

5th Biennial Research Symposium 2021

Positioning Science, Technology and Research
for New Normal Industrial Challenges

10th -12th November 2021

PROCEEDINGS





Industrial Technology Institute

5th Biennial Research Symposium
2021

Positioning Science, Technology & Research for
new normal Industrial Challenges

Abstracts

10th – 12th November 2021

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ISSN 2815-018X

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Published by

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Published date: 10th November 2021

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Message from H.E the President of the Democratic Socialist Republic of Sri Lanka and Honourable Minister of Technology



I am pleased to send this message to the 5th Biennial Research Symposium of the Industrial Technology Institute (ITI), organised under the theme “Positioning Science, Technology & Research for New Normal Industrial Challenges”.

As Sri Lanka and most other developing countries adjust to the new normal conditions that have emerged due to the COVID-19 pandemic, Science and Technology have to play a critical role in dealing with new challenges and achieving our desired goals.

The Government of Sri Lanka has already prepared a National Policy Framework, - Vistas of Prosperity and Splendour- that sets out a forward-looking plan of action towards prosperity. The Research Institutes could play a vital role in this National Policy Framework, and help create a productive citizenry, a contented family, a disciplined and just society and a prosperous nation.

Research & development together with advancing technological innovations in this era of the 4th Industrial Revolution would generate a nexus for a knowledge-based economy and contribute to enriching the livelihood of micro, small and medium entrepreneurs.

I trust this research symposium will pave the way to exchange and share new ideas that would make a significant contribution towards the challenges of the new normal economy.

I would like to extend my best wishes to the presenters, the participants and the organizing committee of the 5th Biennial Research Symposium at ITI and wish it every success.

H.E. Gotabaya Rajapaksa

President of the Democratic Socialist Republic of Sri Lanka and Minister of Technology

November 05, 2021

Message from the Honourable Minister of Digital Technology and Enterprise Development



Technology and Innovation have become the key drivers of growth and development of the modern world. Every nation, that has mapped out its path to progress and economic prosperity has invested and increased emphasis on the technology sector, especially in this post-pandemic environment. The technology sector was one of the key drivers of the global economy throughout this pandemic. It showed the world its true potential and its ability to adapt and change according to any situation it is faced with.

The theme of the 5th Biennial Research Symposium “Positioning Science, Technology & Research for new normal Industrial challenges” is very timely and appropriate in today’s context. I strongly believe that the Research Symposium will be an excellent platform for researchers to showcase their strengths and share original innovations in varied disciplines to a wider global audience. We need to put our innovations and ideas out there for the world to see. Especially at a time when the world is looking for solutions.

What the country needs, is to create a new perception of technology, showcasing its potential to create a livelihood, while contributing to developing new enterprises in line with the vision of the government and building a technology-based society as a ‘Smart nation’. These are all attainable goals.

I take this opportunity to wish every success to this symposium and I commend ITI for taking the initiative despite the challenges imposed by the COVID-19 pandemic and continuing its services to the nation in order that we may continue the journey toward economic revival.

I offer my gratitude and best wishes to the organizers and the presenters of the 5th Biennial Research Symposium.

Thank you,

Hon. Namal Rajapaksa

Minister of Youth and Sports,

Minister of Development Co-ordination and Monitoring

State Minister of Digital Technology and Enterprise Development

Message from the Secretary of the Ministry of Technology and State Ministry of Digital Technology and Enterprise Development



I take great pleasure in sending this message for the 5th Biennial Research Symposium 2021 of the Industrial Technology Institute (ITI). The contribution of Science, Technology, Innovation and Digitalization at a pandemic of Coronavirus disease (COVID-19) is a key for facing current challenges, but also for supporting production efforts and enterprise development aimed at the economic recovery of the country.

The post-COVID-19 world demands more regional integration from us. Technology, Innovation and digitalisation have become the key drivers of growth and sustainability of the country in the new normal condition and to face global challenges such as health issues, sustainable development & climate changes, food security, inclusive growth, energy as well as joining new supply chains.

The ITI symposium under the theme “Positioning Science, Technology & Research for new normal Industrial Challenges” is a forum for the exchange and share of new ideas and discuss key strategies to look at the future of technology and how to use Science, Technology and Innovation to harness its power to address the challenges of the new normal.

I take this opportunity to wish ITI all the very best for the successful hosting of the ITI 5th Biennial Research Symposium. I extended my gratitude and appreciation to the organizing committee of the Symposium for their effort to make this event a success.

Mr. Jayantha de Silva

Secretary of the Ministry of Technology and State Ministry of Digital Technology and Enterprise Development

Message from the Executive Director COMSATS



The Commission on Science and Technology for Sustainable Development in the South (COMSATS) felicitates its esteemed Centre of Excellence in Sri Lanka, the Industrial Technology Institute (ITI) for holding the 5th Biennial Research Symposium. The theme of the event 'Positioning Science, Technology & Research for New Normal Industrial Challenges' is very important in the context of ongoing COVID-19 pandemic, particularly for cultivating capabilities of the developing countries to cope with the post COVID19 industrial challenges. It is also well aligned with the objectives

and efforts of COMSATS aimed at S&T-led socio-economic development of the South.

The post-COVID19 world is expected to be much different, economically and socially, and the overall impact of the pandemic is yet to be fully determined. As a matter of fact, no industry has emerged unscathed from the disruption of COVID-19. The pandemic has affected economies, businesses, and industrial activities around the globe. Food insecurity, unemployment, poverty, and healthcare crisis, production capacity issues and economic uncertainty are envisaged as key challenges to our sustainable future. The appropriate utilization of science, technology and innovation, particularly its applications such as e-commerce, e-finance, e-agriculture, Internet of Things, artificial intelligence, etc., can strengthen industries and SMEs to cope with the challenges in the post-COVID-19 scenario. The holding of this symposium is, therefore, very timely, which would provide a platform for the scientists and researchers of ITI to share their research progress and to collaborate with each other for addressing the afore-mentioned challenges. COMSATS feels privileged to be a part of such forums, where new ideas are born, nourished and promoted.

COMSATS, being an intergovernmental organization of 27 developing countries, is a proactive proponent of South-South and Triangular Cooperation in science and technology for finding solutions to the current global challenges. The Democratic Socialist Republic of Sri Lanka is a founding Member State. COMSATS' scientific and technological strength comes from its Network of International S&T Centres of Excellence, which comprises 24 reputed centres/universities of science and technology, including the Industrial Technology Institute. ITI has been regularly participating in the activities of COMSATS Network, such as organizing capacity building events, facilitating joint research and development activities, hosting statutory body meetings, sharing of human, scientific and technological resources, etc., and is a valuable member of COMSATS' fraternity.

H.E. Dr. Akhtar Nazir

Executive Director, COMSTATS and Federal Secretary, Ministry of Science and Technology, Government of Pakistan

Message from the Chairman



It is with great pleasure that I extend the Chairman's message for the 5th Biennial Research Symposium of Industrial Technology Institute (ITI).

I have a special attachment for this event as the Biennial Research Symposium of Industrial Technology Institute was conceptualized and initiated by me in 2013 as the Director General of the Institute, in order to make a platform for ITI Scientists to present their R&D findings, innovative ideas and technologies developed to the public, and to appreciate the ITI

Scientists, Engineers, and Technologists who contributed for the Science, Technology and Industrial Development of the country.

I'm really privileged and honoured to be a patron of ITI Biennial Research Symposia from the inception. In 2013, 2015 & 2017, I was privileged to spearhead the event as the Director General of the Institute and in 2019 as a referee to the technical abstracts presented and Ex Director General/invitee and 2021 as the Chairman of the Institute.

I consider this event as an important S&T communication activity of the Institute which is aligned with the National Science Week and held on the World Science Day, biannually. This time, though within a Global Pandemic situation, we are fortunate and honoured to have the President of the country as the Chief Guest of the event making the 5th Biennial Research Symposium a landmark event for the ITI history, and a token of recognition of Sri Lanka's S&T personnel's role by the Head of State.

I wish this biennial event be progressed and expanded into an international event and a vibrant Science, Technology & Innovation Communication Platform of Sri Lanka. The Theme for this year "Positioning Science, Technology & Research for New Normal Industrial Challenges" is very appropriate under the present Global Pandemic and opens the most needed discussions among the scientific community and policymakers of the country for new normal developments.

Let me congratulate all those who are receiving awards for their S&T achievements and who do technical presentations over the two days of symposium and wish the Director General, the organizing committee and fellow Scientists, Engineers, Technologists and other Staff of ITI a very successful event.

Dr. G A S Premakumara

BSc, PhD, Dip(Psy Coun), MIBiol, MIChemC, CChem, CBiol, FIBiol, FIChemC, FNAS

Chairman - Industrial Technology Institute (CISIR)

Former Director General & Research Professor - Industrial Technology Institute (CISIR)

Message from the Director General



Industrial Technology Institute (ITI) records sixty-six years of excellence in Research, Technology, and Innovation towards the progression of sustainable industrial development in the country. Our commitment to industrial technology development ensures that industries are supported by undertaking research and development, consultancy, technology transfers, training, and the provision of testing and calibration services.

We are pleased to host the 5th Biennial Research Symposium of ITI under the theme “Positioning Science, Technology & Research for New Normal Industrial Challenges” as the country is adjusting to a new sense of normality due to COVID-19 pandemic.

It is with immense gratification and honour I welcome the scientists, engineers, technologists and other invitees from research institutes, academia, other organizations and ITI to the 5th Biennial Research Symposium, which will be held from the 10th to 12th of November 2021. The three-day event comprises plenary lectures delivered by distinguished professionals and presentations by ITI Researchers on their research findings. A post-symposium workshop on “Entrepreneurship Development in New Normal: Challenges and Way forward” will be held on 15th November 2021 targetting an audience of Micro, Small and Medium Entrepreneurs (MSMEs).

The research symposium will be declared open by H.E. Gotabhaya Rajapaksa the President of the Democratic Socialist Republic of Sri Lanka and Hon. Minister of Technology as the Chief Guest. Hon. Namal Rajapaksa Minister of Youth & Sports, Minister of Development Co-ordination and Monitoring and State Minister of Digital Technology and Enterprise Development will be the Guest of Honour on this occasion. H.E. Dr Akhtar Nazir, Interim Executive Director, Commission on Science and Technology for Sustainable Development in the South (COMSATS) and Federal Secretary, Ministry of Science and Technology, Government of Pakistan will be participating as a Special Guest.

Our sincere appreciation goes to the Chairman, Board of Management, symposium chairperson, organizing committee, authors and researchers who have contributed immensely to make the 5th Biennial Research Symposium a successful and memorable event. My appreciation also goes to all the sponsors for their generous financial assistance toward this event. I wish all of you a most enjoyable and interactive symposium.

Professor J K R Radhika Samarasekera

Director General/CEO

Message from the Symposium Organizing Chair



I am deeply honored and privileged to serve as the organizing chair of the 5th Biennial Research Symposium of the Industrial Technology Institute (ITI). I warmly welcome the respected invitees, scientists, engineers, technologists, academia, policymakers, industrialists, entrepreneurs and the general public who has joined the event. I believe that the country's economy to be kept running under whatever the challenges we face due to COVID-19 pandemic. Since, Science, Technology & Innovation (ST & I) are key drives of the economic growth of a country, this year we geared ourselves under the theme of 'Positioning Science, Technology & Research for New Normal Industrial Challenges'. Being a leading multidisciplinary R&D institution of the country who provides technological solutions and technical support to industry, Biennial Research Symposium is the most significant scientific event organized by the institute to showcase its valuable discoveries and innovative technologies developed through public funds.

The 5th Biennial Research Symposium, which will be held from 10 -12 November 2021 in line with the 'World Science Day' will be a good scientific platform for ITI researchers to disseminate the key findings of their research done in multidisciplinary sciences. The symposium and the post-symposium workshop on 'Entrepreneurship Development in New Normal: Challenges and Way Forward' organized as a special event of the symposium will be valuable forums to share, discuss and debate on scientific outcomes in a wider audience connecting students, researchers, academia, industrialists, policymakers and entrepreneurs.

I take this opportunity to wish all my fellow research scientists, engineers and technologists for a successful future leading to further scientific inventions and innovations to uplift the economy of the country. As the symposium chair, I wish to extend my gratitude to the Chairman & Board of Directors, Director General, symposium secretaries and all staff who contributed for the success of the symposium. I would like to extend my sincere thanks to all the distinguish invitees for joining with us to enlighten the audience with their insightful speeches. I greatly appreciate the financial and other assistance given by our sponsors to glamour this event.

Professor Ilmi Hewajulige

Organizing Chair and Additional Director General R&D

Development of an instant herbal porridge having functional properties and its shelf life evaluation

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Abstract

Herbal porridges labeled with therapeutic claims available in the market are very few and may not be validated scientifically. Hence, the study aimed to prepare an instant herbal porridge mixture (5 min. in boiled water) with antioxidant and anti-diabetic properties to be used as a functional food. The porridge mixture (PM) consists of a mixture of leaf powder [*Cassia auriculata* Linn (Ranawara), *Coccinia grandis* (L) Voigt (Kowakka), *Murraya koenigii* (L) Sprengel (Karapincha) and *Vernonia cinerea* (L) Less (Monorakudumbiya)], processed rice, ginger powder, garlic powder, coconut milk powder, green gram powder and salt. The formulated porridge mixture was subjected to, (a) antioxidant activities (TPC, TFC, DPPH, FRAP, ABTS and ORAC), (b) anti- α -amylase activity and (c) an accelerated shelf-life evaluation based on microbiological, sensory and other chemical properties. The antioxidant and anti- α -amylase activities were carried out for water extracts of leaf powder and the PM. The results revealed that PM exhibited moderate antioxidant activities [as TPC: 2.62 \pm 0.08 mg gallic acid equivalent (GE)/g; TFC: 0.38 \pm 0.02 mg quercetin equivalent (QE)/g; DPPH: 63.56 \pm 1.14 mg Trolox equivalent (TE)/g; FRAP: 1.46 \pm 0.04 mg TE/g, ABTS:5.65 \pm 0.09 mg TE/g, and ORAC:1129.07 \pm 0.79 mg TE/g of PM] and α -amylase activity [IC₅₀ of water extract of PM and acarbose were 433.93 \pm 0.82 mg/ml and 133.88 \pm 4.4 mg/ml respectively]. The initial and final microbial counts of PM subjected to accelerated shelf life for 14 weeks showed, 1.0 \times 10⁵ & 2.0 \times 10³ cfu/g of aerobic plate counts, 8.0 \times 10² & 3.0 \times 10² cfu/g of yeasts and mold counts and >3.0 \times 10⁵ & 1.0 \times 10⁵ cfu/g of lipolytic organisms while no *E. coli* was detected. The sensory evaluation revealed that all the parameters evaluated (appearance, color, odor, taste and overall acceptability) in the samples stored at 27 °C were significantly better (p<0.05) than the samples stored under 42 °C, after 14 weeks of storage. The shelf life of the porridge mixture was calculated as 184 days at 27 \pm 2 °C. The developed instant PM showed functional properties and has good commercial potential.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 18/138)

Physical, chemical and functional properties of NasNarang (*Citrus madurensis*) fruit juice and development of an “Isotonic NasNarang sports drink”

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Abstract

NasNarang is an underutilized medicinal citrus variety used for indigenous medicine in Sri Lanka. Isotonic drinks which showed a significant market growth in the recent past are functional beverages with a similar number of osmotically active particles as present in the human body plasma (i.e. osmolality 275-295 mOsmol/kg). Isotonic drinks help for replenishing the loss of electrolytes and sugar after a physical workout. The present study describes the potential utilization of NasNarang fruit juice in developing an isotonic sports drink and evaluation of physico-chemical and functional properties of fresh NasNarang juice and Isotonic NasNarang sports drink. NasNarang sports drink was developed using varying content of fresh juice of NasNarang 5%, 6.5% and 7.5% (v/v) based on the mouthfeel with other recommended food-grade ingredients. A trained sensory panel (12 Nos) selected the concentration of 7.5% NasNarang fruit juice as the most acceptable level for the product based on the overall acceptability. The physical properties such as total soluble solid content, total acidity and pH of the isotonic NasNarang sports drink were 9.00±0.00%, 0.53±0.01% and 2.45±0.01 respectively. The crude protein, crude fibre, total ash and carbohydrate percentages of the NasNarang fruit juice and the sports drink were 0.47±0.01, 0.53±0.01, 0.47±0.11, 6.97±0.27 and 0.05±0.00, 0.09±0.01, 7.31±0.31 respectively. The energy value of the sports drink was 29.44 Kcal /per 100 ml. NasNarang sports drink contained Na (121 mg/l), K(197 mg/l), Ca(55.9 mg/l), Mg (21.8mg/l) and vitamins including ascorbic acid (0.3 mg/100ml), vitamin B₂ (0.135 mg/100ml), vitamin B₅ (0.15mg/100ml) and vitamin B₆ (0.145mg/100ml). The total phenolic contents of the fresh NasNarang fruit juice and the sports drink were 224±0.02 and 0.029±0.00 mg gallic acid equivalents/ml respectively. Moreover, the total flavonoid contents of the fresh NasNarang fruit juice and the sports drink were 0.139±0.01 and 0.011±0.00 mg quercetin equivalents/ml respectively. NasNarang fruit juice provides natural flavor, color, minerals, vitamins and antioxidants to the product. The total osmolality of developed sports drinks by calculation method was 283mOsmol/l, which falls to the similar range of osmolality of the human blood (275-295 mOsmol/kg). Sports drink from NasNarang juice may help athletes to replace electrolytes, energy and water after intense physical activities.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG19/169)

Development of Veralu (*Elaeocarpus serratus* L.) fruit incorporated pudding and investigation of physico-chemical and functional properties

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Abstract

Elaeocarpus serratus L. (Veralu/Ceylon olive) is an underutilized fruit in Sri Lanka having high amounts of bioactive compounds like ascorbic acid, phenolic compounds, flavonoids and β -carotene. Although fruit contains a high content of phytochemicals, consumption is less among children and adults due to the presence of astringent taste. The present study was carried out to formulate a Ready to Eat (RTE) pudding using Veralu pulp (VP) with the intention of enhancing sensory, nutritional and health properties. An edible portion of partially ripened Veralu fruits was obtained and the fresh fruit pulp was produced by homogenizing at the ratio of 5:3, edible portions to water (w:w). Preliminary trials were carried out by incorporating varying amounts of VP (35%, 40% and 45%), sweeteners (sugar and bee honey) and stabilizers (agar and carrageenan) with a constant amount of fresh milk and whey powder. The most preferable formula was selected as 35% VP with other ingredients including fresh milk 50%, whey powder 8%, sugar 7% and agar 0.2% based on the levels of overall acceptability and texture. The selected product was analyzed for physico-chemical characteristics and antioxidants using standard analytical methods. The pH, acidity and total soluble solid contents of Veralu pudding were 4.86, 0.46% and 21 °Brix respectively. The proximate composition of Veralu pudding contained total minerals ($1.27 \pm 0.02\%$), fibre ($6.99 \pm 0.07\%$), protein ($7.96 \pm 0.2\%$), fat ($1.44 \pm 0.04\%$), carbohydrates ($15.34 \pm 0.15\%$) and sugar ($7.00 \pm 0.00\%$). The total phenolic and total flavonoid contents were 1.69 ± 0.023 mg GAE/g and 0.41 ± 0.005 mg QE/g respectively. High amounts of fiber, low amounts of sugar and fat assure that Veralu pudding can be considered as a healthy dessert for consumers with health concerns such as for overweight and diabetes.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 19/169)

Antioxidant activity and shelf life of vinegar free spicy sauce

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Abstract

Sauces are commonly used in many cuisines to improve the taste flavour. Further, demands for sauces in different applications are increasing constantly: hot sauces give spicy taste to meat, fish and vegetables while sweet sauces give attractiveness to pancakes, and rice etc. In addition to the organoleptic properties of sauces, people are concerned about the nutritive values and health benefits of the product. Most of the time, vinegar is one of the major ingredients in sauce due to its acid content and tangy flavour. Vinegar is made out of the fermentation process and is composed of acetic acid. In general, the acetic acid percentage in vinegar is ranged from 4-7%. Even though many bioactivities such as antimicrobial, antioxidant, antitumor, antiobesity, antidiabetic, cholesterol-lowering effect and antihypertensive effects are reported in vinegar, some people show allergic reactions such as headaches, nasal congestions, changes in skin colour, itching and skin rashes etc. towards vinegar. Hence, the present study attempted to formulate a vinegar free sauce enriched with spices and evaluate its (a) antioxidant activity and (b) shelf life. Total phenolic content (TPC), total flavonoid content (TFC) 1,1-diphenyl-2-picryl hydrazyl (DPPH) radical scavenging activity, and ferric reducing antioxidant power (FRAP) were investigated for the spicy sauce according to the standard protocols. In addition, the shelf life of the formulation was determined at different temperatures (29 ± 2 °C, 37 ± 2 °C and 42 ± 2 °C) for 16 weeks. Results revealed that the scavenging ability of DPPH and FRAP of the spicy sauce was 15.11 ± 0.8 mg Trolox eq/g and 65.42 ± 3.39 mg Trolox eq/g respectively. Total phenolic content in the spicy sauce was markedly higher than (more than 15 folds) that of total flavonoid content. Further, the shelf life was calculated as six months at 29 ± 2 °C. In conclusion, a spicy sauce free of vinegar with antioxidant properties was developed. This was the first attempt at formulating a vinegar free sauce enriched with spices like cinnamon, ginger, garlic, tamarind, chilli, cardamom, nutmeg, clove and pepper. This novel sauce formulation will be beneficial to those who suffer from allergic reactions to vinegar and also provide health beneficial properties.

Assessment of developed multigrain string hopper flour against market samples and prepared string hoppers for nutritional properties

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Abstract

A flour blend from cereals, legumes and oil seeds will deliver more nutrients, phytochemicals and antioxidants which is in demand for maintaining good health when compared to the instant rice flour popularly used to prepare traditional Sri Lankan foods such as string hopper, rotti and pittu. The objective of the present study was to develop a more nutritious and functionally superior multigrain flour compared to market available instant string hopper flour. The developed multigrain flour mixture was composed of six grains namely rice, green gram, soybean, finger millet, gram and wheat flour whose proportions were optimized through preliminary trials together with sensory tests. Improvement of the nutritional and functional properties of the finalized multigrain formula was tested against a popular instant string hopper flour product in the market which contains only rice flour. String hoppers were made using the developed multigrain flour mixture and the instant string hopper market flour. Both flours and prepared string hoppers were evaluated for protein, ash, crude fat (CF), dietary fiber (DF) contents and mineral composition. Nutritional parameters such as protein (16.24 ± 0.15 %), CF (4.8 ± 0.03 %) and ash (2.12 ± 0.03 %) contents of multigrain flour were significantly higher compared to the market string hopper flour. Further, the string hoppers made from multigrain flour had significantly higher protein (17.50 ± 0.10 %), CF (3.02 ± 0.03 %) and ash (3.93 ± 0.07 %) contents than string hoppers made from the market sample. The use of different types of grains with a variety of nutritional profiles has resulted in this improvement in nutritional parameters. DF content of multigrain flour (5.39 ± 0.04 %) was significantly higher than that of the market flour sample (2.02 ± 0.08 %) claiming its potential for a functional diet. More importantly, there was no significant decrease in DF content when string hoppers were made using multigrain flour. Mineral content namely, Fe (24.65 ± 0.22 mg/kg), Mg (808.67 ± 7.09 mg/kg), K (0.46 ± 0.01 %), Mn (13.4 ± 0.12 mg/kg) and Ca (502.10 ± 1.94 mg/kg) were significantly higher in multigrain flour than the market flour sample. Additionally, consumption of 100g of multigrain flour on dry weight basis will provide 32% protein, 19% DF, 15% iron, 56% Manganese and 20% Magnesium of an adult's daily nutritional requirements. In conclusion, the developed multigrain flour is nutritionally and functionally superior to its market rivals mainly composed of rice flour.

Antioxidant capacity of bark of Sri Gemunu (*Cinnamomum zeylanicum* Blume) high yielding cinnamon variety in Sri Lanka

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Abstract

Reactive oxygen and nitrogen species play a vital role in host defense mechanisms and as well as in signal cascades. However, the imbalance of these species leads to oxidative stress paving way for the non-communicable diseases. The use of dietary antioxidants in the food industry and therapies has been the latest focus of researchers as one way of managing these conditions. Sri Gemunu (SG) is one of the two high yielding cinnamon varieties in Sri Lanka. However, biological activities of this variety including antioxidants and antioxidant activity are not yet reported. Therefore, the present study evaluates the antioxidants and antioxidant activity of the bark of SG *in vitro*. Dichloromethane: methanol (DCM:M 1:1, v/v) and water extracts of bark of SG were used in this study. Antioxidants [total polyphenolic content (TPC) and total flavonoid content (TFC)] and antioxidant activity [1, 1-diphenyl-2-picryl-hydrazyl (DPPH), 2-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) and oxygen radical absorbance capacity (ORAC) and ferric reducing antioxidant power (FRAP)] were evaluated using 96-well micro plates-based antioxidant bio assay protocols (n=4) *in vitro*. Results revealed that both DCM:M and water extracts of bark of SG possess antioxidants and antioxidant activity with varying potential. However, DCM:M extract showed significantly ($p < 0.05$) high antioxidants and antioxidant activity for all the studied assays compared to water extract. The mean TPC, TFC, DPPH, ABTS, ORAC, and FRAP values were 31.25 ± 1.33 mg gallic acid equivalents/g of sample (GS), 0.49 ± 0.01 mg Quercetin equivalents/GS, 35.35 ± 0.75 mg Trolox equivalents (TE)/GS, 53.90 ± 0.41 mg TE/GS, 35.11 ± 1.24 mg TE/GS and 17.06 ± 0.79 mg TE/GS respectively. In conclusion, the bark of SG possesses marked antioxidants and antioxidant activity via radical scavenging and reducing power mechanisms. Further, this is the first report on antioxidants and antioxidant activity of bark of SG high yielding cinnamon variety in Sri Lanka and results highlights its potential to use as a natural antioxidant in managing oxidative stress-associated chronic diseases.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 19/176)

Development of a high performance liquid chromatographic method for the determination of sucralose in food and beverages

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Abstract

Consumption of high sugar products has been identified as one of the main causes of diabetes. Therefore, a tremendous demand around the globe including Sri Lanka has for sugar substitutes like natural and artificial sweeteners. Sucralose is one of the non-nutritive sweeteners, which is heavily used in confectionaries, baked products, beverages, pharmaceuticals, food supplements and also as a tabletop sweetener due to its sugar-like taste. Since sucralose inherits excellent stability and has no interactions with other food ingredients, it is categorized as the “Generally Recognized As Safe (GRAS)” compound by the US Food and Drug Administration. However, the substitution has to comply with the food act of Sri Lanka, which is based on Codex or EU regulations. Hence, it is crucial to ensure that the acceptable daily intake (ADI) and maximum permitted levels were not exceeded. Therefore, this study is focused on developing and validating a simple, user-friendly high performance liquid chromatographic method to quantify the levels of sucralose from the local and imported food and beverage samples found in Sri Lanka. The analytes were separated on a Hipler – H column (300 x 7.7 mm, 8 µm particle size) at 35°C using ultra-pure water as the mobile phase and monitored using a refractive index detector. The performance of the developed method was assessed according to Eurochem guidelines. The limit of detection and limit of quantification were 1.2 and 2 mg/kg respectively with a linear dynamic range of 1 to 600 mg/kg having the regression coefficient of 0.9997. Spiked samples having the levels of 25 to 500 mg/kg yielded the recoveries from 81.2 to 108.0%. The precision calculated in terms of repeatability and reproducibility of the method was lower than 6.1% when expressed as relative standard deviation (%RSD) for low, mid and high levels of the sucralose analysis. The percentage expanded uncertainty calculated with the coverage factor of 2(k=2) was 7.7. In conclusion, the developed analytical procedure is a simple, and reliable method which can be utilized to determine the levels of sucralose in routine analysis of carbonated and non-carbonated beverages, food supplements, dairy products and tabletop sweeteners with sufficient accuracy and precision.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 18/150).

Analysis of volatile constituents of leaf and rhizome oils of *Zingiber zerumbet* (L) Smith (Wild ginger) found in Nilgala Forest Reserve

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Abstract

Zingiber zerumbet (L) Smith, a member of the family Zingiberaceae is well known as “Wal-inguru” in Sri Lanka. It is distributed in Bangladesh, India, Malaysia, Nepal and Sri Lanka. The rhizome of *Z. zerumbet* has been used to treat stomach aches and worm infestation in children, cure swelling sores and loss of appetite in traditional medicine in Sri Lanka. Rhizomes of *Z. zerumbet* have anti-inflammatory, anti-ulceration, antioxidant and antimicrobial properties. The leaf and rhizome of *Z. zerumbet* were collected from the Nilgala forest reserve situated in the Uva-Baddula region of Sri Lanka. Essential oils from plant material were isolated by hydro-distillation using a Clevenger type apparatus for 4 hours. The chemical composition of extracted essential oils was studied by Gas Chromatographic- Mass Spectrometry (GC-MS) on a Thermo scientific 1300 system operating in EI mode (70 eV), equipped with a split/ splitless injector (250 °C), a split ratio 1: 50, using a fused silica DB-Wax capillary column for the first time in Sri Lanka. The oil contents were $0.20 \pm 0.05\%$ (v/w) in leaf and $1.20 \pm 0.10\%$ (v/w) in rhizome by dry weight basis. The leaf oil has *trans*-nerolidol (41.0%), β -caryophyllene (21.3%), zerumbone (6.2%) and β -pinene (5.1%) as the major compounds among 26 identified compounds. Fourteen components were identified in the rhizome essential oil and the main components were zerumbone (68.7%), humulene (12.2%) and camphene (3.6%). Further, zerumbone in rhizome essential oil was isolated by recycle-HPLC and characterized using ¹H, ¹³C and 2D-NMR spectroscopy. It was found that zerumbone content is high in rhizome, which is 68.7% and leaf oil contains a relatively low content of zerumbone (6.2%). However, leaf oil contains a higher amount of *trans*-nerolidol (41.0%), which is not present even trace level in the rhizome oil. Previous studies done in Bangladesh and Malaysia confirmed that essential oil in rhizomes of *Z. zerumbet* contained 46.8% and 79.8% respectively. In conclusion, the present study confirmed that *Z. zerumbet* grown in Sri Lanka contains 68.7% zerumbone in rhizome oil.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 13/71)

Evaluation of the suitability of cold plasma technology for sterilization of black pepper corns by means of essential oil content and composition

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Abstract

Investigating the efficacy of Cold Plasma (CP) technology on applications in the food industry is a thriving research area worldwide. The potential for sterilization of spices using the CP technique as a non-thermal technology is widely studied. Essential Oils (EOs) give characteristics odor and flavor to spices. Analysis of EOs after the sterilization process is necessary for characterization of the effects to process in terms of quantity and quality of EOs. With high amounts of EOs present in spices, analysis of EOs after any sterilization process is one of the major concerns. Therefore, the current study was undertaken to determine the effectiveness of CP technology for sterilization of Black Pepper (BP) corns by means of essential oil content and composition. Two cold plasma configurations, Atmospheric Cold Plasma Gliding Arc Discharge (ACPGAD) at 15kV and 50 Hz and Low-Pressure Cold Plasma (LPCP) at 13.56MHz in 30 L vacuum chamber with commercially available BP were used in the study. For both treatments, times were set as 5 min, 10 min and 15 min. EOs were extracted using the hydro-distillation method and the components in EOs were identified by GC-MS and quantified by GC-FID. The Refractive index of EOs was determined. The surface structure of BP was examined using Scanning Electron Microscopy (SEM). In ACPGAD, treatment time of 10 min. yielded the highest EO content (0.037 ml/g) while during LPCP, 5 min. yielded the highest level (0.036 ml/g) and decreased oil yields were observed at 10 and 15 min. Twelve major components of EOs were identified and quantified as (% w/w); α -Pinene (20.84 - 24.78), δ -3-Carene (16.68 - 18.52), β -Phellandrene (14.05 -15.16), Sabinene (12.48 - 13.03), Caryophyllene (11.09 -13.71), β -Myrcene (7.91 - 8.84), D-Limonene (1.98 - 2.48), α -Copaene (0.93 - 1.45), O-Cymene (0.41-0.68), β -Pinene (0.37 - 0.42), δ -Elemene (0.30 - 0.45), and β -Caryophyllene Oxide (0.15 - 0.55). However, there were no significant differences ($P>0.05$) in each component of EOs in both CP treatments. The Refractive index of EOs obtained after ACPGAD and LPCP treatment was not significantly different ($P<0.05$) confirming the results of GC-FID. CP treatment allows reactive species to etch or strip off the surface of BP and this can facilitate channel build-up allowing EOs to escape from the surface. Treating longer times such as 15 minutes with CP can boost

evaporation of oil components during CP treatment which resulted in low extraction of EOs. SEM images proved changes in the surface. Results confirmed both ACPGAD and LPCP do not affect the quality of EOs of BP undesirably. Moreover, CP can be used as a pretreatment for extraction of EOs and future studies are required to optimize the processing conditions.

Acknowledgement: Financial assistance is given by the Ministry of Science, Technology and Research under Indo Sri Lanka Joint Research Program (FP/125)

Metataxonomic analysis of cattle milk microbiota in the wet, dry and intermediate zones of Sri Lanka

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Abstract

The safety and shelf-life of raw milk mostly depend upon the quantity and types of the microorganisms present and its potentiality to cause spoilage or health hazards. Recent developments in high-throughput sequencing technologies have enhanced the efficiency and accuracy of metataxonomic investigations in numerous ecosystems. As the microbiota of raw milk is extremely complex and diverse, this study was conducted to evaluate the bacterial composition of raw cattle milk produced in wet, dry and intermediate zone cattle farms of Sri Lanka using a 16S metataxonomic approach. Raw cattle milk samples (n=90) were collected from 18 dairy farms representing all three climatic zones. The Milk Bacterial DNA Isolation Kit (Cat. 21550, NORGEN BIOTEK, Canada) was used for bacterial DNA extraction and purification. NanoDrop microvolume quantification of nucleic acids technique was employed for the quantification of extracted DNA. The PCR amplification was carried out targeting the V3 and V4 regions of the 16S rRNA gene and sequencing was carried out using IlluminaMiSeq device (Illumina Inc., San Diego, CA, USA). The operational taxonomic units (OTUs) clustering and classification at several taxonomic levels were performed using QIIME2 (version 2019.1) and Phyloseq (an R package). There was a significant difference between the microbial diversity of samples collected from dry and wet zones according to the Kruskal-Wallis pairwise test ($P < 0.05$) as well as Wilcoxon rank sum tests ($P < 0.01$). The diversity between wet and intermediate zones was also significantly different as denoted by Wilcoxon rank sum tests ($P < 0.01$). From the 110 total detected orders from the milk samples, 14 predominant orders were belonging to 8 Classes. The relative abundance (RA) of of Enterobacteriales, Rhizobiales and Rhodobacterales orders were highest in dry zone, Actinomycetales, Pseudomonadales, Xanthomonadales and Bacillales orders were highest in intermediate zone and Bifidobacteriales, Sphingomonadales, Burkholderiales,

Clostridiales, Lactobacillales, Flavobacteriales and Bacteroidales orders were highest in wet zone. As per the RA of the genera, *Macrococcus* was the most prevalent genus in dry and intermediate zones and *Elizabethkingia* is the most prevalent genus in milk collected from the wet zone. Relative abundances of *Kocuria*, *Arthrobacter*, *Acinetobacter*, *Streptococcus* and *Macrococcus* genera were highest in the dry zone, genus *Rothia*, *Helcobacillus*, *Corynebacterium*, *Millisia*, *Enhydrobacter* and *Staphylococcus* were highest in the intermediate zone and the genus *Micrococcus*, *Bifidobacterium*, *Elizabethkingia*, *Bacteroides*, *Granulicatella*, *Lactococcus*, *Atopostipes*, *Atopococcus*, *Clostridium* and *Succinispira* were highest in the wet zone. As per the RA% in the dry zone, *Streptococcus agalactiae* (8.03 %) was the most abundant identified species followed by *Kocuria kristinae* (4.47%), *Enhydrobacter aerosaccus* (4.42%) and *Staphylococcus saprophyticus* (3.06%). The most abundant identified species in the intermediate zone were *Staphylococcus saprophyticus* (9.92%) followed by *Streptococcus agalactiae* (6.02%), *Enhydrobacter aerosaccus* (5.44%), *Rothia nasimurium* (4.43%), *Atopococcus tabaci* (2.75%) and *Millisia brevis* (1.32%). The identified species level microbiome of the wet zone was led by *Atopococcus tabaci* (6.16%) followed by *Streptococcus agalactiae* (2.75%), *Millisia brevis* (1.13%) and *Lactococcus garvieae* (1.11% RA). A microbiome with less pathogenic species was observed in the milk collected from wet zone farms.

Acknowledgement: Financial assistance is given by National Science Foundation (RG/2016/AG/02)

Development of a conventional triplex PCR assay for simultaneous detection of buffalo, cattle and pork meat

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Abstract

Detection of the species origin of raw meat and processed meat products has become a major requirement due to mislabeling and the addition of forbidden meat. The Food and Drug Administration (FDA) is clearly explained that Food fraud, as “the fraudulent, intentional substitution or addition of a substance in a product for the purpose of increasing the apparent value of the product or reducing the cost of its production”. On the other hand, consumers often depend on food labels and therefore, identification is important for the safeguard of health, economic investment, and religious sanctity. Therefore, this study was intended to develop an optimized conventional triplex polymerase chain reaction (PCR) assay for simultaneous detection of buffalo, cattle and pork using three pairs of species-specific oligonucleotide primers targeting the mitochondrial cytochrome oxidase 1 (COI) gene with the target fragment sizes as 313 bp, 294 bp and 255 bp for buffalo, pork and cattle respectively. The DNA of raw and processed meat products were extracted using the DNeasy mericon food kit, Qiagen (Ref No: 69514). To confirm the quality and the quantity of the extracted DNA, a spectrophotometer and fluorometer were used. The multiplex PCR was optimized by adding different concentrations of all three primers in a single reaction mixture. The primer specificity and cross-reactivity were confirmed by carrying out a simplex PCR. Using the developed multiplex PCR assay, a market basket study was carried out for seventeen samples. The results proved food fraud in nine samples and the experiment was duplicated for further confirmation. The results indicated that molecular analysis such as triplex PCR is a reliable method for the detection of meat species in raw and processed meat products.

Differentiation of 3T3-L1 Mouse Embryonic Fibroblast Cells into Adipocytes

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Abstract

Obesity-mediated Type 2 diabetes is characterized by hyperlipidemia with significantly high triglycerides, and LDL levels and decreased HDL levels. Most of the anti-diabetic drugs treat one of the key symptoms of hyperglycemia but exacerbate weight gain and obesity which further contribute to the progression of type 2 diabetes. Therefore, it is highly desirable to find new anti-diabetic agents that stimulate glucose uptake by adipose or muscle cells without inducing obesity or other side effects. The objective of this study was to develop a protocol for differentiation of 3T3-L1 fibroblast into adipocytes, which can be used to evaluate the antidiabetic potential of plant extracts. Cell lines of 3T3L1 (mouse embryonic) were purchased from Merck Life Science, (Pvt) Ltd. The cells were cultured in Dulbecco's Modified Eagle's Medium (DMEM) containing 10% Fetal Calf Serum (FCS), 4 mm Glutamine and 1% antibiotic/antimycotic, in a 5% CO₂ incubator at 37 °C. The pre-adipocytes cells were retained till they are 80% confluent (a week time). Once the cells reach confluency, cells are incubated for an additional 48–50 h prior to differentiation. Cells were incubated for 72 h in 96 well plates in DMEM supplemented with differentiation cocktail 10 µg/ml insulin, 0.5 mM methyl isobutyl-xanthine (IBMX) and 1 µm dexamethasone (DEX) to induce differentiation. Then, the medium was changed into fresh DMEM containing 10 µg/ml of insulin. Intracellular lipid droplets were formed on day 6 and the quantity and size grew within the next 6 days. Finally, more than 90% of the cells resulted in lipid accumulation and conversion to adipocytes with various sizes of droplets. Fully differentiated 3T3-L1 cells were observed after 14 days. To visualize lipid droplets, cells were stained with Oil-Red O on days 6, 8 and 12 which are depicted as red areas within the cytoplasm. This cell differentiation study will be used for further diabetes and obesity studies using different herbal and medicinal extracts and purified fractions which have shown enzymatic inhibition activities.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 18/167)

Evaluation of genetic diversity of *Phyllanthus debilis* populations in Sri Lanka using Maturase K (*matK*) gene region

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Abstract

Phyllanthus debilis Klein ex Willd (*Ela-Pitawakka* / *Bim-Nelli* in Sinhala) is a medicinal plant belongs to the family Euphorbiaceae, which is native to South Asian countries including India and Sri Lanka. The entire plant of *P. debilis* is used to treat diabetes mellitus and various parts are being used as a remedy for jaundice, sickle-cell anemia, diarrhea and kidney stones. Different morphotypes of *P. debilis* can be observed in different field conditions. So far, four phenetic groups of *P. debilis* with clear morphological differences have been identified. The present study was conducted to determine the genetic diversity among the four phenetic groups using polymorphism of the Maturase K (*matK*) gene region. Thirty-six live plants from *P. debilis* were collected from three plant populations (Colombo, Gampaha & Matara) in Sri Lanka, representing four phenetic groups. Three plants were collected from each phenetic group from each district. The genomic DNA was extracted using the CTAB method and PCR was carried out with *matK* primers using genomic DNA as the template. PCR products were purified and sequenced by Sanger sequencing. DNA sequences were analyzed by BioEdit sequence alignment software. A DNA fragment of *matK*, 850bp was used in the subsequent phylogenetic analyses. A phylogenetic tree was constructed using Neighbour-joining (NJ) method in Mega7. According to the sequence data, the phylogram was divided into two monophyletic clades & a morphologically different first phenetic group (P1) formed one monophyletic clade and the other three phenetic groups (P2, P3 & P4) formed another monophyletic clade. The uncorrected pairwise genetic distance between these two clades was 2.9% and no difference was observed within the cluster. Therefore, it could be concluded that the tested Sri Lankan *P. debilis* populations can be divided into two phenetic groups based on molecular data. Further studies with different molecular markers and different populations are necessary to confirm whether two phenetic groups can be classified as different species or subspecies.

Optimization of a DNA extraction method for gram positive bacteria

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Abstract

More than 250 different food borne hazards have been recognized, where human food pathogenic bacteria are mainly gram-positives. The extraction of nucleic acids from gram-positive bacteria for molecular diagnostic applications is difficult due to the thicker peptidoglycan layer on the cell wall, and resultant low yield. Hence partial or complete disruption of the complex cell wall is required to obtain a sufficient quantity of DNA or RNA. However, this involves high-cost commercial kits. Therefore, the objective of this study was to develop a simple mechanical based method using sand granules to disrupt the thick cell wall of the gram-positive bacteria. The bacterial pellets (*Staphylococcus aureus*) were mixed with sieved (0.5-3 mm), acid-washed and sterilized sands and vortexed for 45 min. The pellet and sand mixtures were treated with different lysis buffers. DNA extraction was performed on cell lysate using a Qiagen DNA extraction kit following manufacturers' guidelines. For comparison, DNA extraction was performed using a similar amount of a bacterial pellet by Qiagen DNA extraction kit without any mechanical lysis step. The DNA concentration was measured using a Quantus™ Fluorometer and yields were compared. The DNA concentrations of the sample which used only commercial DNA extraction kit (protocol 1) showed as 4.86 ng/μl and DNA concentrations of other protocols (P) with sand and different lysis buffers were as P2- 8.20 ng/μl, P3- 15.00 ng/μl, P4- 17.00 ng/μl, P5- 8.50 ng/μl, P6- 12.00 ng/μl, P7- 41.00ng/μl, P8- 16.00 ng/μl, P9- 3.88 ng/μl, P10- 4.45 ng/μl, P11 -3.38 ng/μl, P12- 5.40 ng/μl and P13- 3.67 ng/μl respectively, with A260/A280 ratio maintained at 1.8 ± 0.1 . Highest DNA yield, 41 ng/μl was reported in protocol 7 with optimized size (0.5 mm - 0.125 mm) and quantity of 0.666 mg of sand granules along with the lysis buffer containing NaCl, EDTA, Tris-HClGuSCN and SDS (pH 7.6). Therefore, this additional lysis step prior to DNA extraction produces a comparatively higher yield of DNA from gram-positive bacteria at a low cost and avoids the use of hazardous chemicals. The proposed DNA extraction protocol eliminates the problem of lower DNA yields associated with gram-positive bacteria. After optimizing across a range of gram-positive bacteria, and validation, the method has the potential to be used in a DNA extraction kit for gram-positive bacteria.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 19/188)

Screening of selected plant extracts for development of a potential bio-fungicide to control Anthracnose disease in mango

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Abstract

Among the different fruit varieties grown in Sri Lanka under varied agro-climatic environments, Mango (*Manigifera indicia* L.) gains special attention in the local and export market as fresh fruit or a value-added product. Anthracnose caused by *Colletotrichum gloeosporioides* is one of the most common postharvest diseases and a major cause of qualitative and quantitative loss of Mango. Consumer resistance in the use of synthetic fungicides to control postharvest diseases urges scientists to develop organic-based fungicides using botanicals. Hence, the aim of the present study was to investigate the synergistic effects of plant extracts, *Aloe vera* (*Komarika*) peels, *Syzygium cumini* (*Madan*) seeds and *Senna alata* (*Ath Thora*) leaves to control the anthracnose causing fungus. Single and combined extracts (combinations of two and combinations of three) of the above ethanolic plant extracts were tested in 5 different concentrations: 0.2%, 0.5%, 1%, 1.5% and 2%, *in-vitro* to determine the mycelial Colony Inhibition (CI) and Spore Germination Inhibition (SGI) of the fungus and data were analyzed via analysis of variance (ANOVA). The result of the *in-vitro* screening tested against *C. gloeosporioides* revealed that there was a significant difference ($p < 0.05$) in antifungal effect among the 70% ethanolic extracts of their single, two and three combinations at five different concentrations (0.2%, 0.5%, 1%, 1.5%, 2%). Among them, a strong antifungal activity against *C. gloeosporioides* was observed at 0.2% concentration in combination of three plant extracts (*Aloe vera* + *Syzygium cumini* + *Senna alata*) with significantly higher colony inhibition (75%) and spore germination inhibition (79%) compared to that of two combined, single effect of the plant extracts and negative control. The combination of two plant extracts, *Aloe vera* + *Senna alata* at 2% concentration resulted in 73% colony inhibition and 74% spore germination inhibition, as well as the individual extract of *Aloe vera* at 2%, gave 65% CI and 71% SGI. The positive control (Mancozeb) showed complete inhibition (100%) and the negative control showed no inhibition in colony growth and zero spore germination inhibition of the fungus at all concentration levels. The study revealed a promising prospect for the utilization of selected plant extracts in anthracnose pathogen control in Mango.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 19/174)

Preparation and standardization of toothpaste incorporating *Moringa oleifera* Lam. leaves

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Abstract

Oral hygiene is an important aspect to control oral infections such as tooth decay and gum diseases. In novel dentistry, herbal toothpaste is more acceptable and safer with minimum side effects over synthetic preparations. In traditional systems of medicine, *Moringa olifera* L. has been widely used to treat oral inflammations, infections, and abscesses. Therefore, the objective of the present research is to formulate herbal toothpaste by incorporating the leaves of *M. oleifera* and to standardize it as per Sri Lanka Standard (SLS) requirements. The fresh leaves of *M. oleifera* were collected, air-dried under shade for 7 days at 25 °C, ground and passed through a 212 µm sieve plate to obtain a fine powder. Standard toothpaste base formulation was optimized and incorporated with *M. oleifera* leaf powder to develop the Moringa toothpaste. The leaf powder percentage was selected as 5% (w/w) to be incorporated into the optimized toothpaste base formulation, based on the flowing property, flavour, mouth feel, colour, texture, fineness, smell and anti-microbial activity. The net mass, extrusive content, consistency, cohesiveness, stability, tube inertness, moisture content, and volatile matter, pH of the Moringa toothpaste were determined to standardize the final product as per the requirement of SLS Standard (275: 2014). The anti-bacterial efficacy of Moringa toothpaste was evaluated against *Staphylococcus aureus*, an oral pathogenic bacterium. The contents of elements present in the *M. oleifera* leaf powder, that are known to improve oral health including Ca, K, and Mg were also determined. The formulated herbal toothpaste complied with the requirements of SLS Standard (275:2014) indicating acceptable net mass (23.6 g), extrusive content (49.96%), consistency (present), cohesiveness (passed), stability (stable formulation), moisture and volatile matter content (42.6%) and pH (6.3). The Moringa toothpaste showed a significant inhibition activity against *S. aureus* indicating its potential to provide tooth and oral hygiene and to prevent various dental diseases. The contents of Ca, Mg, and K were found as 0.60 ± 0.01 %, 1.70 ± 0.03 %, and 0.14 ± 0.01 %, respectively. The formulation development and standardization of *M. oleifera* based herbal toothpaste, having the potential to improve oral health is reported for the first time in Sri Lanka through this study. This new product can be introduced as an innovative approach to incorporate bioactive plants such as *M. oleifera* in oral care products.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 19/178).

A binder-free composite of graphite and kaolinite as a stable working electrode for general electrochemical applications

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Abstract

Recently, low-cost binder-free composite electrodes have been gained much attention as alternatives for commercially available electrodes. In this study, the fabrication of graphite composite electrode using kaolinite is reported for the first time. The rod-shaped graphite kaolinite composite electrodes (GKCE) were obtained by pressing composite material in a specially design mold and firing at 550 °C in a tube furnace for 30 minutes to increase the strength, stability, and durability of the final product. The Thermogravimetric analysis/Differential Scanning Calorimetry analysis was conducted to confirm the firing temperature of electrodes. Furthermore, the characterization of fired electrodes was mainly achieved by Linear Sweep Voltammetry (LSV), Scanning Electron Microscopy (SEM), and Testometric universal testing machine. Results revealed that the electrode containing 80% of graphite exhibits the highest flexural strength ($5.39 \times 10^6 \text{ N m}^{-2}$) together with the lowest resistivity ($0.08 \times 10^{-2} \Omega \text{ m}$) due to the formation of well-ordered lamella like graphite matrix held by the low amount of microscopic spherical clay particles. The fabricated electrodes were stable in aqueous electrolytes with varied pH values. Moreover, GKCE with 80% graphite was modified as a working electrode and consumed in order to perform the analyte detection in aqueous electrolytes and electro polymerization. The analyte detection feasibility of GKCE is confirmed by a regular cyclic voltammogram with an ammonium ferrous sulfate hexahydrate aqueous solution. Besides, the highest sensitivity (1.2 A m mol^{-1}) towards both Fe^{2+} and Fe^{3+} emphasizes its potency as a working electrode. The SEM images of the electropolymerized electrode indicated the interlinked polymer network consisting of Polyaniline (PANI) nanofibers. The newly fabricated GKCE with enhanced electrochemical properties can be employed as a stable working electrode for general electrochemical applications instead of expensive commercial electrodes.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 16/127)

Heavy metals contamination in shallow sediments of Puttalam lagoon

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Abstract

The aim of this study was to estimate the pollution status of shallow sediments of the Puttalam lagoon of Sri Lanka by analyzing heavy metal content. Puttalam lagoon was divided into five different zones based on major activities during the monsoon season of 2020. Shallow sediment samples were collected from all five zones of Puttalam lagoon with different land use. Approximately 10 bottom sediment samples were collected from each zone of the lagoon using a Peterson grab sampler at an approximate depth of 0.5 m from each location of every zone. All samples were air-dried, microwave digested and analyzed for heavy metals by Inductively Coupled Plasma-Mass Spectrometry (ICP MS, 7900 Agilent, USA). In addition, the quality of lagoon sediments was also compared with Numerical Sediment Quality Guidelines (SQG). The investigation of heavy metals in Puttalam lagoon sediments revealed the order of mean metal concentration as: Fe>Al>Mn>Cr>Ba>Zn>As>Ni>Pb>Cu>Cd>Hg. The average concentrations of heavy metals in the sediments were found below the geochemical background level of world surface rock average Shale values except for As and Ba. Average As concentration of the lagoon sediments varies between 0.86 to 33.67 mg/kg and it exceeds the world surface average value (13.0 mg/kg) in 45% of sampling locations. Whereas average Ba concentration varies between 1.72 to 182.2 mg/kg and it exceeded the world surface rock average (92.0 mg/kg) only in two individual locations and its 3.9% of the total sampling locations. Pollution of sediment with respect to As and Ba was may be due to deposition of point source emissions of fly ash from the coal-fired power plant and cement plant located around the lagoon. The heavy metals such as As, Cd, Cr, Cu, Hg, Ni, Pb and Zn in the Puttalam lagoon sediments were found below the Australian and New Zealand Environment and Conservation Council (ANZECC) given Numerical Sediment Quality Guidelines (SQG) high values (As = 70, Cd = 10, Cr = 370, Cu = 270, Hg = 1.0, Ni = 52, Pb = 220, Zn = 410 mg/kg).

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 19/187)

DSP based low-cost wireless calibration system to calibrate industrial temperature and humidity enclosures

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Abstract

The objective of this study is to describe the design, calibration of a low-cost wireless reference measuring system for real-time measurement of humidity and temperature to calibrate industrial enclosures specially in places such as microbiology laboratories, bio-hazard areas, radioactive areas and freezers etc. where entry is restricted. The proposed design circuit contains data acquisition (DAQ) device and sensors and a graphical user interface (GUI). The DAQ and the GUI are communicating wirelessly. The data acquisition is done by using NI cDAQ-9191 wireless Chassis and NI-9219 data acquisition devices. PT100 4-wire temperature sensors of accuracy 0.1°C and relative humidity (RH) sensors of accuracy 4% were used as sensor modules. A graphical user interface (GUI) was developed using LabVIEW 2015. Digital signal processing (DSP) technique – simple Moving Average (SMA) filters (5 point SMA in temperature, 15 point SMA in humidity) are used to increase the accuracy of the system. By using this system, temperature and humidity data logging can be done with 0.1°C & 4% accuracy respectively. The sensitivity of the system is 253 ppm in temperature (at 23°C) and 953 ppm in RH. The stability of the system is 0.006 °C in temperature and 0.001% in RH. The maximum distance the system can communicate is 20m (Ad-Hoc). The physical dimensions are 200W × 90H × 35 mm D (DAQ), 80W x 75H x 60mm D (temperature sensor) and 130 L x 16mm D (RH sensor). The whole system was calibrated using a temperature Drywell and calibrated environmental chamber at the Industrial Technology Institute (ITI) based on the comparison method. The wireless system was validated by comparing the results with the calibrated reference thermometer and thermo-hygrometer at the ITI. The results showed that the developed system is useful to calibrate sensors at the places where entry is restricted and it can be used as a non-destructive system.

Acoustic communication of Elephants: A case study

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Abstract

Sri Lankan elephants are highly social mammals and are belongs to a subspecies of Asian Elephant. The main mode of elephant communication is using acoustic signals. As they are able to express their complex emotions via this common language that is not much able to do using other senses. This study was carried out to investigate the frequency ranges of elephant acoustic communication using the elephant acoustic communication data collected from a domestic male and female elephant at the Biyagama area, Sri Lanka. During the data collection, different types of elephants' acoustic signals were observed and all of them were recorded using an infrasound microphone B&K type 4193 and analyzed using FFT frequency analysis. According to the study, elephant rumbles consist of strong sound pressure levels in low frequencies in 1 Hz up to about 1 kHz. Both elephant roars and trumpets consist of critical frequencies from lower frequencies up to 500 Hz. Moreover, elephants are capable of communicating using acoustic signals lower than human hearing levels. This research study successfully identifies that elephants are capable of communicating using low-frequency acoustic signals.

Noise level and acoustic analysis of selected children's toys

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Abstract

A study was carried out to determine the existing noise levels in different toys available in the Sri Lankan market. A total of two hundred and five toys belonging to different categories such as tabletop or floor, handheld, squeeze, percussion, wind, rattles, pull along or push, cap firing etc. were selected for this study and evaluated using international references. Noise level descriptors L_{pAeq} , L_{pCpeak} and L_{pAFmax} were recorded during the measurements. Measurement points were selected according to the toy category following a published standard. A total of 1986 measurements were taken and analyzed. The study revealed that 59 (28.8%) toys exceeded two parameters and 35 (17.1%) toys exceeded one parameter of noise level out of 205 toys tested in different categories. Moreover, 94 (45.9%) toys exceeded the prescribed levels in the selected toys. However, cap firing, wind toys and squeeze toys observed higher noise levels compared with international standards. Analysis indicated that peak value (L_{pCpeak}) of cap firing toys exceeded 90% of noise level (129 dB), squeeze toys exceeded 60% of noise level (110 dB) and wind toys exceeded 70% of noise level (110 dB). Similarly, 90% of squeeze toys exceeded equivalent sound pressure level value (L_{pAeq}) of noise level 85 dB and wind toys exceeded 90% of equivalent sound pressure level value (L_{pAeq}) of noise level 85 dB. The 50% exceeded peak values for cap firing, squeeze and wind toys that are respectively 136 dB, 122 dB and 110 dB. The 50% of cap firing and squeeze toys exceeded L_{Aeq} values of 106 dB and 90 dB respectively. The study indicated the necessity for awareness, warning signs and enforcing toy acoustic standards and regulations in Sri Lanka.

Acknowledgement: Financial assistance is given by ITI, Treasury Grant (TG 19/168).

Variation of Particulate Matter (PM): Rehabilitation/improvements to B 157 road, section from Mathugama up to Welipenna interchange

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Abstract

The formation of dust from construction activities and vehicular emissions is a serious issue in road development projects. Particulate Matter (PM), a mixture of solid particles and liquid droplets found in the air affect the environment and health of the human being. Asthma, breathing difficulties, decrease in lung function, non-fatal heart attacks and irregular heartbeat are major health issues that occur when exposed to PM. Decrease in air visibility, deposition of PM in surface water bodies are the major environmental issues created by PM. Therefore, it is essential to measure the levels of PM against the construction activities to safeguard the quality of ambient air. In the present study, levels of PM of aerodynamic diameter equal to or greater than; $10\ \mu\text{m}$ (PM_{10}) and $2.5\ \mu\text{m}$ ($\text{PM}_{2.5}$), two sizes of PM were measured in three locations along the traces of the road project. Samples were collected based on standard guidelines (24 hours' average) using a standard high volume air sampler (EcotechHiVol 3000) with particle size selective heads, and measurements were taken in four faces during the project. Levels of PM_{10} throughout the monitoring period were within Maximum Permissible Levels (MPL) stipulated by Central Environmental Authority ($100\ \mu\text{g}/\text{m}^3$) while the level of $\text{PM}_{2.5}$ was detected slightly higher than MPL ($50\ \mu\text{g}/\text{m}^3$) at some locations (Range: $40\text{--}66\ \mu\text{g}/\text{m}^3$). Even though some fluctuations were observed within the phases of monitoring, average levels of both PM_{10} and $\text{PM}_{2.5}$ were $55.0\pm 10.1\ \mu\text{g}/\text{m}^3$ and $39.3\pm 8.1\ \mu\text{g}/\text{m}^3$ respectively in Phase VI of the monitoring. However, it is slightly lower than that of Phase I of the monitoring showing the improvements in control measures practiced in the final stages of construction. In conclusion, it is important to establish proper control measures to mitigate the levels of PM within the permissible levels or below throughout the construction period.

Evaluation of stakeholder expectations from a call-center operator

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Abstract

The call-center operator is one of the critical characters of an organization. This study was carried out at a leading scientific and testing organization in Sri Lanka that needed to establish an efficient call center targeting the timely delivery of organizational processes. The main objective of the present study is to identify the critical characteristics of the call-center operator expected by the organizational stakeholders. Kano model is used to identify inherent customer's thinking patterns on the product or service characteristics. The question pair is formulated to investigate stakeholders' hidden expectations. Important thirteen characteristics were identified from the opinion pool from the employees of the organization. The Satisfaction Increase Index (SII) and Dissatisfaction Decrease Index (DDI) are calculated using the KANO model calculation method. Effect of the fulfillment of the considered characteristic evaluated through SII and impact on non-fulfillment evaluated by DDI. Highest SII and least DDI are the preferable characteristics. Critical characteristics and DDI values resulted correct information (-0.8958), ethics and etiquette (-0.8542), efficiency on call transfer (-0.8542), quick-response (-0.8333), understanding customer-needs (-0.8298), organizational knowledge (-0.7826), attentiveness (-0.7708) and communication-skills (-0.7500). Stakeholder expectation evaluate according to the SII values and more satisfaction on sweet-voice (0.5208), attentiveness (0.4375), proficiency on many languages (0.3617), ethics and etiquette (0.3750), good public relations (0.375), subject-knowledge (0.3333), quick response (0.2917), focus on duty (0.2708). Considered characteristics other than proficiency of many languages and gentle voice (Attractive category) of the operator were categorized as basic requirements (Must-be category). Therefore, the impact of each characteristic of the call-center operator and train them to enhance organizational stakeholder satisfaction.

Vibration analysis of different locomotive types in Sri Lanka

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Abstract

Train produces a wide range of ground vibrations and air-borne noise while it moves. Therefore, it is a common understanding that any living being should be able to identify those vibrations and noise to make themselves safe. However, the daily increase in mortality rates due to train-elephant collisions shows that this problem needs to be more concerned. The main objective of this study is to find the significant frequency ranges of ground-borne vibrations produced by a moving train in Sri Lanka. A survey was conducted to detect the effective frequency ranges of air-borne noise and ground-borne vibrations of trains to compare with sensitive ranges of animal and human communication. Data were collected from seventy-seven trains observed in the Gampaha, Veyangoda area with the flat ground surface and minimum level of background disturbances. Two instruments produced by Bruel & Kjaer were used for the measurement to detect ground-borne vibration and air-borne noise separately. Among all the trains observed, both locomotive types of engines and power sets were included. Then the data were separately analyzed to have a better understanding of the critical frequency ranges. The results clearly showed the effective frequencies of vibrations and noise produced by trains while they are on the move. Under zero weighted airborne noise detections, the first three highest frequencies produced by each train were considered for the analysis while the train was moving at the speed of 60 km/h. The first highest critical frequency range detected for both locomotive types were from 50 Hz to 100 Hz while 20% of the trains showed 63 Hz as the highest detected air-borne noise frequency. Moreover, 80 Hz was the second-highest frequency detected by 22% of all the trains observed. Moving on to the third-highest frequency, 14% of the rains produced noise of 63 Hz. When considering the ground-borne vibrations, the data were analyzed among all three directions X, Y and Z separately (X- Transverse, Y- Longitudinal, Z- Vertical). The critical range detected along the X direction was 14Hz to 34Hz while 14 Hz to 30 Hz was the range through the Y direction. Along the Z direction, the critical frequency detected was 8 Hz to 22 Hz. The results can be compared with animal and human sensitive frequency ranges to implement solutions for train collisions.

Possibility of multiple machine fault detection using vibration signature and thermal image analysis

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Abstract

In industry, early detection of machine faults is of prime importance as machinery and equipment are costly. A machine fault simulator (MFS) is a representative structure of an industrial machinery setup which could be used to gain an in-depth understanding of machine faults. In the present study, an MFS was designed and constructed and used for the detection of machine faults through the investigation of vibration signatures and thermal image analysis. The MFS consisted of 0.75 kW, 1 hp reconditioned induction motor coupled to a shaft of 3' (~ 0.91 m) in length using a jaw-coupling. A movable 3 different masses of a pulley were placed on the shaft between two UCP 205-16 flange/pillow bearings, namely driven bearing (DB) and non-driven bearing (NDB). Three accelerometer probes mounted on the motor, DB and NDB were used to capture signals in the transverse (X), longitudinal (Y) and vertical (Z) directions. Vibrations signatures were detected using piezoelectric charge accelerometer 4370 (B&K), charge to CCLD converter 2647A (B&K) and analyzed by 4/2-ch. input/output module LAN-XI 3160-A-042 (B&K), and a PULSE Lab Shop software. The observed fast Fourier transform (FFT) spectral patterns did not change significantly with the position of the pulley and did not reflect any significant vibration pattern for different pulleys. However, FFT spectral patterns of the motor dominated in the longitudinal direction and the vibrations at bearings (DB and NDB) were dominated in the vertical direction for a fixed mass of pulley and shaft driven at a fixed speed. Thermal images illustrated that there was a fault in NDB and a misalignment in jaw coupling. The present study demonstrated that detection of multiple machine faults is possible using vibration signature and image analysis.