Diamandis, E.P., Athapaththu, A.M.M.H., Gunathilaka, P.A.D.H.N. and Abeywickreme, W. (2015). Designing of immunogenic peptides from Dengue Virus, NS1 region for production of monoclonal antibodies as diagnostic intermediates. *Proceedings of the Current Research Activities*, Faculty of Medicine, University of Kelaniya Sri Lanka. p.13-14.
3. Munasinghe, M.M.E., Athapaththu, A.M.M.H., Abeywickreme, W., Rodrigo, W.W.P., Fernando, L.K. and Gunathilaka, P.A.D.H.N. (2015). Prevalence of Dengue Fever (DF) and Dengue Hemorrhagic Fever (DHF) in the Gampaha District of Sri Lanka: A cross-sectional study in a selected population of clinically suspected dengue patients. *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.41-42.
4. Kumar, S.A., Athapaththu, A.M.M.H., Gunathilaka, P.A.D.H.N., Rodrigo, W.W.P. and Achala, H.H.K. (2015). Optimization of Reverse Transcriptase Polymerase Chain Reaction based method for the detection of the dengue virus. *Proceedings of the 2nd Biennial Symposium*, Industrial Technology Institute, Sri Lanka. p.40.
5. Kumar, S.A., Gunathilaka, P.A.D.H.N., Rodrigo, W.W.P. and Athapaththu, A.M.M.H. (2016). Optimization of a ribonucleic acid (RNA) extraction protocol for viruses in clinical

samples for disease diagnosis. *Proceedings of the 6th Research Symposium*, Uva Wellassa University of Sri Lanka. p.2.

6. Anand, K.S., Athapaththu, A.M.M.H., Gunathilaka, P.A.D.H.N. and Rodrigo, W.W.P. (2016). Optimization of Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) based method for the detection of the dengue virus and identification of dengue virus serotypes using serotype specific polymerase chain reaction. *Proceedings of the 72nd Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.78.
7. Munasinghe, M.M.E., Korbakis, D., Diamandis, E.P., Chandrasekharan, N.V., Athapaththu, A.M.M.H. and Abeywickreme, W. (2017). Development of monoclonal antibodies against dengue NS1 peptides. *Proceedings of the Joint International Tropical Medicine Meeting (JITMM) 2017; Tropical Medicine 4.0 Effective Collaboration for an Impact on Global Health*, Thailand. p. 26.
8. Munasinghe, M.M.E., Kaneshanathan, K., Athapaththu, A.M.M.H., Jayarathne, L. and Abeywickreme, W. (2017). Surface modification of iron oxide nano particles for antibody conjugation. *Proceedings of the 2nd National Symposium on "Recent Advancement of Dengue Research",* National Research Council, Sri Lanka.
9. Munasinghe, M.M.E., Athapaththu, A.M.M.H. and Jayarathne, L. (2018). Modification of iron oxide nanoparticles using L-Cysteine capped CdTe quantum dots. *Proceedings of the 74th Annual Sessions*, Sri Lanka Association for Advancement of Science. p.636.
10. Munasinghe, M.M.E., Athapaththu, A.M.M.H., Abeywickreme, W. and Jayarathne, L. (2018). Surface modification of super-paramagnetic magnetite nano particles for bio-conjugation. *Proceedings of the International Conference on Health Science*, University of Sri Jayewardenepura, Sri Lanka. p.111.
11. Munasinghe, M.M.E., Jayawardhene, Y.B., Athapaththu, A.M.M.H., Abeywickreme, W. and Jayarathna, L. (2018). Modification of highly fluorescent CdTe quantum dots under atmospheric conditions. *Proceedings of the Research Conference 2018*, Post Graduate Institute of Science, University of Peradeniya, Sri Lanka. p.8.
12. Munasinghe, M.M.E., Kaneshanathan, K., Athapaththu, A.M.M.H., Jayarathne, L. and Abeywickreme, W. (2017). Surface modification of iron oxide nano particles for antibody conjugation. *Proceedings of the 2nd National Symposium on Recent advancement of Dengue research,* National Research Council, Sri Lanka. p.38-43.

Book Chapters

1. Munasinghe, E., Aththapaththu, M., Jayarathne, L. (2019). Magnetic and quantum dot nanoparticles for drug delivery and diagnostic systems. In: *Colloid Science in Pharmaceutical Nanotechnology.* Intech Open. ISBN 978-1-78985-596-8.

Postgraduate Degrees

1. Mr. M. E Munasinghe obtained a PhD from the University of Kelaniya in 2022.
   Thesis Title: Development of a quantum dot-based rapid diagnostic assay for the detection of dengue NS1 antigen.

Cloning thermostable alpha amylase gene into *Pichia pastoris* and optimization of large scale thermostable alpha amylase enzyme production using a fermenter

Grant No: TG 14- 95
Project Team: *Dr. (Ms.) W.W.P. Rodrigo
Ms. H.H.K. Achala
Mr. M.S. Thiwanka
Project Period: 2014 – 2017
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Industrial enzyme production has been a highly successful industry worldwide. The global market for industrial enzymes is expected to reach nearly $7.1 billion by 2018. Alpha Amylases (E.C.3.2.1.1), a widely used enzyme, biologically catalyzes the hydrolysis of internal alpha 1,4-glycosidic linkages in starch in low molecular weight products, such as glucose, maltose and maltotriose units. Although Sri Lanka uses 200 billion rupees worth of thermo-stable alpha amylase annually, it is not locally produced, and the total enzyme requirement is imported. Incorporating genetic engineering approaches to enhance the production of thermo-stable alpha amylases can be used in scaling up the production process to provide for the industry. Therefore, the main aim of this research was to produce thermo-stable α-amylase as a recombinant enzyme on a large scale, using a fermenter.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Establishment of recombinant protein production and purification procedures/methods.

Scientific Communications

1. Thiwanka, M.S., Rodrigo, W.W.P., Achala, H.H.K., Athapaththu, A.M.M.H. and Gunathilaka, P.A.D.H.N. (2015). Isolation and cloning of thermostable alpha amylase gene for the production of recombinant enzyme for industrial purposes. *Proceedings of the 35th Annual Sessions*, Institute of Biology, Sri Lanka. p.63.
2. Thiwanka, M.S., Rodrigo, W.W.P., Achala, H.H.K., Athapaththu, A.M.M.H. and Gunathilaka, P.A.D.H.N. (2015). Amplification and cloning of thermo-stable alpha-amylase gene from *Geobacillus stereothermophilus*. *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.36.
3. Thiwanka, M.S., Rodrigo, W.W.P., Achala, H.H.K. and Aruggoda, A.G.B. (2015). Cloning and expression of thermostable alpha-amylase in *Pichia pastoris* for industrial purposes. *Proceedings of the Faculty of Engineering Technology Student Academic Conference*, The Open University of Sri Lanka. p.2.
4. Jayaram, S., Achala, H.H.K., Thiwanka, M.S. and Rodrigo, W.W.P. (2016). Optimization of a low-cost medium to enhance the growth of *Geobacillus stearothermophilus* for production of thermostable alpha amylase. *Proceedings of the 36th Annual Sessions*, Institute of Biology, Sri Lanka. p.31.

5. Magammulla, L.S. and Rodrigo, W.W.P. (2017). Optimization of factors affecting α-amylase production in submerged fermentation using three *bacillus* strains. *Proceedings of the Postgraduate Institute of Science Research Congress (RESCON 2017)*, University of Peradeniya. p.73.
6. Thiwanka, M.S., De Silva, S.L.S.D., Rodrigo, W.W.P. and Achala, H.H.K. (2017). Optimization of a low-cost medium for the production of alpha-amylase using *Bacillus licheniformis*. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.31.

Development of a diagnostic kit for the detection of anti-rabies antibodies in serum samples after post-exposure rabies vaccination in humans

Grant No: TG 16 -130
Project Team: *Dr. (Ms.) W.W.P. Rodrigo
Dr. (Ms.) A.M.M.H. Athapaththu
Mr. M.S. Thiwanka
Dr. N.V. Chandrasekharan
Project Period: 2016 – 2018
Funded by: Sri Lanka Treasury
Principal Investigator

Background

Rabies is an infectious disease characterized by an acute and profound dysfunction of the central nervous system caused by the Lyssa virus of the family Rhabdoviridae. According to a World Health Organization (WHO) estimate, 50,000 human deaths due to rabies are reported worldwide every year. Tests for rabies antibodies are occasionally ordered to determine if people have been successfully immunized against the disease. Currently, three tests are approved by the WHO for determining the levels of rabies-neutralizing antibodies. Due to the high cost of these tests, it is important to develop and standardize simple techniques such as Enzyme-Linked Immunosorbent Assay (ELISA). Therefore, it is essential to express and purify the rabies virus-specific recombinant protein antigen. Hence, the aim of the present study was the development of a diagnostic kit for the detection of rabies virus-specific antibodies after immunization (post-exposure vaccination) using Enzyme-Linked Immunosorbent Assay (ELISA).

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Construction of pET28a (+) - RVG recombinant vector.
- Transformation of recombinant construct into BL21 bacterial expression cells.
- Optimization of expression conditions.
- Analysis of recombinant protein on SDS-PAGE.
- Establishment of protein expression and purification procedures/methods for recombinant proteins.

Scientific Communications

1. Sewwandi, H.S., Rodrigo, W.W.P., Athapaththu, A.M.M.H., Gunathilaka, P.A.D.H.N., Bandara, K.G.W.W. and Achala, H.H.K. (2015). Cloning of a rabies virus specific glycoprotein coding gene into a bacterial expression system for the expression of a recombinant protein. *Proceedings of the 2nd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.43.
2. Sewwandi, H.S., Rodrigo, W.W.P., Athapaththu, A.M.M.H., Gunathilaka, P.A.D.H.N., Bandara, K.G.W.W., Wijesundara, R.R.M.K.K. and Bulumulla, P.B.A.I.K. (2016). Expression of a rabies virus specific antigen by cloning the glycoprotein gene into *Escherichia coli* expression system., *Proceedings of the 6th Research Symposium*, Uva Wellassa University of Sri Lanka. p.13.
3. Thiwanka, M.S., Sampath, H.W.R.U., Rodrigo, W.W.P., Athapaththu, A.M.M.H., Bandara, K.G.W.W. and Chandrasekharan, N.V. (2017). Expression of rabies virus specific glycoprotein as a recombinant protein in bacterial expression system for the development of diagnostic kit. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.30.

Development of a molecular-based assay to differentiate between *Thunnus obesus* (Bigeye tuna) and *Thunnus albacares* (Yellow fin tuna)

Grant No: TG 16 -131
Project Team: *Dr. (Ms.) W.W.P. Rodrigo
Ms. W.W. Bandara
Ms. W.T.G.S.L. Withana
Project Period: 2016 - 2017
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Tuna fish species identification is traditionally based on external morphological features, including body shape, pattern of colors, scale size and count, number and relative position of fins, number and type of fin rays, or various relative measurements of body parts. In some cases, morphological features are of limited value for identification and differentiation purposes, even with whole specimens, because they can show either considerable intraspecific variations or small differences between species. Besides, once most morphological features have been removed during digestion or processing (e.g., canning, filleting), the identification becomes difficult or even impossible. Frozen tuna is far more difficult to distinguish due to the fin damage, discoloration, skin abrasion and distortion or crushing during the storage process. Taken all together, these difficulties explain why researchers have attempted to develop new methods for identifying fish species without relying on morphological features. In Sri Lanka, there is no method to identify tuna at the species level other than the morphological features, which has also become a major limitation in the tuna fish industry in the country. As a result, some fish processing industries have not been able to export their products due to the absence of a confirmatory test for species identification. Therefore, this study focused on developing a molecular assay to differentiate between *Thunnus obesus* (Bigeye tuna) and *Thunnus albacares* (Yellowfin tuna) species in fresh and processed fish samples.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Development of a molecular-based method to identify fresh tuna samples using cytochrome b gene.
- Development of a Triplex PCR method to identify processed tuna samples.
- Establishment of testing methods to identify tuna species in fresh and processed samples for food processing industry.
- Optimization of DNA extraction protocol for processed tuna samples.

Scientific Communications

1. Perera, D.R.C., Rodrigo, W.W.P., Athapaththu, A.M.M.H. and Gunathilaka, P.A.D.H.N. (2016). Establishment of a molecular based method for the identification of skipjack tuna (*Katsuwonus pelamis*) in large-scale fish processing industry. *Proceedings of the 1st International Conference on Bioscience and Biotechnology* (BioTech – 2016). p.11.
2. Perera, D.R.C., Gunathilaka, P.A.D.H.N., Rodrigo, W.W.P. and Athapaththu, A.M.M.H. (2016). DNA fingerprinting of *Thunnus obesus* and *Thunnus albacares* fish species for

proper identification in large-scale fish processing industry. *Proceedings of the 6th Research Symposium*, Uva Wellassa University of Sri Lanka. p.7.
3. Rupasinghe, R.A.L., Withana, W.T.G.S.L., Rodrigo, W.W.P. and Athapaththu, A.M.M.H. (2018). Conventional triplex polymerase chain reaction: A reliable tool for detection of species adulteration in canned tuna products. *Proceedings of the Vingnanam International Research Conference* – 2018 (VIRC 2018), Faculty of Science, University of Jaffna. p.27.
4. Efrem, S.M., Rodrigo, W.W.P. and Lukshman, S.M.P. (2019). Molecular identification of fresh and cooked tuna samples using triplex-polymerase chain reaction assay. *Proceedings of the International Research Conference 2019* (IRCUWU 2019), Uva Wellassa University of Sri Lanka. p.3.
5. Ariyaratne, S.N.H. and Rodrigo, W.W.P. (2019). Validation of triplex polymerase chain reaction-based method for molecular identification of yellowfin, bigeye and skipjack fresh tuna samples. *Proceedings of the Postgraduate Institute of Science Research Congress*, University of Peradeniya. p.72.

NCBI GenBank Submissions

- Three isolates were deposited in the National Center for Biotechnology Information (NCBI) GenBank, USA.

Development of molecular-based testing for Genetically Modified (GM) food items and diagnostic tests for food-borne pathogens

Grant No: TG- 16 -132
Project Team: *Dr. (Ms.) A.M.M.H. Athapaththu
Dr. (Ms.) W.W.P. Rodrigo
Ms. W.T.G.S.L. Withana
Mr. M.S. Thiwanka
Prof. (Ms.) J.K.R.R. Samarasekara
Project Period: 2016- 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Component 1

The project addressed two main problems for consumers, traders and exporters in the food industry. The targeted problems are the detection of GM food in the market and pathogen detection in raw/processed meat products. A Genetically Modified Organism (GMO) is an organism whose genetic material has been altered by means of genetic engineering. Due to the disadvantages of GMOs, regulation procedures and legislation have been established globally in order to control the importation and cultivation of GM food products and crops, respectively. According to existing law and the Food Act, GM food importation is not banned in Sri Lanka. According to the law, if a food product contains GMO or GM ingredients of more than 0.5%, it should be labeled as 'genetically modified'. Even though GM foods are imported to Sri Lanka from GM manufacturing countries, there is no proper labeling procedure in the local market. Therefore, many genetically modified products can be there in the local market without labels. Consequently, consumers buy GM products unknowingly. Therefore, as a step towards protecting the consumer's rights, this project aimed at developing RT-PCR-based methods to detect GM food products.

Component 2

Food and water-borne diseases, which are mainly caused by food and water-borne pathogens, are serious health hazards in both developing and developed countries. *Salmonella* spp. and *Staphylococcus aureus*, are some of the most common food-borne pathogens found in Sri Lanka. The rapid detection of pathogens in food and water products is becoming increasingly critical for ensuring the safety of consumers. According to regulations set by the Food Control Administration, microbiological assessment of food and water products is a mandatory requirement, before introducing to the market. Hence, rapid, sensitive, inexpensive, and convenient approaches to detect food-borne pathogenic bacteria are essential in controlling food safety. In Sri Lanka, over 2100 cases of food-borne and water-borne diseases were reported in 2018 alone (Epidemiology Unit, 2019). The passive surveillance research already conducted in Sri Lanka has not been adequate to fulfill the requirement of preventing the economic loss that has been occurring in the country. Therefore, more scope remains for research activities in the area of food safety. The proposed research focused on developing molecular-based rapid diagnostic tests for food-borne pathogens in meat products available in the Sri Lankan market in order to facilitate food and water processing industries to evaluate the quality of their products prior to issuing them to the local/export market and also to protect consumers from potential food-borne diseases.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A test method for the detection of GMO for CamV 35S promoter using RT-PCR was successfully developed and is available as a biotechnology testing service**.**
- A test method for the detection of food-borne Salmonella pathogen using RT-PCR was successfully developed and is available as a biotechnology testing service**.**

Scientific Communications

1. Talwatta, V.N., Rodrigo, W.W.P., Achala, H.H.K., Withana, W.T.G.S.L., Athapaththu, A.M.M.H. and Bulumulla, P.B.A.I.K. (2016). Optimization of a polymerase chain reaction-based technique to detect genetically modified foods. *Proceedings of the 6th Research Symposium,* Uva Wellassa University of Sri Lanka. p.1.
2. Gunathilaka, H.M.G.U., Perera, W.A.J.S., Achala, H.H.K., Munasinghe, D.H.H. and Athapaththu, M. (2017). Molecular based method for the detection of *Salmonella* in meat products. *Proceedings of the Postgraduate Institute of Science Research Congress*, Sri Lanka. p.84.
3. Benedict, M.D., Athapaththu, A.M.M.H. and Withana, W.T.G.S.L. (2018). Detection of genetically modified (GM) food items in the market using Real-time PCR (RT-PCR) based assay. *Proceedings of the Vingnanam International Research Conference – 2018 (VIRC 2018),* Faculty of Science, University of Jaffna. p.21.
4. Silva, F.H.C., Kapuruge, T.N., Athapaththu, A.M.M.H., Rodrigo, W.W.P., Perera, W.A.J.S. and Samarasekara, J.K.R.R., (2018). Real-time PCR method for the detection of *Salmonella* spp. in meat products. *Proceedings of the Vingnanam International Research Conference – 2018* (VIRC 2018), Faculty of Science, University of Jaffna. p.28.
5. Siriwardena, V.K., Kapuruge, T.N., Athapaththu, A.M.M.H. and Perera, W.A.J.S. (2019). Real-time PCR based method for detection of viable *Staphylococcus aureus* in dairy products. *Proceedings of the Postgraduate Institute of Science Research Congress*, Sri Lanka. p.94.
6. Senarathna, T.D., Kapuruge, T.N., Athapaththu, A.M.M.H. and Perera, W.A.J.S. (2019). Real-time PCR based method for detection of viable *Salmonella* spp. in meat products. *Proceedings of the Postgraduate Institute of Science Research Congress*, Sri Lanka. p.95.
7. Sayakkara, K.S., Athapaththu, A.M.M.H. and Withana, W.T.G.S.L. (2019). Validation of real time PCR (RT-PCR) based method for identification of genetically modified (GM) baked products. *Proceedings of the Postgraduate Institute of Science Research Congress*, Sri Lanka. p.97.
8. Haroon, H., Hewasinghe, K.A., Withana, W.T.G.S.L and Athapaththu, A.M.M.H. (2019). Determination of the sensitivity of a real-time PCR based method for the identification of GM fruit samples. *Proceedings of the 4th Biennial Symposium*, Industrial Technology Institute, Sri Lanka. p.2.
9. Athapaththu, A.M.M.H., Perera, T.S.N., Milani, M.D.Y. and Archchige, R.C.W. (2019). Molecular characterization of thermophilic bacteria present in solid-waste composting. *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.41.
10. Peiris, W.P.A., De Silva, J.L.I.M., Suriyapperuma, M., Athapaththu, A.M.M.H. and Withana, W.T.G.S.L. (2019). Development and validation of a rapid test method for detection of pork meat with beef meat. *Proceedings of the 4th Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.1.

Development of in-house multiplex real time PCR based methods for food testing (detection of genatically modified food, food/water borne pathogens and meat adulteration in meat products)

Grant No: TG 19 -188
Project team: *Dr. (Ms.) A.M.M.H. Athapaththu
Ms. H.H.K. Achala
Ms. W.T.G.S.L. Withana
Project Period: 2019-2023
Funded by: Sri Lanka Treasury

Principal Investigator

Background

The project addressed three main problems for consumers, traders and exporters in the food industry. The targeted problems were the detection of GM (Genetically Modified) food in the market, food/water-borne pathogen detection in raw/processed food and pork/beef/horse adulteration detection in meat products. Hence, the current study consists of these three components**.**

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

The following outcomes were achieved during the project period

- Development of a separate in-house Real-Time PCR (RT-PCR) Assay using new primers for the detection of *Salmonella* and *Staphylococcus aureus*.
- Establishing a pathogen testing laboratory.
- Development of detection methods for the identification of CaMV35S promoter and T Nos terminator for the identification of GMOs.
- A one-way laboratory for GMO testing was established.
- The GMO laboratory of BTS was upgraded to the national laboratory with more than 100 million worth of equipment funded by FAO.
- Development of PCR-based methods to detect porcine, bovine, buffalo, rat and dog species adulteration in raw and processed meat products.
- Development of two conventional multiplex PCR assays for simultaneous detection of buffalo, pork, beef, rat, dog and pork adulteration in raw and processed meat products.

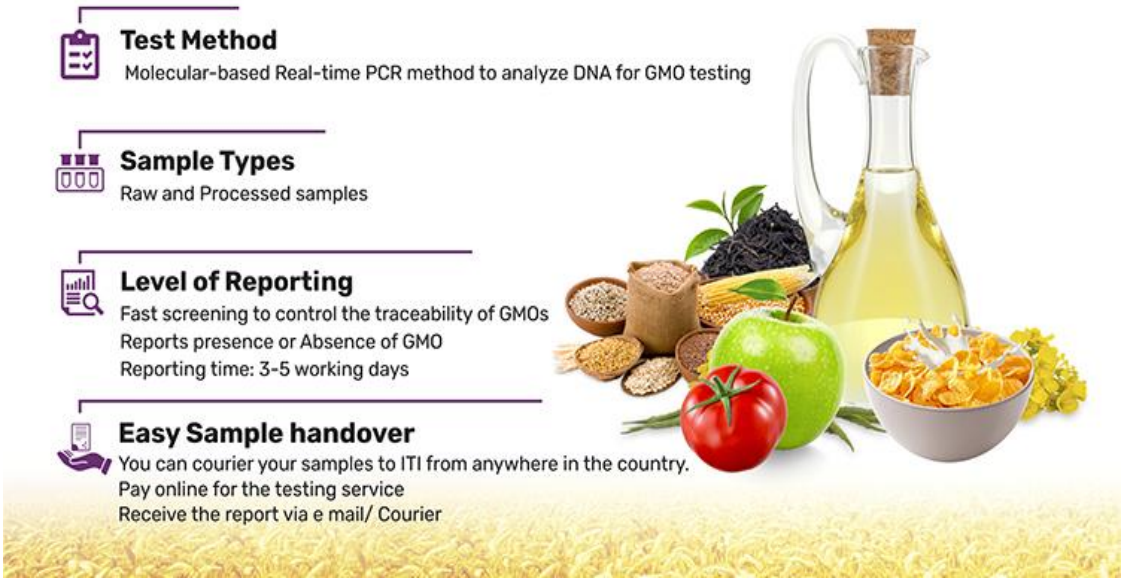
Publications in Refereed Journals

1. Silva, S. D., Chandrasekaran, K.N., Fernando, K.H., Withana, W.T.G.S.L. and Athapaththu, A.M.M.H. (2021). Molecular detection of pork adulteration: A study based on dairy products in Sri Lanka. *International Journal of Innovative Science and Research Technology*, **6**, 1536-1540.

Scientific Communications

1. Lakshika, G., Rodrigo, W.W.P., Withana, W.T.G.S.L. and Kapuruge, T.N. (2018). Development of a polymerase chain reaction based method for the detection of adulterations in chicken and turkey meat products. *Proceedings of the Vingnanam International Research Conference – 2019* (VIRC 2019), Faculty of Science, University of Jaffna, Sri Lanka. p.22.

2. Siriwardena, V.K., Kapuruge, T.N., Athapaththu, A.M.M.H. and Perera, W.A.J.S. (2019). Validation of real-time PCR based method for detection of viable *Staphylococcus aureus* in dairy products. *Proceedings of the Postgraduate Institute of Science RESCON 2019.* p.94.
3. Senarathna, T.D., Kapuruge, T.N., Athapaththu, A.M.M.H. and Perera, W.A.J.S. (2019). Validation of real-time PCR based method for detection of viable *Salmonella* spp. in meat products, *Proceedings of the Postgraduate Institute of Science RESCON 2019*. p.95.
4. Peiris, W.P.A., De Silva, L.I.M., Suriyapperuma, S.M., Athapaththu, A.M.M.H. and Withana, W.T.G.S.L. (2019). Development and validation of a rapid test method for detection of pork meat with beef meat, *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.1.
5. Chandrasekaran, K.N., Withana, W.T.G.S.L. and Athapaththu, A.M.M.H. (2021). Development of a conventional triplex PCR assay for simultaneous detection of buffalo, cattle and pork meat. *Proceedings of the 5th Biennial Symposium*, Industrial Technology Institute, Sri Lanka. p.13.
6. Wathsara, H.P.T., Achala H.H.K. and Athapaththu, A.M.M.H. (2021). Optimization of a DNA Extraction Method for gram positive bacteria. *Proceedings of the 5th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.16.



MATERIALS TECHNOLOGY

The Industrial Technology Institute (ITI) advances materials science through applied and basic research, delivering customized technical solutions and contract research to a range of industries. Our expertise supports sectors including ceramics, minerals, coatings, wood and cellulose natural fibers (such as coconut and banana), rubber, and plastics.

A multidisciplinary team works to develop innovative products, transfer technologies to industry, troubleshoot manufacturing processes, and deliver targeted training programs helping industries enhance quality, efficiency, and sustainability.

Research and development on graphite to graphene Synthesis of graphene and graphene composites from natural graphite using microwave assisted thermal method

Grant No: TG -11-00- 04
Project Team : *Dr. (Ms.) I.R.M. Kottegoda
Dr. C.H. Manoratne
Dr. L.D. Nayanajith
Project Period: 2011 - 2014
Funded by: Sri Lanka Treasury

Principal Investigator

Background

Graphite is being exported at a low price without much value addition. However, purified graphite above 99.9% is several times more expensive than raw graphite. Considering the high demand, graphene was synthesized using high-quality Sri Lankan vein graphite as a value addition to the graphite resource for the first time in Sri Lanka. Chemical methods and physical methods such as microwave-assisted thermal/hydrothermal synthesis, were followed to synthesize graphene and graphene composites. Microwave synthesis is used as it is effective in terms of time, energy, cost, etc.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

The microwave synthesis method is considered as low-cost technique used to synthesize graphene from graphite oxide.

Technologies Transferred/Commercialized

- The technology was transferred in 2022

Patents

- Preparation of graphene oxide and few-layer graphene as a value addition to local graphite (Sri Lanka Patent No. 18157).

Awards

- Won the BEST FIVE AWARD in the International Conference on Chemical Sciences - Institute of Chemistry- on 22nd June 2012, C.H. Manoratne, L.D.C. Nayanajith and I.R.M. Kottegoda.

Publications in Refereed Journals

1. Nayanajith, L.D.C., De Silva, R.C.L., Rosa, S.R.D. and Kottegoda, I.R.M. (2022). Optimization of oxidation time of Kahatagaha vein graphite and reduction time of microwave assisted hydrothermal reduction of Kahatagaha graphene oxide, *Sri Lankan Journal of Physics* **23**(2), 77.

Scientific Communications

1. Nayanajith, L.D.C., Kottegoda, I.R.M. and Rosa, S.R.D. (2013). Characterization of graphene synthesized from microwave assisted hydro-thermal methods using graphite oxide prepared from Sri Lanka graphite. *Proceedings of the 69th Annual Sessions*, Association for the Advancement of Science.
2. Nayanajith, L.D.C., Kottegoda, I.R.M. and Rosa, S.R.D. (2013). Characterization of graphene synthesized from microwave assisted hydro-thermal method. Proceedings of the Annual Research Symposium, Industrial Technology Institute, Colombo .p.35.

Purification of natural graphite of Sri Lanka as a high value addition

Grant Nos: TG 13 -74, FP 113
Project Team : *Dr. (Ms.) I.R.M. Kottegoda
Eng. J.T.S.T. Jayawardana
Eng. H.C.D.P. Colombage
Project Period: 2013 - 2016
Funded by: Sri Lanka Treasury
National Science Foundation, Sri Lanka

**Principal Investigator*

Background

A project was initiated to purify graphite up to 99.99% on a laboratory scale as a value addition to vein graphite sources in Sri Lanka in a cost-effective manner. Purification up to 99.99% was achieved in a laboratory scale for graphite sources in Sri Lanka. TG 13 -74 was demarcated as the first grant received under the Treasury grant category, and further research work continued with NSF grants.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- An efficient and cost-effective method to purify natural graphite to a high level (up to 99.99%) purity was achieved in the laboratory scale.
- Cost for 1kg of graphite purification (in laboratory scale) was calculated and a layout for a graphite purification plant was designed.

Technologies Transferred/Commercialized

- The technology for the purification of natural graphite was transferred in 2022.

Patents

- Purification of natural graphite for preparation of high-quality graphite oxide as a value addition (Sri Lanka Patent No. 18248).

Awards

1. Silver medal was received for Sahasak Nimaum awards 2022 for Purification of natural graphite up to 99.99% for high-end applications as a value addition - J.T.S.T. Jayawardane, H.C.D.P. Colombage, M.T.V.P. Jayaweera and I.R.M. Kottegoda.

Synthesis of graphene & graphene composites from natural graphite for application as electronic materials

Grant No: FP 105
Project Team: *Dr. (Ms.) I.R.M. Kottegoda
Dr. C.H. Manoratne
Dr. L.D.C. Nayanajith
Dr. M.T.V.P. Jayaweera
Project Period: 2013 - 2016
Funded by: National Research Council (NRC), Sri Lanka

**Principal Investigator*

Background

This project is a preliminary investigation of laboratory-scale production of graphene from natural graphite in Sri Lanka. The application of graphene and various graphene composites was investigated as a gas sensor, supercapacitor, Li-ion batteries and in water purification.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Preparation of graphite oxide and graphene oxide from local graphite.
- Preparation of graphene and graphene composites.
- Application of graphene and graphene composite in gas sensors and supercapacitors.
- Lab-scale development of the above products was successfully completed.

Patents

- Preparation of highly oxidized graphite oxide suitable for synthesis of high-quality graphene and composites (Sri Lanka Patent No. 18301).
- Preparation of Graphene/Metal Oxide/Polyaniline nanocomposites for application in energy storage devices (Sri Lanka Patent No. 18303).

Publications in Refereed Journals

1. Jayaweera, M.T.V.P., De Silva, R.C.L., Kottegoda, I.R.M. and Rosa, S.R.D. (2014). Synthesis, characterization and ethanol vapor sensing performance of SnO2/Graphene composite films. *Sri Lankan Journal of Physics*, **15**, 1-10.
2. Kottegoda, I.R.M., Gao, X., Nayanajith, L.D.C., Manoratne, C.H., Wang, J-Z., Liu, H-K. and Gosef, Y. (2015). Comparison of few-layer graphene prepared from natural graphite through fast synthesis approach. *Journal of Materials Science & Technology*, **31**, 907–912.
3. Manoratne, C.H., Rosa, S.R.D. and Kottegoda I.R.M. (2017) XRD-HTA, UV visible, FTIR and SEM interpretation of reduced graphene oxide synthesized from high purity vein graphite. *Material Science Research India*, **14**(1), 19-30.
4. Jayaweera, V., Liyanage, W.L.N.C., De Silva, R.C.L., Rosa, S.R.D. and Kottegoda, I.R.M. (2021). Reduced graphene oxide/SnO_2/Polyaniline ternary composite for high-performance supercapacitors. *Material Science Research India*, **18**(2), 206-216.
5. Perera, D.S.M., De Silva, R.C.L., Nayanajith, L.D.C., Colombage, H.C.D.P., Suresh, T.S., Abeysekera, W.P.K.M. and Kottegoda, I.R.M. (2021). Anti-inflammatory and antioxidant properties of *Coffea arabica*/reduced graphene oxide nanocomposite prepared by green synthesis. *Material Science Research India*, 18(3), 305-317.
6. Nayanajith, L.D.C., De Silva, R.C.L., Rosa, S.R.D. and Kottegoda, I.R.M. (2022). Evaluation of conducting and tensile properties of reduced graphene oxide/polybutylene

adipate terephthalate (rGO/PBAT) nanocomposites. *Material Science Research India,* **19**(1), 26-35.

Scientific Communications

1. Manoratne, C.H., Nayanajith, L.D.C. and Kottegoda, I.R.M. (2012). Synthesis and characterization of graphite composites for the application in lithium-ion batteries and in solar cells. *International Conference on Chemical Sciences*, Institute of Chemistry, Sri Lanka.
2. Jayaweera, M.T.V.P. and Rosa, S.R.D. (2013). FTIR analysis of graphene synthesized using microwave irradiation in different solvents. *Proceedings of the 69th Annual Session,* Sri Lanka Association for the Advancement of Science.
3. Nayanajith, L.D.C., Kottegoda, I.R.M. and Rosa, S.R.D. (2013). Characterization of graphene synthesized from microwave assisted hydro-thermal methods using graphite oxide prepared from Sri Lanka graphite. *Proceedings of the 69th Annual Session,* Sri Lanka Association for the Advancement of Science. p.167.
4. Nayanajith, L.D.C., Manoratne, C.H. and Kottegoda, I.R.M. Synthesis and characterization of graphene oxide from Sri Lanka graphite. *Proceedings of the 1st National Nanotechnology Conference,* National Science Foundation, Sri Lanka. p.77-78.
5. Jayaweera, M.T.V.P., Wijesekara, H., Vithanage, M., Kottegoda, I.R.M. and Rosa, S.R.D. (2014). Synthesis and characterization of nanoparticulate zero-valent iron-Graphene composite. *International Conference on Nanoscience and Nanotechnology*.
6. Jayaweera, M.T.V.P., De Silva, R.C.L. and Kottegoda, I.R.M. (2014). NH_3 sensing performance of SnO_2 graphene composite. *Proceedings of the 70th Annual Session*, Sri Lanka Association for the Advancement of Science. p.
7. Jayaweera, M.T.V.P., Rajapaksha, C.P.H., Daya, D.D.N.B., Rosa, S.R.D. and Kottegoda, I.R.M. (2015). Synthesis and characterization of nano-particulate TiO_2-Graphene composite. *Proceedings of the Technical Sessions,* Institute of Physics, Sri Lanka. p.77-82.
8. Jayaweera, M.T.V.P., Wijesekara, H., Wijebahu, S., Kumarathilaka, P., Kottegoda, I.R.M., Rosa, S.R.D. and Vithanage, M. (2015). Starch coated nano-zero valent iron embedded graphene composite for chromium (VI) removal from aqueous solution. *Proceedings of the 4th Nanotoday Conference,* Dubai.

Book Chapter

1. Kottegoda, I.R.M., Nayanajith, L.D.C., Gao, X., Wang, J., Wang, J-Z., Liu, H-K. and Gofer, Y. (2016). Chapter 12 - Synthesis and characteriazation of few layer graphene from high purity Sri Lankan Vein graphite. In: *Transferring Nanotechnology Concept Towards Business Perspectives.* (Eds. S. Shimazu and S. Tursiloadi), New Delhi: NAM S&T Center.

Postgraduate Degrees

1. Mr. C.H. Manoratne obtained a PhD degree from the University of Colombo in 2017.
   Thesis Title: Synthesis and characterization of graphene and graphene composite from natural graphite.
2. Mr. M.T.V.P. Jayaweera obtained a MPhil degree from the University of Colombo in 2016.
   Thesis Title: Synthesis of graphene and graphene composites from natural graphite for gas sensing and other applications.

Awards

1. National Research Council (NRC) Merit Awards 2015 for the paper titled “Comparison of few-layer graphene prepared from natural graphite through fast synthesis approach”. *Journal of Materials Science & Technology,* **31**, 907–912. - I.R.M. Kottegoda, L.D.C. Nayanajith and C.H. Manoratne.

Further work on the production of high-quality graphene-based materials from local graphite for high-tech applications

Grant No: FP 121
Project Team: *Dr. I. Kottegoda
Dr. L.D.C. Nayanajith
Dr. R.C.L. De Silva
Eng. H.C.D.P. Colombage
Project Period: 2016 - 2019
Funded by: National Research Council, Sri Lanka

**Principal Investigator*

Background

Graphite is a very useful mineral for many applications which is currently being mined on a large scale and being exported at a low price. It is crucial to save graphite by introducing value addition to graphite. Graphene and graphene oxides are highly valuable materials (>1000 times) that can be synthesized from graphite. The laboratory development of reduced graphene oxide (rGO) and graphite oxide (GO) from local graphite as a value addition was conducted at ITI for the first time in Sri Lanka in 2011 and 2012. The present project focused on developing low-cost up-scalable methods to synthesize GO, rGO and graphene as a high-value addition to natural graphite.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- An efficient low-cost method to prepare a few layers of graphene from local graphite.
- Pilot trial synthesis of GO and rGO on a mass scale.
- A patent was filed for an invention on an apparatus to synthesize rGO in a few minutes.
- Reduced graphene oxide (rGO) and rGO nanocomposites for supercapacitors and biomedical applications were investigated and results were published.

Technologies Transferred/Commercialized

- The technology was transferred to one industry and is in the process of commercialization.

Patents

- An apparatus and a method of preparation of graphene and reduced graphene oxide on a mass scale in a few minutes. (Sri Lanka Patent Application No. 20447).
- *Coffea-arabica*/graphene nanocomposite with effective antioxidant and anti-inflammatory properties for biomedical application and preparation method thereof, (Sri Lanka Patent Application No. 22011).

Publications in Refereed Journals

1. De Costa, M.D.R., De Silva, R.C.L., Nayanajith, L.D.C., Colombage, H.C.D.P., Rosa, S.R.D. and Kottegoda, I.R.M. (2018). Fabrication and characterization of rGO/PANI/TiO2 1 as an electrode material for supercapacitors. *Journal of the Sri Lanka Association for the Advancement of Science*,**1**, 50-60.
2. Jayaweera, V., Liyanage, W.L.N.C., De Silva, R.C.L., Rosa, S.R.D. and Kottegoda, I.R.M. (2021). Reduced graphene oxide/SnO_2/Polyaniline ternary composite for high-performance supercapacitors. *Material Science Research India*, **18(**2), 206-216.
3. De Costa, M.D.R., De Silva, R.C.L., Nayanajith, L.D.C., Colombage, H.C.D.P, Milani, M.D.Y., Rosa, S.R.D. and Kottegoda, I.R.M. (2021). Electrical performance and material

characterization of reduced graphene oxide (rGO) / titanium dioxide (TiO2) composite for supercapacitors. *Sri Lankan Journal of Physics*, **22**(2), 1-12.

4. Perera, D.S.M., De Silva, R.C.L., Nayanajith, L.D.C., Colombage, H.C.D.P., Suresh, T.S, Abeysekera, W.P.K.M. and Kottegoda, I.R.M. (2021). Anti-inflammatory and antioxidant properties of *Coffea arabica*/reduced graphene oxide nanocomposite prepared by green synthesis. *Material Science Research*, **18**(3), 305-317.
5. Nayanajith, L.D.C., De Silva, R.C.L., Rosa, S.R.D. and Kottegoda, I.R.M. (2022). Evaluation of conducting and tensile properties of reduced graphene oxide/ polybutylene adipate terephthalate (rGO/PBAT) nanocomposites. *Material Science Research,* **19**(1), 26-35.
6. Abeykoon, A.M.K.L., De Silva R.C.L., Nayanajith, L.D.C. and Kottegoda, I.R.M. (2022). A review on appropriate graphene synthesis methods for diverse applications, *Sri Lankan Journal of Physics,* **23**(2), 125-141.
7. Nayanajith, L.D.C., De Silva, R.C.L., Rosa, S.R.D. and Kottegoda, I.R.M. (2022). Optimization of oxidation time of Kahatagaha vein graphite and reduction time of microwave assisted hydrothermal reduction of Kahatagaha graphene oxide. *Sri Lankan Journal of Physics,* **23**(2), 77-92.

Scientific Communications

1. De Costa, M.D.R., De Silva, R.C.L., Nayanajith, L.D.C., Hettiarachchi, H.A.M.I.T., Kottegoda, I.R.M. and Rosa, S.R.D. (2017). Synthesis of reduced graphene oxide from local graphite using alternative microwave oven. . *Proceedings of the 73rd Annual Session,* Sri Lanka Association for the Advancement of Science. p.175.
2. De Costa, M.D.R., De Silva, R.C.L., Nayanajith, L.D.C., Hettiarachchi, H.A.M.I.T., Rosa, S.R.D. and Kottegoda, I.R.M. (2017). FTIR analysis for reduced graphene oxide/ MnO_2 nanocomposite for energy storage applications. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.56.
3. De Costa, M.D.R., De Silva, R.C.L., Nayanajith, L.D.C., Kottegoda, I.R.M. and Rosa, S.R.D. (2018). Synthesis and characterization of reduced graphene oxide (rGO)/ Titanium dioxide (TiO2) composite using solar simulator, *Proceedings of the Technical Session*, IPSL. p.100.
4. Perera, D.S.M., De Silva., R.C.L., Nayanajith., L.D.C., Colombage., H.C.D.P. and Kottegoda, I.R.M. (2019). Preparation of reduced graphene oxide using *Coffea arabica. Proceedings of the 75th Annual Session*, Sri Lanka Association for the Advancement of Science. p.166.

Post Graduate degrees

1. Mr. L.D.C. Nayanajith obtained a PhD degree from the University of Colombo in 2022.
   Thesis Title: Microwave synthesis and characterization ofg raphene and graphene polymer composites for conducting and other applications.
2. Mr. M.D.R. De Costa is registered for a degree from the University of Colombo.
   Thesis Title: Synthesis of graphene-based nanocomposites for application in supercapacitors and other applications (MPhil pending).
3. Ms. D.S.M. Perera completed a MSc degree from the University of Sri Jayewardenepura Thesis Title - Anti-inflammatory and antioxidant properties of reduced graphene oxide/*coffea arabica* nanocomposite.

Awards

1. Gold Medal 2022 in the Open category under the technical field of Applied Science and Technology for “An apparatus and a method of preparation of graphene and reduced graphene oxide on mass scale in few minutes”, at the Sahasak Nimavum awards ceremony organized by the Sri Lanka Inventors Commission- I.R.M. Kottegoda and R.C.L. De Silva

Development of super absorbent materials from banana fibers for Sanitary napkins

Grant No: TG 11-55
Project Team: *Ms. M.D.Y. Milani
Dr. D.S. Samarawickrama
Mr. H.D.D.P. Gunasekara
Project Period: 2011 - 2013
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The technology developed involved the use of waste banana pseudo-stem fibers, to produce a material suitable for use as a base material in sanitary napkins. The present research work was carried out to develop a process to use the absorbent properties of banana fibers for the said application. The suitability of five common banana varieties ("Kolikuttu", "Alu Kesel", "Seeni Kesel", "Ambun" & "Ambul Kesel") in Sri Lanka was studied. Absorbing behavior of artificial blood, pH and color of processed fibers were studied in comparison with commercial raw fiber, which is used as a base material in sanitary napkins. The chemical and physical behavior of the processed fiber was further studied using Fourier Transform Infrared spectroscopy (FITR) and Scanning Electron Microscopy (SEM). The observations made in the study concluded that the absorption property of processed banana fiber was comparable to the commercial raw fiber. The major advantages of this invention are, made with renewable biodegradable materials, saves foreign exchange by reducing imports, creates new job opportunities, and farmers could utilize agricultural waste material in return for a profit.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Developed a process to obtain white colored absorbent fiber material from five common banana verities in Sri Lanka which is suitable for using as a base material in sanitary napkins. Having the same absorption property for the fiber extracted from underutilized agro waste to the existing synthetic or natural fiber extracted from hardwood/soft wood has special advantages like using natural fiber without deforestation.

Patent

- Processing technology for banana fibers as an absorbent material suitable for using in personal care products (Sri Lanka Patent No. 16653).

Scientific Communications

1. Milani, M.D.Y., Motha, J.T.S., Samarawickrama, D.S. and Senaratne, M.D. (2012). Potential for using banana pseudostem as an absorbent material for personal hygiene products, *Proceedings of the International Symposium on Polymer Science and Technology*, University of Sri Jayewardenepura. p.41.
2. Milani, M.D.Y., Samarawickram, D.S., Hettiarachchi, B.U. and Gunesekara, H.D.D.P. (2013). Comparison study of absorbent properties in banana pseudostem fibers with commercial wood pulp for using in personal care products, *Proceedings of the Annual Research Symposium*, Industrial Technology Institute, Sri Lanka.p.31.

Research & Dvelopment of red clay-based water filters
Development of red clay-based water filter for the removal of fluoride

Grant No: TG 11-56
Project Team: *Dr. (Ms.) I.R.M. Kottegoda
Ms. G.P.C.A. Dharmasiri
Ms. J.T.S.T. Jayewardene
Mr. R.C.W. Arachchi
Ms. H.A.M.I.T. Hettiarachchi
Project Period: 2011 - 2013
Funded by: Sri Lanka Treasury

Principal Investigator

Background

Kidney failure disease is fast spreading in the North Central Province (NCP) of Sri Lanka. The suspected cause for the disease is a high accumulation of elements and ions such as aluminum, magnesium, cadmium and fluoride found in water. Particularly, the fluoride content in water is very high in NCP. Several expensive methods are being used to purify water including reverse osmosis which is not affordable to low low-income community. It is important to provide at least a water filter for people until a permanent solution is provided for them. A clay water filter was developed at ITI for the removal of fluoride for the first time in Sri Lanka which is to be extended to remove other contaminants as well.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Development of red-clay-based water filter for the removal of fluoride.

Technologies Transferred/Commercialized

- Technology is already commercialized.

Patents

- Development of a red clay-based water filter for the remediation of fluoride contaminated water (Sri Lanka Patent No. 16753).
- Regeneration method of red-clay filter for removal of fluoride from water (Sri Lanka Patent No.18302).

Awards

1. Presidential Awards 2018 for Patented Inventions (3rd Place) for the Development of clay filter body with high fluoride binding ability for the remediation of fluoride contaminated water at the awards ceremony organized by the Sri Lanka Inventors Commission – I. Kottegoda, R.C.W. Arachchi, A. Premathilaka, C. Dharmasena and B. Hettiarachchi.

Development of red clay-based water filter for the removal of fluoride and other contaminants

Grant No: TG 14- 90
Project Team: *Dr. I.P.L. Jayaratne
Dr. (Ms.) I.R.M. Kottegoda
Ms. J.T.S.T. Jayawardane
Mr. R.C.W. Arachchi
Mr. H.A. Hettiarachchi
Project Period: 2014 - 2015
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Chronic Kidney Disease of Unknown etiology (CKDu) has been reported to occur in several areas of Sri Lanka, mostly in the North Central and North Western provinces. Water contamination is the suspected cause of the disease. Various organizations are distributing imported filters and local filters. Most of these filters are not tested for their quality with respect to standards from a recognized institute and are not affordable either. In addition, people are unaware of the lifetime, quality, and reliability of these filters. The investigators of the project have developed a low-cost, durable, quality guaranteed water filter for the removal of fluoride, arsenic and cadmium from water, most of the suspected ions for CKDu.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

Developed a red clay-based filter for the removal of fluoride, arsenic, and cadmium ions from water.

Technologies Transferred/Commercialized

1. Technology of development of clay water filter for the removal of fluoride, arsenic and cadmium was transferred to the Red Cross International Organization in 2016.
2. Technology development of a pilot water filter system for the removal of fluoride ions and water hardness was transferred to an ice cream factory in Nikawaratiya in 2015.

Patent

- Red-clay water filter body composition for removal of arsenic, cadmium and fluoride from water (Sri Lanka Patent No. 19158).

Publications in Refereed Journals

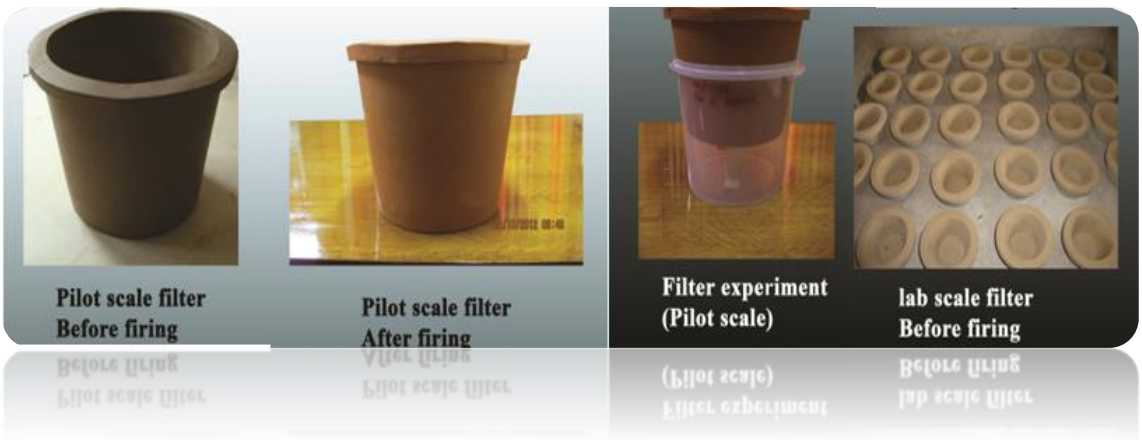
1. Jayarathna, L., Bandara, A., Ng, W.J. and Weerasooriya, R. (2015). Fluoride adsorption on $\gamma - Fe_2O_3$ nanoparticles, *Journal of Environmental Health Science and Engineering*, 13, Article number: 54.
2. Jayarathna, L., Bandara, A. and Weerasooriya, R. (2016). Interaction of bicarbonate with gibbsite: Effect of fluoride. *IORE Journal of Environmental Science*, 2.2.

Scientific Communications

1. Dharmasiri, G.P.C.A., Jayawardane, J.T.S.T., Arachchi, R.C.W., Hettiarachchi, B.U. and Kottegoda, I.R.M. (2013). The fluoride removal ability of proto type red clay pot-filters, *Proceedings of the Annual Sessions*, Industrial Technology Institute, Sri Lanka. p.34.**Awards**
    1. WAITRO (World Association of Industrial and Technological Research Organization) innovation award 2016 – Red clay low-cost domestic water filter for removal of fluoride, arsenic and cadmium from drinking water was selected as a Finalist in the Social Innovation category - I.P.L. Jayarathna, I. . R.M. Kottegoda and R.C.W. Arachchi.
    2. Gold Medal in the Open category under technical field of Applied Science and Technology (2021) for the Development of clay filter for removal of fluoride, arsenic and cadmium from drinking water at the awards ceremony organized by the Sri Lanka Inventors Commission –I.R.M. Kottegoda, I.P.L. Jayarathne, R.C.W. Arachchi, J.T.S.T. Jayawardane and H.A.M.I.T. Hettiarachchi.

Popularization Activities

- During 2016-2019 ITI supplied more than 13,000 filters to the Presidential Task Force on prevention of CKDu. They have been distributed among the CKDu affected families.
- Distribution of 1000 water filters as requested by the Chief Ministry of North Western province in 2015 along with awareness programmes.
- As an awareness programme for Dhamma school children at the temple in Kurunegala, a speech was delivered on “Clean water for drinking purpose” in 2015.
- In the program on filter distribution to the public conducted at ITI a speech was delivered on “How to obtain clean water for drinking purpose”.



Development of red-clay based water filter/apparatus for the removal of hardness in drinking water

Grant No: TG- 16 -125
Project Team: *Dr. I.R.M. Kottegoda
Dr. I.P.L. Jayaratne
Mr. R.C.W. Arachchi
Project Period: 2016 - 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Chronic kidney disease (CKD) leads to a gradual loss of kidney function and also causes death if not properly treated. The reason for CKD in Sri Lanka is unknown (CKDu); however, it is suspected to be due to contamination of drinking water with various ions including fluoride (F), arsenic (As), cadmium (Cd), calcium (Ca), and magnesium (Mg). Materials Technology Section (MTS) invented a filter capable of removing F, As and Cd ions from water and transferred the technology in 2016. The present project was initiated in 2016, aiming at improving the filter/apparatus to remove water hardness as well.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A water filter technology for the removal of hardness and other contamination from water and a regeneration method for hardness removal.
- The technology can directly be applied to the present ITI filter for the removal of fluoride, arsenic and cadmium.
- The filter shape and volume of ITI filter were redesigned for capacities of 3L and 6L.
- A mold was designed and fabricated for a ceramic filter collecting tank in collaboration with the ceramic industry.

Technologies Transferred/Commercialized

- The improved features were incorporated into the already transferred filter.

Patents:

- Serial pot filter system for removal of hardness, fluoride and heavy metal ions from water (Sri Lanka Patent No. 20234).
- Method of clay modification and optimized mineral composition for removal of hardness and other contaminants from water (Sri Lanka Patent application No. 20669).

Clay water filter (in plastic and ceramic-based collector)

Publications in Refereed Journals

1. Perera, B.T., Rajapaksha, R.M.H., Arachchige, R.C.W. and Kottegoda, I.R.M. (2020). Cost-effective and non-toxic method to modify clay to increase the hardness adsorption capacity of clay. *International Journal of Chemical Science*, **4**(1), 22-27.
2. Wickramasuriya, A.I.R., Arachchige, R.C.W. and Kottegoda, I.R.M. (2021). Characterization and modification of clay for removal of drinking water hardness**.** *Material Science Research India*, **18**(3), 318-331.

Scientific Communications

1. Jayarathna, I.P.L., Arachchige, R.C.W., Munaweera, R.R.K.W., Jayawardena, J.T.S.T., Hettiarachchi, H.A.M.I.T., Bandara, A. and Kottegoda, I.R.M. (2017). Suppression of water hardness using red-clay. *Proceedings of the 3rd Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.59.
2. Wickramasuriya, A.I.R., Arachchige, R.C.W., De Silva, R.C.L. and Kottegoda, I.R.M. (2019). XRD, FTIR and SEM analysis and modification of clay for the adsorption of water hardness. *Proceedings of the 75th Annual Session*, Sri Lanka Association for the Advancement of Science. p.185.

Postgraduate Degrees

1. Ms. A.I.R. Wickramasuriya completed a MSc degree at the University of Jayawardanapura (2019).
   Thesis Title: Characterization and modification of clay from Biyagama and Deniyaya areas in Sri Lanka for the removal of water hardness.
2. Mr. R.C.W. Arachchi registered for a postgraduate degree at the University of Peradeniya (MPhil Pending).

Pilot-scale trials for red clay-based superior quality cookware

Grant No: TG 13 - 00 - 01
Project Team: *Dr. (Ms.) I.R.M. Kottegoda
Ms. J.T.S.T. Jayawardane
Eng. H.C.D.P. Colombage
Mr. H.A.M.I.T. Hettiarachchi
Mr. R.C.W. Arachchi
Project Period: 2013 - 2015
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The present project was conducted as a pilot trial of a previous project to add value to red clay deposits by enhancing of product through upgraded R&D capabilities in Sri Lanka to support the ceramic industry and to produce useful and economical products that would be beneficial in households in Sri Lanka. Cookware samples were fabricated to test the required properties under actual domestic conditions. Two pilot-scale trials were carried out and the suitability for cooking was analyzed. Biyagama and Yatiyana clay were used effectively in manufacturing glazed and unglazed red clay cookware.

Technologies Transferred/Commercialized

- Non-toxic, lightweight, thin-walled, and high thermal shock resistant red clay-based cookware for gas cooker, microwave etc.

Scientific Communications

1. Jayawardane, J.T.S.T. and Arachchi, R.C.W. (2013). Optimization of process parameters for manufacturing light weight thin walled red clay decorative articles, *Proceedings of the Annual Research Symposium*, Industrial Technology Institute. Sri Lanka. p.37.
2. Poster presentation titled “Development of Red Clay Based Superior Quality Cookware” for Technology Market Place 2013 organized by the Ministry of Technology and Research.

Photo-catalytic technology for the purification of agrochemical-contaminated wastewater from agrochemical packaging and formulation industries

Grant No: TG 13- 75
Project Team: *Dr. (Ms.) I.R.M. Kottegoda
Dr. S. Prabhagar
Mr. K.S.P. Karunadasa
Eng. W.R.L. Wijesekara
Ms. H.D.D.P. Gunasekara
Mr. H.A.M.I.T. Hettiarachchi
Dr. (Ms.) R.T. Nilusha
Project Period: 2013 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The agrochemical waste from paddy fields and other cultivated lands, as well as disposals from agrochemical packaging and formulation industries, causes serious water pollution. However, highly efficient disposal methods are encouraged, especially for industries. For this purpose, it is quite obvious to adopt a technique involving photocatalysts rather than ordinary chemicals where the latter will account for a number of practical issues. The Materials and Environmental Technology sections of ITI collaboratively worked to develop a photocatalyst for agrochemical waste decomposition, while concentrating on higher stability, efficiency, and a low-cost product that can easily be upgraded to an industrial level. A coating of TiO_2 nanoparticles embedded on a substrate by the inorganic adhesive is a potential photocatalytic element for agrochemical waste decomposition.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

Stable photocatalytic coating for agrochemical wastewater treatment using sunlight.

Patents

- Method of immobilization of TiO2 on a substrate using polymer/binder/adhesive for photo-catalytic air/water purification system (Sri Lanka Patent No. 17486).
- Fabrication of photo-catalytic continuous flow reactor using plastic pipes for decontamination of organic waste (Sri Lanka Patent No.- 18851).
- Catalyst-supported solar treatment for decontamination of agrochemical-contaminated wastewater (Sri Lanka Patent No.20264).

Development of stable and effective TiO_2 coating on the glass surface of prototype solar water reactor

Grant No: TG 13-00 -02
Project Team: *Dr. (Ms.) I.R.M. Kottegoda
Mr. K.S.P. Karunadasa
Ms. H.D.P.P. Gunasekara
Mr. H.A.M.I.T. Hettiarachchi
Project Period: 2014 -2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The contamination of water is a major threat to human health. According to WHO statistics, nearly two million people die every year, from diarrhoeal diseases, including cholera. Up to 88% of water-borne diseases arise from unsafe water supplies and inadequate sanitation and hygiene. A novel glass tube-based reactor was constructed by coating *nano*-TiO_2 or ZnO inside the tube to address organic contamination of drinking water such as bacterial contamination. The photocatalyst TiO_2 or ZnO was deposited on the bottom surface of clear glass and plastic tubes connected in parallel, which is capable of mineralizing a broad range of organic pollutants including bacteria to non-toxic substances upon exposure to sunlight.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

A continuous flow photo-reactor was developed for the removal of bacterial contamination in water in the presence of sunlight.

Patents

Low-cost continuous flow solar reactor for purification of bacterial/organic contaminated water (Sri Lanka Patent 16731).

Reduction of vehicle exhaust emissions by nano particle supported adsorption media

Grant No: TG 16 -126
Project Team: *Dr. I.R.M. Kotteggoda
Dr. R.C.L. de Silva
Eng. H.C.D.P. Colombage
Dr. D.S. Samarawickrama
Eng. A. Sooriyaarachchi
Project Period: 2016 - 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Vehicle emissions cause serious damage to the environment. Adsorption of the emissions is the usual technique being used for remediation. Efforts were made to synthesize and characterize different types of composite materials including Al, Zr, Ca, and Zeolite as adsorbents for vehicle emissions. Aluminum Cement Coated - CaO. Zeolite composition was successful in reducing SO_2 of vehicle exhaust emissions for a reported value exceeding 70%.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed:

- Device to be fixed to the exhaust of a vehicle in order to cut down unwanted emissions.
- A special material (developed) coated honeycomb structure bonded with a special adhesive formula was used.

Scientific Communications

1. Aththanayaka, A.M.S.H., De Silva, R.C.L., Samarawickrama, D.S., Colombage, H.C.D.P., Sooriyaarachchi, A. and Kottegoda, I.R.M. (2018). Synthesis and characterization of calcium oxide/ 4A zeolite composite for reduction of vehicle exhaust emissions. *Proceedings of the 74th Annual Session*, Sri Lanka Association for the Advancement of Science. p.70.
2. Aththanayaka, A.M.S.H., De Silva, R.C.L., Samarawickrama, D.S., Colombage, H.C.D.P., Sooriyaarachchi, A. and Kottegoda, I.R.M. (2018). Synthesis and characterization of calcium oxide/4A zeolite composite for efficient vehicle exhaust adsorption. *Proceedings of the 7th Annual Science Research Sessions*, Faculty of Applied Sciences, South Eastern University of Sri Lanka. p.28.
3. Aththanayaka, S., De Silva, C., Samarawickrama, D., Colombage, D., Sooriyaarachchi, A., and Kottegoda, I. (2018). Characterization of calcium oxide/ 4A zeolite composite prepared through thermal method for vehicle exhaust absorption. *International Research Sessions (iOURS)*, Open University of Sri Lanka. p.100.

Conversion of readily available Sri Lankan natural quartz to solar-grade silicon for applications in the electronic industries

Grant No: TG 16-127
Project Team: *Dr. C.H. Manoratne
Mr. K.S.P. Karunadasa
Mr. A.S. Pannila
Prof. R.M.G. Rajapakse
Project Period: 2016 - 2020
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Sri Lanka is well known for the exquisite varieties of very high-purity minerals such as 100% pure quartz and 99% pure graphite. These resources are exported at very low cost without value addition. For example, pure Quartz is sold at USD 240-250 a ton and Iron-free Quartz stones are sold at USD 300-500 per metric ton. However, solar-grade silicon, a value-added quartz product, can be sold at USD 20-100 per kg. Sri Lanka loses a colossal amount of foreign exchange by selling raw forms of Quartz. This research project will result in a process to extract solar-grade silicon through an economically feasible process from locally available natural vein quartz.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A laboratory ("Clean Energy Laboratory") was established as per the project objectives.
- A stable graphite electrode for high-temperature and general electrochemical applications has been developed with locally available graphite and low cost clay.

Patent

- A stable composite electrode based on graphite and clay for high-temperature and general electrochemical applications. (Sri Lanka Patent Application No. 20844).

Publications in Refereed Journals

1. Karunadasa, K.S.P., Manoratne, C.H., Pitawala, H.M.T.G.A. and Rajapakse, R.M.G. (2018). Effect of prolonged milling time on comminution of quartz. *Powder Technology*, **330**, 266-274.
2. Karunadasa, K.S.P., Manoratne, C.H., Pitawala, H.M.T.G.A. and Rajapakse, R.M.G. (2018). Composition, unit cell parameters and microstructure of quartz during phase transformation from α to β as examined by in-situ high-temperature X-ray powder diffraction. *Journal of Physics and Chemistry of Solids*, **117**, 131–138.
3. Karunadasa, K.S.P., Manoratne, C.H., Pitawala, H.M.T.G.A. and Rajapakse, R.M.G. (2018). Relative stability of hydrated/anhydrous products of calcium chloride during complete dehydration as examined by high-temperature X-ray powder diffraction. *Journal of Physics and Chemistry of Solids*, **120**, 167–172.
4. Karunadasa, K.S.P., Manoratne, C.H., Pitawala, H.M.T.G.A. and Rajapakse, R.M.G. (2019). A potential working electrode based on graphite and montmorillonite for electrochemical applications in both aqueous and molten salt electrolytes. *Electrochemistry Communications*, **108**,106562.

5. Karunadasa, K.S.P., Manoratne, C.H., Pitawala, H.M.T.G.A. and Rajapakse, R.M.G. (2019). Thermal decomposition of calcium carbonate (calcite polymorph) as examined by *in-situ* high-temperature X-ray powder diffraction. *Journal of Physics and Chemistry of Solids*, **134**, 21-28.
6. Karunadasa, K.S.P., Rathnayake, D., Manoratne, C.H., Pitawala, A. and Rajapakse, G. (2021). A binder-free composite of graphite and kaolinite as a stable working electrode for general electrochemical applications. *Electrochemical Science Advances*, **1**(4),1:e2100003.
7. Rathnayake, D.T., Karunadasa, K.S.P., Wijekoon, A.S.K., Manoratne, C.H. and Rajapakse R.M.G. (2022). Low-cost ternary composite of graphite, kaolinite and cement as a potential working electrode for general electrochemical applications. *Chemical Papers*, **76**(11), 6653–6658.

8. Rathnayake, D.T., Karunadasa, K.S.P., Wijekoon, A.S.K., Manoratne, C.H., Rajapakse, R.M G. and Pitawala, H.M.T.G.A. (2023). Polyaniline-conjugated graphite–montmorillonite composite electrode prepared by in situ electropolymerization for supercapacitor applications. *Chemical Papers,***77**, 2923 – 2928.

Scientific Communications

1. Mahanama, M.G.G.C., Karunadasa, Kohobhange S.P. and Manoratne. C.H. (2018). A composite electrode for high-temperature applications as a value addition to local graphite and kaolinite. *Wayamba University International Conference (Win C)*. p. 16.
2. Karunadasa K., Manoratne, C., Pitawala, H. and Rajapakse, G. (2018). Dehydration of calcium chloride as examined by high-temperature X-ray powder diffraction. *Proceedings of the 3rd Asia-pacific Multidisciplinary Research*, Colombo. p.18.
3. Karunadasa, K.S.P., Manoratne, C.H., Pitawala, H.M.T.G.A. and Rajapakse, R.M.G. (2017). The phase transformation of quartz from α to β as examined by in-situ high temperature X-ray diffraction, *Proceedings of the 2nd Asia-Pacific Conference on Multidisciplinary Research*, Colombo. p.49.
4. Rathnayake, D.T., Tharangani, L.W.N., Karunadasa, K.S.P. and Manoratne, C.H. (2019). Mechanically compressed graphite-clay composite electrode for high-temperature application. *Proceedings of the International Research Conference*, Uva Wellassa University, Sri Lanka. p.456.
5. Tharangani, L.W.N., Rathnayake, D.T., Karunadasa, K.S.P. and Manoratne, C.H. (2019). Incorporation of layered type clay in graphite-clay based electrodes as a property enhancement for high-temperature applications. *Proceedings of the International Research Conference*, Uva Wellassa University, Sri Lanka. p.445.

Development of a domestic system to convert biodegradable food waste into compost within 24 hours (Home composter)

Grant No: TG 18-144
Project Team: *Ms. M.D. Yoga Milani
Dr. R.C.L. De Silva
Mr. R.C.W. Arachchi
Dr. (Ms.) A.M.M.H. Athapaththu
Eng. A. Sooriyarachchi
Project Period: 2018 – 2020
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The rate of generation of solid waste has increased due to increased population, technological development and the changes in the lifestyle of the people. There is an urgent need to introduce a domestic system to manage biodegradable food waste at the domestic level, to reduce municipal waste collection. This waste management method enables people to utilize their waste as a fertilizer and promote home gardening without using synthetic fertilizers. Extra income may also be generated by utilizing such systems. A domestic home composter was developed to convert biodegradable food waste into compost within 24 hours.

Project Achievements/Outputs

Technologies/Processes/Methods Developed

- A domestic-level home composter to convert biodegradable food waste into compost within 24 hours. The produced compost complied with SLS 1246:2003.

Patents

- A domestic apparatus for converting biodegradable food waste into compost within 24 hours and method of converting thereof. National Intellectual Property Office (Sri Lanka Patent No.20948).

Scientific Communications

1. Jayawardana, M.D.S.B., Milani, M.D.Y., De Silva, R.C.L. and Wijesinghe, S. (2018). Investigation of the impact of clay as a bulking agent for food waste composting at a controlled raised-up temperature, *Proceedings of the 3rd International Conference on Advances in Computing and Technology*, ICACT. p.27.
2. Jayawardana, M.D.S.B., Milani, M.D.Y. and De Silva, R.C.L. (2018). Study the effect of clay, sawdust and half-composted garden waste as bulking agents in food waste composting at a controlled elevated temperature, *Proceedings of the 74th Annual Session*, Sri Lanka Association for the Advancement of Science. p.124.
3. Attapattu, A.M.M.H., Perera, T.S.N., Milani, M.D.Y. and Arachchige, R.C.W. (2019). Molecular characterization of thermophilic bacteria present in solid-waste composting. *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.41.
4. Bhagya, P.V.G.S., Milani, M.D.Y., Arachchige, R.C.W. and Silva, R.C.L.D. (2019). The effect of enhanced self-microbe population, clay and controlled elevated temperature to accelerate the composting of food and garden waste, *Proceedings of the 75th Annual Session*, Sri Lanka Association for the Advancement of Science. p.184.

Awards

1. Award for the Best Innovation Project 2020 for the project titled "Home composter to compost biodegradable food waste within 24 hrs" at the 5th Biennial Research Symposium, Industrial Technology Institute - M.D. Yoga Milani, R.C.L. De Silva, R.C.W. Arachchige, A.M.M.H. Atapattu and A. Sooriyarachchi.
2. Gold Medal 2022: Medal in the Open category under the technical field of environmental conservation-Home composter to compost biodegradable food waste within 24 h at the awards ceremony organized by the Sri Lanka Inventors Commission - M.D. Yoga Milani, R.C.L. De Silva, R.C.W. Arachchige, A. Sooriyarachchi and S. Kalpa Sandaruwan.
3. A certificate was obtained for "Home Composter" during the program Innovators to entrepreneurs 2022 conducted by the Ministry of Agriculture.

Home Composter developed by ITI

Improvement of thermal conductivity of rubber using graphite based nano composite as a value addition

Grant No: TG 18 - 145
Project Team: *Dr. I.R.M. Kottegoda
Dr. L.D.C. Nayanajith
Dr. R.C.L. De Silva
Ms. M.D. Y. Milani
Dr. D.S. Samarawickrama
Project Period: 2018 - 2020
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The project mainly focused on the improvement of the thermal conductivity of solid tires, enabling heat dissipation from the inner to the outer surface. A systematic study on rubber/graphite-based nanocomposites in the application of rubber-based industries is still limited. This is an essential field of study in Sri Lanka since rubber and graphite are major resources of the country. The local resources need to be utilized effectively to develop value-added products. The objective of this project was to improve the thermal conductivity of rubber using nanocomposites based on rubber and graphite base as a value addition to rubber/graphite.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A graphite/rubber composite with improved thermal conductivity and mechanical properties.

Patents

- Heat conducting wearing resistant rubber/graphite composite and preparation method thereof" was filed at NIPO (Sri Lanka Patent Application No: 20614).

Publications in Refereed Journals

3. Viyanage, M.P., Manage, T.R.T., De Silva, R.C.L., Nayanajith, L.D.C., Milani, M.Y.D. and Kottegoda, I.R.M. (2021). Mechanical property evaluation of natural rubber/ vein graphite composites. *Sri Lankan Journal of Physics,* **22**(1), 29-39.

Scientific Communications

- Viyanage, M.P., Manage, T.R.T., De Silva, R.C.L., Nayanajith, L.D.C., Milani, M.Y.D. and Kottegoda, I.R.M. (2019). XRD, FTIR and SEM Analysis of Natural Rubber/ Graphite Composite, *Proceedings of the 75th Annual Session*, Sri Lanka Association for the Advancement of Science. p.512.
- Nayanajith, L.D.C., Milani, M.D.Y., De Silva, R.C.L., Kottegoda, I.R.M. and Samarawickrama, D.S. (2019). Evaluation of the effect of graphite content on thermal conductivity and mechanical properties of natural rubber latex-graphite composites, *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute. p.30.

Curing of bamboo culm to suit tropical environment and bamboo-based product development

Grant No: TG 18 - 152
Project Team: *Dr. P.N.R.J. Amunugoda
Eng. A. Sooriarachchi
Dr. C. H. Manoratne
Eng. A.M.T. Adikari
Dr. D.S. Samarawickrama
Mr. M. Ariyaratne,
Project Period: 2018 - 2021
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Bamboo is one of nature's most valuable gifts to mankind. Its versatile nature and innumerable uses have earned bamboo the name 'green gold of the forest'. However, its growth characteristics and microstructure make it different from wood. The unique strength properties, coupled with innovative uses by people, have enabled its versatility to be exploited for many industrial and architectural uses**.** Due to the higher amount of parenchyma, it increases the water holding capacity and therefore, bamboo possesses a very high moisture content and has very low resistance to biological degrading agents. Thus, undercover, the untreated bamboo may last 4-7 years. According to durability classification, bamboo falls in class iii, non-durable category. On the other hand, the presence of large amounts of starch makes bamboo highly susceptible to attack by staining fungi, beetles and termites. They cause immense damage during drying, storage, and subsequent use. Therefore, scientifically sound and/or environmentally friendly bamboo preservation techniques for whole culm and bamboo splits are necessary to be reviewed, selected, and further developed according to local climatic conditions and conveyed to SMEs for applications, thereby, increasing the availability of standard bamboo splits, bamboo wood flanks, compressed bamboo and developing floor and wall tiles and bamboo pulp from wastage. On the other hand, because of its beautiful morphological shape, higher ornamental value, and unique oriental culture aura, the monopodial bamboo plantation and bamboo forest play a very important role in landscaping and landscape architecture. The level of intensive sustainable management for bamboo plantations is still new to Sri Lanka. For the sustainable development of the bamboo industry, the raw bamboo material must be guaranteed for sustainable supply via conducting scientific and technological cultivation and improving environmental awareness for sustainable management of the bamboo resource stock.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Stakeholder consultations were done for species identification, total extent estimation, listing/linkages with bamboo nurseries and identification of potential land for cultivation.
- Stakeholder meeting was conducted: Industrial Technology Institute and Institute of Policy Studies (IPS) of Sri Lanka and jointly organized a two-day bamboo international stakeholders conference for country roadmap /Action/ Strategic plan development with the assistance of international experts from International Bamboo and Rattan Organization.

- Established a bamboo processing workshop at ITI: Renovation of the project workshop was carried out and the workshop was equipped with bamboo processing machinery: Bamboo charcoal-producing mini kiln, a bamboo splitting machine, a dryer for culm drying and a blender. In addition, a laboratory-scale heat Pump dryer was purchased.
- Surveyed all the bamboo curing/preservation treatments, selected the best among them and further improvements were carried out.

Product/Process developed

- Bamboo floor tile/charcoal tile development: Process and sample floor tiles were developed with a rough surface for the use of Ecotourism cottages. Process and samples of bamboo charcoal tiles were developed.
- Bamboo Pulp: The systemic pulping process including de-structuring of bamboo, chipping, screening and re-chipping oversized materials, proper cooking technologies and chemical recovery, are important factors. Sample pulp development was done using a chemical bleaching method.

Publications in Refereed Journals

1. Samarawickrama, D.S., Manoratne, C.H. and Amunugoda, P.N.R.J. (2020). Production and characterization of black charcoal from *Bambusa vulgaris* (Yellow Bamboo) and potentiality for advance applications. *Frontiers in Advanced Materials Research*, **2**(1), 28-36.
2. Amunugoda, P.N.R.J. (2022). International agreements and entry points to adaptation and adoption of modern forest technologies, ecological restoration, climate change, ecotourism and agroforest enterprise based advanced materials of Sri Lanka and Regional Countries. *Frontiers in Advanced Materials Research*,**4**(2), 32-43.

Scientific Communications

1. Wishwajith, W.C.R.S., Amunugoda, P.N.R.J., Samarawickrama, D.S. and Manoratne, C.H. (2019). Bamboo charcoal from Sri Lankan species of *Bambusa vulgaris* culm. *Bamboo Stakeholder Conference*, Institute of Policy Studies of Sri Lanka.

Popularization Activities

- Bamboo awareness meeting for SMEs: Several bamboo awareness meetings and programs were held.
- Bamboo stakeholder meeting including the display of bamboo exhibits- IPS, 2019.
- Bamboo species, products and related information delivery at the Exhibition- Green University, Homagama- 2020.
- Two awareness meetings at the Food Technology Section, Malabe.
- Two awareness meetings at two AGA Divisions of Sri Lanka.
- A manual on bamboo propagation/ nursery management/ plantation establishment.
- A catalogue of bamboo products was developed.

Fabrication of low-cost graphite-based composite electrode for electrochemical applications at high temperatures as a value addition to local minerals

Grant No: TG 19-181
Project Team: *Dr. C.H. Manoratne
Mr. K.S.P. Karunadasa
Prof. R.M.G. Rajapakse
Period covered: 2019 - 2021
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The fabrication of binder-free electrodes consisting of graphite is a challenging topic considering high-temperature applications, especially in molten salt electrolytes. Graphite electrodes can be fabricated by adding various binders including non-conductive and conductive polymeric binders. However, both types account for poor thermal and mechanical stability, especially at high-temperatures in molten salt electrolytes. Besides, such electrodes show poor chemical resistance in aqueous electrolytes, thereby limiting their applications. The present research was carried out to fabricate a composite electrode of graphite and clay via mechanical compression and heat treatment without incorporating binders or chemical agents. The main objective of this work was to fabricate a stable and economical electrode with high mechanical and thermal stability. The major application of GCCE can carry out in both aqueous electrolytes and molten salt electrolytes, indicating the application over a vast range of temperatures. Besides, the composite electrode is a potentially cheap alternative for expensive commercial working electrodes including carbon-based and metal types. Therefore, the electrode must be prepared using substances that can tolerate such harsh conditions/environments to prevent the disintegration of the electrode at high temperatures under alkaline conditions. The raw material selection was, therefore, very critical as the amalgamation of two solids seems to be impossible without binders. However, a novel method was introduced to prepare a composite of graphite and clay (graphite-clay composite electrode, GCCE), in such a way that the composite material itself becomes highly thermal and mechanically stable, showing better performance in molten electrolytes.

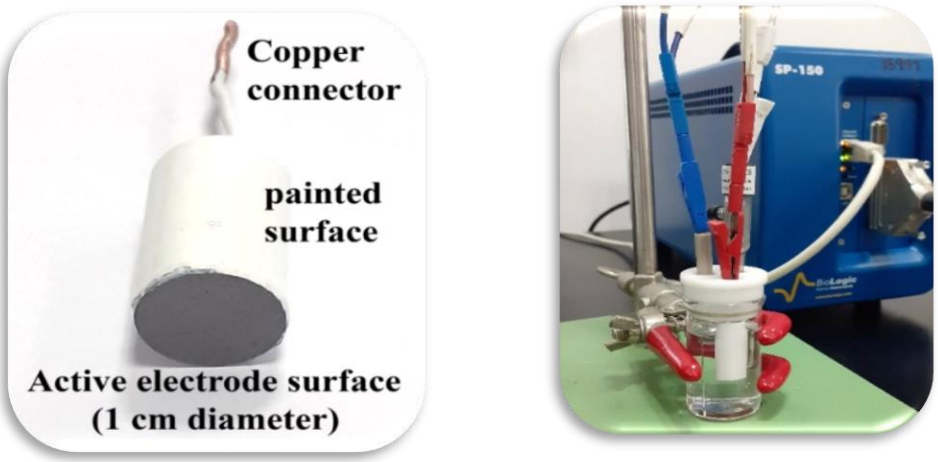
Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A potential electrode consisting of graphite and clay (GCCE) for high-temperature and general electrochemical applications (to replace the expensive commercial working electrodes).
- The technology (Graphite-clay composite electrode) is ready to transfer

Patent

- A stable composite electrode based on graphite and clay for high-temperature and general electrochemical applications (Sri Lanka Patent Application 20844).



Modified GCCE; (b). Electrochemical setup employed in Cyclic Voltammetry

Publications in Refereed Journals

1. Karunadasa, K.S.P., Manoratne, C.H., Pitawala, H.M.T.G.A. and Rajapakse, R.M.G. (2019). A potential working electrode based on graphite and montmorillonite for electrochemical applications in both aqueous and molten salt electrolytes. *Electrochemistry Communications*, **108**, 106562.
2. Karunadasa, K.S.P., Rathnayake, D., Manoratne, C., Pitawala, A. and Rajapakse, G. (2021). A binder-free composite of graphite and kaolinite as a stable working electrode for general electrochemical applications. *Electrochemical Science Advances*, **2021**, e5100003.

Scientific Communications

1. Mahanama, M.G.G.C., Karunadasa, K.S.P. and Manoratne, C.H. (2018). A composite electrode for high-temperature application as a value addition to local graphite and kaolinite, *Proceedings of the Wayamba University International Conference* (Win C), Sri Lanka. p.16.
2. Rathnayake, D.T., Tharangani, L.W.N., Karunadasa, K.S.P. and Manoratne, C.H. (2019). Mechanically compressed graphite-clay composite electrode for high-temperature applications. *International Research Conference*, Uva Wellassa University (IRCUWU), Badulla, Sri Lanka. p.456.
3. Tharangani, L.W.N., Rathnayake, D.T., Tharangani, L.W.N., Karunadasa, K.S.P. and Manoratne, C.H. (2019). The incorporation of layered type clay in graphite-clay based electrodes as a property enhancement for high-temperature applications. *International Research Conference*, Uva Wellassa University (IRCUWU), Badulla, Sri Lanka. p.445.

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Award

1. Award for the Best Innovation Project 2021 for the project titled "Fabrication of low-cost graphite-based composite electrode for electrochemical applications (at high-temperature) as a value addition to local minerals" at the 5th Biennial Research Symposium, Industrial Technology Institute - C.H. Manoratne and K.S.P. Karunadasa.

ENVIRONMENTAL TECHNOLOGY

The Industrial Technology Institute (ITI) contributes to sustainable development in Sri Lanka through advanced environmental technology solutions. Our team of experienced engineers and scientists undertakes consultancy, research, and technology development in areas such as wastewater treatment, industrial air pollution control, and environmental impact assessments.

As a registered consultant with the Central Environmental Authority (CEA), ITI plays a key role in industrial pollution control developing innovative, demand-driven technologies, offering Best Practicable Technology (BPT) to local industries, and promoting responsible pollution prevention practices. ITI also supports the Sri Lankan government with expert advice on environmental policy and sustainable industrialization.

Development of constructed wetland technology for removal of N and P compounds from food industry waste water

Grant No: TG 13-76
Project Team: *Eng. W.R.K. Fonseka
Eng. D.M.H.S. Dissanayake
Dr. (Ms.) R.T. Nilusha
Project Period: 2013 – 2015
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Constructed Wetland (CW) Technology is a promising greener technology for the treatment of wastewater arising from different industries. Although this technology was first implemented in Germany in 1958, in Sri Lanka CW technology is still a freshly minted term. Pilot-scale studies on the treatment of wastewater from the dairy industry which contains high amounts of phosphorus and nitrogen-containing compounds, were conducted. As the initial findings were promising the research project was extended to treat wastewater from other types of food industries.

Project Achievements/Outcomes

Technologies Transferred/Commercialized

- Technology transfer by design of a constructed wetland to treat wastewater generated from a hotel.

Publications in Refereed Journals

1. Nilusha, R.T., Ranwala, S.M.W., Fonseka, W.R.K. and Dissanayake, D.M.H.S. (2016). Comparative study on the growth characteristics of three wetland sedges in dairy wastewater. *Sri Lanka Journal of Environment Management and Planning*, **1,** 21-33.

Scientific Communications

1. Nilusha, R.T., Ranwala, S.M.W., Fonseka, W.R.K. and Dissanayake, D.M.H.S. (2015). Plants for constructed wetlands-a study of wetland plants potential for remediation of dairy wastewater. *Proceedings of the 1st International Symposium on Environment Management and Planning - 2015,* Sri Lanka. p.20.
2. Nilusha, R.T., Dissanayake, D.M.H.S. and Fonseka, W.R.K. (2015). Nutrient removal of dairy wastewater by pilot scale subsurface horizontal flow constructed wetland planted with *Schoenoplectus grossus. Proceedings of the 1st International Symposium on Environment Management and Planning – 2015,* Sri Lanka. p.30.

Assessing observed change in climate extreme & predicting occurrence of climate extreme in the future for selected districts in Sri Lanka

Grant No: TG 15 -97
Project Team: *Eng. W.R.K. Fonseka
Eng. D.M.H. S. Dissanayake
Mr. R.D.S.S. Ranathunga
Project Period: 2015 – 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The main objective of this project was to study temperature and rainfall fluctuations over the past 30-year period in four selected agriculturally and archeologically important districts of Sri Lanka to predict future trends and to identify extreme conditions.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Assessment of 30 years' climate data in the four selected agriculturally and archeologically important districts of Sri Lanka.

Scientific Communications

1. Dissanayake, D.M.H.S. and Ranathunga, R.D.S.S. (2014). Prediction of adverse climatic conditions in archeologically and agriculturally important districts of Sri Lanka. *ICCES International Training Workshop on Asian Monsoon Variability and Predictability*, Beijing, China.p.

Popularization Activities

- International Symposia: International Symposium on Impacts of Extreme Atmospheric Events on Geo-Surface in a Changing Climate, 14-15 May 2015, Colombo, Sri Lanka.
- COMSATS Meeting: Fourth Meeting of COMSATS' ITRG on Climate Change and Environmental Protection, 16th May 2015, Colombo, Sri Lanka.

Use of micro-remediation technique for the treatment of waste water contaminated with pesticides

Grant No: TG 15 -98
Project Team: *Eng. W.R.K. Fonseka
Prof. (Ms.) J.K.R.R. Samarasekera
Dr. (Ms.) W.W.P. Rodrigo
Ms. T.N. Kapuruge
Dr. C.K. Hemachandra
Dr. J.J. Wewalwela
Project Period: 2015 – 2018
Funded by: Sri Lanka Treasury
Principal Investigator

Background

Pesticides are extensively used in agricultural lands to control pests harming crops. Exposure to pesticides has many negative health effects such as cancers, respiratory diseases, mutations and finally can cause death. Excess pesticides in agricultural fields can leach and accumulate in rivers and lakes. Among pesticides, Mancozeb, Glyphosate and Abemactin are the widely used chemicals in developing countries as well as in Sri Lanka. This study aimed at the use of micro-remediation techniques for the treatment of wastewater contaminated with pesticides. The identification of bacteria and fungi that can be applied for bioremediation is important. Therefore, this study aimed to isolate microorganisms that could utilize above mentioned pesticides, to identify the isolated microorganisms and to achieve a pragmatic view of the processes involved in the bioremediation of pesticide-contaminated soil and water bodies.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Establishment of a bacteria isolation procedure from pesticide-contaminated soil and water bodies.
- Establishment of a fungi isolation procedure from pesticide-contaminated soil and water bodies.
- Characterization of bacterial and fungal isolates based on macroscopic and microscopic observations.

Scientific Communications

1. Samarasekera, R. (2017). Isolation and morphological characterization of glyphosate utilizing fungi from contaminated sites in Sri Lanka. *Proceedings of the 3rd International Conference of Dry Zone Agriculture-2017* (ICDA-2017), University of Jaffna. p.97.
2. Wewalwela, J.J., Malith, D.A, Hemachandra, C.K., Rodrigo, W.W P., Kaushalya, W.H., Fonseka W.R.K. and Samerasekara, J.K.R.R. (2017). Identification and characterization of bacterial strains isolated from glyphosate contaminated water in selected agricultural fields. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.32.
3. Kaushalya, W.H., Hemachandra, C.K., Rodrigo, W.W.P., Fonseka, W.R.K. and Samarasekera, R. (2017). Isolation and morphological characterization of possible Glyphosate degrading bacteria from selected contaminated sites in Sri Lanka. *Proceedings of the 73rd Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.22.

NCBI GenBank submissions

- The partial sequences of isolated bacteria strains were deposited.

Microbial bioremediation of petroleum hydrocarbon-contaminated soil and water

Grant No: TG 15-99
Project Team : *Eng. W.R.K. Fonseka
Dr. (Ms.) W.W.P. Rodrigo
Ms. G.A.M.S. Gunaratne
Dr. C.K. Hemachandra
Dr. J.J. Wewalwela
Project Period: 2015 – 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Crude oil is a naturally occurring mixture of hydrocarbon compounds that are produced as a result of thermal decay of buried organic matter over geologic time. The refining process of crude oil produces a wide variety of petroleum-based products which have become the major source of energy for life and industry in the world. Thus, petroleum hydrocarbons have many positive impacts in terms of supplying the energy needs of the world. With their increased usage, intentional/unintentional releases of petroleum products have also increased and are of particular concern to the environment. Detoxification/ recovery of the petroleum hydrocarbon contaminated sites has become important at present. Bioremediation is a promising technology for the treatment of these contaminated sites since it is cost-effective and would lead to complete mineralization. Therefore, the aim of this study was to isolate, characterize and develop a bio-product for bioremediation.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Establishment of bacteria isolation procedure from crude oil-contaminated sludge and water bodies.
- Establishment of fungi isolation procedure from crude oil-contaminated sludge and water bodies.
- Characterization of bacterial and fungal isolates based on macroscopic and microscopic observations.
- Study about growth kinetics of crude oil utilizing bacterial isolates.
- Molecular characterization of crude oil utilizing bacterial and fungal isolates.
- Establishment of bio-product development by environmentally friendly materials.

Scientific Communications

1. Iddamalgoda, H.K.S.P.S., Hemachandra, C.K., Rodrigo, W.W.P. and Fonseka, W.R.K. (2017). Isolation and morphological characterization of petroleum crude oil degrading bacteria from contaminated sites in Sri Lanka. *Proceedings of the 3rd International Conference of Dry Zone Agriculture-2017 (ICDA-2017),* University of Jaffna. p.103.
2. Wijesinghe, L.H., Perera, N.S., Rodrigo, W.W.P., Hemachandra, C.K., Iddamalgoda, H.K.S.P.S. and Fonseka, W.R.K. (2017). Molecular characterization of bacterial and fungal strains isolated from petroleum contaminated sites in Sri Lanka. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.33-34.

3. Manilgama, T.T.D., Hemachandra, C.K., Wewalwela, J.J., Kapuruge, T.N., Rodrigo, W.W.P. and Fonseka, W.R.K. (2018). Isolation and identification of novel bacteria that could potentially capable of degrading crude oil from heavily contaminated sites in Sri Lanka. *Proceedings of the Vingnanam International Research Conference*-2018 (VIRC 2018), Faculty of Science, University of Jaffna. p.36.
4. Mirihana, M.A.S.H., Hemachandra, C.K., Wewalwela, J.J., Kapuruge, T.N., Rodrigo, W.W.P. and Fonseka, W.R.K. (2018). Isolation and identification of potential crude oil utilizing bacterial species from chronically contaminated sites with petroleum hydrocarbons located in the Gampaha district, Sri Lanka. *Proceedings of the Annual Research Symposium*, Faculty of Technology, University of Colombo. p.265.
5. Iddamalgoda, H.K.S.P.S., Hemachandra, C.K., Rodrigo, W.W.P. and Fonseka, W.R.K. (2017). Isolation and morphological characterization of petroleum crude oil degrading fungi from chronically contaminated sites in Sri Lanka. *Proceedings of the 73rd Annual Sessions*, Sri Lanka Association for the Advancement of Science. p.167.
6. Yapa, Y.M.S.M., Rodrigo, W.W.P., Ranawake, A.L., Hemachandra, C.K., Wewalwela, J.J., Kapuruge, T.N. and Fonseka, W.R.K. (2019). Developing a microbial consortium that could effectively degrade the petroleum hydrocarbons. *International Symposium on Agriculture and Environment* (ISAE 2019). p.12.

NCBI GEN Bank submissions

- The partial sequences of thirteen isolated bacterial strains were deposited in Genbank of NCBI, USA.

Degradation kinetics of glyphosate residues, metabolites and additives in conventional fields of application and simulated environments

Grant No: TG 16-133
Project Team: *Ms. D.A.T.W.K. Dissanayake
Mr. M.N.A. Mubarak
Dr. P. Ranasinghe
Prof. A.N. Nawaratne
Prof. S. Malavipathirana
Project Period: 2016 - 2020
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Glyphosate, (N-Phosphanomethyl glycine) is a broad-spectrum, post-emergence, non-selective herbicide, and is the active ingredient in many commercial herbicides such as RoundUp™. Glyphosate herbicides are widely used in agriculture and in home gardens for total weed control. These herbicides usually contain glyphosate in combination with other ingredients such as Polyethoxylated tallowamine (POEA) to improve solubility in water and soil. The toxicity of the glyphosate-based formulations is debatable. Therefore, this project was proposed to study the degradation of glyphosate into its major metabolite aminomethyl phosphonic acid (AMPA) and POEA. Since there was no method available at ITI and also in Sri Lanka to analyze the above three analytes in both environmental matrices, analytical methods were developed and validated and the degradation of the analytes was studied.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Method validation for the determination of Glyphosate and AMPA in water by Waters T3 column with an internal standard.
- Method validation for the simultaneous determination of quantitative and qualitative identification of Glyphosate and AMPA in water.
- Method validation for the determination of glyphosate and AMPA in water by Waters X Select column with lower LOD.
- Method Validation for the determination of glyphosate and AMPA in soil.
- Method validation for the determination of POEA in water and soil.

Scientific Communications

1. Malavipathirana, S., Navarathne, A.N., Mubarak, M.N.A. and Dissanayake, D.A.T.W.K. (2017). Liquid chromatography-tandem mass spectrometry (LC-MS/MS) for the determination of aqueous phase glyphosate and aminomethylphosphonic acid - validation of direct and fast method. *Proceedings of the Postgraduate Institute of Science Research Congress*, Sri Lanka. p.17.
2. Malavipathirana, S., Navarathne, A.N., Mubarak, M.N.A. Ranasinghe, P. and Dissanayake, D.A.T.W.K. (2018). Development of simultaneous qualitative and quantitative method by LC-MS/MS for Glyphosate and AMPA and study on degradation kinetics– A preliminary approach. *Proceedings of the 12th European Pesticide Residue Workshop* (EPRW), Germany. p.62.

3. Malavipathirana, S., Navarathne, A.N., Mubarak, M.N.A., Ranasinghe, P. and Dissanayake, D.A.T.W.K. (2019). Degradation of glyphosate in water at selected biotic and abiotic conditions: A preliminary approach with LC-MS/MS detection, *Proceedings of the International Symposium on Water and Air Pollution: Recent Trends in Research*. p.14.
4. Dissanayake, D.A.T.W.K., Malavipathirana, S., Mubarak, M.N.A., Rathnayake, R.A.I., Ranasinghe, P. and Navarathna, N. (2019). Direct determination of Glyphosate and Aminomethylphosphonic acid (AMPA) in soil by Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS)-Single laboratory method validation, *Proceedings of the 4th Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p.33.

Postgraduate Degrees

1. Ms. D.A.T.W.K. Dissanayake registered for a PhD degree at the Post Graduate Institute of Science, University of Peradeniya.
   Thesis Title: Degradation kinetics of Glyphosate residues, metabolites and additives in conventional fields of application and simulated environments (Pending).

The evaluation of impacts of agrochemicals on Grape vine cultivating soil and water; study of heavy metals, nitrates and phosphates

Grant No: TG 18 -143
Project Team: *Dr. S. Prabagar
Eng. W.R.K. Fonseka
Prof. R.M. Dharmadasa
Mr. M.N.A. Mubarak
Dr. (Ms.) P. Jasotha
Project Period: 2018 - 2019
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Grapes are popular as a fruit and also an important raw material in wine manufacturing. It is a good source of crude fiber, vitamins, minerals and organic acids. Grape vine cultivation in Sri Lanka is mainly found in the Jaffna district and has a good demand in the local market due to its low price compared to exported varieties. It has been reported that the world's grape pulp is contaminated with approximately 13–38% of heavy metals but there are no reported studies on local grape varieties. Therefore, it is necessary to study the status of heavy metals in local grape varieties. Even though the use of fertilizer and pesticides provides an immediate solution to increase the yield, this may contaminate the soil and the water bodies and subsequently the produce. The study was conducted to evaluate the impact of agricultural chemicals such as NO_3, PO_4, SO_4 and heavy metals in soil and water samples of the grape vine cultivated areas.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The contents of Ni and Mg exceeded the maximum permissible limits in soil set by FAO/WHO. The heavy metals, such as Zn, As and Pb content in well water were found to be less than 0.001mg/kg. Nitrate and Phosphate content was also found to be within the permissible level in the well water of grape yards in the Jaffna district.

Publications in Refereed Journals

1. Prbagar, S., Dharmadasa, R.M., Lintha, A., Thuraisingam, S. and Prabagar, J. (2021). Accumulation of heavy metals in grape fruit, leaves, soil and water: A study of influential factors and evaluating ecological risks in Jaffna, Sri Lanka. *Environmental and Sustainability Indicators*, **12**, 100147.

Scientific Communications

1. Fasna, M.I.F., Prabagar, S. and Prabagar, J. (2020). Impact of agriculture practices on water quality parameters of groundwater from Valikamam area in Jaffna district, Sri Lanka. *Proceedings of the 7th Ruhuna International Science and Technology Conference*, RISTCON 2020. p.101.

Popularization Activities

- Awareness of farmers regarding the application of fertilizers and pesticides.

Determination of cyanotoxins in surface waters of Sri Lanka

Grant No: TG 18-156
Project Team: *Dr. (Ms.) K. Mahatantila
Ms. S. Liyanage
Ms. P.S.F. Perera
Period covered: 2019- 2020
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The majority of Sri Lankan population relies on surface fresh waters for drinking and recreation. Hence, they are potentially exposed to a number of chemical contaminants in surface waters which have been shown to cause adverse health effects on humans. Except for the anthropogenic contaminants, the presence of cyanobacteria (blue-green algae) in water is receiving increasing attention worldwide as a potential health concern. Cyanobacteria are a diverse group of aquatic photosynthetic prokaryotes. Under positive conditions, they produce potent cyanotoxins. Among the cyanotoxins, Microcystins (MCs), nodularins (NODs) are most common and mainly concentrated in the liver, causing necrosis that produces massive hemorrhage and death. MCs have also shown a potential tumor-promoting activity. Mouse bioassay studies have shown CYN can affect the kidney, lung and intestine and liver. Therefore, the main objectives of the research were to: Validate a method to determine the main species of cyanotoxins in water (MCs, NODs and CYN) and study the cyanotoxins in surface water in different agro-ecological zones of Sri Lanka.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Two test methods were developed and validated to determine MCs, NOD and CYN in water samples and a technical service was initiated.

ELECTROTECHNOLOGY

ITI's accredited Noise & Vibration Laboratory offers comprehensive noise measurement and analysis services, deployed using world-class, calibrated equipment traceable to international standards. These services are tailored for a wide range of environments from residential neighborhoods to industrial zones ensuring accurate identification of noise levels, source mapping, and baseline establishment for in-depth studies.

Development of an early warning system for landslides

Grant No: TG 11- 58
Project Team: *Dr. (Eng.) R.M. Weerasinghe
Mr. M.S.M. Aroos
Mr. R.A.S. Dewapriya
Project Period: 2011 - 2014
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

When a landslide is in the active state the top soil layer becomes gradually unstable and starts to move. This movement will not happen suddenly. At the initial stage, large cracks may appear on the ground indicating early signs of soil movement underneath. Therefore, the objective of this project was to develop a system to detect ground movements during a landslide. To address the requirement an extension meter system was developed with a remote indication system.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- An extension meter system was developed with remote audio and visual indication systems. The system was installed at Garandiella landslide as a pilot scale installation with the collaboration of NBRO (National Building Research Organization). The same instrument was tested at Kokmaduwa landslide in the Southern Expressway.
- The experience gained from this project was used by NBRO to install extension meter systems at landslide-prone areas. A local specification was developed for the extension meter systems by ITI to implement extension meters at potentially landslide risk locations.

Automated acid rain monitoring station

Grant No: TG 11- 61
Project Team: *Dr. (Eng.) R.M. Weerasinghe
Mr. M.S.M. Aroos
Mr. A.S. Pannila
Project Period: 2013 - 2017
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Acid rain is caused by a chemical reaction that occurs when compounds like sulphur dioxide and nitrogen oxides are emitted to the atmosphere by various activities such as the burning of fuel. Once these substances reach the upper atmosphere, they react with water, oxygen and other chemicals to form acid rain and fall back to the ground as rain or snow. The persisting acid rains affect the existing environment's chemical balance by increasing the acidity of soil and water bodies and hence the ecosystem. This project was aimed at developing an instrument to measure the pH and conductivity of rainwater via online.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The automated acid rain monitoring station was developed and tested in the field as a laboratory scale module.

Technologies transferred/Commercialized

- The device is scaled up to reach prototype level by improving the reliability and reducing the cost.

Publications in Refereed Journals

1. Weerasinghe, R.M., Pannila, A.S., Jayananda, M.K. and Sonnadara, D.U.J. (2012). Study of diurnal and seasonal wind characteristics for wind resource assessment. *International Energy Journal*, **13**(4), 177-188.
2. Weerasinghe, R.M., Pannila, A.S., Jayananda, M.K. and Sonnadara, D.U.J. (2016). Multifractal behaviour of wind speed and directions. *Fractals* **24**(1) doi: 10.1142/S0218348X16500031.
3. Weerasinghe, R.M., Pannila, A.S., Jayananda, M.K. and Sonnadara, D.U.J. (2019). Real time measurement of acidity and conductivity in rain water. *International Journal of Instrumentation Technology*, **2**(2), 135-147.

Scientific Communications

1. Weerasinghe, R.M., Aroos, M.S.M., Pannila, A.S., Jayananda, M.K. and Sonnadara, D.U.J. (2015). Automated Rain Sampler for Real-time pH and Conductivity Measurements. *IPSL Annual Sessions*. p.39-44.

Postgraduate Degree

1. Mr. R.M. Weerasinghe obtained a PhD degree from the University of Colombo in 2017. Thesis Title: Automated acid rain monitoring station

Development of automated streetlamp control systems and field trial for automated streetlamp controller

Grant No: TG 11-59 and TG 13-62
Project Team: *Mr. M.S.M. Aroos
Dr. (Eng.) R.M. Weerasinghe
Mr. A.S. Pannila
Mr. R.A.S. Devapriya
Project Period: 2013 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

With the increase of fuel prices, there is a major concern for power consumption. As a result, it was targeted to implement effective and sustainable power management solutions for various applications. The street lamps installed all over the country consume considerable amounts of energy. Also, it is a common observation that most of the street lamps are operating during the daytime as well, which is a waste of energy. As a solution, an automatic switch was designed and tested under the TG11/59 project. The switch was operated using an audio signal pattern transmitted from a radio station. Under TG 13/62 the above switch was tested in the field by installing at different locations and collecting data.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Automatic switch which can be operated using an audio signal pattern transmitted from a radio station.

Scientific Communications

1. Weerasinghe, R.M., Aroos, M.S.M., Pannila, A.S. and Illeperuma, G.D. (2013). Radio frequency-based street light management system. *Proceedings of the Annual Sessions*, Institute of Physics, Sri Lanka. p.49-56.
2. Weerasinghe, R.M., Aroos, M.S.M. and Pannila, A.S. (2013). Street Light Controlling System using Existing Radio Broadcasting, *Proceedings of the National Energy Symposium 2013*, Sustainable Energy Authority.

Awards

1. Second place under open category C – Computer Science, Software, electronics, electricity, methods of communication (2012) for the Automated street lamp system at the Sahasak Nivamum exhibition organised by Sri Lanka Inventors Commission. - M.S.M. Aroos, R.M. Weerasinghe, A.S. Pannila and R.A.S. Devapriya.
2. Best Research Paper Award - 2nd place (2013)- for the publication “Street light controlling system using existing radio broadcasting” at the Vidulaka National Energy Symposium — M.S.M. Aroos, A.S. Pannila and R.M. Weerasinghe.

Remote noise & vibration monitoring station

Grant No: TG 13- 63
Project Team: *Dr.(Eng.) R.M. Weerasinghe
Mr. M.S.M. Aroos
Mr. D.C. Jayarathne
Mr. A.S. Pannila
Project Period: 2013 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

In order to meet the growing demand and to offer more competitive prices, it is necessary to find new service areas through continuous research and development. The strong research and development facility and modern laboratory facility at ITI are the competitive advantages of ITI. Taking this into consideration, the development of a real-time noise and vibration monitoring station was initiated. Regarding this, a real-time data acquisition card was obtained, and the development of the system was started.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A real-time vibration monitoring station was developed using a data acquisition card with a Lab view interface to monitor the vibration in construction sites.
- Initiated a new service to the customers to monitor vibration in construction sites continuously.

Community based security alarm system

Grant No: TG 15- 113
Project Team: *Mr. A.S. Pannila
Mr. A.S.M. Aroos
Dr.(Eng.) R.M. Weerasinghe
Project Period: 2015 – 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

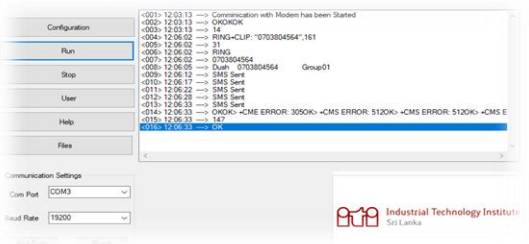
Background

The safety and security of citizens are of utmost importance for a country to live in peace and harmony. A communication system to alert the neighbours when someone is in an emergency or danger will be an ideal way for a secure society. Hence, a security system was developed for domestic installation. The person at risk can dial the system through a dedicated number, where the system will send security alerts to the neighbours. At the same time, a siren will operate to alert the neighbours. The system can be installed at various levels with diverse security features according to requirements and can d be altered when required. As an example, this could be used to minimize the human elephant conflict with modifications.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- A device was developed to ensure the safety of the community living in the village's streets etc. The system was tested and evaluated for its performance in different conditions.
- With some customization, the system will be installed to mitigate human elephant conflict in villages affected by wild elephants. An agreement was signed with the Echo System Conservation and Management Project (ESCAMP) to be executed under the Department of Wildlife. Under this agreement, two security systems will be implemented in Galgamuwa area (Ehetuwewa and Walpolagama villages).
- With the success of the project, the same will be proposed to be implemented in other areas. At this stage, the system will be implemented through a technology commercialization to a third-party company.



Community based Security Alarm System

Development of a landslide movement detection sensor network for NBRO

Grant No: FP 119
Project Team: *Mr. M.S.M. Aroos
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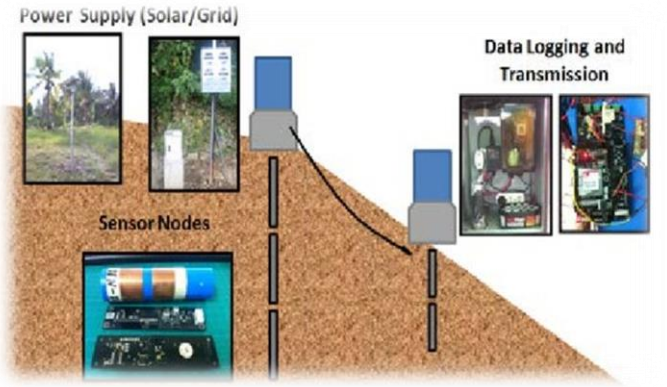
Mr. A.S. Pannila
Project Period: 2016
Funded by: National Building Research Organization (NBRO), Sri Lanka

Principal Investigator

Background

As an impact of environmental changes due to various reasons, the frequency of landslides during heavy rains has increased recently, leading to loss of lives and property. Thus, to minimize the damage due to landslides a sensor network was developed and tested. The system consists of underground sensors that could detect the movements of the bottom soil layers. The movement data from the underground sensor is transferred to a data receiving module installed in the ground level and the data receiver unit transmits the data to a remote data monitoring station. Based on the ground movements preventive action and steps to minimize the losses could be taken.



Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The system consists of underground sensors that could detect the movements of the bottom soil layers. The movement data from the underground sensor is transferred to a data receiving module installed in the ground level and the data receiver unit transmits the data to a remote data monitoring station.
- The system is supposed to be installed at three locations which have unstable land conditions with the collaboration of NBRO. The project was funded by NBRO through UNDP.

Electrotechnology

Scientific Communications

1. Weerasinghe, R.M., Rathnayake, R.M.C. and Buddika, P.D. (2018). IMU Based real time underground Soil Layer Movement Detection System an illustrative case. *IEEM Conference*. DOI: 10.1109/IEEM.2018.8607491.

Determination of noise level and acoustic analysis of toys for children: Electronic and mechanical toys

Grant No: TG 19-168
Project Team: *Mr. C.M. Kalansuriya
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Project Period: 2019 - 2022
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

The main objective of this study was to determine the noise levels emitted by different toys available in the Sri Lankan market. Baseline data were established in order to facilitate the control of the noise levels of toys in Sri Lanka. It was identified that all kinds of toys available in the market do not indicate the sound emission level. Hence, the sound emission limit of the toys and the recommended distance from the children's ear which are considered as useful references in protecting children, are not mentioned in any toys sold in Sri Lanka. The Industrial Technology Institute conducted a research study to investigate the noise emission from toy items available in the market. It was revealed that some of the toys emit significantly higher noise levels and some toys exceed the noise levels stipulated in the international standards. The results indicated that 59 of (28.8%) tested toys' noise levels exceeded two parameters and 35 (17.1%) of the toys exceeded one parameter out of 205 toys. In total 94 (45.9%) items exceeded the prescribed noise levels. Accordingly, with respect to the selected toy categories, tabletop or floor toys, percussion toys, rattles pull-along or push toys are better compared to other toys in consideration of noise level emission. Further, it was observed that cap-firing toys, wind-up toys, and squeeze toys emit higher noise levels in accordance with International Standards.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- The study indicates the necessity for awareness, warning signs and enforcing the toys acoustic standard and regulations in Sri Lanka.

Scientific Communications

1. Kalansuriya, C.M., Weerasinghe, R.M., Jayaratne, D.C. and Darshana, K.K.N. (2021). Noise level and acoustic analysis of selected children's toys. *Proceedings of the 5th Biennial Research Symposium,* Industrial Technology Institute, Sri Lanka. p.23.

Popularization Activities

- Conduct an awareness programme for the relevant stakeholder institutions and authorities about the findings of the research project in order to undertake necessary actions to establish required guidelines to minimize the selling of high noise-generating toys in Sri Lanka.

INDUSTRIAL METROLOGY

The Industrial Metrology Laboratory (IML), a key division of the Industrial Technology Institute (ITI), plays an essential role in Sri Lanka's National Quality Infrastructure (NQI). It delivers internationally competitive calibration and measurement services to a diverse clientele including local and foreign industries, BOI companies, public sector regulatory authorities, and independent test laboratories. IML's expertise covers a comprehensive range of metrological domains: thermometry, mass, electrical, pressure, dimensional, volumetric, and force each traceably linked to SI units, ensuring global measurement integrity

Developing a method to calibrate humidity temperature recorders

Grant No: TG 13-85
Project Team: *Dr. W.M.S. Wijesinghe
Ms. M.R. Motha
Project Period: 2014 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

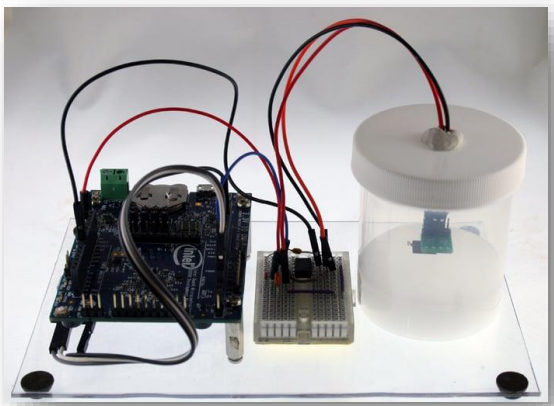
Background

There was a great demand for the calibration of temperature and humidity meters in Sri Lanka. The services were not available within the country and therefore, the development of standard procedures and systems was urgently needed. The calibration system of the temperature and humidity data logger system was proposed to fulfill the industrial demand.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Developed a method to calibrate humidity and temperature which is capable of measuring the temperature and humidity data, 0.1 ^{o}C and 3%, respectively.
- ITI was able to fulfill the industrial requirement and maintain the traceability of the humidity meter calibration.



Humidity / Temperature record instrument

Developing a method to calibrate power analyzers and watt-hour meters

Grant No: TG 13-86
Project Team: *Dr. W.M.S. Wijesinghe
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Project Period: 2013 - 2016
Funded by: Sri Lanka Treasury

**Principal Investigator*

Background

Power and energy calibration play an important role in the calibration world. The new standard for power & energy management, ISO 50001: 2011, has been practiced not only in developed countries but also in Sri Lanka. Therefore, it is important to have a power and energy calibration system for our industrial metrology laboratory. A high precision AC voltage measurement at power frequencies, 50 Hz to 60 Hz, is essential in accurate power measurements and for the calibration of high precision reference power analyzers. Therefore, research was carried out to develop a system to make precision power measurements using three three-phase calibrator - Fluke 6003A and a reference power analyzer – Radian RD-30.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

A calibration system was built to calibrate the following equipment and functions;

- Power meters – Voltage, Current, Active Power (W), Reactive power (VA), Power factor, Harmonics, THD.
- Energy meters – kWh, Meter constant/ Pulse constant.
- Power Analyzers – Voltage, Current, Active Power (W), Reactive Power (VA), Power factor, Harmonics, THD, kWh.
- Reference standards – Voltage, Current, Active Power (W), Reactive power (VA), Power factor.

Developing a humidity & temperature data acquisition & monitoring system for Industrial Metrology Laboratories

Grant No: TG 15-111
Project Team: *Dr. W.M.S. Wijesinghe
Ms. M.R. Motha
Mr. R.A.D.S.D. Ranasinghe
Project Period: 2015 - 2018
Funded by: Sri Lanka Treasury

Principal Investigator

Background

Temperature and humidity maintenance is an essential processes in an accreditation laboratory. When implementing a calibration according to a calibration procedure, the existing temperature and humidity should be monitored and mentioned in the calibration data sheet and in calibration reports. Therefore, those two parameters need to be monitored precisely. At the Industrial Metrology Laboratory (IML), a paper-based system was used to monitor those two parameters. Because of the low accuracy in this system a temperature and humidity data logger system was proposed and developed instead of a less accurate and inconvenient paper-based system.

Project Achievements/Outcomes

Technologies/Processes/Methods Developed

- Developed the environmental data logger system that can be used to measure the temperature and humidity data, 0.1 ^{o}C and 3%, respectively in real-time.
- Designed a high-precision virtual thermometer for temperature measurement and calibration.
- Established the environmental data logger system for all the labs in the IML and satisfied the quality requirements.
- This system can be introduced to the industry who are willing to establish a data logger system with greater accuracy with a real-time data monitoring facility

Scientific Communications

1. Wijesinghe, W.M.S., Ranasinghe, R.A.D.S.D. and Motha, M.R. (2018). DSP Based Environmental Monitoring System, *Proceedings of the 34th Technical Session*, Institute of Physics, Sri Lanka.p. 1-7.
2. Wijesinghe, W.M.S., Ranasinghe, R.A.D.S.D. and Motha, M.R. (2017). DSP Based Environmental Monitoring System. *Proceedings of the 3rd Biennial Research Symposium*, Industrial Technology Institute, Sri Lanka. p. 55.

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Acknowledgments

We gratefully acknowledge the financial assistance provided by the following organizations.

Sri Lanka Treasury

- **Ministry of Science, Technology, and Research**
- **Horticulture Innovation Labs (HortCRIPS), USA and USAID**
- **Ministry of Rural Industries**
- **HTEC Grant-University of Jaffna**
- **National Building Research Organization (NBRO)**
- **Department of Ayurveda**
- **Bio Power Lanka (Pvt.) Ltd**
- **CIC Holdings (Pvt.) Ltd.**

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