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September 15th, 2022 THAILAND

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Sustainable Bioresources for Green Energy and Economy

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ASEAN Bioenergy and Bioeconomy Conference

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EDITED BY

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ASEAN BIOENERGY AND BIOECONOMY CONFERENCE 2022: SUSTAINABLE BIORESOURCES FOR GREEN ENERGY AND ECONOMY

September 15th, 2022

Queen Sirikit National Convention Centre (QSNCC), Bangkok, Thailand

Opening Ceremony (Room: MR 109AE, 1st Floor)

Local time in Thailand (24-hour clock time)

Moderator:	Dr. Chayanon Sawatdeenarunat, Chiangmai Rajabhat University
09.00 – 09.30	Registration
09.30 – 09.45	**Report on the opening ceremony** Dr. Pilanee Vaithanomsat, Director of Kasetsart Agricultural and Agro-Industrial Product Improvement Institute (KAPI), Kasetsart University, Thailand
09.45 – 10.00	**Opening ceremony** Assoc. Prof. Dr. Sutkhet Nakasathien, Vice President for Research and Creation, Kasetsart University, Thailand
10.00 – 10.45	**Keynote presentation** **"Thailand's climate change policy and actions on mitigation"** **Ms. Nareerat Panmanee** Director of Climate Change Management and Coordination Division, Office of Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment, Thailand
10.45 – 11.00	Coffee break and *separate to session rooms*

Bioenergy Session (Room: MR 109D, 1st Floor)

Local time in Thailand (24-hour clock time)

Chairman:	Dr. Chayanon Sawatdeenarunat
11.00 – 11.30 [Online]	Invited presentation 1 **"Renewable energy promotion strategy in Lao PDR"** **Mr. Vilaythong Airmixay** Research Institute for Energy and Mines, Ministry of Energy and Mines, Lao PDR
11.30 – 11.50	Oral presentation 1 Tar reduction for producing synthetic gas via 3-stage gasification technology from corn cob **Waranyu Phondet** Expert Center of Innovative Clean Energy and Environment, Thailand Institute of Scientific and Technological Research (TISTR), Thailand
11.50 – 12.10	Oral presentation 2 Blockchain technology for selling Napier grass to biomass power plant **Prasit Jirothkul** School of Engineering, University of the Thai Chamber of Commerce, Thailand
12.10 – 13.30	*Lunch*
13.30 – 14.00 [Online]	Invited presentation 2 **"Carbon neutrality and energy transition"** **Dr. Robert Edyvean** Department of Chemical and Biological Engineering, The University of Sheffield, United Kingdom
14.00 – 14.20	Oral presentation 3 Quality by composition variety of briquette from straw and rice husk in Kuantan Singing Regency **Putra Gunawan** APP Sinarmas Forestry, Indonesia

14.20 – 14.40	Oral presentation 4
[Online]	Effect of environment condition on the biomass production from *Spirulina platensis* in open pond conditions **Obaid Bhat** School of Renewable Energy, Maejo University, Chiang Mai, Thailand
14.40 – 15.20	Coffee break and *Poster session*
15.20 – 15.40	Oral presentation 5
	Scaling up of microbial lipids production from crude glycerol for sustainable biofuel and oleochemical industry **Apichat Boontawan** School of Biotechnology, Institute of Agricultural Technology, Thailand
15.40 – 16.00	Oral presentation 6
[Online]	Mealworm (*Tenebrio molitor*) oil characterization and optimization of biodiesel production via response surface methodology **Shangeetha Ganesan** School of Chemical Sciences, Universiti Sains Malaysia, USM, Penang, Malaysia
16.00 – 16.30	*Announcement of Presentation Awards and Closing Bioenergy Session*

Bioeconomy Session (Room: MR 109H, 1st Floor)

Local time in Thailand (24-hour clock time)

Chairman:	Asst. Prof. Dr. Patthra Pason, King Mongkut's University of Technology Thonburi
11.00 – 11.30	Invited presentation 1
[Online]	**"New approaches for biomass deconstruction and conversion: towards low cost and sustainable production of cellulosic biofuels and biochemicals"** **Dr. Yannick J. Bomble** National Renewable Energy Laboratory, United States

11.30 – 11.50 [Online]	Oral presentation 1 Immobilized glucose isomerase from *Lactobacillus reuteri* for high fructose syrup production **Hary Isnanto** Division of Biochemical Technology, School of Bioresources and Technology, King Mongkut's University of Technology Thonburi, Thailand
11.50 – 12.10	Oral presentation 2 Assessment of fractional factorial design for green block rubber flooring formulation **Nanthiya Hansupalak** Department of Chemical Engineering, Faculty of Engineering, Kasetsart University, Thailand
12.10 – 13.30	*Lunch*
13.30 – 14.00 [Online]	Invited presentation 2 **"How the fundamental research may promote a better transformation and use of biomass in food sectors"** **Dr. Erwann Durand** CIRAD - QualiSud Joint Research Unit, France
14.00 – 14.20	Oral presentation 3 Forecasting sugarcane yield in Kanchanaburi province using seasonal ARIMA-MLR models **Arisara Techabunya** Industrial Toxicology and Risk Assessment, Department of Environmental Science, Faculty of Science, Chulalongkorn University, Thailand

14.20 – 14.40	Oral presentation 4 A forestry-based sustainable model for developing underdeveloped and unpopulated areas: Evidence from Urban Forest Innovation Lab (UFIL) in Cuenca (Spain) **Alberto Alcalde-Calonge** Department of Business Administration, University of Castilla-La Mancha, Cuenca, Spain
14.40 – 15.20	Coffee break and *Poster session*
15.20 – 15.40	Oral presentation 5 Development of antimicrobial packaging-film from jackfruit peel containing bioactive substances and its application **Ronakit Nimitr** Program in Food Science and Technology, School of Food Industry, King Mongkut's Institute of Technology Ladkrabang, Thailand
15.40 – 16.00	Oral presentation 6 Fluorescent films based on carbon quantum dots (CQDs) **Ongart Suntijitrungruang** Department of Physics, Faculty of Science, Kasetsart University, Thailand
16.00 – 16.30	*Announcement of Presentation Awards and Closing Bioeconomy Session*

PREFACE

Dr. Chongrak Wachrinrat
President
Kasetsart University, Thailand

IT IS MY PLEASURE to extend to all of you a warm welcome on behalf of Kasetsart University to the "ASEAN Bioenergy and Bioeconomy Conference 2022". I will start by wishing you and your families good health and safety during these difficult times as the global COVID-19 pandemic continues. The ABB2022 conference will be held in-person at the Queen Sirikit National Convention Centre (QSNCC), Bangkok, Thailand, but the event will adhere to the recommended health guidelines to prevent the spread COVID-19. These preventive measures are intended to ensure the safety and well-being of all attendees. Indeed, some of the oral presentations provided by speakers located abroad or outside the Bangkok Metropolitan Region will be provided on-line.

I wish to extend a special welcome to the distinguished keynote speaker, Miss Nareerat Panmanee, from the Ministry of Natural Resources and Environment, Thailand, and also to our honorable speakers who have been invited to address us during the bioenergy and bioeconomy sessions: Mr. Vilaythong Airmixay, Ministry of Energy and Mines, Lao PDR; Dr. Robert Edyvean, The University of Sheffield, United Kingdom; Dr. Yannick J. Bomble, National Renewable Energy Laboratory, United States; and Dr. Erwann Durand, CIRAD, France. We sincerely thank you for honoring our invitation despite your busy schedules.

We all share the same collaborative commitment to develop Sustainable Biomass programs throughout the ASEAN community. I am confident that this symposium will open more opportunities for researchers, scientists, and technologists to share their expertise, innovation, and research methods.

PREFACE

I would like to express my sincere appreciation to the organizing committee, led by Dr. Pilanee Vaithanomsat, Director of Kasetsart Agricultural and Agro-Industrial Product Improvement Institute (KAPI), for organizing this conference and ensuring the continuity of this event. My gratitude is also given to King Mongkut's University of Technology Thonburi, Chiang Mai Rajaphat University, and Informa Markets (Thailand) Co., Ltd. as well as the other companies, universities, and organizations that cooperated and contributed to this important conference. I am confident that this symposium will achieve its objectives and provide tremendous value to our global society. In closing, I wish you a fruitful discussion and successful symposium.

I am honored to declare this conference officially open.

MS. NAREERAT PANMENEE has graduated in the M.Sc. of Environmental Engineering from Kasetsart University and Sustainability (Ecological Economics) from University of Leeds, UK.

Ms. Nareerat is currently the Director of Climate Change Management and Coordination Division (CCMC) at the Office of Natural Resources and Environmental Policy and Planning (ONEP), Ministry of Natural Resources and Environment (MNRE) of Thailand.

ONEP is the National Focal Point of UNFCCC and mainly responsible for developing and coordinating the implementation of domestic policies, strategies and related instrument/mechanisms to tackle climate change such as Thailand's Long-term strategy (LTS), Nationally Determined Contribution (NDC), National Adaptation Plan (NAP), Guideline and Mechanism for Carbon Credit Management, as well as Thailand Greenhouse Gas Emission Inventories System (TGEIS). Now, ONEP is developing LTS (revision version) for submitting to UNFCCC, and drafting climate change law for supporting the implementation in the near future.

Ms. Nareerat is invited as a speaker from the various agencies to present Thailand's policy and Implementation on climate change. She attended the Bonn Climate Change Conference last June and will participate at COP27 in Egypt this November.

Invited Speaker – 1

BIOGRAPHY

Dr. Vilaythong AIRMIXAY

Research Institute for Energy and Mines,
Ministry of Energy and Mines, Lao PDR
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Mr. Vilaythong AIRMIXAY, Researcher of the Research Institute for Energy and Mines, Ministry of Energy and Mines, Lao PDR and the coordinator of China-Laos Joint Lab for Renewable Energy Utilization project.

He received a Master degree in Agricultural Bio-Environmental and Energy Engineer in Yunnan Normal University, China PR, since 2018. His Master degree study is Solar Energy Utilization, focusing on solar thermal application. The China-Laos Joint Lab project, he involved for installing all equipment on demonstration site of the project.

From 2011-2021, he worked for Renewable Energy and New Materials Institute, Ministry of Science and Technology. His works mainly focused on solar energy fields and Biomass fields for promoting cooking stove efficiency.

In the recent year, he has been working for Research Institute for Energy and Mines, Ministry of Energy and Mines for solar energy utilization in Laos, and cooperation with China PR on China-Laos Joint Lab project to develop and utilize on Renewable Energy in Laos. He is the manager website of Biomass Technology Information and Learning Center (BTILC) of the Project on Reducing Greenhouse Gas Emission in Industrial Sector through Pelletization Technology Lao PDR, gef, UNIDO.

Renewable energy promotion strategy in Lao PDR

Vilaythong Airmixay*

China PRResearch Institute for Energy and Mines, Ministry of Energy and Mines, Lao PDR
*E-mail: vilaythongair@gmail.com

ABSTRACT

This strategy aims to develop new renewable energy resources which are not yet widely explored in Lao PDR to replace resources that will be exhausted in the future, also known as “non-renewable energy” (fossil fuels, coal, natural gas etc). These renewable energy resources comprise biomass energy (biofuels, biogas…); solar energy; wind; small hydropower.

Energy is essential for meeting the peoples’ basic needs as well as vital in fuelling economic development. The increase in population and economic growth has resulted in increase of energy consumption. Reserves of non-renewable energy, being the dominant traded energy commodity, are declining. In particular, liquid fossil fuels are estimated to be depleted within the next few decades. Many countries in the world have recognized the importance of renewable energies, and therefore have undertaken technology research and development, and have set up goals for the development and effective use of their Renewable energy resources.

Bio-energy provides an alternative fuel supply for the transportation sector and in the supply of energy to rural communities. Without domestic oil and gas resources, Lao PDR is completely dependent from external sources for its petroleum fuel requirements. The country imported 560 million liters of fossil fuels in 2010, a significant increase 5 percent a year. With higher economic growth prospects, oil imports are expected to high. This increases the country’s vulnerability to external supply disruptions and fuel price volatility, and the negative impacts to the country’s balance of payments. To reduce the importation of fossil fuels and optimize the use of marginal lands, the Government will encourage and actively promote development of fuel crops in the country with a preference for smallholder production under maintained community land ownership and control.

References

Renewable Energy Development Strategy in Lao PDR, 2011

Renewable Energy Promotion Strategy in Lao PDR, 2021

Keywords: Potential of RE, RE Development, Strategy and Policy

INVITED SPEAKER -2

BIOGRAPHY

Dr. Robert EDYVEAN

Department of Chemical and Biological Engineering,
The University of Sheffield, United Kingdom
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Dr. Robert has a B.Sc. from the University of Wales, UK, a M.Sc. from the University of Portsmouth and Ph.D. from the University of Newcastle upon Tyne, UK. Robert's MSc included a study of biogas production from seaweed waste and he has been involved in the study of energy related issues for over 40 years.

Following a Ph.D. related to the offshore oil industry, Robert helds the Royal Society Sorby Research Fellowship at the University of Sheffield, UK and was then Lecturer/Senior Lecturer in the Department of Chemical Engineering, University of Leeds, UK. His researches have included alternative energy sources, particularly biological systems (methane and hydrogen production). He returned to The University of Sheffield as Reader and Deputy Head of the Department of Chemical and Biological Engineering continuing a range of energy related studies. He is now a consultant and Honorary member of that Department.

Carbon neutrality and energy transition

Robert Edyvean,[a] Supatchalee Sophonthammaphat [a,b]*

[a]Department of Chemical and Biological Engineering, The University of Sheffield, UK.
[b]Department of Alternative Energy Development and Efficiency, Ministry of Energy, Thailand
*E-mail: supatchalee88888@gmail.com

ABSTRACT

Background:

Currently, the human race is facing huge global challenges. Countries are beginning to realise that they must take measures to tackle Global warming and the anthrophomorphic release of carbon dioxide and other "greenhouse gasses". At COP26 in November 2021 (Glasgow, UK) the international forum agreed to reduce the amount of GHGs and CO_2 released by reducing fossil fuel use. This agreement has been incorporated into the internal policies, planning and legislation of many, but not all, countries and the level of actual commitment to meet or even go beyond the goals set is highly variable. Given the effects of the covid-19 pandemic and its ramifications to the global economy, such variability of pace and level of commitment is understandable especially given the short term nature of the priorities of most governments. However, as with many difficult issues, the problems only increase if left and the effects, and costs of solutions, grow hugely with time. Not only is it a challenging time to champion the concept of carbon neutrality and how it relates to an individual or country but it is also a difficult time to take on the cost burden that the concept demands. However, there are positives, for example, a global increase in energy prices enables alternative, carbon neutral, sources to be more competitive. This study investigates how the concept of carbon neutrality is affecting energy transition both now and in the future.

Purpose:

The study investigates how the concept of carbon neutrality is affecting energy transition, both now and in the future. The goals, and the plans to meet those goals, may help to grow economic development in new ways after covid declines. In addition, the study highlights some effects which may come from the energy mix.

Methodology:

Data was gathered by literature review on the concept of carbon neutral policy and planning and on energy transition to help meet these goals in the EU, the UK, the US, China

and Thailand. How countries set the targets to reduce CO_2 and how they plan to use the energy mix towards meeting those targets is investigated. The data was compared and analysed via SWOT and Gap analysis.

Results:

The study found that the countries considered have the policy and planning to implement net zero emission in 2050. There is a willingness to reduce GHG and CO_2 emissions. However, opportunities to develop projects by providing financial support and legislation are often missed, impeding progress. In addition, the current financial and energy problems can cause clashes between the policy and the practicalities on the ground.

Analysis found a need for both in-country and international multi-agency co-operation to improve; 1) Policy and planning; CO_2 reduction should be countable and tracked to internationally agreed standards when running projects. Governments should regularly publish CO_2 reductions for various industries against goals; 2) Budget and timelines being appropriately linked to goals; 3) Standardization of carbon footprint and LCA analysis to enable international comparisons; 4) Training and skills to provide suitable expertise in the workforce to fill employment opportunities; 5) Standards and guidelines for Industry; 6) Government backed R&D and financial support for both innovation and roll-out of the best technology; 7) Information to stakeholders/customers to enable everyone to understand de-carbonisation and energy transition concepts and the need for them; and more internationally; 8) Support for the more vulnerable (and usually smaller, poorer and less polluting) countries in a time of international financial and resource upheaval.

Conclusions:

The study found that countries have an expressed willingness to reduce CO_2 emissions to meet “net zero in 2050”, for example, by replacing fossil fuel, using renewable energy and being more energy efficient. The policies and planning take into account the importance of various developments. However, we should be concerned on two levels: firstly the potential abandonment or delay in meeting goals and commitments due to global financial constraints, energy costs and food concerns and secondly the problems in “joining-up” thinking on energy needs into the future which has to link security, economy, society, human resources (employment), and the environment.

It is a challenging time to develop a country CO_2 reduction planning goals. Fossil fuel use should be phased out in industry as much as possible. In addition, various renewable

energy mixes should be developed for electricity supply, for energy in buildings, road and rail transport etc. Green concepts, such as renewable energy, energy efficiency, the Green Economy, BCG (Bio Circular Green Economy) models can be used to meet goals and to enhance economic and employment.

External factors such as covid-19, war and subsequent energy and food price rises should not be allowed to delay or sideline commitments to achieving net zero emissions. Indeed there may be silver linings, for example, higher energy prices mean that alternative energy is more financially competitive. However, countries should help each other to develop together.

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Keywords: Carbon neutrality, Decarbonisation, Energy transition, Net Zero Emission

INVITED SPEAKER -3

BIOGRAPHY

Dr. Yannick J. BOMBLE

Biosciences Center, Research Group Leader - Molecular Biology and Biophysics,
National Renewable Energy Laboratory (NREL), Golden, CO, U.S.A
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Yannick J. Bomble is a Research Group Leader in biophysics and Distinguished Research Scientist at the National Renewable Energy Laboratory in Golden, Colorado. His team is multidisciplinary and has broad research interests including 1) The Study of biomass deconstruction mechanisms in the biosphere, 2) Metabolic pathway and enzyme engineering to improve the production of biofuels and bioproducts, 3) Biochemical/structural characterization and rational engineering of plant biosynthetic enzymes to enhance plant cell wall structure, growth properties, and reduce recalcitrance, 4) Development of ML/AI approaches to predict protein function, structure, and promiscuities to improve activity and expand substrate specificity, 5) Development of new approaches to enable the cost competitive use of cell free biocatalysis as an alternative to conventional microbial fermentations. He received his Ph.D. in Chemical Physics from the University of Texas at Austin (2006) and conducted his postdoctoral work in Computational Biology at the Scripps Research Institute in La Jolla, California (2007). Prior to, this he obtained a B.S. in Physics and Chemistry from the Universite de Lille (France) (2001) after two years of Mathématiques Superieures and Mathématiques Speciales at the Lycée Faidherbe in Lille (France).

New approaches for biomass deconstruction and conversion: Towards low cost and sustainable production of cellulosic biofuels and biochemicals

Yannick J. Bomble*

Biosciences Center, Research Group Leader – Molecular Biology and Biophysics, National Renewable Energy Laboratory (NREL), Golden, CO, U.S.A

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ABSTRACT

Microorganisms have evolved different and yet complementary mechanisms to deconstruct and utilize biomass in the biosphere. We focus on understanding and leveraging these different approaches to engineer robust microbes for the deconstruction and conversion of biomass to value added products. Beyond exploring natural design principles, we also put a lot of emphasis on rational enzyme design to improve biomass degrading and plant biosynthetic enzymes to develop more sustainable and carbon efficient processes. Also, more recently, we have started developing new approaches for the conversion of cellulosic sugars and waste streams using cell free biocatalysis. In these approaches, enzyme cascades are used instead of microbial biocatalysts therefore circumventing many of the impediments encountered in traditional fermentation processes.

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Keywords: Biomass, Cell free biocatalysis, Cellulosic, Enzyme design, Value added products

INVITED SPEAKER -4

BIOGRAPHY

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Dr. Erwann DURAND from CIRAD (UMR QualiSud) received a multidisciplinary formation in organic and analytical chemistry. His expertise and research interests are focused on the study of microstructures in order to figure out how they may affect the molecular reactivity, e.g. understanding the molecular mechanisms affecting lipid oxidation (and antioxidant) phenomena in complex microstructure is fundamental in food sciences (quality, nutrition, safety, etc.). In this context, he went to implement new antioxidant strategies for preserving oxidation of lipid-based formulation products. In addition, he is doing research activities in the context of green chemistry, with the willingness to design less harmful processes using mild conditions and renewable resources, they mainly encompass the extraction of bioactive molecules (phenolic compounds, lipids, proteins, etc.) from biomass, along with their purification, (bio) transformation and characterization. In this context, he went to investigate for many years the Natural Deep Eutectic Solvents in different research areas (extraction, biocatalysis, formulation, etc.).

He has co-supervised 3 Post-doc, 10 Ph.D. and more than 20 B.Sc. or M.Sc. international students (for 2 to 6 months) either in France, in USA, or in Thailand. The past and on-going grants were funded either by French and international industrial partners, or supported through international programs.

He has authored 55 publications (published or accepted) in peer-reviewed scientific journals. In addition, he has authored 3 book chapters, and gave 11 oral communications at international conferences. He was also associated author in 28 posters/orals communications. Finally, he has an H-index of 17 and, combined together, his articles have been cited almost 1,600 times (source: Scopus).

How the fundamental research may promote a better transformation and use of biomass in food sector

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ABSTRACT

Background:

The oxidation of formulated products, especially when enriched in lipids, is a complex phenomenon that affects the overall quality of manufactured food, cosmetic and pharmaceutical products. Avoiding lipid oxidation is therefore crucial, especially as manufacturers are incorporating higher amounts of unsaturated lipids into their products for health reasons, thereby making them more sensitive to oxidative degradation. Even though the efficiency of synthetic antioxidants has been recognized, both consumers and manufacturers are looking for more innovative, healthy and quality products while rejecting synthetic additives due to their concern about safety, along with their environmental impact issues.

Hypothesis/Purpose:

To solve this issue, and to propose efficient, long-term economic and environmental solutions, both the fundamental research to better understand the lipid oxidation mechanisms and the plant biomass, which have shown to be rich in compounds and have raised interest for the isolation of novel naturally occurring antioxidants, are essential.

Results and conclusion:

A review of the different works that have been conducted by our team will be presented, with the aim at highlighting how:

- The fundamental research is essential to better understand the chemistry behind the oxidation of formulated products that are enriched in lipids.
- The plant biomass may be the source of novel naturally occurring antioxidants, which could be used to substitute the synthetic ones.
- An approach using the concept of bio mimicry with NaDES could respond to the challenges of sustainable transformation and recovery of biomass and open up great eco-innovative opportunities.

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Keywords: Biomass, Food, Lipid oxidation, NaDES, Sustainability

ORAL PRESENTATION

'BIOENERGY'

EN-R001

Tar reduction for producing synthetic gas via 3-stage gasification technology from corn cob

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Abstract

Since the demand of energy consumption from renewable resources has been increasing, renewable energy from biomass becomes a primary alternative to generate an electrical energy for purposes of energy resilience and environment aspects. Gasification technology is thermochemical reaction to produce syngas as fuel for generator with high efficiency and low emissions. However, tar content from gasification process is mainly issue that can contaminate in product gas and effect to generator engine. High amount of tar causes cloggage and blockage in engine and pipeline. In this research, the 3-stage gasification in pilot-scale was used to produce syngas by using a corn cob as raw material that is one of the potential agricultural wastes in Thailand. The 3-stage gasification consists of three main parts which are pyrolysis, oxidation, and reduction zone with clearly separated in each zone. Operating condition performed without addition of any catalyst. The experiment was conducted for a corn cob feed rate average at 150 kg/h and equivalent ratio average at 0.39 by using air as a gasifying agent. The average of air flow rate was 242.33 m^3/h and injected into both pyrolysis and combustion zones. Temperature of pyrolysis, oxidation and reduction were 501.80, 862.14, and 685.04 ^oC, respectively. Higher temperature in oxidation zone causes a result of thermal cracking of tar. The gas composition of syngas was observed, and syngas flow rate was 422.75 Nm^3/h The cold gas efficiency and the high heating value equal to 62.75% and 3.74 MJ/Nm^3, respectively. Tar content was 0.4125 g/Nm^3 that was lower than one-half to one-fifth comparing to other gasifier types. The char properties were also compared with the raw material. The 3-stage gasification reactor has highly performance to produce syngas with low quantity of tar. Therefore, the 3-stage gasifier type has the possibility to upscale into commercial level for electricity producing from potential biomass.

Keywords: Corn cob, Gasification, 3-stage gasification, Tar

EN-R002

Blockchain technology for selling Napier grass to biomass power plant

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Abstract

This research aims to apply blockchain technology for selling Napier grass to biomass power plant based on software development life cycle that begin with problem definition, feasibility study, system analysis and design, validation, and evaluation. To explore the purchasing system of Napier grass from farmers to biomass power plant and develop a smart contract system to facilitate the business activities among those parties on planting, harvesting, and selling Napier grass using blockchain technology. The smart contract was written in Hardhat, Node.Js and Solidity programming and utilize Oracle blockchain to communicate with databases in other systems. The results can demonstrate that the community enterprise acts as a mediator in providing Napier grass sapling for farmers to grow, buying the grown grass from farmers and then selling to the Biomass Power Plant. The automatic payment system bases on smart contract under blockchain when predetermined conditions are met using the USDT stable coin as means of payment among entities and the ERC20 as gas fee with 100% accuracy. It can be concluded that the smart contract is a successful proof of concept which could be further developed to facilitate the business activities among Biomass power plants, community enterprises and farmers who grows Napier grass or other kind of plants. The further studies on the Napier grass moisture should be done to set the standard prices which are recognized among Biomass power plants, community enterprises and famers in each province.

Keywords: Biomass power plant, Blockchain, Community enterprise, Napier grass, Smart contract

EN-R003

Quality by composition variety of briquette from straw and rice husk in Kuantan Singing Regency

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Abstract

Kuantan Singingi Regency is a supplier of 20% of rice in Riau province. However, the waste produced has not been utilized because people still use fossil fuels. To increase the usability of one of the untapped and renewable biomass sources, a research on the manufacture of briquettes was carried out. The research used Completely Randomized Design with five treatments and three replications. The treatments were ratio of rice straw and rice husk 90:10, 75:25, 50:50, 25:75, and 10:90. Data obtained were analyzed using Analysis of Variance and followed by Duncan's Multiple Range Test at 5% level. Straw and rice husks made into charcoal flour with a particle size of 40 mesh and added with 10%. Variations in the composition of straw and rice husks in the manufacture of biochar briquettes have a significant effect on water content, ash content, compressive strength, density, calorific value, combustion power, and volatile matter content. The best treatment based on the parameters tested was biochar briquettes from the treatment of straw charcoal and rice husk charcoal 10:90 which had a moisture content of 9.4543%, ash content 30.2718%, density 1.0110 g/cm^3, compressive strength 0.0120 kg /cm^2, the calorific value is 3794.3530 cal/g, the combustion power is 0.0081 g/second, and the volatile matter is 0.0198%. It is necessary to do further research on variations in the composition of other biomass and methods of manufacture in order to produce briquettes that meet the quality standard of SNI 01-6235-2000.

Keywords: Briquette, Indonesian National Quality Standard, Rice husk, Rice straw

EN-R004

Effect of environment condition on the biomass production from *Spirulina Platensis* in open pond conditions

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Abstract

Spirulina platensis has been developed as one of the most important feedstocks. They are quickly growing biomass that can be converted into various useful products like feed for animals and biofuel. The effect of various environmental conditions like temperature, light intensity, and pH on the biomass production of *S. platensis* species has been investigated extensively in this study. The experiment was conducted in open pond environmental conditions. Light intensity and temperature have a direct effect on the growth of microalgae. The optical density of *S. platensis* increases with light intensity and temperature. The optimum light illumination for better growth was between 800 – 1200 lux. It was found that 30°C to 32°C temperature produces the highest growth value during the growth phase of *S. platensis*. The maximum dry cell weight (DWC) was 0.545 g/L. The optimal pH level for the growth of *S. platensis* in open environmental conditions ranges between 8.5 to 9.5 pH. Optical density values increased with an increase in pH; with a further increase in pH above the 9.5 value, there was a decrease in the optical density (OD). These results can be used to cultivate *S. platensis* in full-scale applications, like an open raceway.

Keywords: Biomass, Light intensity, Microalgae, *Spirulina platensis*

EN-R005

Scaling up of microbial lipids production from crude glycerol for sustainable biofuel and oleochemical industry

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Abstract

A production of biolipids from an oleaginous yeast *Rhodotolula paludigena* CM33 was investigated using industrial crude glycerol as the main substrate. Chemical characterization showed that it composed of 58.5 % glycerol in addition to other impurities. To enhance the lipid yield, molasses concentration, glycerol concentration, and ammonium sulfate (AS) were chosen as independent variables using response surface methodology. For scaling up in a 50-L bioreactor, fed-batch fermentation was the most effective strategy in comparison to batch, batch, and repeated-batch modes. The highest lipid and biomass concentrations of 10.6 g/L and 32.7 g/L were obtained within 7 days. This approach could contribute to a sustainable production of biodiesel and oleochemical feedstock from agro-industrial waste.

Keywords: Biofuel, Biolipids, Crude glycerol, Fed-batch, Oleaginous yeast

EN-R006

Mealworm (*Tenebrio molitor)* oil characterization and optimization of biodiesel production via response surface methodology

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Abstract

The thriving global energy demand has driven the need for potential alternatives to replace the commercially available oil resources. One of the alternatives being is the insects, which known to have high-fat content depending on their behavior, feeding patterns and worldwide availability. This study strives to discover the potential of mealworm (*Tenebrio molitor*) to be a stand-in bioenergy resources and converting it into biodiesel by optimizing the process using response surface methodology (RSM). Mealworm has a high oil content of 37.54 ± 0.78% with a high free fatty acid (FFA) content of 10.84 ± 0.005%. The primary fatty acids of mealworm oil were oleic acid (35.26%), linoleic acid (31.15%), and palmitic acid (17.25%). The pyrolysis of mealworm oil was done from room temperature to 750 ^{0}C at a heating rate of 10 ^{0}C per min under a nitrogen gas atmosphere and it decomposed almost completely after 470°C. An acid-catalyzed esterification pretreatment was conducted to reduce the high level of FFA content to a range below 1% using the optimum parameter of 5.8% w/w sulfuric acid as catalyst, 24:1 methanol to oil ratio, 174 min reaction time at 74°C to be favorable for alkali-catalyzed transesterification to take place and convert the triglycerides in the oil into biodiesel. The pre-treated oil is then converted to FAME at the yield of 96.98% at optimized reaction conditions (catalyst concentration 3%, methanol to oil ratio 16.3:1, reaction time 120 minutes and reaction temperature 65°C) and the properties were found to meet the ASTM D6751 standards.

Keywords: Esterification, Fatty acid composition, Free fatty acid, Mealworm, Physicochemical properties, Response surface methodology (RSM)

ORAL PRESENTATION

'BIOECONOMY'

EC-R001

Immobilized glucose isomerase from *Lactobacillus reuteri* for high fructose syrup production

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Abstract

Importance of the work: Immobilized glucose isomerase (GI) from *Lactobacillus reuteri* using calcium alginate is novel and favorable for High fructose syrup (HFS) production.

Objectives: To optimize the recombinant GI production and investing the properties and reusability of calcium alginate-immobilized GI for HFS production.

Materials and Methods: The GI gene of *L. reuteri* was cloned and expressed in *Escherichia coli* BL21 by induction with 0.1 mM of IPTG at 16 ^{0}C. The purified GI was immobilized with calcium alginate to form beads. The enzyme assay and isomerization product were determined by HCl-resorcinol.

Results: The result shows that the immobilized enzyme can maintain its activity in acidic and alkaline conditions compared to the free enzyme. The higher relative activity of the immobilized enzyme at a broad pH of 5.0-10.0 indicates it is more resistant to pH changes. The immobilized enzyme's optimum temperature of 55 ^{0}C suppress the formation of hydroxymethyl furfural during HFS production. In addition, the immobilized enzyme can be recycled four times.

Main Finding: Immobilization recombinant GI from *L. reuteri* using calcium alginate is the novel research. This research represents an economical approach to HFS production due to its improved properties of enzyme and increase in re-use.

Keywords: Glucose isomerase, HFS, Immobilized enzyme, *Lactobacillus reuteri*

EC-R002

Assessment of fractional factorial design for green block rubber flooring formulation

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Abstract

The substitution of synthetic rubber in block rubber floorings with natural rubber (NR) is necessary for making the product greener, complying with the Thailand's BCG economy model. This paper demonstrated the use of fractional factorial design to screen factors that affected tensile strength and hardness of block rubber floorings. The factors of interest were amounts of NR, ethylene propylene diene (EPDM) rubber, butadiene rubber (BR), and styrene butadiene rubber (SBR). These polymers were well mixed with other compounding ingredients including sulfur using a two-roll mill, prior to molding. Due to limited budget, the fractional factorial design with resolution IV gave eight experiments. The ANOVA results showed that SBR and BR significantly affected hardness (Shore A), while NR and EPDM influenced the tensile strength at a 95% confidence level. In addition, 7 of 8 runs produced compounded rubbers having hardness and tensile strength values surpassing the standard values (TIS 2378-2559). These formulations could be used to develop a mathematical model for optimization purposes in the future.

Keywords: Block rubber flooring, Fractional factorial design, Natural rubber, Rubber formulation, TIS 2378-2559

EC-R003

Forecasting sugarcane yield in Kanchanaburi province using seasonal ARIMA-MLR models

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Abstract

Sugarcane, one of Thailand's most important commercial crops, is used as a raw material in sugar production. Reliable forecasting of sugarcane yield can provide insightful information not only from an industrial perspective but also from an environmental perspective. The aim of this study was to forecast sugarcane yield in Kanchanaburi province, Thailand, from 2020–2025. Three steps were required to achieve the study goal: i) investigate the significant explanatory factors impacting sugarcane yield, ii) predict future values of significant regressors obtained from the previous step, and iii) forecast sugarcane yield. Monthly data on plantation area, climatic variables, and sugarcane price based on crop year between 2010/11 and 2019/20 were collected. Stepwise multiple linear regression (MLR) and autoregressive integrated moving average (ARIMA) were employed. The results revealed that relative humidity, maximum temperature, and Oceanic Niño Index were significant variables influencing sugarcane yield in Kanchanaburi province ($p<0.01$). The seasonal ARIMA (1,0,0) (2,1,1), (2,0,0) (2,1,1), and (2,0,0) (2,1,0) models were selected for prediction of relative humidity, maximum temperature, and ONI, respectively, based on root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), and adjusted R^2. The models were validated by comparing them with actual values. The forecasting models indicated that annual sugarcane yields during crop years 2020/21 to 2024/25 fluctuated from 9,423,369 tons to 9,959,199 tons, according to climatic variability.

Keywords: ARIMA, Forecast, Multiple linear regression, Sugarcane yield

EC-R004

A forestry-based sustainable model for developing underdeveloped and unpopulated areas: Evidence from Urban Forest Innovation Lab (UFIL) in Cuenca (Spain)

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Abstract

In line with the wide attention given to depopulation and care for the environment in the 2030 Agenda for Sustainable Development, the European Union is increasingly focusing on how to develop sustainable models that help combat the structural problem of depopulation in certain European regions. While some initiatives and models have been proposed, there is still not enough knowledge on effective institutional models that develop economically and socially depressed areas from a sustainable point of view. This paper aims to fill this void and describes a model, the “Urban Forest Innovation Lab" (UFIL) project, which is being developed in the municipality of Cuenca and its forest (Spain). Nurturing from the circular bioeconomy perspective, UFIL uses training and other mechanisms to promote entrepreneurship in the forest bioeconomy field to develop the forest of the municipality of Cuenca from a sustainable perspective. This paper will deepen into and will analyse this project from the theory of entrepreneurship and sustainable entrepreneurship to identify their strengths, weaknesses, opportunities, and threats (SWOT) and to evaluate the results achieved so far in terms of employment generation and starts-up creation.

Keywords: Business model, Entrepreneurship, Environment, Forestry Resources, Sustainability

EC-R005

Development of antimicrobial packaging-film from jackfruit peel containing bioactive substances and its application

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Abstract

This study aimed to develop a biofilm that incorporated jackfruit peel and polyvinyl alcohol (PVA) as a crosslinking agent. Biofilm made with the homogenized jackfruit power (JK powder) had a smoother surface compared to non-homogenized JK powder. The color values of biofilm from jackfruit powder were examined with a colorimeter and found that the film brightness was 81.89 – 85.59. In this study, suitable concentration of clove essential oil added into biofilm to provide antimicrobial activity was determined. Antimicrobial activity of the biofilm was tested against bacterial strains including *Bacillus subtilis, Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Salmonella enterica* by zone of inhibition assay. Biofilm containing clove essential oil exhibited antimicrobial activity against *B. subtilis.* The potential of biofilm JK powder incorporated PVA and clove essential oil to preserve food was investigated via total viable count (TVC) assay. Biofilm JK powder incorporated PVA led to effective preservation of food samples compared to PVA film considering microbial growth. The addition of clove essential oil into the biofilm inhibited microbial growth on food sample compared to biofilm alone. Based on these results, the biofilm JK powder incorporated PVA had high potential for utilize as biodegradable food packaging to control food quality and extent shelf life. Moreover, it is good for further develop as a bioactive food packaging.

Keywords: Antimicrobial substance, Bioactive film, Clove essential oil, Food packaging film, Jackfruit waste

EC-R006

Fluorescent films based on carbon quantum dots (CQDs)

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Abstract

Development of efficient, inexpensive, and environmentally friendly light have been fascinating due to diverse applications in the lighting industry, photonics, solar energy, and others. Carbon quantum dots (CQDs) have presently attracted engineers and researchers owing to their unique optical properties and wide ranges of applications. In this work, we report the synthesis of CQDs and fabrication of fluorescent film, by the technique called hydrothermal in specific conditions. We synthesized CQDs with different chromatic blue (bCQDs), green (gCQDs) and red (rCQDs) emissions through facilely changing the reaction solvent during the hydrothermal process. We employ Polyvinyl alcohol (PVA) as a transparent plastic matrix for dispersing synthesized CQDs. Finally, we show the physicochemical properties of our synthesized CQDs that are morphology, chemical and optical by transmission electron microscope (TEM), X-ray photoelectron spectroscopy (XPS), and UV–Vis spectrophotometer respectively. Photophysical characterization of the as-prepared CQDs particles showed the average diameter of the 5-7 nm (upon excitation with 365 nm light, the strong emission at 400-700 nm when increased as the concentration of CQDs in the PVA matrix). These favorable properties confirm the promising potential of bgrCQD incorporated PVA matrix (bgrCQDs@PVA) that can be considered for a useful application as a light conversion film.

Keywords: Carbon quantum dots, Fluorescent films, Hydrothermal, Polyvinyl alcohol

POSTER PRESENTATION

EN-P001

Increased $PM_{2.5}$ -ophthalmic disease risk in biomass burning dominant areas of the upper northern Thailand

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Abstract

Ambient air $PM_{2.5}$ is a major global health hazard. In the upper northern Thailand where biomass burning of forest fire is dominnant, during hot and drought seasons. $PM_{2.5}$ and eye adverse effects are one of the most obvious complaints especially when $PM_{2.5}$ is acute. However, population epidemiological studies of the acute association between $PM_{2.5}$ and the eye and adnexa diseases have been very lacking to confirm wheter the association exits. This work aimed to investigage the association by analyizing inpatient cases (n = 192,545) in 118 hospitals across 9 upper north provinces of Thailand, 2016 to 2020. Fifteen $PM_{2.5}$ monitoring stations were acquired for air pollutants and meteorological indicators. Their hourly measurements were aggregated to daily average lagged days 0 – 7. A time-stratified case-crossover design controlling for the day of the week and season trend and multivariate conditional logistics regression adjusted for PM_{10}, O_3, temperature, and relative humidity were performed by the R® software. Results showed significant correlation coefficients of $PM_{2.5}$ and others of PM_{10}, O_3, and relative humidity. Adjusted odds ratios and their confidence intervals (ORs and CIs) disclosed statistically significant risk for the increase in $PM_{2.5}$ level per interquartile range rising of 26 $\mu g/m^3$. This increase in $PM_{2.5}$ was found significantly associated with the increment of the eye and adnexa inpatient admissions (1.04, CI: 1.02 - 1.07, $p < 0.001$, lag 6). The association was riskiest in the hot (1.23, CI: 1.17 - 1.29, $p < 0.001$, lag 6) following by the wet raining season (1.10, CI: 1.08 - 1.12, $p < 0.001$, lag 0) and no positive association observed in the cold season. For subgroups, risks were slightly higher in males than females and also in younger cases (≤65 y) than older cases (>65y). This stratified risk result is a need indication for $PM_{2.5}$ abatement strategy development for the season and the identified sensitive population.

Keywords: Biomass burning, Eye and adnexa diseases, Forest fire, $PM_{2.5}$

EN-P002

Associated risk of biomass burning $PM_{2.5}$ during forest fire period and respiratory morbidity in the upper northern Thailand

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Abstract

$PM_{2.5}$ from traffic and industry is well known to develop respiratory diseases but $PM_{2.5}$ risk characterization from biomass forest burning expousre is still limited and questionable, especially during a hazard fire period. This research investigated an acute association between $PM_{2.5}$ and respiratory disease hospital admission, covering 816,139 respiratory inpatients from 118 hospitals in 9 provinces from 2016 to 2020. $PM_{2.5}$, co-pollutants and meteorological data were obtained from 15 monitoring stations. A time-stratified case-crossover design was used to control personal and time-dependent confounders by matching and conditional logistic regression was used to control other pollutants and meteorological confounders. Results showed $PM_{2.5}$ very well correlated with PM_{10} likely from same sources of traffic and forest fire and ozone also well correlated with $PM_{2.5}$ as its precursors possibly originated from traffic sources. The inter quartile range of $PM_{2.5}$ was 25.87 $\mu g/m^3$ with a max of daily mean of 398.13 $\mu g/m^3$, a max of daily PM_{10} mean of 438.88 $\mu g/m^3$ and a max of 8-hour ozone of 128.50 ppb, all far exceeding their standards. $PM_{2.5}$ was found associated with the increases of respiratory hospital admisson during the hazard fire period at an lagged expousre day 1 or lag1 (odd ratio (OR) = 1.058, confident interval (CI): 1.041 to 1.075, $p < 0.001$), for male at lag2 (OR = 1.057, CI: 1.035 to 1.079, $p < 0.001$) and for female at lag1 (OR = 1.082, CI: 1.055 to 1.108, $p < 0.001$). Significant risks regarding age groups were found in elderly ≥ 60 yr at lag1 (OR = 1.070, CI: 1.047 to 1.093, $p < 0.001$) and in children ≤ 6 yr at lag7 (OR = 1.055, CI: 1.018 to 1.093, $p < 0.01$). These statistically significant risks were only detected during the forest fire hazard period and can not be noticed in full 5-year period. As new findings, these increased risks specific for different pouplation have been confirmed during the forest fire hazard period. The findings suggested that before the fire period, both central and local authorities need extra certain $PM_{2.5}$ fire abatements of more efficient precaution of respiratory protection and greater local hospital preparation.

Keywords: Biomass burning, Forest fire, $PM_{2.5,}$ Respiratory diseases

EN-P003

Preparation of nitrogen-doped carbons from teak sawdust for low-cost cathode catalysts in fuel cells

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Abstract

A fuel cell is a promising energy conversion device in the future due to its clean energy, high power density, and zero CO_2 emission. However, the wide commercialization of fuel cells is hindered by the high cost and scarcity of Pt-based catalysts for oxygen reduction reaction (ORR) at the cathode. Therefore, the development of a low-cost ORR catalyst to replace Pt has attracted a lot of interest and remains challenging. In this work, nitrogen-doped carbons (NCs) were prepared from teak sawdust (a waste product of woodworking industries), and its potential ability for use as an ORR catalyst was studied. The sawdust was first cleaned and then pyrolyzed at 900 ºC to obtain carbon products. Subsequently, they were mixed with urea (CH_4N_2O) at different ratios and then pyrolyzed at 700, 800, and 900 ºC for nitrogen doping. From the characterization results, NCs derived sawdust exhibited an amorphous structure with the almost absence of functional groups. The ORR activity of NCs was evaluated by cyclic voltammetry (CV) and linear sweep voltammetry (LSV) using a three-electrode system in 0.1 M potassium hydroxide (KOH) solution under N_2 and O_2 saturation. The cathodic peak corresponding to ORR was observed for all samples in the O_2-saturated solution. The NCs revealed a significantly positive shift of the ORR onset potential concomitant with an increase in the current density, as compared to undoped carbon. The NC pyrolyzed at 800 ºC showed the best ORR activity since it yielded the highest surface area with the predominance of pyridinic-N and graphitic-N. Although the ORR activity of NCs obtained in this work was still inferior to commercial Pt/C, it had better durability under long-term operation and stronger methanol resistance than Pt/C. NCs derived from sawdust show good potential for further developing as an alternative low-cost ORR catalyst in the fuel cell.

Keywords: Electrocatalysts, Fuel cells, Nitrogen-doped carbons, Oxygen reduction reaction, Sawdust

EC-P001

Analysis of truck and bus bias-tire business: BCG matrix

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Abstract

Over the past 10 years, the bus and truck tire market between bias tires and radial tires has been fiercely competitive. Although there were still some domestic demands for bias tires at present, the entrepreneurs were concerned about the decline of bias tire demand. This current work aimed to analyze truck and bus bias-tire business using the BCG Matrix in hope of answering the questions raised by the entrepreneurs. The primary data gathered from stakeholders' interviews in 2020 showed that the trend of this truck and bus bias-tire business had been decreasing since 2010. Hence, this product was clearly in the Dogs zone in the BCG matrix. Therefore, two theoretical suggestions for the stakeholders to choose from would be as follows. Firstly, the company could choose to continue the business but needed to reduce both the production volume and the cost of goods in order to increase the relative market share and the cash flow, and importantly should stop investing in this bias-tire business. Meanwhile new markets that were still in need for bias tires should be looked for, such as markets in underdeveloped countries where most of the roads in the countries have rough surfaces. Lastly, the company could discontinue production and sell assets to invest in other products with higher market potential.

Keywords: BCG matrix, Bias tire, Bus tire, Natural rubber, Truck tire

EC-P002

Analysis of truck and bus bias-tire business: Cost estimation

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Abstract

The current situation of the bias-tire industry for buses and trucks is considered a crossroad for some of Thai entrepreneurs who might not know whether to continue or stop the production. This current work aimed to estimate the average cost of a bias tire for trucks and buses by taking into account the uncertainties of raw material costs using the Monte-Carlo simulation. The information obtained directly from this work was intended to help answer the entrepreneurs' questions. Based on a general formulation for a bias tire, the average total cost of one bias tire was 2,606.07 ± 12.50 Baht at a 95% confidence level, and the range of the production cost of one tire was 2,325.03–2,987.37 Baht, based on the 5th and 95th percentiles. The cost estimation showed that the cost of a single bias tire was about four times lower than the selling price in 2021. Thus, it suggested that the bias-tire business can still be continued at present. The production cost was greatly influenced by the cost of raw materials, especially natural rubber, canvas, and synthetic rubber, respectively.

Keywords: Bias tire, Cost estimation, Monte Carlo simulation, Natural rubber

EC-P003

Optimization of enzymatic hydrolysis condition of edible bird's nest using plant enzymes to obtain maximum antioxidant activity

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Abstract

An edible bird's nest (EBN) is a product of the saliva of the swiftlet. Protein is the main component in a bird's nest. This study focused on determining the optimum enzymatic hydrolysis conditions of EBN using papain to achieve the maximum antioxidant activity. The response surface methodology (RSM) was used to determine the optimum condition for hydrolysis of the EBN. A central composite design (CCD) experiment was applied to substrate concentration (0.16-1.84% w/w), enzyme concentration (270-3,130 Unit/g protein) and hydrolysis time (40-140 min). The results showed that these three factors affected the maximum antioxidant activity. The optimum conditions for the hydrolysis of EBN were at a substrate concentration of 0.5%, a papain concentration of 2,261 Unit/g protein, and a hydrolysis time of 104 min. The rejuvenate peptide powder is the product of this experiment that contained protein by 66.52% and total amino acid content of 53.98 mg/100 mg. It is nontoxic to human skin fibroblast cells. It has antioxidant activity by the ABTS method (107.32±0.16 µM Trolox/mg extract) and the greatest potential to inhibit hyaluronic acid activity (65.75±0.52%). Moreover, the rejuvenate peptide powder was developed into a cosmetic product for facial skin care which helps reduce wrinkles.

Keywords: Antioxidant activity, Edible bird's nest, Enzymatic hydrolysis, Response Surface Methodology

EC-P004

Cellulolytic enzyme production via solid-state fermentation and application for lignocellulosic biomass

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Abstract

A large number of microorganisms habitat in soil are capable of producing various enzymes, especially they produce enzymes capable of completely hydrolyzing cellulose. Fungi are the main cellulase-producing microorganisms. In this study, twenty fungi isolated from soil samples were screened and compared for their ability to produce cellulase. Cellulase-producing fungal colonies were selected after 7 days of incubation and flooding the plates with 1% (w/v) Congo red, followed by washing with 1 M NaCl. Four fungal isolates showed halo-forming zone and were selected for cellulase production under solid state fermentation (SSF). Fungal isolate NI3 showed the highest CMCase and FPase activities at 139.67 IU/g substrate and 8.22 FPU/g substrate, respectively. The crude fungal cellulases were tested for their ability to degrade pretreated sugarcane bagasse. The enzymatic hydrolysis of the sugarcane bagasse was carried out with varied crude enzyme loading per gram of bagasse for 72 h at 50 °C. Under these conditions, the cellulose present in the pretreated bagasse yielded reducing sugar at 173 mg/g cellulose. Molecular identification of ITS sequence revealed that isolate NI3 similarity to 99.67% with *Aspergillus piperis*. Therefore, this isolate would be a good candidate for textile waste recycling.

Keywords: Cellulase, CMCase, Enzymatic hydrolysis, FPase

EC-P005

Improvement of biodegradable plastic—Polyhydroxybutyrate (PHB) production by a newly isolated strain of *Bacillus* sp. KAPIBS10-2

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Abstract

Polyhydroxybutyrate (PHB) is a naturally occurring biodegradable polymer synthesized by some bacteria and archaea with functions comparable to conventional plastics. Previously, our research team isolated a new bacterial strain, *Bacillus* sp. KAPIBS10-2 from the soil in Si Nan national park, Nan province, Thailand. This strain produced 17 ± 2 wt% dry cell weight (DCW) of PHB using 3% v/v molasses as a carbon substrate. However, the optimal condition for PHB production of this strain has not been studied so far. Therefore, this study aimed to enhance PHB production using statistical techniques, Response surface methodology (RSM) employing central composite design (CCD). Three significant factors, i.e., molasses concentration (0.8-9 %v/v), shaking speed (100-300 rpm) and temperature (29-45˚C), were evaluated to maximize the PHB production in a flask scale. The results showed that the maximum PHB accumulated up to 34.1 ± 1 wt% DCW with cell biomass of 2.6 ± 0.6 g/L were obtained using the optimized condition, representing 96.6% validity of the predicted models for PHB production. According to the results, it can be concluded that *Bacillus* sp. KAPIBS10-2 is a promising strain for PHB production in the flask scale. In addition, RSM can enhance PHB production by this strain.

Keywords: *Bacillus* sp., Bioplastic, Molasses, Polyhydroxybutyrate, Response surface methodology

EC-P006

Natural rubber composites using silane-functionalized spent coffee grounds as potential replacement alternatives to commercial reinforcing silica fillers

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Abstract

Utilization of waste-derived reinforcing fillers in natural rubber (NR) composites has drawn great attention over the recent years for economic and environmental concerns. In this work, the silane-functionalized spent coffee grounds (SCGs), of which the starting materials are abundant wastes from the production of instant coffee and coffee brewing, were preliminarily tested for their potential replacement alternative to commercial reinforcing silica fillers for the truck tire tread formulations. It was found that the NR compound filled with 20 phr of the TESPT-functionalized SCGs (NR/TESPT-SCGs) exhibited a lower curing rate as compared to that of the NR compound filled with the commercial silica (NR/Silica) at the same loading. The results from the hardness, tensile strength, elongation at break, and 100% modulus measurements indicate that the mechanical properties of the NR/TESPT-SCGs composite are comparable to those of the NR/Silica formulation, but the heat buildup is measured to be significantly lower. These preliminary results suggest that TESPT-SCGs is an environmentally friendly and low-cost starting material that can be potentially used to replace commercial silica in the formulation of the NR composites for the truck tire tread.

Keywords: Natural rubber composite, Reinforcing filler, Silane, Spent coffee grounds, TESPT

EC-P007

Multiple shoot induction and plant regeneration from axillary buds of *Eucalyptus* hybrid clones

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Abstract

The present study investigated multiple shoot induction and plant regeneration from axillary bud cultures of two commercial *Eucalyptus* hybrid clones (*E. urophylla x E. grandis* and *E. urophylla* x *E. pellita*) under axenic conditions. Primary shoots were obtained from axillary buds of explants cultured on Murashige and Skoog (MS) media supplemented with different concentrations of 6-Benzylaminopurine (BAP) and 1-Naphthaleneacetic acid (NAA) for 3 months. The combination of BAP and NAA has shown positive effects on shoot formation and development. The optimum medium for shoot induction in *E. urophylla x E. grandis* clone was MS medium supplemented with 0.8 mg/L BAP + 0.5 mg/L NAA + 0.3 mg/L PVP + 15 g/L riboflavin, producing an average number of 8 ± 1.7 shoots. The highest number of shoots in *E. urophylla* x *E. pellita* clone (11 ± 0.94) was obtained in medium containing 0.6 mg/L BAP + 0.6 mg/L NAA + 0.3 mg/L PVP + 15 g/L riboflavin. Explants achieved 100% rooting in a half-modified MS medium supplemented with 2 mg/L indole-3-butyric acids (IBA) + 0.3 mg/L PVP. This research demonstrated that axillary buds of *Eucalyptus* hybrid clones could be induced, regenerated, and rooted *in vitro*. The results are useful for genetic engineering, bioenergy research, and industrial forest plantations.

Keywords: Axillary bud, *Eucalyptus*, Shoot induction, Tissue culture techniques

EC-P008

Effect of polyhydroxybutyrate (PHB) application on yield, growth, and soil microbes in maize fields

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Abstract

Polyhydroxybutyrate (Poly-β-hydroxybutyrate, PHB) is a biopolymer. It is fully biodegradable by microorganisms to produce carbon dioxide and water. At present, it is applied in many different fields such as packaging, medicine, pharmacy and agriculture. This research examined the effect of polyhydroxy butyrate on yield, growth and soil microbes in maize (Nakhon Sawan 3) cultivated in the Nam Phong soil series. The experiment has 6 treatments with 5 replications. Treatment 1 was the control (without fertilizer). Treatments 2 and 3 were 1 and 6 g of chemical fertilizer respectively. Treatments 4 and 5 were added with 1 and 6 g of PHB. Treatment 6 was 1 g of PHB and 6 g of chemical fertilizer. The results showed that the treatment with 1g of PHB and 6 g of fertilizer provided the highest root, ears, and height. For the microbes' community in soil, the results showed that the application of PHB with fertilizer had the highest number of microorganisms ($139x10^{-4}$ CFU/g). This microorganism might improve the soil nutrition. The study showed that the use of a small amount of PHB with chemical fertilizer can enhance yield, growth, and increase soil microbes better than fertilizer or PHB alone in maize cultivation.

Keywords: Growth, Maize, Microbes, Polyhydroxybutyrate (Poly-β-hydroxybutyrate, PHB), Yield

EC-P010

Effect of enzymatic pre-treatment with accelerated solvent extraction on *in vitro* anti-diabetic and antioxidant inhibition activities *Garcinia cowa* Roxb. leaf extract

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Abstract

Garcinia cowa Roxb. (Chamuang) is a local edible plant in Thailand that has been demonstrated to have anti-diabetic properties. This research aimed to determine the phytochemical compounds, anti-diabetic and antioxidant inhibitory activities of enzymatic pre-treatment combined with accelerated solvent extraction (ASE) on Chamuang leaf extract. First, an optimal enzyme screening of three enzymatic pre-treatments on Chamuang leaf using cellulase, hemicellulase, and viscozyme was performed. The results showed that the hemicellulase-treated combined with ASE sample had the highest total xanthone content (14.23±1.04 mg α-mangostin/g), total phenolic content (28.31±0.09 mg GAE/g sample), and flavonoids content (18.73±0.17 mg CE/g sample). *In vitro* anti-diabetic properties were determined by α-glucosidase and α-amylase inhibitory activities. The inhibition of α-glucosidase assay results revealed that the viscozyme and hemicellulase-treated samples at a concentration of 10 mg/mL, exhibited the maximal inhibitory effects of 28.22±4.22% and 24.91±2.31%, respectively, which were more effective than that of nontreated sample. While α-amylase inhibitory activities of cellulase, hemicellulase, and viscozyme-treated samples were not significantly different ($p>0.05$). Antioxidant activities were determined by DPPH radical scavenging capacity assay and ferric reducing antioxidant power (FRAP) assay. The results showed that the hemicellulase-treated sample had the highest value of 42.53±2.27 mg TE/g sample by DPPH assay and the highest FRAP value of 344.21±11.12 µmol of Fe (II)/g sample. These results suggest the potential of *Garcinia cowa* Roxb. leaf extract obtained from hemicellulase pre-treatment combined with accelerated solvent extraction as a rich source of natural phytochemical, anti-diabetic, and antioxidant ingredients.

Keywords: Anti-diabetic, Antioxidant activity, Chamuang leaves extract, Enzymatic pre-treatment, Phytochemical

EC-P011

KPSC903 hybrid purple corn (*Zea mays* L.) cob as a potential source of anthocyanin and phenolic compounds for cosmetic applications

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Abstract

This research was conducted to evaluate the potential of the Purple Corn Cob KPSC 903 extracts for use as an active ingredient in the cosmetic industry. The KPSC903 hybrid purple corn cob was extracted and determined for the antioxidant, anti-aging, anti-inflammatory and inhibition of cellular tyrosinase activities. The total phenolic content (TPC) and total anthocyanin content (TA) of the extract were investigated using spectrophotometric assays and the main compounds were evaluated using HPLC. The results revealed that the purple corn cob KPSC 903 extract contained a high content of TPC (130.65 mg GAE/g extract) and TA (60.58 mg cyanidin-3-glucoside/g extract). The extract exhibited high free radical scavenging activities through DPPH, ABTS and FRAP assays with IC_{50} values of 75.50 and 1286.98 µg/mL, respectively, and FRAP value of 1271.17 µmol/g extract. The extract was investigated for its anti-aging effect by collagenase inhibition assay, which showed a high inhibitory effect against collagenase with an IC_{50} value of 0.11±0.01 mg/ml. Inhibition of cellular tyrosinase activity in melanoma B16F10 cells showed that the extract exhibited strong inhibitory effect with tyrosinase inhibition of 69.91±10.49 % at 1mg/ml. The anti-inflammatory effects of the extract in LPS-stimulated RAW264.7 cells demonstrated that the extract suppressed nitric oxide (NO) generation in LPS-induced RAW 264.7 cells in a concentration-dependent manner. The main components found in the extract were delphinidin, cyanidin-3-glucoside, catechin, ferulic acid, caffeic acid and gallic acid. The purple corn cob KPSC 903 extract has great potential as a source of bioactive compounds which could be used as an active ingredient in cosmetic products.

Keywords: Active ingredient, Anti-aging, Anti-inflammatory, Cosmetic products, Purple corn

EC-P012

Utilization of low-grade fruit for mixed fruit wine fermentation and its non-destructive quality control by FT-IR spectroscopy

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Abstract

The utilization of low-grade fruits as substrates for winemaking is an interesting approach in terms of using alternative resources and adding value to them from an economic point of view. The production of wine using low-grade fruits may vary between fermentation cycles due to the quality of the raw materials from different sources that are difficult to control. To provide quality standards of such situation, various parameters are required to inspect the samples throughout the fermentation process. Different conventional methods and instruments must be used to determine key parameters, such as GC and HPLC analysis. Such approaches take a long time and waste samples and solvents, causing limited measurements. Therefore, this research carried out the fermentation of fruit wine using low-grade pineapple and red dragon fruits and developed a non-destructive and rapid method for the quantitative determination of key parameters in wine samples by using FT-IR (Fourie transform-infrared) spectrometer in the region of 4000-650 cm^{-1}. A partial least squares regression (PLSR) model for each component was developed using the FT-IR spectra of the fermenting sample and its constituent content detected by the reference method. From the results, it was found that the wine obtained using pineapple juice and dragon fruit juice, including fruit peel, had a higher total phenolic content than the fermentation using the only pulp of fruit with a significant difference at a confidence interval of 95%. For FT-IR analysis, the calibration equation could predict contents for ethanol, total phenolic, total soluble solids, total acidity, total volatile acid, total yeast cells and reducing sugar in wine samples with the root mean squares error of cross-validation (RMSECV) of 0.506 %, 11.508 µg/mL, 0.544 ^{o}Brix, $5.394x10^{-3}$ %, $0.946x10^{-4}$ %, $3.713x10^{6}$ CFU/mL and 5.103 g/L, respectively.

Keywords: Dragon fruit, Fermentation, FT-IR spectroscopy, Low-grade fruit, Pineapple, wine

EC-P013

Eco-friendly 3D printed TiO_2/SiO_2/photopolymer scaffold for wastewater treatment

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Abstract

Numerous catalysts and adsorbents have been developed in recent years for mitigating pollutants in water. However, the development of catalysts and adsorbents embedded in 3D structures remains challenging. This study aims to fabricate 3D printed TiO_2/SiO_2/photopolymer composites for treating water containing three types of organic dyes, including methylene blue, methyl orange, and rhodamine B. TiO_2/SiO_2/photopolymer scaffolds were fabricated by stereolithography (SLA) 3D printing method using TiO_2 photocatalyst synthesized via solution combustion process, silica adsorbent from sugarcane leaves, and photocurable resin as feedstock. The composition of TiO_2 in TiO_2/SiO_2/photopolymer composite was varied at 1, 3, and 5 percent by weight, whereas the SiO_2 content was fixed at 5 percent by weight. The adsorption activity was conducted in the dark until adsorption equilibrium was reached, and photocatalysis was examined under UV light radiation (λ = 365 nm). The surface area of as-synthesized TiO_2 and SiO_2 was 44 m^2/g and 298 m^2/g, respectively. The silica from sugarcane leaves showed the amorphous phase, and TiO_2 revealed the anatase phase, as confirmed by X-ray diffraction. Scanning electron microscopy image revealed that TiO_2 and SiO_2 uniformly deposited on the photocurable resin in TiO_2/SiO_2/polymeric scaffold. The TiO_2/SiO_2/photopolymer scaffold demonstrated its potential as the adsorbent and photocatalyst for dye degradation. The reusability of the scaffold was also tested. The results revealed that after hydrogen peroxide treatment, the used scaffold demonstrated the degradation ability in a comparable range with the as-fabricated scaffold. An application of 3D printing technique for water pollution reduction was successfully demonstrated in this study.

Keywords: Biomass, Photocatalysts, Stereolithography 3D printing, Wastewater treatment

EC-P014

From industrial carpet waste into adsorbent materials for removal of dyes in water

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Abstract

The massive amount of carpet waste from the industrial processes is usually dumped in landfills, causing environmental problems with no value creation. The conversion of carpet waste into a higher value-added product is an optional way to manage carpet waste with the most benefits and values. This work shows the conversion of industrial carpet waste into adsorbents for dye removal. The pre-consumer carpet waste was directly pyrolyzed at different temperatures from 500 to 900 °C under an inert atmosphere. Owing to the high fraction of calcium carbonate ($CaCO_3$) filled in the adhesive layer of the carpet, $CaCO_3$ was obtained at 500 and 600 °C, whereas the calcium hydroxide ($Ca(OH)_2$) with a hexagonal platelet-shaped crystal began to form at 700 °C. Carbon was also found in the samples due to the carbonization of the polymeric fibers and backings. The specific surface area tended to increase from 15 to 26 $m^2\ g^{-1}$ with increasing pyrolysis temperature. Potential application as dye adsorbents was examined using methylene blue (cationic dye) and methyl orange (anionic dye) at concentrations of 10, 15, and 20 mg L^{-1}. Among all samples, the carpet waste pyrolyzed at 900 °C showed the highest adsorption efficiency of about 100% for methylene blue and 93–99% for methyl orange at the dye concentration of 10–20 mg L^{-1}. The lower adsorption efficiency of methyl orange than methylene blue was attributable to the electrostatic effect between the dye molecules and the adsorbent surface. The results presented in this work provide useful information for converting carpet waste into adsorbents for wastewater treatment.

Keywords: Calcium carbonate, Calcium hydroxide, Carpet waste, Dye adsorbents, Pyrolysis

EC-P015

Decolorization of dispersed dyed polyester knit fabric using reducing agents before recycling polyester fibers

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Abstract

Recycling waste from industry was an important issue for environmental protection in the world. The production of polyethylene terephthalate (PET) consisted of 60% used for fiber production and 30% used for bottle production. For polyester fibers, they are still be not yet concerned to recycling materials for melting and re-spinning to be recycled fibers. Before recycling process, the decolorization of polyester fabric was concerned for pretreatment. The objective is to study the effect of two reducing agents and their conditions to decolorize the disperse dyed polyester fabric. The piqué polyester knit fabrics were dyed with 1% (o.w.f) CI Disperse Blue 79 (DB79). Then, sodium hydrosulphite as a general reducing agent was selected to decolorize of dyed polyester fabric compared with organic reducing agent, thiourea, at a concentration of 50 g/L containing of 2 g/L Na_2CO_3 at various temperatures (130-140 ^oC). Moreover, both reducing agents were investigated with the effect Na_2CO_3 or NaOH. The results found that increasing in decolorized temperature for both reducing agents affected on color discharge performance (*delta E** and whiteness) and effect of sodium hydrosulphite can decolorize to be pale than thiourea on color discharge performance of dyed fabrics. Nevertheless, the results indicated that NaOH could help reducing agents to decolorized dyed better than Na_2CO_3. Moreover, the bursting strength of each decolorized fabric was analyzed to study the mild condition for decolorizing method. This result could be applied to the decolorization of dyed polyester fabric before recycle treatment, which could produce recycled knit polyester fabric in the future.

Keywords: Decolorization, *Delta E**, Polyester, Reducing agents, Whiteness

EC-P016

Characterization of calcium carbonate obtained from pearl oyster shell powder (*Pinctada maxima*) to be used as the cosmetic ingredient

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Abstract

The pearl oysters are the economic animal that creates enormous value in the jewelry industry of Thailand each year. Nevertheless, after obtaining pearl, the shells became a waste with the estimated quantity of around 10,000 tons per year. Chemically, the pearl oyster shell consisted of more than 80 percent calcium crystals. To utilize this large amount of by product, this research aims at extracting calcium carbonate from pearl oyster shells and investigating its characteristic for using as the ingredient in the cosmetic and healthcare products hopefully to add more value to pearl farmers. Two types of pearl oyster shell powder i.e., deproteinized pearl oyster shell powder (P1) and whole pearl oyster shell powder (P2) were used to extract calcium carbonate under mild alkali pH (8.0). Their physical and chemical properties were characterized and compared with commercial calcium carbonate (P3). The morphology and the proportion of calcium carbonate characterized by Scanning electron microscopy and Energy Dispersive X-Ray Spectroscopy (SEM-EDS) showed that P1 and P2 surface consisted of calcite structure with the shape of rhombohedral crystals while P3 was spherical. The purity determined from the percentage weight of the calcium carbonate ($CaCO_3$) composed elements obtained from both types of oyster powder was not significantly different from the commercial one (up to 99%). In addition, the color of the deproteinized (P1) and whole pearl oyster shell powder (P2) was darker than the commercial pearl powder (P3) as observed from its highest L* value of 96.99 while P2 was the darkest in color as indicated by the significant lowest L* (81.83) and b* (11.57). In conclusion, pearl oyster powder could be simply prepared under this condition and its purity was comparable with the commercial $CaCO_3$. Though the morphology and color were different, pearl powder with mainly structure of calcite was also reported to be used in exfoliating products and sunscreens. Thus, this study suggested the potential use of pearl oyster shell by-product as a main source for $CaCO_3$ production for cosmetic application.

Keywords: Alkaline solution, Calcium carbonate, Pearl oyster shell, *Pinctada maxima*

EC-P017

Development of the cleansing products from *Melaleuca cajuputi* extract in Kantang Community Enterprise for sustainable income and quality of life improvement for the community

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Abstract

Kantang Community Enterprise is a community that uses local biological resources such as aloe vera, plai, turmeric and lemongrass to develop the featured products of the community like bar soap, body lotion, body moisturizing gel, etc. In addition to the plants mentioned above, there are many *Melaleuca cajuputi* trees in the community without any uses and cannot generate any profit. Therefore, this research focused on the utilization of the *Melaleuca cajuputi* leaves by extracting and analyzing their biological components and adding value by applying them to cosmetic products. The benefits of *Melaleuca cajuputi* leaf extract are the antioxidant and anti-bacterial effects therefore, it can be developed as an active ingredient in many cleansing cosmetic products. Products from this research included shower gel and facial cleansing gel. The shower gel obtained was an orange-yellow clear liquid. The L* a* and b* were 51.58±0.17, 2.10±0.06, and 16.12±0.08, respectively and the pH was 5.70±0.01. The facial cleansing gel was a pale-yellow opaque liquid which have the L* a* and b* values of 43.06±0.28, 0.80±0.003, and 8.39±0.20, respectively. The pH of facial cleansing gel was 5.50±0.01. The microbiological qualities of both products met the Thai Industrial Standard. These products have a shelf life of 2 years. In this project, the extraction technology and the cleansing products production process were transfered to the community members and the satisfaction score of the project was at the most satisfactory level. The transfer of production process can increase income and create sustainable occupations within the community.

Keywords: Cleansing product, Community enterprise, Kantang products development *Melaleuca cajuputi*, Sustainable development

EC-P018

Improvement and quality evaluation of pineapple wine by adding dragon fruit juice

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Abstract

Red dragon fruit is a tropical fruit known for its red skin and powerful antioxidant activity due to the naturally-occurring pigments. This study aims to improve the quality of pineapple wine supplemented with dragon fruit. The ratios of fresh pineapple juice to water or dragon fruit to obtain 2 treatments, which were T1—2:1 (pineapple juice: water), and T2—2:1 (pineapple juice: red dragon fruit). The ^{o}Brix and pH of all treatments were adjusted to 25^{o}Brix and 4, respectively. All experiments were fermented with *Saccharomyces cerevisiae* var *burgundy*, at 25°C for 10 days. The changes in alcohol content, Total Soluble Solid (TSS), and pH during the 10-day fermentation between the 2 treatments were not significantly different. The average alcohol content of both wines is in the range of 10.07-10.71%. The total phenolic content of pineapple wine and pineapple wine supplemented with red dragon fruit as gallic acid equivalents (GAE) was found to be 337.30 and 444.36 mg/L GAE, respectively. The antioxidant activity determined by DPPH of pineapple wine and pineapple wine supplemented with red dragon fruit were 110.17 µg/g TE and 252.37 µg/g TE, respectively. Results suggested that the antioxidant capacity of the wine produced from pineapple juice supplemented with red dragon fruit was higher than that produced from the pineapple juice, which was consistent with the higher total phenolic compound content found in the pineapple juice supplemented with dragon fruit wine.

Keywords: Antioxidant activity, Fermentation, *Saccharomyces cerevisiae*, Total phenolic compound

EC-P019

Extraction and characterization of nanocellulose from textile waste

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Abstract

This research aims to study the extraction and characterization of nanocellulose from textile waste. The nanocellulose was extracted from the textile waste by 0-20% alkaline sodium hydroxide (NaOH) treatment, acid hydrolysis process, respectively. The characterization of nanocellulose was done by using absorption, transmission and reflection spectra. The absorption spectrum result shows the maximum peak around 400 nm. In the case of transmission and reflection spectra show increasing of their wavelength from 400 nm. The nanocellulose extracted shows blue color under UV light. These nanocellulose might use as one of the candidate materials for making film composite. It can be used as a new type of biodegradable film. The qualities of the obtained eco-friendly film composite might be improved and had sufficient potential for replacing the used of plastic film in the future.

Keywords: Absorption, Nanocellulose, Transmission, Textile waste, Reflection

EC-P020

The development of Look Pang to create Salak Flavored Khao Mak

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Abstract

This research aims to create a Look Pang (solid starter culture) using yeast isolate from Salak to create a Salak flavored Khao Mak (sweet fermented rice) which make Look Pang 2 formulas with different ratio of water to rice flour as follows: 1) the formula 1 is 85 : 100 and 2) the formula 2 is 75 : 100. The result found that the physical characteristics of the formula 1 of Look Pang are white, light, no crack, no musty smell, and low moisture, and the formula 2 of solid starter culture are white-brown, light, crack, and little moisture. In addition, the pH-alkalinity of both Khao Mak recipes is in the range of 6.6 – 4.8 respectively, and the amount of dissolved solids in a Khao Mak juice is in the range of 6.03 – 11.40, respectively.

Keywords: Khao Mak, Look Pang, Salak flavored, Sweet fermented rice

EC-P021

Investigation of simple and scalable method for Cannabis extraction

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Abstract

The government policy to promote cannabis utilization for medical purpose resulted in an increase of cannabis growers including launching of various finished products made by certain legalized cannabis plant parts. From record, the number of organization work on cannabis extraction and production was still limited to public organization. Therefore, cannabis extraction is a focal point for research in order to support a future needs. Nowadays, various extraction technologies ranged from the simple solvent extraction to the advance methods such as supercritical fluid carbondioxide (SFC), and microwave or ultrasonic assisted extractions are available. To select, the extraction yield and purity may not be the only important criteria for cannabis-based medicinal extract, but also characteristic and bioactivity of the obtained extract. This study aims to investigate the potential extraction method based on the simple available techniques. Comparison of extraction yield, CBD profile and content of the ground (G) and non-ground (NG) cannabis inflorescences extracted from 24 hour maceration (T1) and 15 min sonication (T2) in ethanol were performed. The highest extraction yield (GT1; 21.63% w/w dry weight sample) was obtained from 24 hour maceration of ground inflorescences. A comparable yield was observed between 24 hour maceration of non-ground (NGT1; 18.10%) and 15 min sonication of ground inflorescences (GT2; 18.12%) while the lowest yield was from 15 min sonication of non-ground inflorescences (NGT2; 15.63%). The profile of crude extract from each condition detected on TLC showed no obvious differences and CBD was the major compound extracted. Analysis of CBD content by GC-MS indicated that GT1 condition that gave the highest extraction yield had significantly lower CBD content (10.2% w/w inflorescences) than GT2 (12.2%). It was noticed that 15 min sonication was efficiently to extract CBD and grinding of sample prior to extraction increased an extraction yield and consequently the CBD content. Nevertheless, longer extraction time (24 hour maceration) did not significantly increase the CBD content. Thus, the grinding is matter only short time extraction. Nevertheless, scaling up maceration may be more suitable and the work suggested that further study could be done on non-ground samples in less than 24 hours of extraction.

Keywords: Cannabis, CBD, Extraction, Maceration, Sonication

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