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Fostering Sustainability through Emerging Trends in Agriculture Technology and Bioprocessing

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Johor Darul Takzim, Malaysia

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e-Proceeding of the International Conference on Agritechnology and Bioprocessing Innovation 2024 (ICAgBio 2024)

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FOREWORD

Agriculture today faces significant global challenges, from the impacts of climate change and environmental degradation to the growing demands for food security and sustainable resource management. In response, the convergence of sustainable agricultural practices, innovative food processing, biotechnology, and digitalization offers transformative solutions to these issues. The International Conference on Agritechnology and Bioprocessing Innovation (ICAgBio) 2024 provides a collaborative platform to address these critical areas, fostering the exchange of ideas, research, and innovations that are shaping the future of agriculture.

This e-Proceeding presents the latest research and insights shared at ICAgBio 2024, reflecting the conference's core themes: Sustainable Agriculture, Food Processing and Product Development, Biotechnology in Agriculture, Biobased Products, Biowaste Management, and Agriculture Digitalization. The papers compiled here showcase diverse approaches and breakthroughs aimed at making agriculture more resilient, efficient, and environmentally sustainable.

Central to the discussions is the theme of sustainability. Sustainable agriculture promotes long-term strategies that enhance productivity while protecting ecosystems. The contributors to this proceeding demonstrate how biotechnological innovations are boosting crop yields, improving disease resistance, and reducing reliance on chemical inputs, all while minimizing environmental impacts. These advancements are crucial to addressing the food demands of a rapidly growing global population.

In addition, the development of new food processing technologies is playing a vital role in reducing food waste, improving the nutritional value of food products, and optimizing supply chains. Biotechnology’s integration into food processing enables the creation of healthier, more sustainable products. At the same time, digitalization is revolutionizing agricultural practices through data-driven decision-making, precision farming, and improved resource management. From smart irrigation systems to automated harvesting technologies, digital tools are transforming agriculture at every stage of production.

This e-Proceeding reflects the collaborative efforts of researchers, industry experts, and policymakers who are committed to tackling the complex challenges of modern agriculture. The insights and innovations shared here not only provide technical solutions but also explore the broader social, economic, and environmental implications of these advances. Together, they represent a shared commitment to advancing agriculture in a way that balances productivity with sustainability.

We extend our deepest gratitude to all the contributors, participants, and reviewers for their dedication to the success of this conference. It is our hope that the knowledge shared in this e-Proceeding will continue to inspire collaboration and drive meaningful progress toward a more sustainable agricultural future.

Thank you.

ASSOCIATE PROFESSOR IR. DR. DAYANG NORULFAIRUZ ABANG ZAIDEL
Head of Scientific Committee
ICAgBio 2024

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Evaluation of the Hive's Climate Control Effect on Stingless Bees Meliponiculture at 30°C, 33°C, and 36°C

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Extended Abstract

Stingless bees (Meliponini) are vital pollinators in tropical and subtropical ecosystems, playing a crucial rolein maintaining biodiversity and supporting agricultural productivity. However, the success of stingless bee colonies is heavily influenced by environmental conditions. This study investigates the effects of controlled and uncontrolled temperature conditions on the behavior, honey production, colony size, and health of stingless bee (*Heterotrigona itama*) colonies. A new hive design was developed, incorporating both a heatingbox and a trap box to facilitate the IoT system. The heating box, equipped with the Peltier device, had an entrance hole for the bees. The Peltier device was connected to the IoT system, which produced heat throughelectricity. The system was directly connected to the hive, allowing for continuous temperature monitoring and adjustment. The control method utilized the Blynk app as shown in Figure 1, which can monitor the temperature and humidity in the hive.

Fig. 1: Monitoring through Blynk application

The study was conducted at the Share Farm, UiTM Melaka Jasin Campus, using four hives: three with a climate control system and one without. A temperature and humidity control setup was implemented using temperature controllers, humidity regulators, sensors, and an IoT system for remote monitoring. The speciesused in this study was *Heterotrigona itama*, a common stingless bee species in tropical and subtropical regions, particularly in Southeast Asia. The experiment spanned 30 days for each temperature setting (30°C,33°C, and 36°C) at 80% humidity. Observations were conducted daily, focusing on bee behavior, honey production activity, colony size changes, and hive health. Data was collected through direct observation andphotographic documentation.

At 30°C, bees showed a gradual increase in activity over time, transitioning from inactive to highly active by the end of the observation period. At 33°C, bee behavior fluctuated between inactive and active states. At36°C, bees exhibited periods of inactivity interspersed with active phases. Active honey production was observed from day 16 onwards at 30°C, while at 36°C, it began from day 11. At 33°C, honey production activity was intermittent throughout the study period. Hive health remained consistently healthy at 30°C and36°C under controlled conditions. At 33°C, hive health fluctuated but

was generally stable. At 30°C, the colony size initially remained unchanged but showed changes later in thestudy, with stable population dynamics. At 33°C, colony size changes were observed with stable populationdynamics. At 36°C, both colony size and population dynamics remained mostly unchanged. The results indicate that temperature plays a crucial role in stingless bee behavior and productivity. The 30°C controlledenvironment showed the most promising results, with a gradual increase in bee activity and consistent honeyproduction. This suggests that 30°C might be an optimal temperature for stingless bee colonies, particularlyduring challenging weather conditions. The 33°C environment resulted in more variable behavior and production patterns, indicating that this temperature might be less suitable for consistent colony performance.The 36°C environment, while showing early onset of honey production, also resulted in mixed activity periods, suggesting that higher temperatures might induce more variable behavior patterns. These findings align with recent research by [1], who reported that stingless bees can adapt to different temperature rangesthrough behavioral and physiological mechanisms. The observed patterns in bee behavior across different temperature regimes are consistent with the current understanding of stingless bee thermoregulation. The variation in honey production across different temperatures provides valuable insights into the optimal conditions for stingless bee productivity. These findings are supported by recent research from [2], who found that temperature significantly affects honey viscosity, enzyme activity, and overall quality in stinglessbees. The consistent health of hives under controlled conditions at all three temperatures demonstrates the remarkable adaptability of stingless bees to different thermal environments, as long as the temperature remains within a tolerable range. This aligns with recent work by [3] on the thermoregulatory abilities of stingless bees. The observed changes in colony size and population dynamics, particularly at 30°C, indicate that temperature can significantly influence colony growth and development. This is consistent with recent findings by [4], who demonstrated that different stingless bee species have varying thermal tolerances that affect their survival, reproduction, and population dynamics.

Keywords: Stingless bees, Meliponiculture, Hive climate control, Temperature regulation, Honey production

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Performance Evaluation of IoT-Based Coffee Bean Dryer Machine

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Extended Abstract

Advancements in the Internet of Things (IoT) technology have had a substantial impact on various industries [1]. The objective of this research is to assess the efficiency of a recently advanced Internet of Things (IoT) based coffee bean drying machine (CBDM). The objective of this study is to examine primary performance indicators in order to demonstrate the efficacy of this system. These indicators include the maximum temperature attainable, the time required to reach the temperature, and the least humidity level achievable throughout the drying process. The IoT technology is employed to continuously monitor and precisely regulate temperature. This system is implemented using an ESP32 microcontroller to control the automation of the coffee bean drying process. The device operates usinga 12V 30A power source, which is adjusted to 5V using the LM2596 voltage level regulator. The DHT22 sensor monitoring the temperature and humidity provides valuable data to the control algorithmof the drying process. An electrical activation switch, namely a 5V relay, is employed to initiate the heating process by stimulating two Thermoelectric Peltier (TEP) devices. Each of them is equipped with a 12V 6A power input and functions as a heating device. An electric 12V fan facilitates the convection. The arrangement of components is depicted in Fig 1. The system depends on Internet of Things (IoT) capabilities facilitated by the Blynk IoT platform to guarantee active monitoring of temperature and humidity. While the Blynk program monitors both metrics, temperature is the sole parameter that may be modified via the dashboard. The capacity of the drying chamber, developed using CATIA V5, was determined to be 0.06624m². Experimental testing was conducted in an indoor environment to evaluate the system using single and dual TEP heater setups. Furthermore, the system was set to a target temperature of 60°C, obtained from the original ambient temperature of around 28°C.The studies were followed by an analysis of the acquired data mostly utilizing descriptive statistics. Inaddition, trend analysis and correlation analysis were employed during the analysis. The analysis clearlydemonstrates that the dual TEP system is superior compared to the single TEP system, as shown in Fig
2. When using the single TEP system, the necessary temperature may be achieved after a considerable duration. Evidently, during the initial 120 minutes of the experiment, the temperature rose from 27.98°Cto 60.01°C for the dual TEP setup. Concurrently, the humidity dropped from 85.94°C to 39.2°C withinthe same observed period. While the temperature objective was successfully accomplished in the first system, there is a possibility that the temperature may rise to excessively high and occasionally uncontrollable levels within the same timeframe. Nevertheless, it is evident that the dual TEP system successfully maintained the necessary end temperature of 60°C throughout the drying phase. The trends monitored in temperature and humidity indicate that while the duration of reaching higher temperaturesis longer, the system is capable of reaching them. It is advisable to adjust the electrical settings and determine the number of TEPs and the size of drying compartments based on the coffee bean type and ambient circumstances. The potential of the IoT-based system for coffee bean drying machines (CBDM) lies in its ability to get the precise temperature required for the drying process. Simultaneously,specified parameters undergo immediate changes, and the reaction occurs instantaneously, indicating

that the results of the operation are optimal based on the conditions. The implementation of the technology will enable the attainment of the initially specified higher temperature regimes. Despite the optimization of electronic systems in the present system, there is room for implementing some modifications and enhancements. A potential future study might explore the impact of increasing the quantity of TEPs and using customizable compartment size improvements that can be more specifically designed for certain types of beans or environments. In conclusion, the current study illustrates that the Internet of Things (IoT) has the capability to redefine several agricultural processes, with a specific focus on processes related to post-harvest activities, which may derive the most advantages. The presentwork considers the drying of coffee beans as an illustrative case of the ordinary but crucial task that may be transformed when the Internet of Things (IoT) is employed in combination with fundamental drying procedures. Control, efficiency, and adaptability of IoT-assisted drying have been addressed in the study's outcomes description. The lessons derived from this study will be beneficial and applicablein several aspects, such as the advancement and use of advanced drying systems, the broader domain of agricultural engineering, and post-harvest technology.

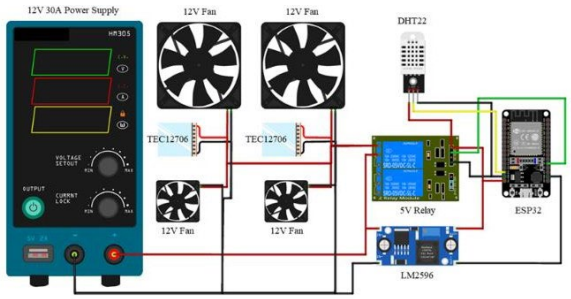

Fig SEQ Figure * ARABIC 1:Schematic diagram of the CBDM

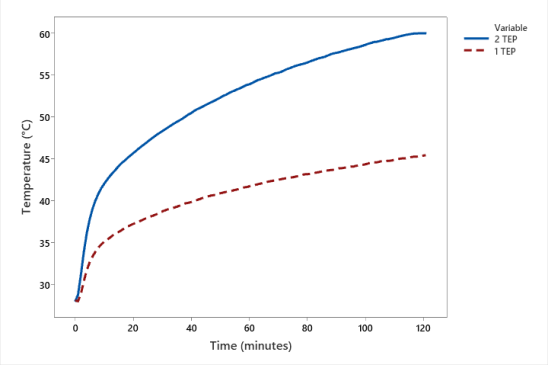

Fig 2: Comparison of application singleand Dual TEP.

Keywords: Temperature control, Coffee bean dryer machine, Arduino-based system, Temperature regulator, IoT-based coffee bean dryer machine

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I would like to express my sincere gratitude to Fakulti Perladangan dan Agroteknologi, Universiti Teknologi MARA (UiTM) for providing the necessary resources and facilities. Thank you also to my team members for their collaboration and insightful discussions, which enhanced the quality of this work.

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Smart Pineapple Farming Assistant Mobile Application on Identifying Diseases in MD2 Pineapple Cultivation

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Extended Abstract

Pineapple has many types of varieties that differ in color, shape, size, and flavor. The famous pineapple varieties that have been cultivated in Malaysia are Sweet Cayenne, MD2 and N36 [1]. Pineapple has a high nutritional value which gives benefits to those who consume it correctly. Pineapple is a good sourceof carbohydrates, water, dietary fiber, sugars, organic acids, vitamins (such as ascorbic acid, niacin, and thiamin), and minerals including magnesium, manganese, and copper [2]. Pineapple also contains bromelain, a proteolytic enzyme that aids in the digestion process and has therapeutic effects. Bromelain has the potential to be used as an anti-inflammatory, antioxidant, anti-cancer agent, and a substance that protects the heart [3]. In addition, Pineapple's bromelain can also be helpful for relieving menstrual issues, which is especially beneficial for women during pregnancy and menstruation by reducing water retention in the body [4]. However, there are several diseases can affect pineapple plants, causing significant damage to the crops and reducing yields. The most diseases infected pineapple cultivation is bacterial heart rot, deep eye, stem break, mealybugs caused, rhizopus rot, internal brown spot, phytophthora root rot, leaf spot, fruit spot, powdery mildewsome and more. However, this study focuses on bacterial heart rot, deep eye, stem break and mealybugs as in Fig 1.

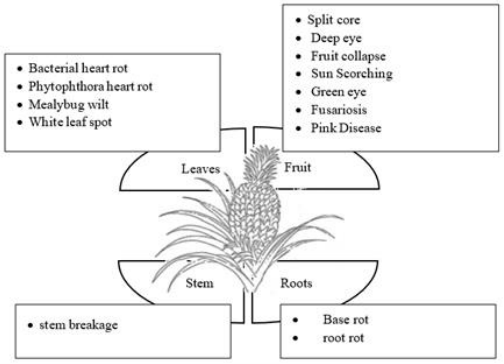

Fig 1: Pineapple disease

The study implements computer vision technique, the model was trained by using deep learning, before imported into the “Android Studio” to develop a mobile application Smart Pineapple Farming Assistant (SPFA) as shown in Fig 2.

Fig 2: Smart Pineapple Farming Assistant Mobile Application Interface (b)

Fig. 2 shows a sample interface of the system that consists of setting, gallery, camera, pineapple background, diseases and management. In the implementation phase, the SPFA mobile application was implemented as shown in figure 6 in MFL Enterprise located in Segamat, Johor and also approved for its usability by the pineapple expert that had a certificate from Malaysian Pineapple Industry Board (MPIB). Based on the study, SPFA application was well-received by users, as indicated by a System Usability Scale (SUS) score of 71.88, demonstrating positive perceptions of usability. In conclusion, the developed system has successfully met its objectives of assisting users, particularly smallholders, in identifying diseases which are Bacterial Heart Rot, Deep Eye, Stem Breakage and Mealybug Wilt and managing it in MD2 pineapple cultivation. The application has proven to be a valuable tool in the agricultural sector, providing crucial support to cultivators in disease identification and management. Smallholders can efficiently identify related diseases affecting MD2 pineapple crops, enabling them to take timely and appropriate actions to mitigate the spread and minimize the negative impact on their cultivation. The developed application has proven to be a valuable resource for smallholders in identifying diseases and managing them effectively in MD2 pineapple cultivation.

Keywords: pineapple, pineapple disease, pineapple cultivation, smallholders

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Brown Planthopper Outbreak Management with Early Warning System

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Extended Abstract

In Malaysia, the incidence of Brown planthopper (BPH) infestation has been increasing in recent years and more hopperburn cases have been reported. Heavy infestation results in significant yield loss and deterioration of the rice quality [1]. As they are also virus and disease carriers, such as the Rice Ragged Stunt and Rice Grassy Stunt, early detection systems are essential [2]. Furthermore, the symptoms of BPH only arise when the stage of infection is critical. Therefore, it is very crucial to take action before this happens. Actual observation of the BPH population in the field requires high labor usage. Therefore, the development of methods to monitor the BPH population continuously and apply the pesticide onlyif necessary is needed to prevent the outbreaks. An early warning system would be beneficial to the farmer because it would reduce the farmer's time and effort in monitoring the rice field physically. It would also give the farmer sufficient time to plan and employ appropriate pest control methods such asnatural chemical and biological control, integrated pest management, and other methods which can be very beneficial to the farmer and most importantly to the environment.

The early warning system has been developed to forecast the outbreak risk based on a model developed by Samsuri et, al. [3]. The results of the study by Samsuri et al. [3] showed that environmental parameters which are temperature and relative humidity, the age of the rice plant and the type of crop variety had a significant correlation to the number of brown planthopper populations in the field. The early warning system consists of four main components, namely a light trap system equipped with a weather station, a mobile image capture system, a system for identifying and counting BPH populationsand e-SiAAP applications for risk index mapping. Figure 1 shows the relationship between all these main components.

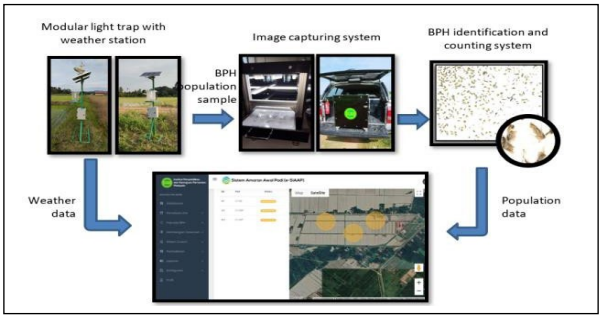

Fig 1: The main component of the early warning system.

The light trap system was used as a sampling method that uses light to attract and trap BPH. The main components of the system are a light trap box equipped with a 30W lamp, a solar panel with a capacityof 12V, 10W and a 60A battery, A3-sized sticky transparent plastic, a programmable timer and a weather station. Light traps are installed in the field according to the monitoring locations. The portableImage Capturing system takes high-resolution images of insects on plastic samples and stores the dataon a cloud server. The components consist of Raspberry Pi 4 model B processor and 6 Raspberry Pi camera modules with high-quality 16mm telephoto lenses. The system also displays the geolocation data of the pest population for the sampling area.

The BPH identification and counting system was used to identify and count the BPH found in each captured image. This system can distinguish the BPH from other insects with an accuracy of up to 90% and the efficiency of the identification and counting process is increased by 50% compared to manual methods. For the calculation of the risk and mapping the risk the e-SiAAP was used. e-SiAAP is a web-based application and can be accessed through the link https://www.siaap.my/user-login either througha computer, laptop or mobile phone. This application integrates all the data from the other componentsand produces an outbreak risk prediction map. The risk map is produced based on the model developedby [3]. Each light trap is displayed in the form of a color indicator index. Three levels of outbreak riskcolor index are green represents low risk, yellow represents medium risk and red represents high risk.

The system was successfully installed and tested in the MARDI plot at Parit, Perak and 3 other granary areas which are MADA, KADA and IADA Barat Laut Selatan for one planting season. Comparison between predicted outbreak level from the system and the actual data shows that the system was able to give the early warning of the outbreak at 100% accuracy for low-risk warning and 66.7% accuracy for high-risk warning. As a conclusion, the application of an early warning system gives farmers sufficient time to plan and employ appropriate control methods to prevent BPH outbreaks. Furthermore,it can reduce labour usage, speed up control measures and increase the efficiency of detecting the probability of a BPH infestation and possible outbreak.

Keywords: Brown planthopper outbreak, rice production, pest, early warning system

Acknowledgment

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Classification of Water Bodies in Paddy Field Using UAV-Based Remote Sensing Imagery

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Extended Abstract

Approximately 75% of rice is grown in irrigated systems, while rainfed rice is grown in one quarter of the world's rice lands [1]. Rice planting in flooded conditions requires a significant amount of water. Water scarcity, due to climate change and competition with other sectors, is impacting irrigation availability. In the rice granaries of Malaysia, there are seasonal water shortages, leading to conflicts over the use of water stored in dams. Shortages of water for rice irrigation during dry months are also frequent every year. As a result, proper water management is essential for the timely and equitable distribution of irrigation water among farmers, ensuring optimal crop production and efficient water use. Remote sensing has become a crucial tool for monitoring, mapping, and observing rice ecosystemsat various time and spatial scales [2]. It provides reliable information in an instantaneous and cost- effective manner. The Malaysian Agricultural Research and Development Institute (MARDI) has developed an image processing technique to analyze UAV-based remote sensing data. This technique was used to generate multi-temporal water bodies classification images and highlighting the status of the flooded area in the paddy field. The information from the classified images is essential for irrigationmanagers to make better decisions when managing and operating the irrigation system. A proof of concept test was conducted at MARDI Seberang Perai for monitoring flooded areas in the paddy plot using digital image processing technique. A paddy plot covering approximately 3400 m^2 was preparedon 12 September, 2012. A water flow rate of 0.0125 m^3/s was pumped using a centrifugal pump and then conveyed to the field through a flexible pipe for 3 hours. Aerial red (R), green (G), and blue (B) digital images corresponding to the paddy plot were captured using a quadcopter unmanned aerial vehicle (UAV) system mounted with a digital camera. An aerial digital image was taken every 30 minutes for a duration of 3 hours. The RGB digital images were processed using image enhancing andimage classification methods. Firstly, image enhancing was performed by transforming the RGB images to principal component analysis (PCA) images. The PCA is a statistical technique that transforms a multivariate data set consisting of intercorrelated variables into a data set consisting of variables that are uncorrelated linear combinations of the original variables. Secondly, the PC transformed image wasclassified into water and soil clusters using Iterative Self-Organizing Data Analysis (ISODATA) imageprocessing technique. ISODATA is an unsupervised classification method that uses an iterativeapproach incorporating a number of heuristic procedures to compute clusters. This clustering method uses a minimum spectral distance formula, which is based on the Euclidean distance equation to form clusters [3]. Fig 1 shows the process transforming the RGB image to PCA image and classification image. Flooded area in the paddy plot can reach 98% in 180 minutes, with a rapid 71% increase in thefirst 90 minutes. However, the flooded area slowly increases for another 90 min for flooding 21% area.This is due to uneven ground in the paddy plot. A study was conducted to map the water bodies on a 100-hectare paddy field in Kampung Setia Jaya, Yan, Kedah. Aerial red (R), green (G), and near- infrared (NIR) digital images of the paddy field were captured using the UAV system equipped with adigital camera. Two sets of aerial digital images were taken on 14 April 2013 and 18 April 2013 to

monitor the flooded areas in the paddy field. These images were transformed into PCA images and then were classified into water and soil clusters using the ISODATA algorithm. Fig 2 shows that the flooded area increased from 56% to 94% in a 4-day duration. The results showed that the average overall accuracy classification of water bodies for R, G and B images and R, G, NIR images were 98% and 96% respectively. The classified image is useful for irrigation managers to monitor the status of floodedareas in the paddy plot for water management.

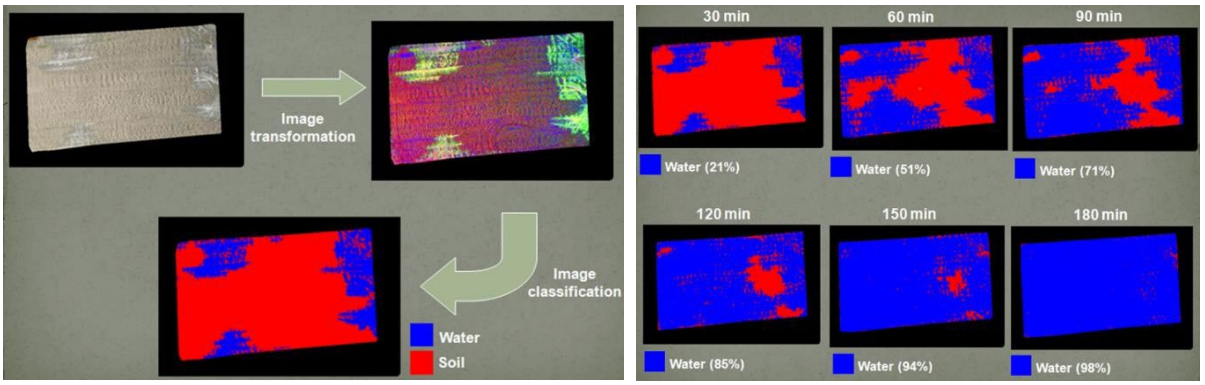
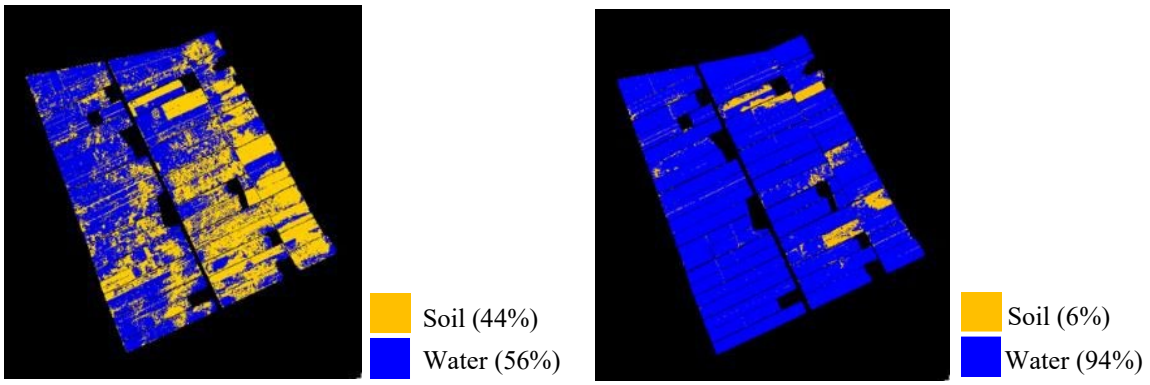


Fig 1: Process transforming the RGB image to PCA image and classification of image



14 April 2023

18 April 2023

Fig 2: Classified image

Keywords: Rice, water management, remote sensing, unmanned aerial vehicle

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Optimization of Algae Photobioreactor Cultivation and Detection using Multispectral Imaging and Machine Learning

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Extended Abstract

Chlorella sorokiniana was cultivated in a 1000L custom reactor at Ecopark, UTM, after being grown in BG11 media at 30°C in a laboratory, with a biomass concentration of 3.21 g L^{-1}. The algae growth was monitored using time-lapse and aerial imaging and supplemented daily with chicken manure to optimise growth conditions, increasing NDVI values over 30 days [1,2]. While the multispectral cameraprovided high-precision data, current segmentation methods require manual annotation, complicating analysis. The cultivation data was used to train a YOLOv7 model to detect and classify algae maturitystages, achieving high confidence scores (0.97 to 0.99) in real-time object localization, demonstrating the model's accuracy and reliability [3].

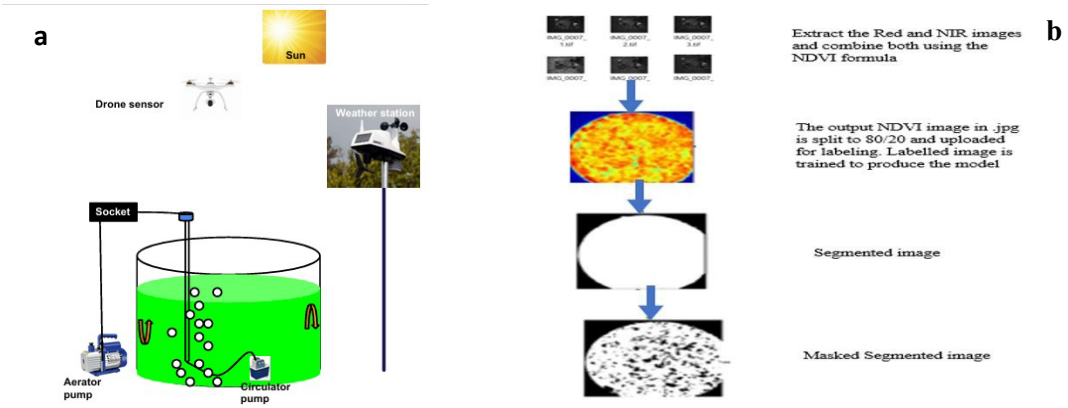
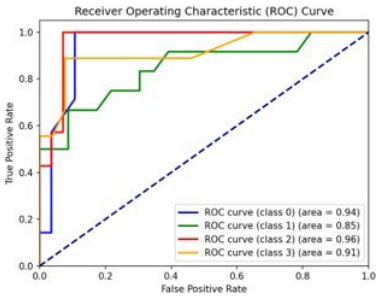


Fig. 1: (a) Cultivation setup and (b) Image segmentation

This experiment used a tank with several benefits compared to the pond or river used in several papers. First, the nutrients will always be available for the microbes and will neither be swept off nor be infiltrated by predator organisms. These will minimize data-gathering issues to the benefit of the cultivation. Moreover, satellite imaging is replaced by a drone with an attached multispectral sensor for imaging, culminating in minimal atmospheric disturbance and high temporal and real-time examination (Choi et al., 2023). A randomForestRegresssor was initialised to train and fix missing values in the dataset by prediction. The dataset was now reclassified using label encoding for maturity features. Then,a RandomForestClassifier was initialised for maturity detection with precision, recall, and F1-score, aswell as the confusion matrix, displaying the correct and incorrect predictions for each class. The ROC curves for all classes are plotted in a single graph, visually assessing the model's performance across allclasses. Figure 2a shows the ROC curve and AUC values for algae maturity detection, indicating strong

classifier performance for immature, mid-stage, and fully mature algae but weaker for early-stage maturity. Figure 2b and Table I highlight the need for improvement in detecting early-stage and fully mature algae, where misclassifications and lower recall rates are observed.

a



b

```
[[6  1  0  0]
 [3  7  2  0]
 [0  1  6  0]
 [1  1  2  5]]
```

Fig 2 (a) ROC curve (b) Confusion matrix

Table 1 Maturity Classification Report

Class	**Accuracy parameters**			
	Precision	***Recall***	***F1***	***Support***
0	0.6	0.86	0.71	7
1	0.7	0.58	0.64	12
2	0.6	0.86	0.71	7
3	1	0.56	0.71	9

Keywords: detection, optimization, prediction, processing, spectral, vegetation

Acknowledgment

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An Enhanced Genetic Algorithm for Solving the Capacitated Vehicle Routing Problem Using Cluster-Based Optimization and 2-Opt Refinement

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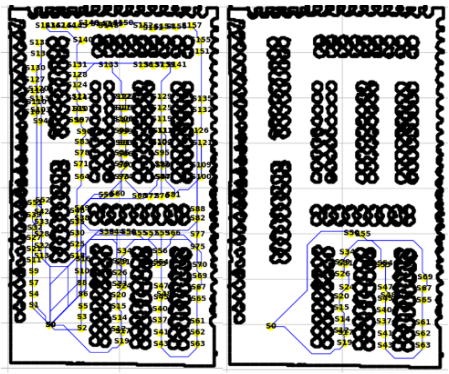
Extended Abstract

Precision agriculture (PA) employs robotic automation to optimize pesticide application, enhancing resource efficiency and minimizing environmental impact. However, treating large numbers of saplings with a single mobile robot, which has limited tank capacity, presents significant challenges— particularly when prioritizing heavily infected areas. This problem is modeled as a Capacitated VehicleRouting Problem (CVRP) aiming to minimize travel distance. The objective is to achieve this while also prioritizing the treatment of heavily infected areas to prevent the spread of infestation within the greenhouse. Many studies have explored diverse approaches to the CVRP using different algorithms, with some focusing on optimal solutions and others for near-optimal results across various applications.In certain situations, it is necessary to balance achieving optimal solutions with addressing other critical issues, such as resource allocation and specific constraints. For instance, a constrained clustering method proposed by [1] for large-scale CVRPs assumes that each cluster can be served by a single vehicle. However, this does not align with our goal of balancing travel distance minimization with the prioritization of heavily infested areas, which necessitates multiple routes due to tank constraints. Therefore, we accomplish this by clustering saplings based on spatial coordinates and optimizing routes using a hybrid Dynamic Programming and Genetic Algorithm (DPGA) approach, with 2-opt refinement [2,3]. The first step involves determining the positions of all saplings in a spatial coordinate system, then calculating the distances between each pair of infected saplings and between each infected saplingand the depot using Dijkstra's algorithm. This generates a distance matrix that serves as the foundationfor further optimization. Subsequently, k-means clustering is performed with the number of clusters k based on the greenhouse's dimensions. Prioritization is based on the percentage of infected saplings relative to the total number of saplings within each cluster. Routes are then formed by grouping infectedsaplings s around each centroid c using a distance threshold $d(s, c) \leq R$, where R is the radius threshold. The process starts with the farthest infected sapling $s = argmax(d(s, depot))$ from the depot, ensuring that the total pesticide demand $\sum_{s \in C_k} q_s \leq Q$ (where q_s is the demand of s in cluster C_k
and Q is the vehicle's tank capacity), adheres to the vehicle's constraints within each cluster. In cases where the number of infected saplings exceeds the tank capacity, the robot will refill and return to the same cluster to accommodate the remaining saplings. On the other hand, if the remaining saplings within a cluster are fewer than the tank capacity, the robot will move to the next cluster, treating additional saplings to fully utilize the tank capacity. Each route is optimized using DPGA, followed by2-opt local search to minimize total travel distance. Findings are shown in Figure 1.a, which depicts theoptimized routes for 157 infected saplings, while Figure 1.b highlights a prioritized route based on infestation levels, with the depot labeled as S_0 and saplings marked as black circles. These are presentedwithin a simulated greenhouse measuring 9.3 meters wide by 15.7 meters long and featuring approximately 250 saplings. For a relevant comparison, we evaluated our results against Google's OR-

Tools Routing Library [4]. Although OR-Tools calculates routes efficiently, it does not prioritize areas, unlike our algorithm, which balances route efficiency with area prioritization. Table 1 shows the gap in performance across three examples, demonstrating our algorithm's balance between route efficiency and prioritization. In conclusion, the proposed hybrid approach effectively optimizes clustering routes for precision agriculture. In comparison to OR-Tools, the proposed method demonstrated gaps of 19.60%, 15.18%, and 9.17% for instances with 120, 157, and 197 saplings, respectively. Even with promising results, particularly given that distances are calculated using Dijkstra's algorithm to accountfor obstacles rather than Euclidean distances, the gaps indicate room for improvement. Future researchshould focus on refining both clustering and optimization techniques to further reduce the gap and achieve more practical and efficient solutions.

Table.1 Comparison of travel distance between OR-Tools and the proposed algorithm for differentsapling instances

Saplings	Or-Tools	Proposed Algorithm	Gap %
120	13557	16214	19.60
157	17435	20082	15.18
197	21174	23115	**9.17**



(a) (b)

Fig 1: (a) Optimized routes for 157 infected saplings out of 250, (b) Prioritized route based oninfestation levels

Keywords: Precision Agriculture, Capacitated Vehicle Routing Problem, Dynamic Programming Genetic Algorithm, Clustering, 2-opt Heuristic

Acknowledgment

The authors acknowledge Universiti Teknologi Malaysia and Ministry of Higher Education Malaysia, for their financial support through two research funds, Vote No. R.J130000.7723.4J626 and R.J130000.7323.4J686.

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Development of Internet of Things (IoT) Monitoring System for Kelah Fish

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Extended Abstract

In kelah (*Tor tambroides*) hatcheries, maintaining optimal water quality is crucial to ensure a conducive growing environment. Based on our observations at a local commercial kelah hatchery in Johor, Malaysia, revealed that the water quality monitoring process was conducted manually, with a dedicated worker measuring key parameters daily. These parameters typically include water pH, temperature, dissolved oxygen (DO), and ammonia levels. These parameters are important to maintain a healthy aquatic environment, which directly influences the growth and survival of fish species [1-3]. To address the limitations of manual monitoring, this paper presents the development of an Internet of Things (IoT) monitoring system for kelah fish in hatchery settings. The core components of the monitoring system are as shown in Table 1 and the block diagram illustrates how various components of the system interact is shown in Figure 1:

Table 1: Key components of the IoT monitoring system for kelah fish in hatchery setting

	Components	Function
1	Arduino ESP32-WROVER-IE	A microcontroller that serves as the brain of the monitoring system, managing sensor data and handling wireless communication.
2	RS-PH-N01-3 integrated pH and temperature transmitter	Responsible for measuring essential environmental parameters including pH level and water temperature and transmit continuously reports to the monitoring system.
3	RS-LDO-N01-2 fluorescent DO transmitter	Tracks the DO concentration in the hatchery water. Proper oxygen levels are vital for the respiration of fish and other aquatic organisms, making it crucial to monitor and maintain these levels.
4	Vultr cloud platform	The data collected from the sensors is uploaded to this cloud platform for real-time analysis and storage. The cloud enables remote monitoring of water quality and allows users to access historical data to make informed decisions.
5	Telegram app	A Telegram bot is integrated into the system to provide real-time notifications and automatically alerts users if any water quality parameter falls outside the predefined safe limits. Users can also manually request current water quality data through the app, to ensure that critical updates are easily accessible from anywhere with internet connectivity.

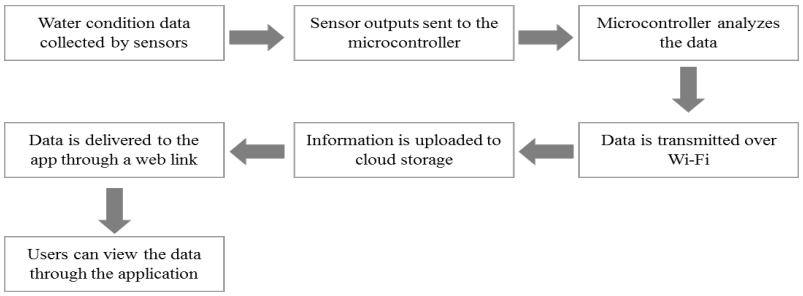

Figure 1: The block diagram illustrates how various components of the system interact

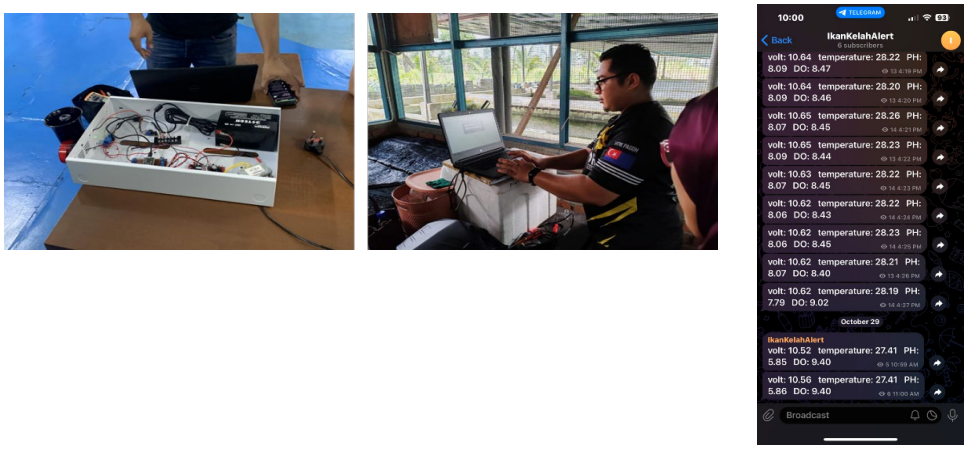

Figure 2: (left) The monitoring system, (middle) on site testing, (right) Telegram bot

Keywords: kelah, internet of things (IoT), aquaculture, monitoring

Acknowledgment
Authors would like to thank for the support from Universiti Teknologi Malaysia for providing funding for this project under grant UTMSPC 2.8: IOT Based Breeding Monitoring System for Kelah Fish Broodstock Performance (R.J130000.7723.4J619).

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Smart Pineapple Farming in Peatland: IoT-Based Early Warning System for Monitoring Fire Vulnerability

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Extended Abstract

Peatlands, including pineapple plantations in the Tangkit Village Peat Agriculture Area, Jambi, Indonesia, are prone to drought due to hydrological factors affecting moisture content. Manual monitoring of peat water content with peat soil samples is resource intensive. Necessitating more accessible parameters, such as groundwater level, strongly correlated to moisture content [1]. The groundwater level must not be 40 cm below the ground surface as a critical limit of fire vulnerability. This study investigates a smart agriculture system for pineapple plantations using Internet of Things (IoT) technology, focusing on the relationship between fuel characteristics, weather conditions, and groundwater level as a fire early warning parameter. IoT in the peat pineapple plantation area consists of weather and fuel sensors. The sensors are divided into two: a weather sensor installed at a height of 2 meters above, a fuel sensor on the surface and a groundwater level sensor installed below the surface. The network is a LoRaWAN gateway with 3 watts of electricity, while the IoT power is from an 18 WP Solar Panel. Data collected from IoT devices during October-November 2023 includes groundwater level, rainfall, temperature and relative humidity. The Internet of Things (IoT) architecture consists of three main layers (Figure 1a): devices, networks, and applications. The first layer is a sensor that collects environmental data in real time. These data are then sent through the network. The last layer is an application that can process, analyze, and generate data displays for users or be used to control devices automatically.

These data were analyzed using correlation tests in R Studio to determine the relationships among parameters and assess fire vulnerability. The distribution of fluctuations in data on groundwater level parameters, relative humidity, temperature and rainfall is shown in Figures 1b and 1c. Fuel conditions cause fluctuations in groundwater levels and weather changes over a certain period. The IoT device successfully recorded the values of various parameters in various ranges. Groundwater level ranged from 27.72 - 49.82 cm, Rainfall ranged from 0 - 30.60 mm/day, temperature ranged from 23.43 - 30.88°C and Relative Humidity ranged from 69.11-99.16 VWC. The fluctuations of each parameter are interrelated. The relationship between each parameter and the parameter that has the most influence on the groundwater level is shown in Figures 1d and 1e. Then, the correlation test shows the most influential parameters and indicates the vulnerability range of all parameters. The correlation of groundwater level with the other three parameters varies. The correlation of groundwater level with rainfall and temperature shows a value of -0.15 and -0.09, which indicates a negative correlation, meaning that the higher the rainfall and temperature value, the lower the groundwater level value or, the closer it is to the ground surface so that the water content is greater. Conversely, the relationship between humidity and water level shows a positive value of 0.16, where increasing humidity also increases the groundwater level value. This is because the greater groundwater level value, the further it will be from the surface and cause drought; this is what causes fire vulnerability to also be influenced by weather factors [2].

This study shows that of the three parameters tested for their influence on groundwater levels, the most critical order is known to be relative humidity, temperature, and rainfall. This is in accordance with research [3], which shows the importance of these three parameters in estimating groundwater level values. In addition, if the data are observed in more detail, rainfall consistently affects increasing groundwater levels. Increased rainfall causes an increase in groundwater levels one day later, so prolonged droughts can be dangerous for decreasing groundwater levels. The results of this study explain smart pineapple agriculture, which can be monitored in real time using an Internet of Things (IoT) system. Continuous monitoring of groundwater levels can help understand the spatiotemporal fluctuations of subsurface water resources.

This data can be used to study climate variations that can be used in estimating fire vulnerability [4]. This study underscores the value of IoT technology in improving monitoring efficiency for fire vulnerability pineapple plantations on peatlands, offering insights for stakeholders to enhance fire management. The synergy between technological and socio-economic approaches must be prioritized in peatland fire control in Indonesia through multi/transdisciplinary approaches to achieve greater effectiveness [5]. This study recommends pineapple plantation farmers on peatlands to understand and observe weather changes that affecting to groundwater level decline.

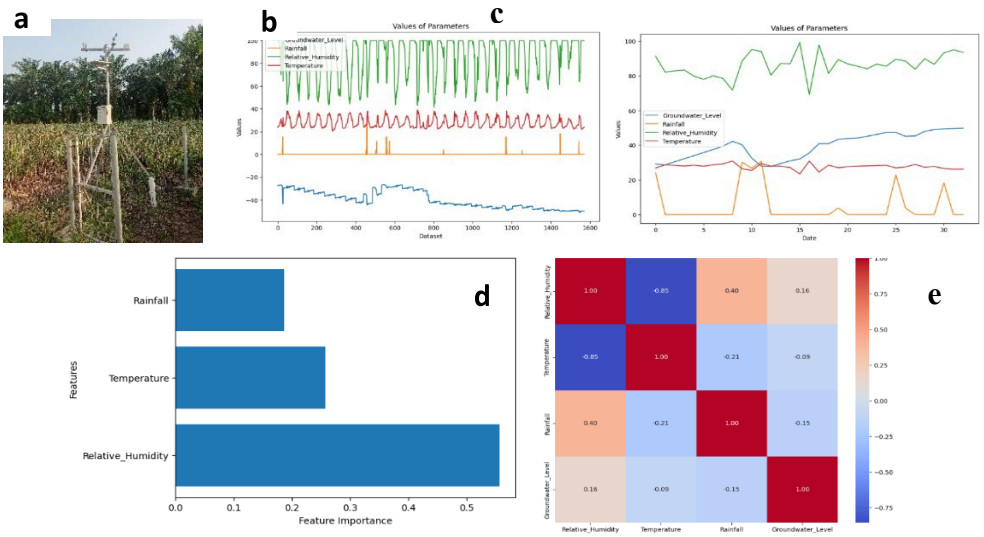

Fig 1: (a) IoT devices in the middle of a pineapple plantation; (b) & (c) Fluctuations in changes in groundwater level, temperature, humidity and rainfall during one month; (d) & (e) Feature important and correlation matrix

Keywords: Fire, internet of things, peatland, pineapple plant, smart agriculture

Acknowledgment

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Sustainable Certification in the Oil Palm Industry: A Comparative Analysis of MSPO, RSPO, ISPO and ISCC Schemes

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Extended Abstract

Palm oil is a very versatile raw material, used in everything from food products to cosmetics and biofuels. Yet, the industry is not without its sustainability challenges deforestation, biodiversitydepletion and social problems like violations of labour rights or displacement of local communities. The increasing challenges in maintaining the industry have brought more scrutiny, along with calls for further sustainability. Certification schemes have evolved into a viable mechanism for mitigating the impacts of unsustainable practices in palm oil production. They outline criteria for environmental and social responsibility, designed to reduce the damage associated with palm oil production. This enablesproducers to show their dedication to sustainability, which can improve their access and reputation in the market. Note that certification schemes also contain a framework to trigger the structural changes well as new practices need time for adoption. This concept paper compares four important certificationschemes – Malaysian Sustainable Palm Oil (MSPO), Roundtable on Sustainable Palm Oil (RSPO), Indonesian Sustainable Palm Oil (ISPO) and International Sustainability & Carbon Certification, in order to assess their efficacy in the promotion of sustainability within the oil palm industry. Through an investigation of the governance structures, standards, verification processes and market recognitionenjoyed by these schemes, the study aims to identify where they may or not be performing well with respect to sustainability impacts.

MSPO is a national standard developed by the Malaysian Government for oil palm industry sustainability in Malaysia. Initially introduced in 2015, MSPO (MS2530:2013) was later made mandatory by the end of 2019 for all oil palm industry players in Malaysia. The certificate has undergone a revision incorporated with very different industry baseline knowledge on sustainable oil palm management practices and is now under the application of MS 2530:2022 [1]. The main aim of MSPO certification is to show that Malaysian palm oil production meets the sustainability and credibility needed by international markets. Its existence helps change the industry image and make it universally acceptable, adopts corporate environmental responsibility for species conservation. Being amechanism to elevate palm oil management systems of an organization through sustainability and providing benefits for businesses such as cost reduction, better working safety principles, practices, andprotection towards smallholders' rights, the MSPO certification is significant.

Malaysia has a long history regarding the uptake of Roundtable on Sustainable Palm Oil (RSPO) certification, dating back to its formation in 2004 as an international response towards increasing global concerns over environmental impact and social fallout of palm oil production [2]. The way to seize the RSPO certification process in Malaysia will involve many steps, such as a challenging audit process using an accredited certification body. The process requires all companies to complete initial

assessments, annual surveillance audits and recertification every five years in order to keep their certificate. The Malaysian government has been supportive of the RSPO certification process because they have acknowledged that it is needed to ensure sustainable palm oil in Malaysia.

The ISPO was implemented in 2011 through a government regulation, making it a mandatory certification scheme for nearly all palm oil producers operating inside Indonesia. As the international dimension of palm oil environmental and social concerns increasingly emerged as an issue in Indonesia, pressure also grew to enforce a series of sustainability measures' including efforts by global buyers to exclude production from unsustainable production. The ISPO certification itself is built on seven principles: legality, plantation management, environmental and social plantations stewardship including observations of laws concerning labor rights & responsibilities, continuous business improvement and marketplace transparency. The significance of ISPO certification is that it can enhance the sustainabilityas well as international acceptance to Indonesian palm oil. It acts as a vehicle to show that national regulations are being met and sustainable practices applied — improving market access and concurrence. The International Sustainability and Carbon Certification (ISCC) standard, established in2006 from an open multi-stakeholder process that began with sustainability for biomass production only. Over the years, it has evolved to support an increasing number of sustainable feedstocks – including agricultural and forestry biomass, biogenic wastes, and residues as well as circular materials.

The RSPO model, a multi-stakeholder approach to standard setting is in clear distinction to MSPO or ISPO which are essentially government-led (covering all sustainability targets) and applications for even the palm oil supply base. Each standard and criteria of each scheme is reviewed for its environmental, social, and economic outcomes. There is some sort of discussion on deforestation, biodiversity and greenhouse gas emissions in all schemes, focusing on social aspects such as labour rights or community relations. To be credible, certification schemes must have auditing and enforcement mechanisms. All four identified third-party audits to assess supplier compliance but the specificity and transparency of practices differ. Market demand for certified products is also uneven, with the RSPO enjoying highest level of international standards and price premiums. The results pointto some of the specific advantages and challenges each scheme present. The RSPO with its wide sustainability coverage globally, while MSPO and ISPO which have strong national frameworks aligned to the local legislations provide a comprehensive approach concept. The study concludes that stakeholder engagement, transparency in auditing and potential harmonization opportunities could enhance the effectiveness of these schemes. Concerning the policy context, future research should inquire into how certification operates at scale to maintain sustainability in combination with studies on governing forestry towards an end where policies need to broaden from specific initiatives to wider- focused frameworks.

Keywords: Sustainability, palm oil supply chain, sustainable agriculture, sustainability certification

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Utilization of Selected Agro-waste for Soilless Cultivation on Tomato

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Extended Abstract

Soilless culture offers opportunities to provide optimal conditions for plant growth and reduces the challenges facing soil-based farming. Efforts should be escalated to establish and expand soilless media, asbeing an important input in sustainable agriculture. Application of agricultural waste such as empty fruit bunches and coconut husks significantly improved the quality parameters, nutrient uptake, and fertility status of crops. Planting media is a major determinant of plant growth and crop yield as it affects growth and nutrient cycling in agriculture. The interface between plant roots and the environment significantly influences vegetable plant growth and yield. Tomato (*Solanum lycopersicum*) was chosen and grown in thisstudy. Tomato is one of the most widely cultivated and economically significant vegetable crops globally.It is a staple in diets worldwide, valued for its rich nutritional content, including vitamins A and C, potassium, and antioxidants such as lycopene. Tomatoes are also highly versatile, used in a variety of culinary applications, from fresh salads to processed products like sauces and juices [1].

Therefore, this study aims to determine the effectiveness of selected agricultural waste as a soilless mediumon the growth of tomato (*Solanum lycopersicum*) and its potential application for sustainable agriculture. Selected agro-waste of empty fruit bunches (EFB), rice husks, and coconut husks were mixed as a soilless medium for tomato. Soil and mixed soil were used as a control treatment for comparison with the soilless medium. The tomato seedlings were transplanted 19 days after sowing (DAS) with 3-4 leaves and a heightof 7.6 cm. Plant growth parameters (height and number of flowers) and yield (fruit) are recorded for thirteenweeks from transplanting. The collected data were subjected to statistical analysis using appropriate methods like analysis of variance (ANOVA) to compare the growth performance of tomatoes across different planting media treatments. Data interpretation was focused on evaluating the effectiveness of various agricultural waste-based planting media on the growth and productivity of vegetable crops.

Tomatoes grown in soilless media demonstrated better growth recorded early 7 days for flowering and fruiting stages compared with control media (soil). The time points correspond to the development stages of tomatoes in conventional soil and serve as a reference for comparison [2]. The observations made on soil medium act as a control where normal tomato development under conventional farming is expected. The tomatoes that were grown in the soilless medium, had a faster growth rate compared with normal growth (soil). This early flowering, with an 80% advancement compared to the soil medium, indicates that the soilless medium creates conditions that expedite vegetative growth and the development of reproductive structures. This acceleration is attributed to improving the quality of nutrients and water in the soilless media, which increases the efficacy of plant growth [3]. This rapid increase in the growth rate of the soillessmedium can be acknowledged to the appropriate nutrient and water supply. The ability to advance the stagesof growth is especially helpful in commercial farming since it helps to grow crops at a quicker pace therebyincreasing yields, and hence, revenue. The systems improve root aeration and disease control, increasing plant health and vigor [4]. However, the mixed soil planting medium had a different growth pattern in the study. Mixed soil medium grows at a lower rate than soilless medium due the its characteristics affect water

and nutrient management in planting media. A mixed soil medium is not as effective as a soilless mediumin encouraging fast plant growth.

The one-way ANOVA analysis for tomato yield across different planting media (soilless, soil, and mixed soil) (Table 1) showed no statistically significant difference, with a p-value of 0.068, though it was close to the significance threshold ($p < 0.05$). Despite soil media yielding the highest individual value, the standard deviations suggest variability across treatments.

Table 1: One-way ANOVA of Tomatoes Yield with Different Types of Planting Media

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.009	2	0.004	4.054	0.068
Within Groups	0.007	7	0.001		
Total	0.016	9			

Soilless medium had a positive impact on tomato growth and yield better than soil medium. The soilless medium enhanced growth stages by 20% with plants achieving a height of 125% of those in the soil by 35 days after transplanting (DAT). Also, the mean yield under the soilless medium was 11.80% higher at 0.118kg per plant compared to the yield obtained using a soil medium of 0.08kg. The findings of this study imply that turning agricultural waste into a soilless planting medium not only increases plant productivity but also aligns with sustainable agriculture goals by reducing waste and improving resource efficiency. This approach offers an effective solution for developing the sustainability and effectiveness of growing tomatoes and other crops.

Keywords: Agriculture waste, soilless media, tomato, sustainable agriculture

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Mechanization Package for Pineapple Production on Peat Soil in Malaysia

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Extended Abstract

The mechanization technology package for pineapple cultivation on peat soil includes prime movers and machinery for various production stages: land preparation, planting, crop care, harvesting, and post-harvest waste management. The primary key to using mechanization in peatland conditions is to knowthe soil's bearing capacity to accommodate the machinery load on the surface of the peatland. Peat soilhas a low soil-bearing capacity in most areas, less than 0.3 MPa. The Kubota L3800 tractor, equipped with a rubber track system to reduce surface contact pressure, has been used as a primary prime moverfor operating in peat soil conditions. This tractor has been modified with all four wheels replaced by rubber tracks that are 350 mm wide. Using these tracks creates a ground contact surface of 2.36 m² andproduces a surface contact pressure as low as 0.0075 MPa for the tractor's dry weight of 1,805 kg (unladen weight). The same tractor using standard wheels has a surface contact pressure of 0.08 MPa, with a ground contact area of 0.142 m² and a dry weight of 1,125 kg. Additionally, the axle height has been increased from 340 mm to 800 mm to enable operation within the crop area. The key to using mechanization in pineapple production for peat soil is the prime mover that can hold weight soil bearing and operate in peat soil conditions. This mechanization package has been divided into five sections/operations: Design farm layout for mechanization to ensure that mechanization can be used smoothly and efficiently, mechanization of land preparation, mechanization assistance in planting, mechanization in crop maintenance, mechanization of harvesting assistance, and post-harvest residue management, as shown in Figure 1. Some of the machines implemented in this mechanization technology package are specifically designed for use in peat soil with small-scale sizes and adopted existing machines in the markets that suit our local soil condition. These machines and implements, such as pedestrians, are either mounted on tractors or operated independently. The total cost of the package technology is estimated at RM406,000. Based on studies and observations, this mechanizationpackage has significantly increased pineapple production productivity and reduced time consumption, as it enhances operational efficiency, reduces labor dependency, improves crop yield and quality, mitigates labor shortages, optimizes soil management, ensures uniformity in crop production, enhancessafety and facilitates scalable agricultural practices.

Figure 1. Mechanization Package for Pineapple Production on

Keywords: Mechanization package, Peat soil, machinery, Pineapple

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Elucidating the Use of Paddy Waste (Rice Bran) in Poultry Feed toImprove Broiler's Meat Quality

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Extended Abstract

Chicken production has been important to human society for thousands of years, and the demand for animal protein meals is increasing the need for stable protein sources. Chicken feed additives raise chicken prices, a vital protein source. Chicken feed accounts for 70–80% of farm output costs. Currently, researchers are developing low-cost diets to meet nutrient needs and improve grill starter andfinisher meat quality [1,2]. It is also demand for halal animal feeds. Therefore, the objective of this study was to produce organic poultry feed from locally generated rice bran, one of the common agricultural wastes. It was introduced as a commercial feed option to improve chicken development andmeat quality. This study involved 500 commercial strain grill chicks, with each group consisting of 50chicks. Group A was provided with commercial meals formulation and group B was received the test meals formulation. Battery brooder chicks received initial meals for 8–14 days, followed by the administration of a test diet for 60 days. We quantified dietary intake, excrement production, and breastand thigh tissue. We also assessed the grill meat's quality by examining the post-mortem muscle micro- structure, colour, and cooking shrinkage. The post-mortem micro-structure of the muscle, which affects colour and water retention capacity, directly determines the quality of grill meat. By utilising a colourimeter, we assessed the hue of the meat and measure the CIE system colour profile and pH value24 hours after death. We quantified the cooking loss by measuring the weight loss during roasting andexamined the total lipid content in both raw and roasted breast and thigh meat, including the skin. Lastly,water retention capacity was measured using the Wierbicki and Deatherage methods.

As in figure 1 (I) shows the meat color analysis at 24 hours after slaughtering, the results reveal that group A score rate for brightness at early phase of PSE (pale, soft and exudative) reading whereas broiler group B score only 50.62 within the allowable range for normal meat. After 10 days preservation,the score rate for group A entered in PSE range as the reading to 59.25 whereas group B, it shows consistency of brightness score rate at 52.83 still in at normal score rate for broiler's meat brightness. A major problem in poultry industry recently is the increasing of PSE meat in broiler's production (PSE)-like ($L^*>53$, pH24 h<5.7) and 60 normal ($46<L^*<53$, 5.7<pH24 h<6.1) according to [3]. The innovative formulation of meals has shown the enhancement of firmness, leanness, and durability of chicken flesh. The graph as in figure 1 (II) reveals a slight difference in quality level between group Band group A, with group B experiencing a more consistent pH drop, whereas group A experienced a rapid drop, resulting in a pH score of 3.95 at 24 hours. Water-holding capacity refers to the ability of postmortem muscle to retain water despite external pressures. Unacceptably high moisture loss, often known as purge or drip loss, is a common issue in broiler meat quality. Pectoralis major's group A meatexperiences 30.96 higher moisture loss per gram than group B meat, causing an increase in the meat's pH value. Pectoralis major's group A moisture loss in gram is 30.9650 higher than group B, causing rapid losses in broiler meat and increasing its pH value. Therefore, rice bran could replace corn and soybean meal as poultry feed. The quality test of livestock meat products reveals firmer, less fat meat,

more durable meat with less water content, and a weight reduction of 200-320 grams compared to other food formulations in the market. In conclusion, rice bran, an agricultural waste, has been shown to provide an improved nutritional composition for feed formulation [4]. These findings suggested that agricultural waste byproducts include the capacity to improve the nutritional value of chicken meat andboost poultry earnings.

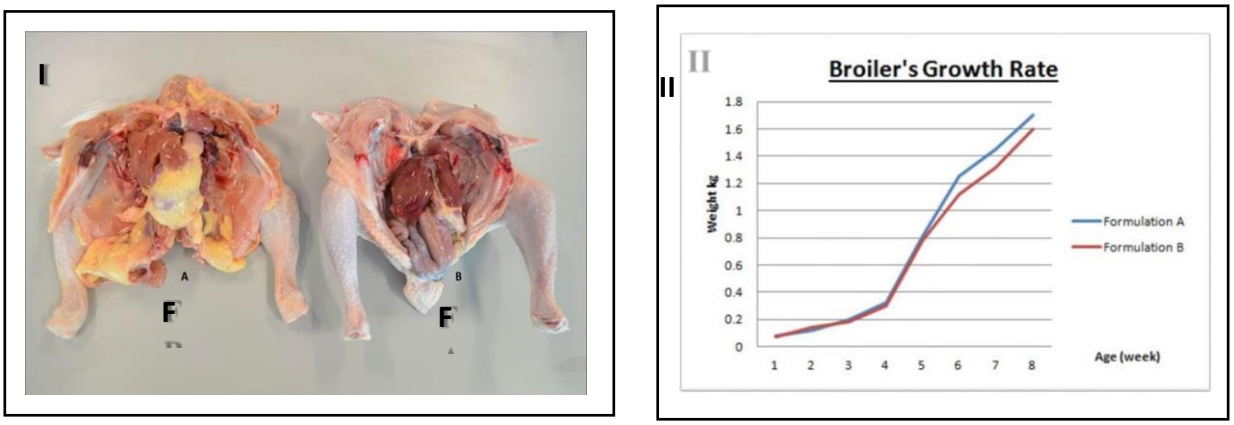

Fig 1: Comparison between (I) meat appearance (FA: conventional feed formulation, FB: tested feed formulation), and (II) broilers growth rate between these two feed formulations.

Keywords: Chicken feed, alternative protein, agriculture waste, chicken meat quality, poultry

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Green Synthesis of Selenium Nanoparticles Using Leaves Extract of *Psidium guajava*

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Extended Abstract

Selenium is an essential micronutrient for various organisms, including humans, animals, and plants, when consumed in small amounts. However, excessive selenium can be harmful and toxic. Selenium exhibits biological functions such as antioxidant activity, antagonistic roles, immune regulation, and antifungal capacity [1]. In contrast to organic and inorganic selenium molecules, selenium nanoparticles (Se-NPs) are considerably less hazardous. The utilization of nanoparticles in nanotechnology is steadilyon the rise. Additionally, the biosynthesized Se-NPs differ from those produced by chemical and physical processes in that they are more suitable with human tissues and organs [2].

The synthesis of selenium nanoparticles (SeNPs) using plants, specifically *Psidium guavaja* L. leaves,as a reducing agent offers several advantages over conventional methods. Both chemical and physical processes include harsh toxic chemicals that result in substances that are detrimental to the environment,are therefore very expensive, and require sophisticated energy-specific instrumentation [3]. *Psidium guajava*, popularly known as guava, is a big dicotyledonous tree of the *Myrtaceae* family. Guava leaf extracts contain phytochemicals such as vitamins, flavonoids, and phenolic compounds, catechia, and gallic acid, which act as reducing and stabilising agents during nanoparticle synthesis [4]. This study aims to synthesize selenium nanoparticles using *Psidium guavaja* L. leaves extracts

The synthesis of SeNPs was performed by mixing guava leaves extract with sodium selenite (Na_2SeO^3) solution. The mixture was then put inside the microwave to complete the synthesis reaction. Change of the colour to red was monitored in these experiments as evidence for selenium nanoparticle formation. The synthesized nanoparticles were then subjected to various characterization techniques including UV-vis spectroscopy, Fourier-transform infrared spectroscopy (FTIR) and dynamic light scattering DLS. Using UV-Vis spectroscopy, absorption peak was observed at about 275 nm, which indicated formation of the selenium nanoparticles. This peak, which indicates a successful synthesis, is indicative of surface plasmon resonance (SPR) in selenium nanoparticles. SeNP content and peak intensity were correlated, indicating an effective reaction and evenly distributed nanoparticles in the solution. Through the FTIR analysis, significant peaks at 3266 cm^{-1} and 1636 cm^{-1} were detected. Thesepeaks correspond to hydroxyl (–OH) and carbonyl (C=O) functional groups, respectively. The presenceof hydroxyl groups, as indicated by the peak at 3266 cm^{-1}, may contribute to the stability of the producedSeNPs. The peak at 1636 cm^{-3} is linked to carbonyl groups, suggesting that several bioactive substancesfrom the guava leaves extract were involved in the stability of the nanoparticles and the reduction of selenium ions. These functional groups are essential for the interaction between the biomolecules in theextract and the selenium nanoparticles, which improves the stability and performance of the produced nanoparticles. The DLS analysis showed that synthesized SeNPs were found to have high levels of intensity size distribution of 89.9% with an average size of 127.4 nm. Based on this, it may be inferre

that a considerable percentage of the nanoparticles have uniform sizes, which is necessary to provide consistent properties across many applications such as nanofertilizer.

In conclusion, this study successfully biosynthesized selenium nanoparticles using *Psidium guavaja* L. leaves extract through a green synthesis method. Further research and development in this area could lead to the utilization of these green synthesized SeNPs in various biomedical and agriculturalapplications.

Keywords: Selenium nanoparticles (SeNPs), *Psidium guavaja* L. leaves, green synthesis.

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A Semi-Continuous Sub-Critical Water Process for Recovery of Palm Oil and Valuable Material from Oil Palm Empty Fruit Bunch (EFB)

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Extended Abstract

In Malaysia, empty fruit bunches (EFB) are commonly mulched in plantations due to legal restrictionson burning. However, it requires significant manpower and can attract pests. The process involves shredding and pressing EFB to extract residual oil, but the fibrous nature of EFB results in a low oil yield of just 1.5%, making the method inefficient. Existing extraction methods using organic solvents such as Soxhlet extraction and supercritical liquefaction, struggle with issues like low efficiency, high costs, and the use of toxic solvents. Therefore, strategies in extracting value-added products and treating EFB using an environmentally friendly solvent and process is required to minimize the disposals.

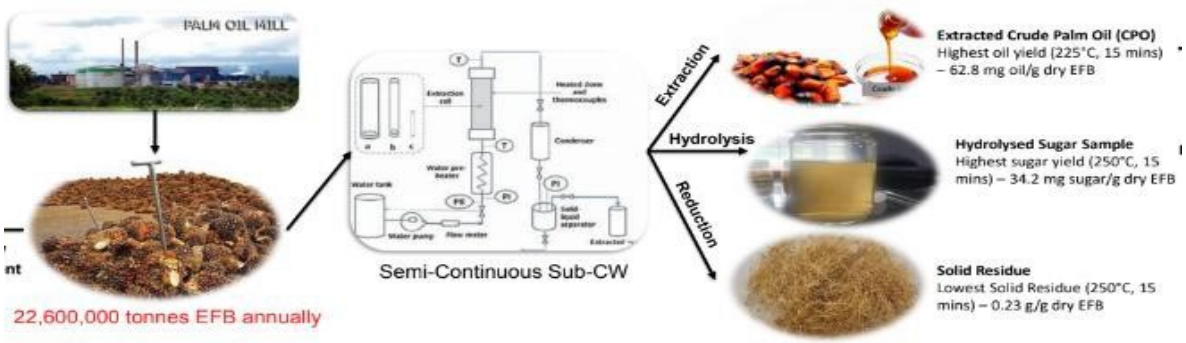

Fig 1: Summary of the Semi- Continuous Sub-CW Process

In this study, EFB sourced from Sime Darby Labu Palm Oil Mill was cut, dried and weighed to about 5 grams before treating with Sub-CW in a semi-continuous process equipment as shown in Figure 1. Prior to the treatment process, the continuous process equipment which only allowed liquid treatment was assembled to integrate a reactor using 2 Swagelok fittings to allow the solid treatment of EFB. Sub-CW has a relatively low dielectric constant of water due to weakening of hydrogen bonds of water at higher temperature and this makes Sub-CW behave like non-polar solvent. This characteristic of Sub- CW enables it to efficiently extract oil from EFB. Similarly, as temperature increases water's ionic production constant also increases drastically which maximizes hydrolysis of hemicellulose in EFB intosugars. This not only produces sugar but also reduces the EFB mass as it degrades into sugars ultimatelyreducing waste.

A 5 g sample of dried EFB is loaded into the reactor and tightened before 100 ml of distilled water is circulated into the reactor at 20 ml/min under 30 MPa pressure after getting heated in the salt bath, causing Sub-CW to hydrolyze the EFB and extract oil. The Sub-CW sample, is then cooled and

collected. After the reaction time, the sample is collected, centrifuged to separate the oil-hexane and aqueous layers. The oil-hexane layer is dried and weighed to determine oil yield, while the aqueous phase's total sugar content is analyzed using the phenol-sulfuric acid method with a UV-VIS spectrometer. The extracted oil undergoes GC-MS analysis to detect the presence of free fatty acids (FFAs), which are important for assessing the quality of crude palm oil (CPO).

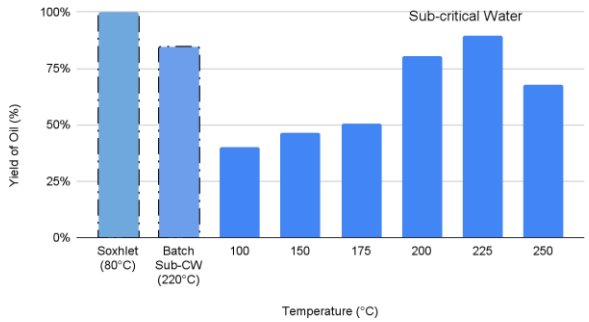

Fig 2: Efficiency of semi-continuous sub-CW extraction of oil at various temperatures (15 min) when compared to Soxhlet extraction and batch Sub-CW

The study assessed the efficiency of semi-continuous sub-CW extraction for oil by comparing it to the Soxhlet extraction method as illustrated in Figure 2. Sub-CW extraction achieved 89.5% efficiency relative to Soxhlet, indicating it is highly effective for extracting oil from empty fruit bunches (EFB) without using harmful solvents. It can also be observed that the oil yield was highest at 225°C with 62.8 mg-oil/g-dry EFB recorded. Additionally, sub-CW extraction was more efficient than batch sub-CW extraction by [1], which had an 84.5% efficiency. Overall, the study highlights the superior efficiency of semi-continuous sub-CW extraction compared to traditional methods like Soxhlet.

Keywords: oil palm empty fruit bunches, semi-continuous sub-critical water (sub-CW) process, Soxhlet, free fatty acids

Acknowledgment
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Yield and Quality Evaluation of Vertical-Grown Microgreens Cultivatedon Different Substrates

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Extended Abstract

Substrates significantly impact the yield and quality of microgreens, offering valuable insights for growers to select optimal growing mediums [1]. Coco peat contains essential macro- and micronutrientssuch as potassium, phosphorus, and calcium, and helps neutralize soil acidity while improving water retention and aeration [2]. Peat moss, on the other hand, provides ideal physicochemical conditions, enhancing biomass output and growth rate, though it may lower phenol concentrations. Microgreens grown on natural fiber substrates tend to show higher nitrate and macro-mineral content compared to those grown on synthetic substrates [3].

Microgreens, immature plants harvested 10–14 days after sowing, offer unique nutritional benefits and have gained popularity for their vibrant colors, flavors, and high nutraceutical value due to their bioactive compounds like antioxidants and vitamins [4]. Broccoli microgreens, for example, are rich in glucosinolates, which have anti-inflammatory and antibacterial properties [5]. However, despite their health benefits, microgreens have limitations, such as rapid quality decline post-harvest, restricting their commercial reach (Bulgari et al., 2021). Thus, the aim of this project was to investigate the influence of different growing media (coco peat and peat moss) on yield and quality evaluation of microgreens (*Broccoli - B. oleracea var. Italica* and Green basil - *Ocimum basilicum L*).

Two varieties of the microgreens, were each weighed at 3 grams and sown on two substrates: 200 gramsof coco peat and 700 grams of peat moss, in germination trays. The substrates were lightly moistened and the seeds evenly distributed. Coco peat trays received 1.2 liters of water, while peat moss trays received 1.0 liter. After a four-day blackout phase, the trays were exposed to a 16-hour light/8-hour dark cycle. On day 6, microgreens were irrigated with half-strength Hoagland's solution. Growth was maintained at 23°C for 21 days. Yield was determined by measuring fresh weight and height. The quality measurement based on Chlorophyll a, b, and total chlorophyll were quantified using a spectrophotometer, while total phenolic content (TPC) was assessed via a gallic acid standard.

Two-way ANOVA revealed striking differences in the yield and quality of broccoli and green basil microgreens grown on coco peat and peat moss. Three variables—fresh weight, total chlorophyll, and phenolic content—were significantly affected by both the microgreen species and substrates. Broccolion coco peat achieved the highest fresh weight (35.76 ± 4.68 g), whereas green basil consistently showed lower weights. Height was unaffected by substrate choice.

Fig 1: Microgreen's in vertical grown rack, broccoli microgreen cultivated on coco peat and greenbasil microgreen cultivated on coco peat

Green basil on coco peat had the highest total chlorophyll content (22.83 ± 0.01 mg/mL), demonstratingthe substrate's significant impact. Broccoli grown on peat moss exhibited the highest phenolic content (103.11 ± 10.09 mg GAE/g), likely due to peat moss's superior nutrient profile and physicochemical properties. Duncan's multiple-range test highlighted significant differences in fresh weight and phenoliccontent, with broccoli outperforming green basil. Coco peat enhanced fresh weight, while peat moss excelled in phenolic content. These findings underscore the importance of substrate selection for optimizing microgreen yield and quality.

In conclusion, coco peat significantly improves microgreen yield and quality, especially in fresh weight, chlorophyll, and phenolic content, making it a cost-effective alternative to peat moss. Future research should explore outdoor cultivation with sustainable substrates like rice husks and evaluate total antioxidant content to leverage the nutritional and commercial potential of microgreens. Optimizing growing conditions is crucial for sustainable production.

Keywords: Coco peat, Cotyledon leaves, Microgreens, Peat moss, Vertical farming

Acknowledgment
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Effect of Light Conditions and Substrates on Microgreens Grown in a Vertical Farming System

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Extended Abstract

Microgreens, young vegetable greens harvested at the cotyledon stage, are prized for their high nutritional content and fast growth, typically ready for harvest in 7 to 21 days. Despite their small size,they are rich in vitamins, minerals, phenolic compounds, and flavonoids, making them popular"superfoods" among health-conscious consumers [1]. They can be cultivated both indoors and outdoors,offering flexibility in farming. However, their growth and quality are sensitive to environmental factorslike light, temperature, and substrate, making consistent, high-yield production challenging, thus requiring optimized growing conditions for best results [2].

This study examines the impact of light conditions and substrate type on the growth and nutritional quality of microgreens, focusing on broccoli (*Brassica oleracea*), green basil (*Ocimum basilicum*), andmustard (*Brassica juncea*). The effect of different light environments (indoor with artificial lighting andoutdoor with natural sunlight) and substrates (coco peat and peat moss) on microgreen development were investigated. Coco peat, known for its excellent water retention and aeration, promotes healthy root growth, while peat moss is recognized for its moisture retention and nutrient-holding capacity. The experiment involved growing the microgreens in trays containing either coco peat or peat moss, placed under indoor or outdoor light conditions. After 10 days, plant height, fresh weight, and yield were measured to assess growth performance. Nutritional quality was determined by evaluating total chlorophyll content, phenolic content, and antioxidant activity.

Fig 1: Microgreens of Mustard (*Brassica juncea*), broccoli (*Brassica oleracea*) and green basil basil (*Ocimum basilicum*) after 10 days of cultivation

The results revealed significant effects of both substrate type and light conditions on growth and quality.For broccoli microgreens, substrate type significantly influenced all measured variables, including plantheight, fresh weight, total chlorophyll content, phenolic content, and antioxidant activity. A similar

trend was observed in green basil and mustard microgreens, with the exception of plant height. Microgreens grown in coco peat generally exhibited superior growth and yield compared to those grownin peat moss. This is likely due to coco peat's better water retention and aeration properties, which support root health and nutrient uptake. Conversely, peat moss, though beneficial for moisture retention,may have limited oxygen availability to the roots, negatively impacting growth performance.

Regarding light conditions, the study found that outdoor-grown microgreens, especially broccoli, had higher phenolic content and antioxidant activity compared to their indoor counterparts. This is due to natural sunlight, as UV radiation is known to stimulate the production of phenolic compounds in plantsas a defense mechanism [3]. These findings suggest that outdoor cultivation may enhance the nutritional quality of microgreens by increasing their phenolic content and antioxidant activity. For green basil and mustard microgreens, light conditions significantly affected all variables except fresh weight and total chlorophyll content, respectively. This indicates that while light plays a crucial role in chlorophyll production and nutrient synthesis, it may not directly impact the biomass accumulation of these species. Interestingly, mustard microgreens showed no significant difference in total chlorophyll content basedon light conditions, suggesting that this species may have a stable chlorophyll synthesis mechanism regardless of light exposure. In contrast, broccoli microgreens were more responsive to light conditions, particularly in terms of their phenolic content and antioxidant activity, further highlighting species-specific responses to environmental factors.

This study is particularly relevant for improving microgreen production in various settings, including urban farming, where light conditions and substrate choice play a significant role in crop success. Coco peat proved more effective for cultivation due to its superior water retention and aeration. Outdoor sunlight improved phenolic content and antioxidant activity. However, species-specific responses suggest growing conditions should be tailored for each variety. Future research could investigate additional factors like temperature and humidity to further improve cultivation practices.

Keywords: Microgreens, light, substrates conditions, antioxidant activity, nutritional content

Acknowledgment

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Consumer Behaviors and Purchase Intention for Kombucha-like Powder from *Phyllanthus emblica*

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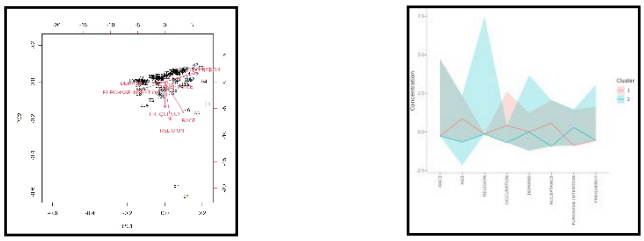
Extended Abstract

Fruit-based beverages have garnered considerable attention due to their perceived positive impact on health. Kombucha, produced through fermentation, offers various health benefits and sensory experiences. Developing a kombucha-like beverage using specific ingredients requires balancing bioactive compound preservation and sensory attributes. While there are opportunities in the nutraceutical market, challenges such as consumer understanding and pricing exist. Consumer behavioris important for developing and marketing health-oriented products [1,2].

This study investigated consumer behaviors and buying intentions towards a kombucha-like beverage powder, containing extracts of *Phyllanthus emblica* and *gula apong* as substrate and sugar replacer. It also examined the main factors that affect the purchase decision of kombucha-like beverage powder inrelation to sociodemographic characteristics. This study employed a structured survey comprising threesections for market demand assessment, customer insights, and demographic data collection. Data collection occurred from January to February 2024, yielding 115 valid responses from over 150 regularfermented beverage consumers. Random sampling and diverse outreach methods were utilized to achieve representative results. Descriptive statistics enabled the examination of data distributions. Chi square test was subsequently employed. Principal Component Analysis (PCA) was utilized to investigate relationships among sociodemographic and categorical variables. K-means Cluster analysis identified consumer segments based on perceived quality and other factors [3]. Multiple regression analysis aimed to ascertain predictors of purchase intention and acceptance of the kombucha-like beverage. Pearson's correlation coefficient measured the strength and direction of relationships among continuous variables and demographic factors.

Research data showed that most participants were female (77.4%) and young adults (63.5%). The participants were mainly Malay (92.2%) and Muslim (98.3%). A substantial portion of the participants were students (59.1%), followed by government workers (26.1%), self-employed individuals (7.8%), and industry employees (7%). Chi square test between sociodemographic factors and purchase intentionshows that age and occupation significantly correlate with purchase intention, evidenced by p-values of 0.06 and <0.001, respectively. This indicates that these factors are critical in shaping consumer purchasing behaviour. Alternatively, aspects like gender ($p = 0.195$), race ($p = 0.436$), and religion ($p= 0.656$) fail to demonstrate significant connections with purchase intention, pointing to a restricted role of these sociodemographic characteristics in shaping consumer preferences. The PCA score plot (Figure1a) reveals the distribution of key demographic factors and their impact on consumer preferences. Occupation and age are prominently positioned on PC1, indicating their significant influence on consumer behaviour. Religious affiliation, positioned on PC2, also plays a notable role. The significant

loading of occupation on PC1 (0.49087) suggests that professional status strongly influences consumer interest in the kombucha-like powder. This may be due to the association between higher socioeconomic status and greater health consciousness, as supported by research indicating thatprofessionals are more likely to seek out nutraceuticals. Age also significantly influences consumer behaviour, with a loading of 0.53247 on PC1. This is in line with studies showing that younger demographics are more open to trying innovative health products. The loading of religious affiliation on PC2 (-0.66539) suggests that religious beliefs may impact consumer acceptance, particularly in regions where dietary restrictions play a significant role. The K-means cluster analysis (Figure 1b) identified two distinct consumer groups with varying levels of acceptance. Cluster 1, with a high meanscore of 0.57, represents consumers who are more receptive to the kombucha-like powder. This clusterconsists of younger consumers with high product demand, frequent use, and strong purchase intent. Individuals in this group typically hold jobs that afford disposable income or flexibility, facilitating greater product engagement. Meanwhile, Cluster 2 includes older consumers exhibiting reducedproduct demand and infrequent product use with a low mean score of -0.37, shows lower acceptance levels. The positive correlation between purchase intention and product demand ($\beta = 0.21381$, $r = 0.214$,$p < 0.05$) underscores the importance of market readiness. The negative correlation between age and purchase intention ($\beta = -0.29116$, $r = -0.291$, $p < 0.01$) as well as the positive correlation between age and profession ($\beta = 0.36137$, $r = 0.361$, $p < 0.001$) indicates that older consumers tend to have more established careers, which may correlate with a greater interest in health products due to increased health awareness and disposable income. This result also aligned with the chi square test result that significantly highlights relationship between age and occupation with customer purchase intention. Thisresearch demonstrates that consumer behavior is influenced by both product attributes and demographicfactors. Highlighting health benefits, halal status, and unique features can enhance market expansion and provide insights for targeting both local and global markets.



(a) (b)

Figure 1: (a) PCA biplot; (b) K-means clustering

Keywords: consumer behaviors, *gula apong*, kombucha, *Phyllantus emblica*, purchase intention

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Assessment of Fermented Noni Juice: Microbial Enumerations, Antioxidant Activity, and Volatile Compound Analysis

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Extended Abstract

Noni fruit comes from a plant that is scientifically named *Morinda citrifolia*. It belongs to the Rubiaceae family. Noni is naturally fermented by its intrinsic enzymes and natural mutualistic microorganisms. The main objective of this study was to assess the fermented noni juice for microbial enumerations, antioxidant activity, and volatile compound analysis. Three samples were taken: noni fermented in theyears 2020 and 2021 and fermented noni with added honey. To assess the microbial enumeration of thethree samples, they were serially diluted and plated in nutrient and potato dextrose agar and incubated at 35°C for 24 hours. After incubation, the plates were observed for individual colonies. The obtained colonies were further streaked onto Eosin-Methylene Blue (EMB) agar, Mannitol Salt agar (MSA), DeMan-Rogosa-Sharpe (MRS) agar plates, which were then inverted and incubated at 37°C for 24 hours.Microbial colonies were observed in all three samples and in all three different specific media. Coloniesobtained from MSA were further streaked on Baird Parker agar and black shiny colonies were obtainedwhich could conclude the presence of *Staphylococcus aureus* a common pathogenic organism present in food [1]. To analyze the volatile compounds, the samples were run into an electronic nose (E-nose) which obtained the data from the inbuilt library. A total of 26 compounds were identified from all threesamples studied. Hexonic acid was the major odor-responsible compound that caused the unpleasant odor of the sample. Studies have shown a decrease in hexanoic acid content could contribute to a less pungent aroma in noni juice [2]. Antioxidant activity was determined by DPPH and ABTS assay. The noni juice fermented in the year 2021 showed higher antioxidant capacity (96.4147 ± 1.74 (%)) in the DPPH assay while compared to the other two samples. In contrast, fermented noni with an added honeysample showed a slightly higher antioxidant capacity (98.84 ± 0.14 (%)) in the ABTS assay.

Table 1: Antioxidant activity of fermented noni juice samples (Concentration at 25%)

Sample	**DPPH**	**ABTS**
Fermented noni juice 2020 (FNJ20)	89.6733 ± 1.88	98.1915 ± 0.16
Fermented noni juice 2021 (FNJ21)	96.4147 ± 1.74	98.7435 ± 0.20
Fermented noni + honey (FNH)	95.21 ± 1.26	98.84 ± 0.14

The anti-inflammatory activity was detected by lipoxygenase enzyme inhibition and all the samples exhibited high anti-inflammatory activity, noni fermented in the year 2020 (79.33%), noni fermented in the year 2021 (96.06 %), and fermented noni with added honey (99.37%).

Table 2: Lipoxygenase inhibition (%) of fermented noni juice samples

Samples	**Lipoxygenase inhibition (%)[a]**
Fermented noni juice 2020 (FNJ20)	79.33± 2.80[b]
Fermented noni juice 2021 (FNJ21)	96.06 ± 0.57[b]
Fermented noni + honey (FNH)	99.37 ± 0.49[b]
NDGA (control)	97.68 ± 0.91

The study showed promising results for a better understanding of the fermented product.

Keywords: Noni, Microbes, E-nose, DPPH, ABTS

Acknowledgment

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Halal Authentication of Animal-Derived Fatty Acids using FTIR-ATR Spectroscopy and the Principal Component Analysis Approach

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Extended Abstract

Halal is a term coined in Arabic that describes any goods that, in accordance with Islamic law, that Muslims are permitted to consume. In the recent year, animal fats and vegetable oils have been considered as economic sources for food and oleochemical and pharmaceutical industries. The adulteration of fats and oils has been widespread in the food industry, involving the replacement of higher value products with lower grade, cheaper and more readily substitutes. The authenticity of fats and oils has been extensively investigated because they can easily be adulterated due to economic purposes. Mixing of animal fats with vegetable sources is a cause of concern for certain groups of consumers due to religious obligations and health complications [1]. The IR spectroscopy has drawn interest in the analytical community for use in the quantitative measuring of fats and oils. Due to IR is a vibrational type of spectroscopy and offers quick evaluation while being cost-effective, it is an excellent analytical approach for analyzing food and pharmaceutical products. Hitherto, the objective of this study is to evaluate the efficiency of FTIR-ATR and MVDA for halal authentication of animal fatty acids which might be broadly utilized in various industries including food production, cosmetics and pharmaceuticals. The important outcome of this FTIR-ATR spectroscopy effectiveness blended with MVDA techniques in differentiating among halal and non-halal animal fatty acids. The dried of lard and mutton oils FTIR spectra were obtained from INHART, IIUM through freeze dried method and were used directly. The fresh chicken, beef and pork were cut into smaller pieces using commercialcutter by 1 cm · 1 cm cube and were put into a vacuum drying oven and dried at 80 °C of temperature,
0.32 bar of pressure for 24h. The dried meats were collected and stored in the freezer. In the fat extraction procedure, 20 g of the dried meats were weighed and grinded as fine powder using a commercial blender before being put into cellulose extraction thimble. The extraction process was donein 6h using petroleum ether as the solvent. The obtained extracts were mixed with a spoonful of $MgSO_4$ as to remove water, filtered through Whatman 125 mm diameter of filter paper, which then, later evaporated using a rotary evaporator, as the resultant oil were stored in glass vials. The Thermo Scientific Nicolet iS5 spectrophotometer model was used in the measurements. The ATR accessory equipped with diamond cell was used. All spectra were recorded within a range of 4000 – 650 cm^{-1} with4 cm^{-1} resolution and 32 scans. The spectra were converted into CVS format, imported to the dataset table in XLSTAT 2024 version software and the dataset was analysed accordingly for adequacy for thePCA analysis. All the FTIR-ATR spectra of functional and fingerprint's spectra specifically of oil samples from dried meats and palm oil standard were measured at the wavenumber ranging from 4000to 650 cm^{-1}, respectively. The stretching vibration of -CH, CH_2 and CH_3 from aromatic and alkene could

be observed at a peak of 3000 cm^{-1} whereas the stretching vibration of –CH, CH_2 and CH_3 from aliphatic alkane was found at peaks of ~2900 – 2800 cm^{-1}. It is observed that all the oils samples of animal/plant origin have a sharp and intense peak at the carbonyl (C=O) region of ~1700 cm^{-1}. The absorption bandat ~1400 cm^{-1} was correlated to the stretching vibration of C=C. The absorption bands at 1100 – 1000 cm^{-1} arise from the vibration of C–O stretching. In addition, vibrations at 1200 – 700 cm^{-1} were associated with bending vibrations of –CH, CH_2 and CH_3 fatty acid aliphatic backbone. Figure 1 showsthe outcomes of the PCA results from the FTIR-ATR wavenumber of 4000 – 650 cm^{-1} of all the animalsand palm oils samples. Moreover, before the PCA can proceed, all the FTIR-ATR spectra were subjected towards KMO test using the XLSTAT software for data adequacy and eligible for further analysis so that it must meet the requirement of KMO greater than 0.5. It is noted that the outcome of the KMO test of the FTIR-ATR spectra for the wavenumber of 4000 – 650 cm^{-1} is within the range of 0.757 – 0.888 meaning that all the spectra data is considered agreeably good. All the score plot of PCAshows distinct grouping of the animals and palm oil samples, respectively. Noteworthy, the lard showeda cluster grouping among the oils, and it is negatively correlated due to the opposite direction among all the samples. Visualising the PCA using the entire spectra in this complex due to the high number ofvariables as PCA cannot always solve multicollinearity-related problems with parameter estimation bymulticollinearity [2].

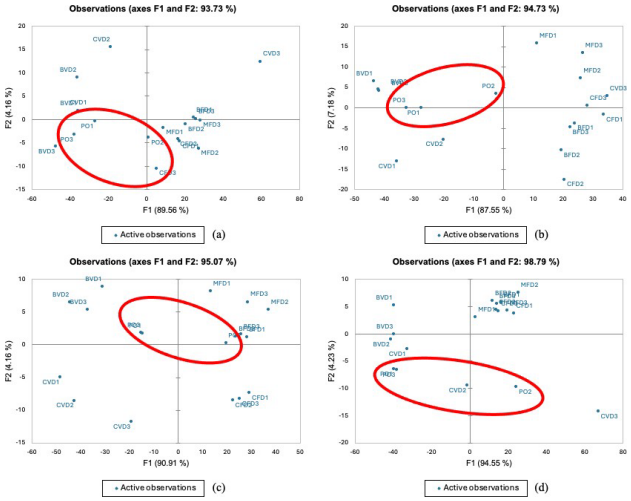

Fig 1: The PCA on various animal's oil dataset with observation value of 93.73 – 98.79% at the FTIR region of (a) 2500 – 2000 cm^{-1}; (b) 3000 – 2501 cm^{-1}; (c) 3500 – 3001 cm^{-1} and (d) 4000 – 3501 cm^{-1}

Keywords: Animal fatty acids, FTIR spectroscopy, PCA, Halal authentication

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Challenges and Opportunities in Expanding Indonesian Ginger (*Zingiber officinale*) Exports

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Extended Abstract

Indonesia, the world's fifth-largest producer of ginger, faces significant challenges in maximizing its export potential. Stringent international quality standards and inconsistencies in pre- and post-harvest handling within the complex supply chain hinder Indonesia's ability to compete effectively. This paper explores challenges and opportunities to expand Indonesian ginger exports through advancements in processing and product development, alongside improvements in Good Agricultural Practices (GAP).

Data was sourced from reliable sources including periodic publications by the Indonesian Ministry of Trade, Ministry of Agriculture, Central Statistics Agency, data from the Food and Agriculture Organization (FAO), Food and Drug Administration (FDA), and various international trade portals were utilized. Relevant laws, Codex Alimentarius (CODEX) standards, and regulations pertaining to the ginger industry were also considered. Collected data were organized and analyzed using Microsoft Excel and visualised through diagrams.

Our study reveals that Indonesia's popular ginger varieties—ginger emprit, red ginger, and elephant ginger—known for high bioactive compound levels and superior quality in terms of essential oils, starch, and fiber, compared to ginger from competitors like Vietnam and Thailand [1]. Based on the data in Figure 1, despite being the world's fifth-largest producer, Indonesian ginger exports are ranked12th. Indonesian exports have decreased, averaging only 8,448 tonnes annually between 2018 and 2022compared to 31,178 tonnes in the 2013-2017 period [2]. This decline was due to challenges such as market competition, climate variability, and quality control issues, including contamination leading to export rejections.

The study also identifies that contamination is a significant problem in ginger production. The FDA recorded 168 ginger import refusals between 2014 and 2022, primarily due to pesticide residue and microbial contamination [3]. One notable incident in 2017 involved the rejection of Indonesian ginger imports by the US due to Salmonella contamination.

Our study identified key obstacles to Indonesia's ginger export growth and proposed strategic solutions. Implementing Good Agricultural Practices (GAP) throughout the supply chain, from cultivation and storage to processing, can ensure consistent quality that aligns with international standard, code of practice and guidelines. Specifically, GAP implementation across the supply chain could be directed to enhance quality and reduce contamination risks by ensuring better farming practices, pest management, and harvest handling. Estimates indicate that full GAP adoption could improve production efficiency by 30% [4].

Furthermore, the study suggests that developing value-added products like ginger powder, essential oils, and ginger-based beverages can boost export values. Given the growing demand for natural healthproducts globally, this offers a critical opportunity for Indonesia. Advanced processing methods such

as freeze-drying and infrared drying are recommended to improve product quality, preserve bioactive compounds, and extend shelf life, thus making Indonesian ginger more competitive [5]. Furthermore, investing in high technology, such as nano-grinding, to produce nano-ginger powder could further enhance the value and appeal of Indonesian ginger products. Nano-ginger powder offers potential benefits like improved bioavailability, enhanced solubility, and increased stability, making it a valuableaddition to food and beverage formulations.

In conclusion, addressing these challenges could position Indonesia as a key player in the global ginger market, contributing significantly to the national economy through the export of high-quality, value-added ginger products.

Fig 1: Indonesian ginger export data 2012-2022 (WITS 2024)

Keywords: Ginger, *Zingiber officinale*, Indonesian exports, Good Agricultural Practices, ginger processing, quality control

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Evaluation Ascorbic Acid, Total Phenolic Compound, Sensory Attributes and Proximate Analysis of *Phyllantus emblica*-Derived Beverage

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Extended Abstract

Phyllanthus emblica (PE), also known as Indian Gooseberry or Buah Melaka, is highly regarded for its rich vitamin C content, surpassing oranges by over 30 times. Although PE fruit is nutritionally dense, its strong taste limits its appeal for direct consumption, resulting in its underrepresentation in the Malaysian functional beverage market and making it less popular compared to fruits like oranges or grapes. PE is primarily used for landscaping, and its health benefits remain underappreciated. This research addresses this issue by formulating beverages with different sweeteners, assessing their vitamin C content, total phenolic compounds (TPC), sensory attributes, and proximate analysis.

The goal is to determine which formulation best balances taste and health benefits, making PE fruit a viable ingredient for health-promoting beverages. Four beverage formulations were developed using 500 ml of PE extract and 125 g of various sweeteners such as honey (F2), Japanese black sugar (F3), and stevia (F4), with one formulation serving as a control (F1). Carboxymethyl cellulose (CMC) was added to improve texture and stability. Vitamin C content was measured using a modified 2,6- dichlorophenol indophenol (DCPIP) titration method [1], while TPC was determined using the Folin- Ciocalteu method [2]. The sensory evaluation involved 40 participants who ranked the formulations based on taste, odor, texture, and color. The most favored formulation underwent proximate analysis toassess calorie content, carbohydrates, protein, fat, water, and crude ash. Statistical analyses, including one-way ANOVA and Friedman tests, were conducted to identify significant differences among the formulations. IBM SPSS software version 27.0 was used for data analysis, with a significance set at $p<0.05$.

The vitamin C content of the formulations varied significantly. The F4 had the highest vitamin C contentat 527±32 mg/g, followed by F2 with 468±66 mg/g. The F1 contained 350±125 mg/g, while the F3 hadthe lowest vitamin C content at 286±73 mg/g. TPC results showed that F2 had the highest phenolic content (94.7±5.9 mg GAE/100 ml), followed by the control (92.0±4.4 mg GAE/100 ml), F4 (89.6±3.1 mg GAE/100 ml), and F3 (87.7±2.5 mg GAE/100 ml). Sensory evaluation indicated that F2 was the most preferred for taste, odor, and color as shown in Figure 1. Proximate analysis of F2 revealed that every 100 ml of the beverage contained 118±2.0 kcal, 27.9±2.2 g carbohydrates, 0.04±0.1 g protein, 0.8±0.2 g fat, 71.1±4.1 g water, and 0.3±0.0 g crude ash. These findings align with commercial fruit juices, making the PE beverage nutritionally competitive. This study demonstrated that PE fruit can be

transformed into a nutraceutical beverage, particularly when sweetened with honey, which provides both palatability and high nutrient retention. The honey-sweetened formulation emerged as the top performer in sensory evaluations and nutritional content, with a vitamin C concentration of 468±66 mg/g and TPC of 94.7±5.9 mg GAE/100 ml. Honey's natural sweetness helped mask the bitterness of PE, resulting in a balanced and appealing beverage. Moreover, the antioxidant properties of honey contributed to higher TPC values, as darker honey is known to have increased phenolic content, enhancing the overall health benefits of the beverage. The F4, despite having the highest vitamin C content, was less preferred in sensory evaluations, likely due to its aftertaste, which is common with stevia. Nevertheless, stevia's ability to prevent the degradation of vitamin C over time, protecting its quality. The F3 had the lowest vitamin C and TPC values, which may be attributed to its sugar content,which can accelerate vitamin C degradation. Sensory evaluations revealed that participants consistentlyfavored the F2 formulation in taste and odor, indicating that honey can effectively counter the astringency of PE while providing a pleasant sweetness. The proximate analysis further confirmed that the F2 had a well-balanced nutritional profile, with moderate calories and carbohydrates, making it comparable to existing fruit juices on the market. Among the formulations, the honey-sweetened beverage (F2) stood out as the most preferred option in sensory evaluations, with high vitamin C and TPC values. Overall, PE fruit offers a viable opportunity for the functional beverage industry, combining unique flavors with significant health-promoting properties.

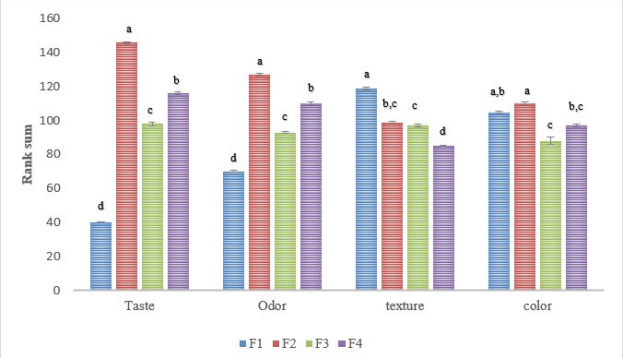

Fig 1: The rank sum scores for each formulation's attributes were determined. Scores with the same letters are not significantly different based on the Friedman test at a 0.05 significance level.

Keywords: nutraceutical beverage, *Phyllanthus emblica*, vitamin C content, total phenolic compound, sensory evaluation

Acknowledgment
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Evaluation of Process Efficiency in Ginger Puree Processing

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Extended Abstract

Ginger, the rhizome of *Zingiber officinale Roscoe* which belongs to the Zingiberaceae family, is one ofthe most widely used spices globally. The tubers, which are commonly referred to as ginger roots or rhizomes, have been used in various culinary and medicinal applications for centuries. Ginger purees were processed from ginger roots and have been widely incorporated into various food and beverage products due to their distinctive flavour, pungency, and associated health benefits [1]. The need for efficient processing methods of ginger puree processing will ensure maximum recovery, efficient use of resources, and enhanced product quality. The present study aims to explore the optimization of gingerpuree processing steps to improve the physicochemical properties of the final product.

Fresh ginger was purchased from a local market and stored chilled at 5°C before processing. The damaged rhizomes were manually trimmed, and the remaining ginger was peeled using a roller brush type ginger peeling machine at 1, 3 and 5 minutes peeling time. The ginger was then ground into a finepuree using a tabletop vegetable chopper, which is commonly known as a bowl chopper. Ground gingerwas pasteurized at 80°C for 1 minute, hot-filled into Nylon pouches, blast frozen to -18°C, and stored in a freezer. For the retort-processed puree, the ginger was filled in Aluminum pouches, packed and then sterilized at 121°C for 20 minutes using an immersion retort machine. Peeling efficiency was calculated for the evaluation of the degree of ginger peeling and analyzed using ImageJ for the image analysis. The particle size distribution of the ginger purees was measured using Malvern MS3000 Hydro EV. Physicochemical analyses, including pH, total soluble solids (TSS), and colour, were analyzed to determine the quality of the ginger puree. A pH meter, refractometer, and chromameter were used for these measurements. Microbiological analyses (TPC, yeast & mould, coliforms, E. coli, etc.) were measured using a standard method of analysis.

Figure 1 presents a Sankey diagram illustrating the mass and water flow throughout the ginger puree production process. The yellow streams represent the ginger mass as it moves through key processing stages, including sorting, peeling, and grinding. After the peeling process, the ginger recovery was 80%,and during the grinding process, the recovery of ginger puree was 77% of the initial ginger weight. Some losses occurred during grinding, primarily due to spillage as the chopper pot rotated. The total ginger puree recovery from the initial ginger rhizomes was 60.8%. The blue streams denote the water flow used primarily in the peeling and pretreatment phases, indicating significant water consumption throughout the process, especially during the peeling and pretreatment stages. Two final product streams, frozen and retorted ginger puree, are shown at the output stages. Additionally, waste streams are identified, consisting of ginger peels, rotten ginger, and wastewater.

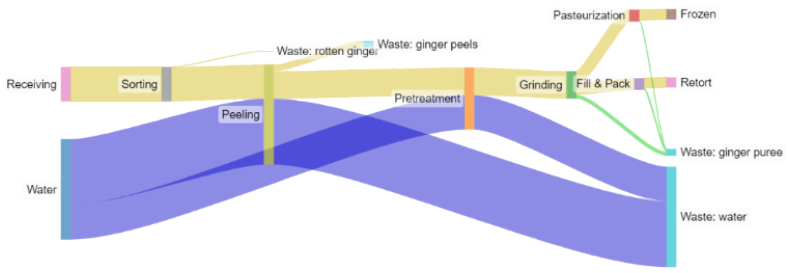

Fig 1: Sankey diagram of ginger puree processing

The key processes in ginger puree processing include peeling, grinding and its preservation methods - freezing and sterilizing. Traditionally, peeling has been a labour-intensive and time-consuming task, often leading to significant waste. Peeling at 1 minute achieved a recovery of 93.4 ± 2.6 %, whereas after 3 and 5 minutes, the recovery yields were 81.1 ± 0.6 % and 74.7 ± 1.3 %, respectively. Although the recovery was high at 1 minute of peeling, the ginger was only partially peeled visually. Analyzing the degree of peeling using ImageJ analysis proves that peeling at 1 minute only peeled 66.3 ± 16.9% of the surface area, 3 minutes of peeling is 90.2 ± 7.7% and 94.7% ± 5.3% of the surface area. The grinding process is another crucial step in ginger puree production to produce fine particles of puree. The particle size distribution of ginger puree produced by the bowl chopper was comparable for both samples. Bimodal peaks were present at about the same size ranges for each sample, with the greatest peaks around 300-3000 microns and lower peaks at 35-100 microns, consistent across both types of ginger puree. The initial microbial load of the raw ginger puree was high, with a total plate count (TPC)of $2.75 \times 10^6 \pm 3.54 \times 10^5$ cfu/g, yeast and mould count were $1.51 \times 10^4 \pm 1.41 \times 10^2$ cfu/g and the totalColiform is $3.15 \times 10^3 \pm 4.95 \times 10^2$ cfu/g. After processing ginger into puree, the amount of the TPC reduced to $2.30 \times 10^2 \pm 1.41 \times 10$ cfu/g. The pasteurization process maintained the TPC at $5.00 \times 10^2 \pm 2.83 \times 10^2$ cfu/g, indicating that both values are within the same logarithmic range. In contrast, the retort process effectively eliminated all microbes, as no microorganisms were detected in the samples.

The optimization of ginger puree processing is essential not only for maximizing recovery but also for maintaining the quality and safety of the final product. The analysis results using image processing techniques indicated that optimising the peeling time to 3 minutes peeled 90.2 ± 7.7% of the surface area, with 65.20 ± 7.20 % efficiency. The grinding process produced a consistent particle size distribution for both types of ginger puree. Furthermore, the microbial analysis revealed a substantial reduction in total plate count (TPC) from $2.75 \times 10^6 \pm 3.54 \times 10^5$ cfu/g in raw ginger to $2.30 \times 10^2 \pm 1.41 \times 10$ cfu/g in the puree, with pasteurization maintaining TPC at $5.00 \times 10^2 \pm 2.83 \times 10^2$ cfu/g and retort processing eliminating all detectable microbes. Future research should focus on refining water and waste streams further to achieve an even higher quality, fresh-like product while ensuring resource efficiency and environmental sustainability.

Keywords: ginger, ginger puree, frozen paste, retort, preservation

Acknowledgement: The project is funded by the 12th Malaysian Development Plan Project.

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Ultrasonicated of Shortfin Scad (*Decapterus Macrosoma*) Waste Protein Hydrolysate for Potential Food Supplement: Techno-functional Properties, Microstructure and Antioxidant Activity

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Extended Abstract

Shortfin scad (*Decapterus macrosoma*) waste peptides offered a solution to underutilizing fish by-products through protein hydrolysis. Shortfin scad protein hydrolysate has been reported to possess essential amino acids and bioactive peptides with antioxidant and ACE inhibitory activity. Additionally, food production usually involves the flesh of the fish, while the fish frames, bones, skin, and heads are underutilized and considered low value; thus, they are typically discarded, indicating severe environmental pollution. However, conventional hydrolysis methods produced low yields and properties. One of the potential methods that can aid in the hydrolysis process is ultrasound-assisted extraction. The sonication could increase their surface hydrophobicity by altering the secondary structure of proteins. This study investigated the impact of ultrasound-assisted hydrolysis on the yield,techno-functional, and antioxidant properties of shortfin scad waste protein hydrolysate (SSWH).

In order to obtain SSWH, the shortfin scad wastes were subjected to enzymatic hydrolysis (50°C, pH 9, 60 mins. 2.92% enzyme-substrate concentration) using Alcalase after the treatment of ultrasonication (25°C, 40 kHz frequency, and 15 mins). Degree of hydrolysis (DH) was determined by using trichloroacetic acid percentage and Kjeldahl method to calculate the nitrogen content. Solubility of SSWH was measured following the method described by [1] where the mixture of sample and distilledwater was adjusted to different pH levels (4, 7 and 10). Distilled water was added to each mixture and centrifuged. The protein content in the supernatant was then measured following the biuret technique. The amino acid composition of SSWH was determined using a Waters-Pico Tag Amino Acid AnalyzerHigh-Performance Liquid Chromatography (Waters 2690/5, Waters Co., Milford, USA) system. Antioxidant properties of SSWH were analysed with DPPH inhibition, hydroxyl radical scavenging activity and metal chelating activity. The assays were determined by different concentrations of SSWHsamples (0.5, 1.0, 5.0, 10.0, and 20.0 mg/ml). The DPPH radical scavenging activity was established when 0.02% (w/v) DPPH in 99.7 % ethanol was mixed with 500 µl of each sample concentration and left to stand in the dark for 60 mins. The absorbance was detected using a A UV-Vis spectrophotometerat 517 nm. For the hydroxyl radical inhibition, each sample concentration was combined with 1.0 mM$FeCl_3$, 1 mM 1,10-phenanthroline, 0.2 M phosphate buffer (pH 7.8), and 0.17 M H_2O_2. The reaction was initiated by adding H_2O_2. The mixture was incubated for 5 mins and the absorbance was measuredat 560 nm.

Results showed that ultrasound-assisted extraction increased the yield, DH and solubility of SSWH. The higher yield obtained by SSWH with ultrasound-assisted extraction (FHU) at 13.17 % compared to SSWH without ultrasound-assisted extraction (FH) (11.27 %), was attributed to ultrasound techniques, which facilitated the breakdown of amino acids and improved the interaction between the enzyme and shortfin scad protein. This result can be verified by the previous study, which had a similarresult for conventional enzymolysis SSWH (14.13 %) [2]. The sample with ultrasound pre-treatment has significantly higher DH (77.88%) than the untreated sample (57.06%). This showed the sonicationeffect to the enzyme activity due the formation of a cavitation bubble that led to the unfolding of proteinsand more exposure of the protein surface and increased the enzyme accessibility to the peptide bond [3]. The amino acid composition of SSWH was high in methionine, glycine, glutamic acid, leucine, valine, and histidine. This result showed that the SSWH has a high amount of hydrophobic amino acids,which was attributed to the ultrasound-assisted extraction. The study on the protein hydrolysate of freshwater mussels provided evidence for the increase in hydrophobic amino acids following ultrasonicapplication [4]. They explained that peptide passage through target organs could be facilitated by hydrophobic interaction with the membrane lipid bilayer, hence enhancing antioxidant activity. Ultrasound-treated SSWH demonstrated significant antioxidant activity, including DPPH radical inhibition (83.72%), hydroxyl radical inhibition (98.54%) and ferrous chelating activity (94.52%). A study from [5] demonstrated that ultrasound-assisted extraction of sea bass side streams resulted in higher antioxidant activity, likely attributed to ultrasound's role in facilitating the release of antioxidant compounds from within cells. They also noted that ultrasound enhanced proteolysis, leading to the release of more bioactive peptides. The ultrasound-assisted extraction exhibited enhanced techno- functional and antioxidant properties of SSWH, making it a potential health supplement for pharmaceutical and nutraceutical applications.

Keywords: Fish protein hydrolysate, shortfin scad, ultrasound-assisted extraction, techno-functional properties, antioxidant activity.

Acknowledgment
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Cooking Quality, Physicochemical and Sensory Properties of Fresh Pasta Incorporated with Rice Bran

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Extended Abstract

Pasta, a significant component of human nutrition due to its rich complex carbohydrates, primarily consists of wheat flour and water [1]. Durum wheat semolina is widely recognized as the optimal ingredient for traditional pasta [2]. Traditional pasta often lacks nutrients, as it typically comprises only wheat flour and water. Rice bran (RB) is an agricultural waste that contains significant amounts of nutrients which make it highly interesting to be added to food formulation. Thus, this study aims to investigate the cooking quality, physicochemical properties, and sensory acceptance of fresh pasta (Fettuccine) incorporating varying amounts of rice bran.

Four levels (5%, 10%, 15% and 20%) of RB were chosen to substitute durum semolina content in the fresh pasta formulations. The products were analyzed to determine cooking quality, colour, texture, nutritional composition (proximate analysis), and sensory acceptance. The optimal cooking time was determined according to the method described by American Association of Cereal Chemists (AACC) Method 66-50.0 [3] while cooking loss was assessed using the American Association of Cereal Chemists (AACC) method 44-15.02 (1999). The colour was measured using a Chromameter CR-400 (Konica Minolta, Tokyo, Japan) equipped with a D65 illuminant, following the CIE Lab* system (Ritthiruangdej et al., 2011). The sample was placed in a clean table and L*, a* and b* readings were obtained directly from the instrument. ΔE was calculated to determine the alteration in the colour of samples and control, following equation: $\Delta E = \sqrt{(\Delta L)2+(\Delta a)2+(\Delta b)2}$. The texture profile characteristicswere analyzed by using a texture analyzer (TA-xT2i, Stable Micro Systems, Godalming, U.K.)equipped with a 36mm cylinder probe with radius (P/36R) and a 5kg load cell. For chemical composition, the standard methods, including moisture content (AACC, 2001, method No.44-16.01), crude ash (AOAC, 2005), crude fat (ether extract) (AOAC, 2006), crude protein (AOAC, 2005), crudefiber (AACC, 2000), and crude carbohydrate, were employed for analysis. Sensory acceptance of the pasta produced was evaluated using a 7-point hedonic scale involving 30 untrained panelists. The attributes evaluated included cooked pasta colour, surface smoothness, firmness, elasticity, odour, chewiness, stickiness, and overall acceptability. All data obtained were expressed as means ± standarddeviations (SD) by one-way analysis of variance (ANOVA) using Tukey's tests, Minitab 21 statistical software where probability ($p<0.05$) was considered statistically significant.

The addition of RB increased the cooking loss and darkness and redness of the pasta. For texture, the increase in the percentage of RB led to an increase in hardness, adhesiveness, gumminess, and chewiness, while the cohesiveness and resilience showed a decreased trend. Meanwhile, decrease in carbohydrates (59-49%), an increase in crude protein (9.63-10.16%), crude fiber (0.31-2.64%), crude fat (0.01-4.99%), and ash (0.77–2.06%) in the RB incorporated pasta was observed. For sensory acceptance, the rice bran pasta obtained an acceptable score (more than 4) on the 7-point hedonic scale. Overall, fresh pasta incorporated with 10% RB was the best formulation in terms of cooking quality, physicochemical properties and sensory acceptance. In conclusion, the use of RB to replace durum wheat semolina altered the cooking quality, improved some nutritional composition and obtained high

acceptability of RB fresh pasta. Improvement in the nutritional values of fresh pasta will offer health benefits to the consumer such as lower cholesterol and blood pressure. The RB fresh pasta makes a favorable choice for individuals with specific dietary requirements.

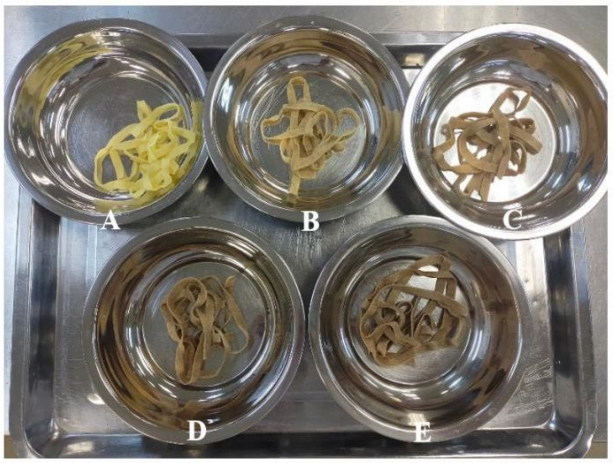

Fig 1: Fresh pasta incorporated with different percentages of rice bran. A - Pasta with (0% wheat flour, 100% RB); B - Pasta with (95% wheat flour, 5% RB); C - Pasta with (90% wheat flour, 10% RB); D - Pasta with (85% wheat flour, 15% RB); E - Pasta with (80% wheat flour, 20% RB)

Keywords: Rice bran, Fettuccine, Fiber, Fresh pasta, Durum semolina

Acknowledgment
Authors gratefully acknowledge the support provided by Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu.

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Effects of Bromelain Enzyme on the Texture, Protein Content, andCooking Quality of Marinated Lamb Meat

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Extended Abstract

Meat quality is defined by several sensory and technological properties, including texture, flavor, juiciness, tenderness, and water-holding capacity. Among these, tenderness plays an important role in consumer preference and repeat purchases. Proteolytic enzymes, such as bromelain, are widely used inthe meat-based food industry to tenderize meat. Bromelain, derived from pineapple, is particularly effective in improving the texture of tough cuts of meat, thus enhancing consumer appeal. However, the application of proteolytic enzymes, such as bromelain, poses challenges related to balancing improved meat tenderness with the potential increase in moisture loss, which can affect overall cookingquality. This study aimed to investigate the impact of bromelain enzyme at concentrations of 0.025% and 0.5% on the texture, protein content, and cooking quality of shoulder cuts of lamb meat, includingdrip loss and cooking loss. Additionally, sensory evaluation was conducted to assess the overall acceptability of enzyme-treated samples.

Lamb shoulder cuts were obtained from a local market in Johor, Malaysia. The meat was cut into uniform sizes (1.0 cm thick, weighing approximately 100 g each) and stored at –20 °C before use. Analytical-grade reagents and food-grade bromelain enzyme powder (100,000 U/g) were used in this study. For drip loss analysis, lamb meat samples (20 g) were treated with two bromelain concentrations(0.025% and 0.5% w/w in 10 mL of distilled water) by injection. The initial weight (W1) of each samplewas recorded. The samples were vacuum-packed and stored at 4 °C for seven days. After storage, the samples were blotted dry, and the final weight (W2) was measured, and drip loss was calculated. Cooking loss was determined by vacuum-sealing the samples and cooking them in a water bath at 80
°C for 30 minutes. The initial weight (W1) and post-cooking weight (W2) were recorded, and cooking loss was calculated. The pH of the lamb samples was measured using a pH meter. The samples were blended with 10 mL of distilled water, and the pH was measured at room temperature. The protein content was analyzed using the Kjeldahl method with a conversion factor of 6.25. Sensory evaluation was conducted with 17 participants, consisting of 10 females and 7 males, who were staff members and postgraduate students at the Innovation Centre in Agritechnology (ICA), Universiti Teknologi Malaysia, Pagoh. The marinated lamb was grilled for four minutes on each side and allowed to cool before being cut into uniform pieces (3 x 3 cm). The panellists were asked to evaluate chewiness, lambflavor, hardness, juiciness, taste, and overall acceptability.

The study demonstrated that bromelain treatment significantly increased both drip and cooking losses. The sample treated with 0.025% bromelain exhibited a drip loss of 11.74% compared to 8.02% in the control. Similarly, cooking loss increased by 4% in the enzyme-treated samples compared to the control (39.87% vs. 35.80%). Despite the higher moisture loss, sensory evaluation revealed that the enzyme-

treated meat, particularly at 0.025%, had improved texture and flavor, as shown in Figure 1. The protein content of bromelain-treated meat was also higher than that of the control (14.57% vs. 12.60%), indicating that the enzyme enhanced the nutritional profile of the meat. Bromelain effectively tenderizedthe lamb meat by breaking down muscle proteins, contributing to a softer texture. However, the increased proteolysis also weakened the structure of the meat, leading to higher drip and cooking losses.These findings are consistent with previous studies, which reported that proteolytic enzymes improve tenderness at the expense of moisture retention. [1] and [2] found that while bromelain improves tenderness, it also compromises water-holding capacity, resulting in higher drip and cooking losses. Although moisture retention is a concern, consumer preference for tenderness may outweigh the impactof moisture loss. Panellists rated the bromelain-treated meat higher in texture and flavor, indicating thatthe benefits of tenderness enhancement justify the moisture loss. Further optimization of bromelain concentration and marination conditions, including treatment time or the combination of bromelain enzyme with other ingredients that can retain water, could determine the best balance between meat tenderness, moisture retention, and flavor.

This study highlights the role of bromelain in improving the tenderness of lamb meat. The optimal bromelain concentration of 0.025% provided a balance between enhanced texture and minimized moisture loss. Further research is required to optimize the marination process and improve moisture retention without compromising the desired sensory attributes. These findings are valuable for developing marination techniques that enhance meat quality, making it more appealing to consumers.

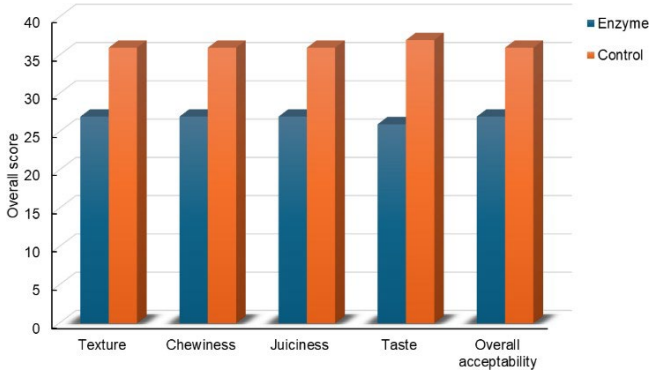

Fig 1: The sensory evaluation of lamb meat treated with enzyme and control

Keywords: Marinated lamb, bromelain enzyme, texture profile, sensory evaluation, protein.

Acknowledgment
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Quercitrin Extract from *Cosmos Caudatus* Kunth by Ultrasonic-Assisted Extraction

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Extended Abstract

Cosmos caudatus (Asteraceae), commonly known as Ulam Raja, is widely used in Malaysia for its medicinal properties. Rich in bioactive compounds, particularly quercitrin, its health benefits span from antioxidant to anti-inflammatory effects [1]. Despite the growing demand for quercitrin in the functional food industry, there is limited research on its extraction from *C. caudatus*, particularly for quercitrin. Previous studies have emphasized the importance of efficient extraction methods to enhance quercitrin recovery [2]. This study compares two UAE methods to optimize quercitrin recovery, potentially offering scalable solutions for the industry.

Two ultrasonic-assisted extraction techniques—ultrasonic bath and ultrasonic probe—were evaluated.A one-factor-at-a-time (OFAT) approach was applied to assess the effects of ethanol concentration (20-100%), solid to solvent ratio (SSR) (1:10-1:80 g/mL), particle size (180-850 μm), extraction time (2- 30 minutes), and ultrasonic amplitude (20-60%). The quercitrin yield was measured using high- performance liquid chromatography (HPLC), while total phenolic content (TPC) and antioxidant activity were evaluated using the Folin-Ciocalteu and DPPH assays, respectively. Statistical analyses were performed using one-way ANOVA.

Both methods showed optimal quercitrin extraction at 50-80% ethanol, with 100% ethanol being less effective. Direct UAE reached a peak of 91.24 mg/g at 50% ethanol, while indirect UAE recorded 51.70 mg/g [3]. An SSR of 1:30 g/mL was ideal for both methods. The direct UAE technique produced higher quercitrin content, suggesting superior efficiency due to enhanced cavitation effects [2].
Smaller particle sizes (<180 μm) yielded the highest quercitrin levels (97.45 mg/g with direct UAE), confirming the importance of sample fineness in promoting efficient mass transfer during extraction [4]. While the ultrasonic probe demonstrated superior performance at lower amplitudes (20%), the ultrasonic bath required higher amplitudes (60%) to achieve comparable results [5]. Maximum quercitrin recovery was achieved in 5-10 minutes using direct UAE, whereas indirect UAE required longer times (20 minutes) to reach optimal yields [2]. This efficiency highlights the advantages of directsonication for time-sensitive extraction processes.

Direct UAE produced a significantly higher TPC (371.59 mg GAE/g dw) compared to indirect UAE (164.98 mg GAE/g dw) [2]. However, no significant difference in antioxidant activity (IC50) was observed between the two methods, with both showing similar inhibition rates at around 33 mg/L.

The ultrasonic probe method is more efficient in extracting quercitrin from *C. caudatus*, attributed to its stronger cavitation effects and rapid mass transfer. The optimized conditions for this method—50% ethanol, 10 minutes extraction time, and <180 µm particle size—result in a higher quercitrin yield withless energy and solvent consumption. Additionally, the direct UAE method significantly enhances TPCwithout compromising antioxidant activity. These findings provide a foundation for the industrial-scaleproduction of quercitrin-rich extracts, with potential applications in the nutraceutical and functional food industries.

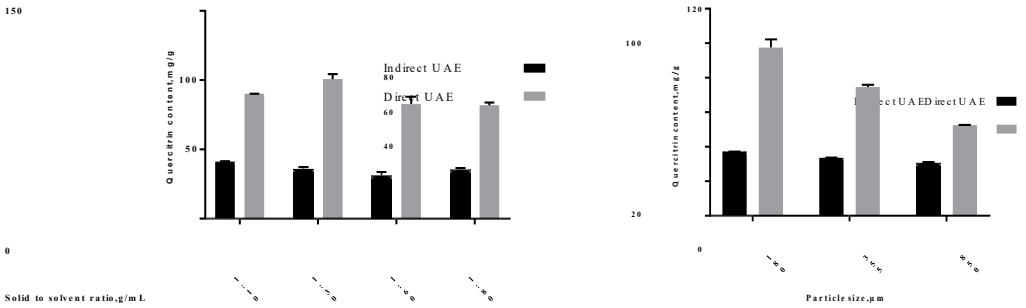

Fig 1: Effect of two ultrasonic on two extraction parameters. The error bars indicate the standard deviation for n = 3. Alphabets that are different from each other ($p<0.05$) indicate significant differences between the amplitude level and extraction methods. Indirect UAE is represented by uppercase letters, while direct UAE is represented by lowercase letters.

Keywords: *Cosmos caudatus*, quercitrin, ultrasonic-assisted extraction

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Enzyme-Assisted Citric Acid Extraction of Pectin from Red-Purple Pitaya Peel

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Extended Abstract

The peel of the red-purple pitaya, derived from the *Hylocereus polyrhizus* fruit, has attracted significant attention for its various applications in the food, health, and cosmetic industries. Rich in bioactive compounds, including polyphenols, flavonoids, and betalains, the peel exhibits potent antioxidant properties, which can help mitigate oxidative stress and reduce the risk of chronic diseases [1]. Besides,the peel is also known for its high dietary fibre content, ranging from 69% to 79% [2]. Previous studiesindicate that pectin, a type of dietary fibre can be extracted from pitaya peels using conventional heating,microwave-assisted, or ultrasound-assisted extraction methods. Pectin is often used as a gelling, thickening, and stabilising agent, particularly in producing jams, jellies, and fruit preserves in the food industry. Meanwhile, in the pharmaceutical industry, pectin serves as a drug carrier, excipient, and component in wound healing formulations. Commercial pectins are usually extracted from apple and citrus pomaces. However, there is a growing research interest in discovering alternative sources of pectin that can contribute to a higher pectin yield with improved functionalities. This study aimed: (i) to determine the optimum conditions for pectin extraction from pitaya peel puree pre-treated with cellulase using distilled water as the pectin-extracting solution, and (ii) to compare the pectin yield obtained when citric acid of varying concentrations (0.5 – 2.0%) was used as the extracting solution. The parameters studied for optimisation of pectin extraction from enzymatically pre-treated pitaya peelpuree include temperature (25 – 50 °C), time (30 min – 180 min), pH (3.0 – 5.4) and enzyme concentrations (50 – 300 µL/100 g pitaya peel puree). It was found that the pitaya peel pectin yield increased with increasing cellulase concentration up to 100 µL/100 g pitaya peel puree. The highest pectin yield was noted when the puree without pH adjustment was used (original pH of the puree: 5.40).As for the temperature and time effect on the pectin yield, a positive effect of temperature on the pectinyields up to 37 °C was observed and an extraction time of 120 min resulted in the highest yield. At theoptimum conditions of enzymatically pre-treated puree (temperature: 37 °C, time: 120 min, pH: 5.40 and cellulase concentration: 100 µL/100 g pitaya peel puree) using distilled water as the extracting solution, 22.30% of pectin was extracted following the method described by [3]. Further investigation carried out with varying concentrations of citric acid (0.5 – 2.0%) as the pectin extracting solution indicated a significant increase in the pectin yield (24.63%) at 1.5% concentration of citric acid solutionusing the pitaya peel puree pre-treated with enzyme under optimum conditions. In conclusion, about 25% of pectin from red-purple pitaya peel can be recovered using cellulase assisted-citric acidextraction method. Red-purple pitaya peel can be utilised as an alternative source to extract pectin for applications in selected food and pharmaceutical products.

Keywords: Red-purple pitaya, fruit peel, pectin, enzyme-assisted citric acid extraction

Acknowledgement

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Characterization of Collagen Derived from Different Freshwater Fish Species via Ultrasonic-assisted Techniques

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Extended Abstract

Freshwater fish-derived collagen (FF-dC) offers several distinct advantages compared to collagen sourced from land animals (bovine and porcine) and marine fish. FF-dC stands out due to its lower riskof disease transmission, which is particularly pertinent given the increasing concerns surrounding zoonotic diseases associated with land animal sources. Additionally, FF-dC is often more cost-effectiveto produce, freedom from religious and ethical constraints, high biocompatibility, low molecular weight, and environmental sustainability [1]. This study focused on extracting FF-dC using ultrasonic-assisted techniques from the skin of three different freshwater fish species commonly found in SoutheastAsia: Tilapia (*Oreochromis niloticus*), Barramundi or Siakap (*Lates calcarifer*) and Kelah (*Tor tambroides*), also known as Mahseer. Siakap, known for its mild flavor and firm texture, is popular in cooking and is farmed for its high protein and omega-3 content. Tilapia, widely farmed across tropical regions, is valued for its mild taste, affordability, and fast growth, making it a staple food source rich inprotein and vitamins. Meanwhile Kelah is a prized but rarer species due to its difficulty in farming, known for its firm texture and rich flavor, and is sought after both for its meat and as a sport fish. Thus,collagen derived from Kelah fish is less reported in the literature. The extraction and characterization of collagen from various freshwater fish species are of growing interest, as different species may yieldcollagen with distinct biochemical and physicochemical properties, which can be tailored for specific applications. Advances in extraction techniques, particularly ultrasonic-assisted methods, have further enhanced the yield, efficiency and quality of collagen derived from freshwater fish, as well as the reduction in extraction time making it a viable and valuable resource for a wide range of industrial applications [2]. Following extraction, the collagen was analyzed using ATR-FTIR Spectroscopy, determination of total protein using Kjeldahl Method, determination of hydroxyproline (Hyp) content using HPLC-DAD and SDS-PAGE to separate it based on molecular weight. The result of collagen extracted using ultrasonic-assisted extraction (UAE) is shown in Table 1. The extracted collagen in Tilapia skin was found to be the highest with 60.66% w/w of total protein among the other three freshwater fish collagen; Siakap (47.08% w/w) and followed by Kelah (22.44% w/w). Meanwhile, thecontent of Hyp in Siakap collagen (137.30 mg/100g) was higher than Kelah collagen (99.91 mg/100g)and Tilapia collagen (48.57 mg/100g). Total protein provides an estimate of the overall collagen contentin a sample, while hydroxyproline, a distinctive amino acid found predominantly in collagen, serves asa marker for assessing the purity and structural integrity of the collagen. A higher hydroxyproline content is indicative of a more stable and robust collagen network, as this substance plays a critical rolein maintaining the triple-helix structure of collagen fibres [3]. Thus, the hydroxyproline level reflects the collagen's quality and its potential for applications requiring high structural stability. All fish collagens have been shown to have characteristic features in several absorption bands in FTIR spectra that include the Amide A, Amide B, amide I, amide II, and amide III vibrational modes. Based on the

SDS-PAGE results, collagen from all three freshwater fishes was identified as type 1 (molecular weight approximately from 95 to 130 kDa) collagen. In conclusion, this study demonstrates that the investigated freshwater fish species have the potential to serve as alternative sources of collagen. The variations in protein content and Hyp levels among the species suggest that each may be suited for different applications, warranting further research into their specific uses in industries such as cosmetics, pharmaceuticals, and biomedicine.

Table 1: Total protein and hydroxyproline content in Kelah, Siakap and Tilapia Collagen extract with UAE.

Fish Collagen	**Total Protein**	**Hyp Content**
	g/100 g DW	**mg/100g**
Kelah	$28.44^{a} \pm 1.177$	$99.91^{a} \pm 1.70$
Siakap	$47.08^{b} \pm 1.167$	$\mathbf{137.30^{b} \pm 8.59}$
Tilapia	$\mathbf{60.665^{c} \pm 0.913}$	$48.57^{c} \pm 1.17$

Values are mean ± SD (n = 3). Different superscripts indicate significant different ($p<0.05$)

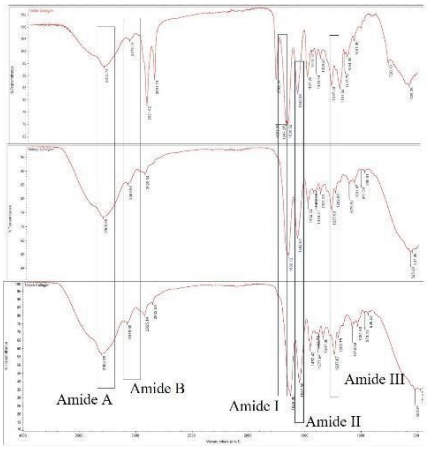

Figure 1: FTIR Spectra for different FF-dC

Keywords: Ultrasonic-assisted extraction, fish collagen, freshwater fish, hydroxyproline, protein

Acknowledgment
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Palm Oil-Based Base Oil as a Sustainable Alternative to Mineral Oils in Electric Vehicles Application

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Extended Abstract

The transition from internal combustion engine (ICE) cars to electric vehicles (EVs) is one of the alternatives in reducing the reliance on fossil fuels and mitigating climate change. However, the continued use of mineral base oils obtained through conventional refining processes from fossil reserves in EV lubricants presents significant environmental challenges. The exploration of vegetable-based lubricants has gained a lot of attention as they pose superior properties and the ability to biodegrade.

The utilization of renewable raw materials is very important in the development of environmentally sustainable products. Researchers have focused their attention on various vegetable oils, such as canolaoil, soy oil, rapeseed oil, and palm oil, as potential substitutes for petroleum-based lubricants. Among these oils, palm oil stands out due to its higher yield per hectare, making it a promising candidate for biolubricant applications. The global production of palm oil in the year 2020/21 was estimated at approximately 73.8 million metric tonnes [1], with Malaysia contributing around 25.8% of the total production.

The existing literature is reviewed and analysed on the chemical and physical properties of palm oil- based lubricants to demonstrate their performance at par with conventional lubricant while significantlyreducing the impact on the environment. Palm oil has been known for its biodegradability, exceptionallubricating characteristics, elevated viscosity indices, low volatility and high flash points [2] making itsuitable for the operating conditions of EV transmissions. Its exceptional lubricating characteristics alsocontribute to the reduction of friction and wear, fostering the durability and efficiency of mechanical systems. Palm oil also has shown promising tribological properties such as good lubricity, high viscosityindex and has thermal stability [3]. Studies have shown that palm oil-based lubricant can achieve comparable tribological performance to mineral-based lubricants.

Biolubricants including palm oil are susceptible to oxidation, a chemical reaction that can cause the destabilisation of the lubricating film that is created between metal surfaces in contact. Through chemical modification, it can be used to overcome the deficiencies of crude vegetable oils to meet thestandard requirement for bio-based lubricants. More stable biolubricants can be synthesized through various methods including esterification, transesterification, epoxidation, ketonization and estolide formation from vegetable oils [4].

When compared with conventional lubricants, palm oil-based lubricants show a competitive performance. Laboratory-scale tribological tests based on standard such as four-ball wear and pin-on-

disk tests, have demonstrated that palm oil-based lubricant can reduce friction and wear [5]. Reducing wear on transmission in EVs is very crucial for long-term efficiency and optimum performance.

Incorporating palm oil-based base oil in formulating new transmission fluid for EVs has demonstrateda promising potential, especially due to its environmental benefits. While challenges exist, further research and development can help to overcome the problems. Since EVs represent a greener, more sustainable alternative to ICE vehicles, a sustainable substitute is a must. It can also contribute to the transition towards a circular bioeconomy, supporting both sustainable lubricant production and also vehicle systems.

Keywords: Electric vehicle; Lubricant base oil; Palm oil; Palm oil-based lubricant; SustainableLubricant

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Exopolysaccharide from *Lactobacillus paracasei* Isolated from Pineapple on its Functional Properties and Physicochemical Characteristics

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Extended Abstract

Exopolysaccharide (EPS) from *Lactobacillus paracasei* isolated from pineapple was evaluated for its functional properties and physicochemical characteristics. EPS extracted from *Lactobacillus* species manifest a distinct result when supplied with different types of nutrients. These aspects will contribute various potential benefits to the current industry. Therefore, the aim of this study was to determine the effect of different types of carbon and nitrogen sources on the bioactivity and physicochemical properties of EPS extracted from the cultivation broth of *L. paracasei*. The strain was cultured in a standard growth medium containing different types of carbon sources (glucose, fructose, glycerol, sucrose) and nitrogen sources such as meat extract, peptone, yeast extract and ammonium sulphate. TheEPS was then extracted and analysed antimicrobial assay, FTIR and SEM analysis. The EPS yield washighest when glycerol was used as the carbon source (1.45 ± 0.78 g/L) and ammonium sulphate as thenitrogen source (3.29 ± 0.94 g/L). However, no inhibition zone was observed in the agar disc diffusiontest, indicating that the EPS has no antimicrobial properties. The result for FTIR analysis shows almostsimilar spectrum for all EPS supplemented with different types of nutrients, suggesting that no changesin EPS functional group occurred when using different types of nutrients. In contrast, in SEM analysis,each EPS shows different characteristics of microstructure surface morphology. This study provides a valuable insight into the effect of different carbon and nitrogen sources on the morphology that affectsits physio characteristics of EPS by *L. paracasei*. This is important elements for industrial application in different fields.

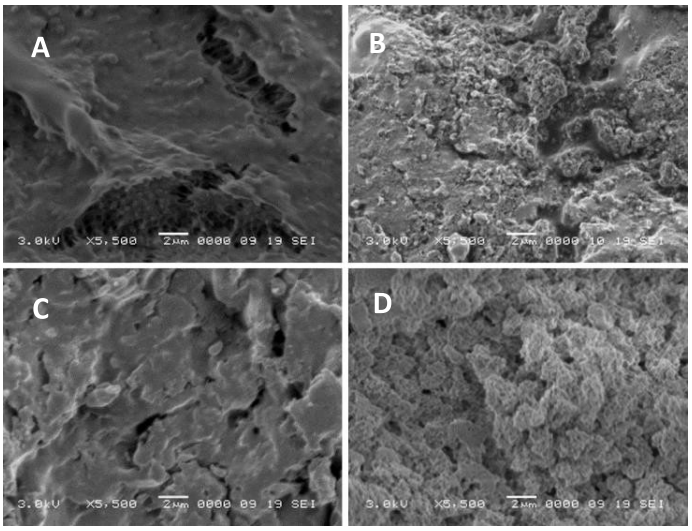

Fig.1: SEM analysis of exopolysaccharide supplied with glucose (A), fructose (B), sucrose (C) and glycerol (D) as carbon sources

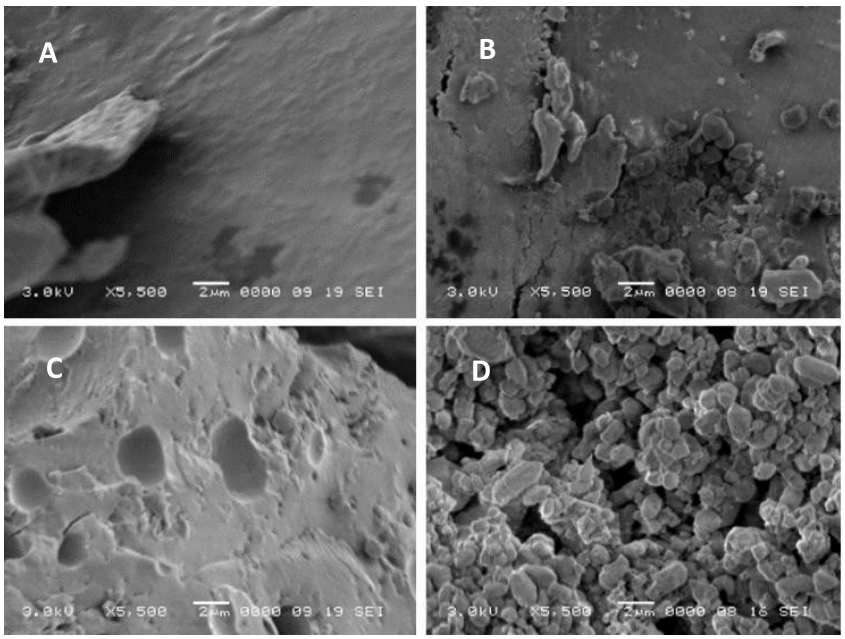

Fig.2: SEM analysis of exopolysaccharide supplied with meat extract (A), peptone (B), yeast extract (C) and ammonium sulphate (D) as nitrogen sources

Keywords: *Lactobacillus paracasei*, exopolysaccharide, functional, physiochemical

Acknowledgment
This research was supported by Universiti Teknologi Malaysia through Fundamental Research Grant (Q.J130000.3809.22H12).

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Synthesis of Fe/Ba/γ-Al_2O_3 Catalyst for Transesterification of Low-Grade Cooking Oil for Biodiesel Production

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Extended Abstract

In the 8th Malaysia Plan (2001-2005), the Five Fuel Diversification Policies stated that renewable energy was considered as the fifth source of energy mix supply in the country [1]. Besides, the Renewable Energy Policy was also introduced in the 10th Malaysia Plan, indicated the government manifestation to develop and promote the renewable energy sources [2]. Due to energy security awareness, biodiesel is popularized on the global fuel market and gaining prominence as a superior alternative source of energy to replace petroleum-based fuel in transportation. Production of biodiesel is set to increase in forthcoming years as it offers several promising benefits associated with energy security, agriculture sector expansion, economics and limiting pollutant emission. However, in developed countries biodiesel cost is about 1.5–3 times higher as compared to the cost of fossil diesel [3]. Homogeneous catalyst has wide acceptability in biodiesel production because of fast reaction rates.However, postproduction costs incurred due to the problematic in separation process, corrosion and soap by-product led to the search for alternatives. Thus, heterogeneous base catalyst was developed to cater these problems.

In this study, an oxide of barium and iron heterogeneous catalyst was synthesised to promote the transesterification of low-grade-cooking-oil (LGO) in biodiesel production. This catalyst was produced using a wet impregnation method, where barium as a basic catalyst and iron as a dopant, impregnated with alumina beads (Fe/Ba/γ-Al_2O_3). The production was optimized by response surface methodology (RSM) with a central composite design (CCD) using Design Expert 11.0 software to study the parametric effect of calcination temperature (600-1000 °C), the percentage of iron-to-barium doping (3.18%-36.82%) and the time of the calcification (3-7 hours). During the synthesis, barium nitrate ($Ba(NO_3)_2$) solution was mixed and stirred with iron (III) nitrate solution ($Fe(NO_3)_3$). After 30 minutes,5g of alumina beads were modified by soaking in the mixture solution, then, removed and dried on filterpaper at room temperature. The process of soaking and drying were repeated for three times. Next, themodified alumina beads were dried at temperature 80-90 °C for 24 hours followed by a calcination process. The optimisation conditions were varied by 20 sets to analyse the catalytic efficacy against thetransesterification process of LGO with methanol. The conditions of LGO to methanol ratio, reaction temperature, rate of reaction and the percentage of Fe/Ba/γ-Al_2O_3 catalyst were fixed at 1:18, 65 °C, 3 hours and 6%, respectively. Biodiesel obtained were analysed using the gas chromatography with mass spectrometry detector (GC/MS) for components identification and gas chromatography with flame ionization detector (GC-FID) to quantify the biodiesel yield in term of fatty acid methyl ester (FAME)using nonadecanoic acid (C19) as the internal standard.

From the results obtained analysed by RSM, it was found that by using Fe/Ba/γ-Al_2O_3 calcined at 800 °C at 5 hours, the increasing of Fe-to-Ba doping from 3.18 wt% to 20 wt% increasing the catalytic activity from 83.95 % to 85.57 %. However, the biodiesel production reduced to 85.36 % when the catalyst was doped with 36.82 wt% of Fe-to-Ba. The low Fe-to-Ba doping concentration was insufficient to optimize the catalytic activity, whereas the increasing of Fe-to-Ba doping concentration could increase the production of biodiesel. However, due to the lower ability of Fe to crystallize compared to Ba, the excessing of Fe-to-Ba doping could result in the agglomeration in the active site surface area and forming aggregation at high calcination temperature. According to the calcination temperature study, the increasing of calcination temperature decreasing the catalytic activity, where theproduction of biodiesel decreased from 86.59 % to 83.83 % when using the catalyst calcined at 631.82 °C dan 968.18 °C, respectively, at fixed 20% of Fe-to-Ba doping percentage and 5 hours calcination period. The difference in activity might be due to the agglomeration of metal on the surface of catalystat high temperature leading to the reduction of active site surface area. At fixed Fe-to-Ba doping percentage at 20 wt% and calcination temperature 800 °C, the calcination period was studied between 98 min and 501 min to analyse the catalytic activity. The result shows that the FAME production increased from 80.81 % to 85.57 % at optimum calcination period 300 min, and decreased back to 80.27 % when the calcination period increased to 501 min. This condition can be explained according to [4], where the crystallinity percentage analysed using x-ray diffraction (XRD) increased by the increase ofthe calcination time, but the highest crystallinity percentage can be seen at the optimum calcination time. A crystalline catalyst often exhibits better thermal and chemical stability during reactions, especially at high temperatures. The high crystallinity percentage indicated that the metal was highly dispersed throughout the catalyst base. The low crystallinity percentage may lead to metal leaching during transesterification reaction of LGO [5].

From this study, it can be concluded that Fe/Ba/γ-Al_2O_3 heterogeneous catalyst can promote the transesterification of LGO with methanol in biodiesel production at moderate reaction condition. Two major peaks C16:0 methyl palmitate and C18:1 methyl oleate were detected from GC-MS at 15.802 min and 16.467 min respectively, indicated the presence of FAME in the biodiesel. Fig 1 shows the coefficient of determination (R^2) of quadratic model obtained from RSM with CCD was 0.9945. The regression model with value more than 0.95 indicated that the model has a high correlation between thepredicted value and the actual value of the FAME production.

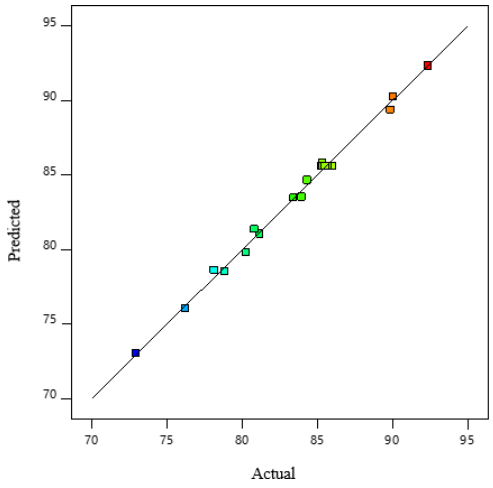

Fig 1: The coefficient of determination (R^2) of quadratic model obtained from RSM with CCD.

From the analysis, the production of Fe/Ba/γ-Al_2O_3 catalyst was optimum at calcination temperature 700 ° C for 180 minutes with Fe-to-Ba doping by 10 wt%. Its optimum catalytic activity was detected form GC-FID, which 83.02 % biodiesel was produced from transesterification reaction using 1:18 LGO to methanol ratio, 6 wt% of catalyst at 65 °C within 3 hours.

Keywords: Catalyst, metal doping biodiesel, transesterification, low grade cooking oil

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Preparation of Activated Carbon derived from Water Treatment Sludge activated via Carbonization using Superheated Steam

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Extended Abstract

Clean water treatment process at water treatment plant (WTP) produces substantial quantities of sludge.In Malaysia, it is reported about 100,000 tonnes of sludge are disposed annually. Disposing of WTP sludge in landfills or directly releasing it into water bodies is not only expensive but also ecologically unsustainable. If not handled correctly, the sludge can pose environmental hazards and possible concerns to human well-being. Therefore, strategies in converting the WTP sludge to value-added product such as biochar and activated carbon (AC) is required to minimize the disposals.

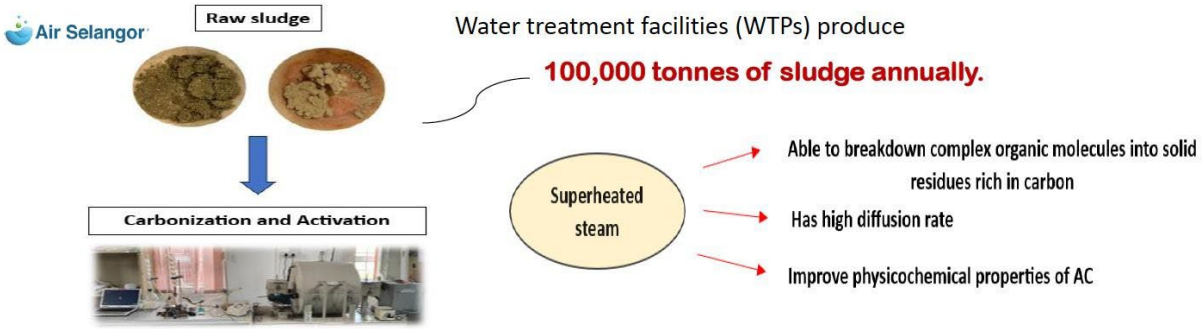

Fig 1: Carbonization and activation of raw sludge from water treatment sludge

In this study, AC was formed by treatment of the WTP sludge with superheated steam via carbonizationand activation processes in a rotary kiln as shown in Fig. 1. Superheated steam is capable of breaking down complex organic molecules, possess high diffusion rate and shown to improve physicochemical properties of AC. The WTP sludge utilised in this study was sourced from two different Air Selangor plant, which are WTP Semenyih 2 and WTP Batu 11 Cheras. The effect of activation temperature towards their physical properties and adsorption capabilities, the difference river sources were studied.

The WTP sludge was carbonized at 400°C (BC400), followed by activation at 600°C to 900°C for 1h. The AC produced were denoted according to the treatment temperature as AC600, AC700 AC800 and AC900. Before the treatment, the WTP sludge was dried at 110°C to determine the moisture content. 200 g of the WTP sludge was placed in the rotary kiln and superheated steam generated from water (1mL/min) was supplied directly into the kiln. Treatment temperatures were provided by the external heating furnace equipped with temperature control and condenser to collect the condensed steam [1]. After 1h, the kiln was left to cool to room temperature and were collected to determine the yield. The AC were then characterised by proximate analysis, BET, FTIR, SEM, and XRD. Methylene blue was used to evaluate its adsorbent capabilities.

Activated carbon produced at 700°C (AC700) of WTP Semenyih 2 source exhibit the most positive characterization results compared to those treated at other temperatures. Its proximate analysis resultedin moisture, volatile matters, ashes and fixed carbon of 3.88 wt%, 12.7 wt%, 82.95 wt% and 0.48 wt%, respectively. The BET surface area, micropore vol, total pore vol, and pore size were 147 m^2/g, 0.0108 cm^3/g, 0.38 cm^3/g, and 5.21 nm, respectively. The FTIR analysis demonstrated that AC contained a significant number of oxygen functional groups.

For the adsorption test, AC700 exhibited the greatest percentage methylene blue removal rate (99.57%) when compared with WTP sludge activated at other temperatures as shown in Fig. 2. The AC material produced from WTP sludge by superheated steam was analogous to the commercial AC derived from coconut husk (ComAC), as evidenced by all physicochemical properties. This could be due to the superheated steam at 700°C stimulated the pore development of the AC and precluded oxygen from the system to prevent excessive burn-offs. Consequently, this study has confirmed that the physicochemical properties of AC derived from WTP sludge were significantly improved by the carbonisation and activation processes at 700°C using superheated steam. Thus, preparation of AC from WTP sludge by means of superheated steam is achievable and its quality is highly promising as a new adsorbent in the effort to reduce the disposal of water treatment sediment.

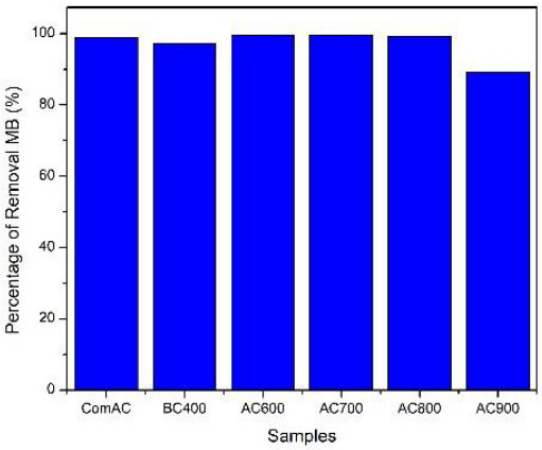

Fig 2: Percentage of methylene blue removal during adsoption testing for the coconut husk derived commercial AC and WTP sludge derived AC treated with superheated steam at various temperatures.

Keywords: Water treatment plant sludge derived activated carbon, Superheated steam activation

Acknowledgment
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Isolation, Identification and Antagonistic Activity of Potassium Solubilising Bacteria (KSB) from Forest Soil on Oil Palm Pathogen, *Ganoderma boninense*

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Extended Abstract

The purpose of this study was to isolate and identify potassium solubilising bacteria (KSB) from Forest Research Institute Malaysia (FRIM) forest soils and assess their antagonistic properties against *Ganoderma boninense*, the causal agent of basal stem rot (BSR) disease in oil palm.

The serial dilution and spread plate technique [1] was done on Aleksandrow agar (AA) plates in triplicate. Potassium solubilising bacteria (KSB) isolates were confirmed using the spot plate method, and their solubilisation zone, index, and efficiency were measured [2]. The KSB isolates were also tested for phosphate (P) and zinc (Zn) solubilisation. Promising isolates were identified via 16S rDNAsequencing and assessed for antagonistic activity against *G. boninense* ET61 using a dual culture technique based on percentage inhibition of radial growth (PIRG) [3]. This dual culture assay was repeated twice.

Twenty-one (21) potential KSB isolates were selected for further analysis based on their potassium (K) solubilisation test results. These isolates showed K solubilisation zones of 1.58 to 3.50 cm (Fig. 1), solubilisation indices of 4.10 to 8.0, and efficiencies ranging from 310% to 700%. Some isolates were also able to solubilise P and/or Zn. Molecular identification by 16S rDNA sequencing found that 17 isolates belong to the *Burkholderia* family and the remaining four were *Enterobacteriaceae*. In dual culture assay against *G. boninense* ET61, the isolates varied in their ability to inhibit mycelial growth. Figure 2 shows that only four isolates had a PIRG greater than 50%, while the rest had PIRG less than 50%.

We identified four KSB isolates with a percentage inhibition of radial growth (PIRG) greater than 50% against *G. boninense* ET61, making them candidates for further evaluation. This study highlights the potential of KSB for both enhancing soil fertility and managing BSR for a more sustainable agriculture.

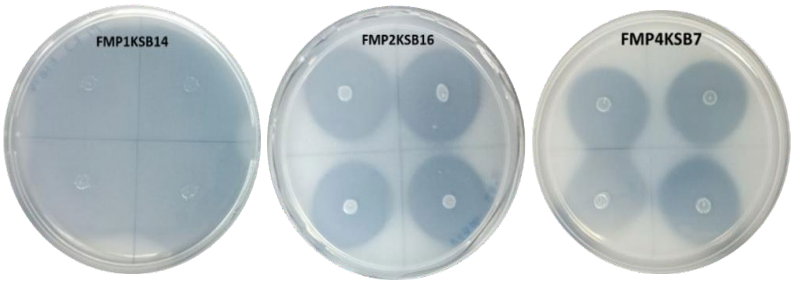

Fig 1: A few samples of validation test result for potassium (K) solubilisation ability by putative KSB isolated from FRIM forest soil on Aleksandrow agar (AA) plates, demonstrating a range of varying K solubilisation zones.

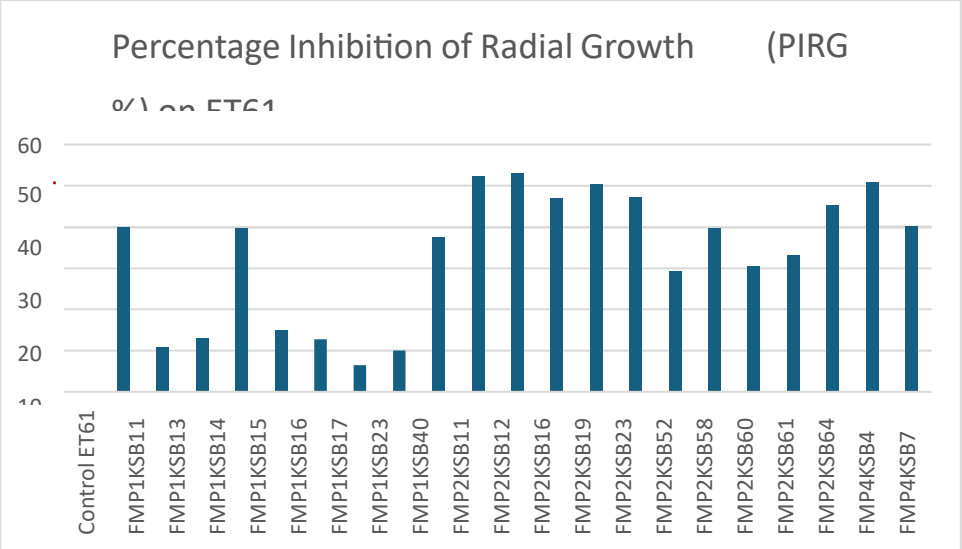

Fig 2: Effect of putative KSB isolates from FRIM forest soils on the radial growth of *Ganoderma boninense* ET61 in dual culture assay at five days of incubation.

Keywords: Potassium Solubilising Bacteria, *Ganoderma boninense*, Basal Stem Rot, Soil Fertility, Sustainable Agriculture

Acknowledgment

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Impact of Different Light Conditions on the Growth and Physiological Characteristics of *Talinum fruticosum* (L.) Juss. Callus

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Extended Abstract

Talinum fruticosum (L.) Juss., commonly known as Ceylon spinach, waterleaf or Javanese ginseng, is a medicinal plant valued for its nutritional and therapeutic properties, including antioxidant, antimicrobial, hepatoprotective, and neuroprotective activities [1]. Rich in bioactive compounds such as flavonoids, saponins, and lignans, it holds significant potential for food and pharmaceutical research[1]. The ability to culture and propagate *T. fruticosum* through plant tissue culture techniques offers significant potential for large-scale production of its valuable secondary metabolites. One critical factorin successful tissue culture is the manipulation of external growth environments including light, whichplays a pivotal role in the growth, development, and physiological responses of callus [2]. However, the specific effects of different light conditions on the growth and physiological characteristics of *T. fruticosum* callus are not well-documented and this study could provide essential insights for optimizing*in vitro* culture protocols for this plant species. This study aims to investigate the impact of different light conditions, specifically white LED, blue:red LED, and complete darkness on the growth and physiological characteristics of *T. fruticosum* callus.

Callus formation was induced from stem explants of two months *in vitro* plantlets of *T. fruticosum* usingthe transverse thin cell layer (tTCL) technique [2]. Explants were cultured on MS medium with 3% sucrose, 1.0 mg/L TDZ, and 2.5 mg/L 2,4-D. The medium, adjusted to pH 5.7 and solidified with 0.3%Gelrite, before being autoclaved at 121 °C for 20 minutes. Cultures were incubated at 24 ± 2 °C for fourweeks under white LED, blue:red LED (ratio 1:2), and darkness (control). Afterward, callus growth, chlorophyll, carotenoid levels, colour and morphology were assessed.

Different light conditions significantly impacted *T. fruticosum* callus growth and water content. The blue:red LED produced the highest fresh weight (2.85 ± 0.41 g), promoting more biomass accumulation than the white LED (2.14 ± 0.53 g) and dark conditions (0.69 ± 0.19 g). Dry weight showed smaller variations, with the white LED yielding the highest (0.07 ± 0.01 g), followed by blue:red LED (0.06 ± 0.01 g), and darkness the lowest (0.04 ± 0.01 g). This indicates that although both light conditions promote similar dry matter production, the white LED is slightly more efficient in generating solid biomass. The good performance of the blue:red LED treatment could be attributed to the specific lightspectra that enhance photosynthetic activity and stimulate growth [2, 3]. Callus color varied, with whiteLED producing greenish-red, blue:red LED yielding greenish-white while darkness led to reddish- white. Morphologically, white and blue:red LED resulted in compact and friable callus, while dark conditions produced friable callus. Water content was also influenced by different light conditions, withblue:red LED promoting the highest water retention (97.89 ± 0.13%), followed by white LED (96.57 ±0.28%) and darkness (93.91 ± 0.23%). The higher water content under blue:red and white LED suggeststhat light exposure encourages water retention, possibly due to enhanced cellular metabolism and wateruptake processes, which are typically light-dependent [3].

Table 1: Biomass of *Talinum fruticosum* callus under different light conditions.

Light Conditions	Fresh Weight (g)	Dry Weight (g)	Percentage of Water Content (%)
White LED	2.14 ± 0.53^{b}	0.07 ± 0.01^{a}	96.57 ± 0.28^{b}
Blue:Red LED	2.85 ± 0.41^{a}	0.06 ± 0.01^{a}	97.89 ± 0.13^{a}
Dark	0.69 ± 0.19^{c}	0.04 ± 0.01^{b}	93.91 ± 0.23^{c}

Mean values ± SD (n=5) with different upper-case letters are statistically different within columns ($p < 0.05$).

The results show that white LED light promoted the highest total chlorophyll content (1.64 ± 0.45 mg/g)and carotenoid level (1.04 ± 0.61 mg/g), making it the most effective for photosynthetic pigment production (Table 2). The blue:red LED produced moderate chlorophyll levels, while darkness led to the lowest chlorophyll pigment accumulation of moderate carotenoid level. Although blue:red LED wasless effective in this study, previous research on other species suggests that it can enhance photosynthetic pigment production, implying that the specific blue:red ratio and exposure duration mayplay a critical role [2, 3].

Table 2: Chlorophyll and carotenoid content of *Talinum fruticosum* callus under different light conditions

Light Conditions	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll Content (mg/g)	Carotenoid (mg/g)
White LED	0.93 ± 0.42^{a}	0.71 ± 0.18^{a}	1.64 ± 0.45^{a}	1.04 ± 0.61^{a}
Blue:Red LED	0.79 ± 0.34^{ab}	0.54 ± 0.36^{a}	1.33 ± 0.47^{ab}	0.35 ± 0.25^{c}
Dark	0.46 ± 0.17^{b}	0.52 ± 0.24^{a}	0.98 ± 0.40^{b}	0.74 ± 0.34^{ab}

Mean values ± SD (n=5) with different upper-case letters are statistically different within columns ($p < 0.05$).

This study concludes that white LED light is the most effective for promoting growth and pigment production in this species, while blue:red LED light shows moderate results. Optimizing light conditions is crucial for maximizing growth and pigment accumulation. Future studies should explore different blue:red LED ratios and incubation periods to further enhance pigment and phytochemical production in *T. fruticosum*. Overall, integrating white and blue:red LED light presents a promising approach to improving growth and the quality of callus production in *T. fruticosum*.

Keywords: callus, carotenoid, LED, pigment, *Talinum fruticosum*

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Integration of MgFe Layered Double Hydroxide on the Surface of TeaStalk Based Activated Carbon for Enhanced Cd(II) Adsorption

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Extended Abstract

The contamination of water bodies by heavy metals is a pressing environmental issue, primarily drivenby the rapid expansion of industrial activities. Among these heavy metals, cadmium is particularly hazardous due to its high toxicity, even at low concentrations, and its ability to bioaccumulate in livingorganisms [1]. The present work attempted to remove heavy metal ions such as cadmium (Cd) from anaqueous solution via the adsorption process. Activated carbon was synthesized from tea stalks, an abundant agricultural waste, to provide a low-cost and sustainable adsorbent for the removal of Cd(II) ions from aqueous solutions. The synthesis process involved microwave-induced activation, which wasemployed due to its outstanding heating efficiency in producing high-quality activated carbon in a shorter time compared to conventional physical activation methods [2]. The microwave radiation activation process was carried out in the presence of carbon dioxide (CO_2) gas, which acts as a gasifyingagent to enhance the porosity and surface area of the activated carbon. The Response Surface Methodology method (RSM) was used to obtain the optimal preparation parameters for AC fabrication.The most ideal preparation condition was at microwave radiation power of 400W for 7 minutes of activation time, which gave up to 61.05% of Cd(II) ion removal and TSAC yield of 37.33%. To further improve the adsorbent adsorption capacity, modification was done on the surface of the tea stalk-basedactivated carbon (TSAC) by incorporating MgFe-layered double hydroxide (MgFe-LDH). A facile co-precipitation approach using $Mg(NO_3)_2 \bullet 6H_2O$ and $Fe(NO_3)_3 \bullet 9H_20$ salts was utilized to integrate the LDH onto the adsorbent surface. Characterization on elemental analysis revealed a high MgFe/TSAC carbon content of 82.25% compared to the raw tea stalk precursor, tea stalk char, and TSAC. Moreover,the modified MgFe/SLAC also exhibited superior physical properties, with high a Bruneaur-Emmet- Teller (BET) surface area of 853.3 m^2/g and a total pore volume of 0.484 cm^3/g surpassing the precursorand unmodified TSAC. These significant pore structure changes were presented in SEM analysis as demonstrated in Fig 1. Fig 1(a) of raw tea stalk displayed a dense and fibrous surface structure with novisible pore, while SEM images of MgFe/TSAC in Fig 1(b) show numerous porous structures resultedfrom carbonization and activation processes. The MgFe/TSAC also established an improvement in terms of surface functionality (fourier-transform infrared spectroscopy, FTIR) with the presence of hydroxyl, carbonyl, and carboxyl functional groups. The adsorption performance of MgFe/TSAC for Cd(II) ion removal was evaluated by a batch equilibrium adsorption process where the effects of 4 different variables (initial Cd(II) ion concentration, contact time, solution temperature, and solution pH)on the adsorption uptakes and removal efficiency were studied. It was found that Cd metal ion uptakesby MgFe/TSAC were increased (up to 98.45% removal) with the increases of initial concentration, contact time, and solution temperature. Similar trends were observed by [3] in their research on heavy metal ions removal via the adsorption process. Meanwhile, in the case of pH, it was well known that the dissociation of heavy metal ion in water is heavily dependent on the solution pH. The optimum pHfor Cd(II) ion removal was obtained at 7. Increasing and decreasing the solution pH decreases the Cd(II)removal efficiency. This is because, at lower pH levels, the competition between protons and metal

cations for adsorption sites on the adsorbent surface results in reduced metal ion uptake, while at higherpH levels, the efficiency decreases due to low metal solubility and the tendency for the metal ions to precipitate [4]. On the other hand, adsorption equilibrium analysis of the MgFe/TSAC adsorption system was found to well match the Langmuir isotherm model with a high monolayer adsorption capacity (Q_m) of 401.20 mg/g at 30°C. Kinetics studies showed that the Cd-MgFe/TSAC system followed pseudo-first order, suggesting a physical adsorption mechanism. Lastly, in regeneration studies, the reusability performance of the MgFe/TSAC adsorbent for heavy metal ion adsorption dropped from 100% to 88% after 6 cycles. In summary, the MgFe/TSAC adsorbent demonstrates goodpotential for the efficient removal of Cd(II) ions from wastewater, thus highlighting the importance of optimizing adsorbent materials for enhanced environmental remediation.

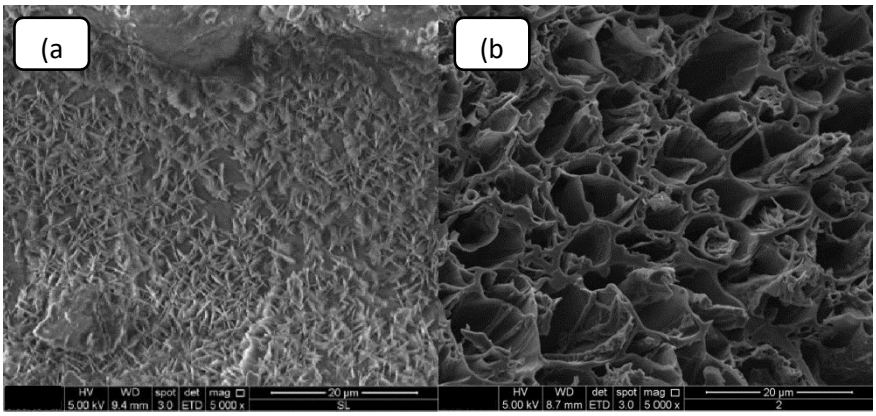

Fig 1: SEM images of (a) raw tea stalk precursor and (b) MgFe/TSAC adsorbent.

Keywords: Heavy metals, wastewater, adsorption, activated carbon, layered double hydroxide

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Metabolic Cooperation & Transcriptomic Response of *Comanonas* strain R2 in the Phenol Biodegradation Engineered Ecosystem

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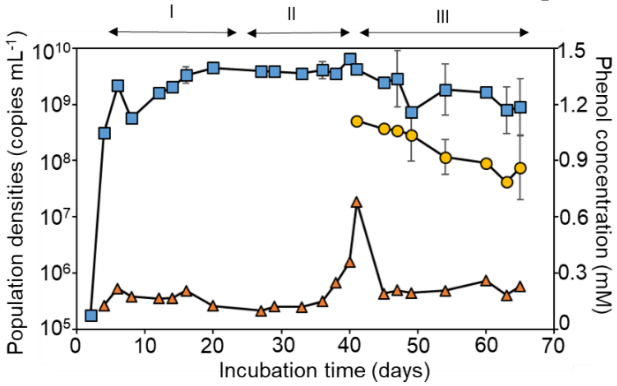
Extended Abstract

Microbial communities are typically composed of diverse multiple species interconnected by the multitude of interspecies interactions. Predictive understanding of the whole ecosystem based on a given simple synthetic microbial community with the view of phenol as a model single substrate willbe instrumental in providing insight of how a simple niche construction process taken by pairwise bacterial interaction. A central question in studying microbial communities is whether community member cooperate or compete each other on single supplied resource. For example, finding by [1] discussed the coexistence occurrence fate between three phenol-degrading strains under chemostat condition. Initially, all strains namely, HAB24, C26 and LAB06 coexist and continue to degrade phenol, probably through resource sharing. However, after replacing strain C26 with another phenol-degrading strain, chemo32 the chemostat starts to accumulate phenol, indicating the system was collapsed and all strains cannot have coexistence. In this study, we recently present an evidence for the interesting phenomenon that *Comamonas* strain R2, a phenol-degrading bacterium, collapsed under phenol-fed chemostat culture. Interestingly, presence of strain Y reduced the negative inhibitionand led to coexistence in the phenol condition. This work will contribute to understanding the generalrule of thumb underlying the formation of metabolic interconnectedness.

The chemostat (1.5 L) with *Comamonas* strain R2 inoculum were constructed by routinely fed with 16 mM phenol as a sole carbon source at the flow rate of 6.25 mL h^{-1} corresponding to a dilution rate (C) of 0.1 d^{-1}. In the case of mixed chemostat reactors, after strain R2 pure chemostat culture showingsign of phenol accumulation, 1.25% (v/v) inoculum of strain Y was co-cultured. Hydraulic residencetime (HRT) was calculated as 10 days. Population densities monitoring of each strains was performedby real-time qPCR targeting the genes encoding the large subunit of phenol hydroxylase (*aphN*) for strain R2 and 16S rRNA for strain Y. To access the potential collapse or inhibition mechanism of strain R2 under the chemostat culture, kinetic analysis was performed at various phenol concentrations. The apparent kinetic constant, *K*s (affinity constant) and *V*max (maximum velocity) in Haldane's equation were determined using Lineweaver-Burk plot. For accessing the effect of strainR2 supernatant on phenol-degrading activity, strain R2 pure culture was added into chamber together with strain R2 supernatant and strain R2 supernatant treated with strain Y. For control, no addition ofstrain R2 supernatant was performed. Total RNA from pure chemostat culture containing strain R2 and mixed chemostat culture consisting of strain R2 and strain Y was used to compare the transcriptomic profiles. The expression level of each gene was calculated as number of reads mappedper length of gene in kilobases and divided by 1 million scaling factor. The number of reads mapped to each gene were determined using StringTie ver. 1.3.5 and differential expression gene (DEG) analysis was performed using edgeR package to compute *P*-values and fold changes.

Strain R2 was maintained stable from initial day of incubation until day 40 before phenol starting to accumulate at day 41. Population density of strain R2 on day 41 was slightly reduced as compared to previous day 40. This time point was selected based on the possible indication for growth recovery ability possessed by strain Y towards loss of the phenol-degrading ability of strain R2. As expected, after strain Y co-culture, no phenol accumulation was detected throughout the incubation time (Fig.1). Strain R2 maintained their population density with approximately 9.46 ± 0.5 cells mL^{-1}. All strains coexisted. Population density of strain Y was approximately recorded to be 8.06 ± 0.3 cells mL^{-1}. From Lineweaver Burk plot, phenol degradation of strain R2 in the presence of strain R2 supernatant was completely inhibited. Whereas, kinetic analysis after addition of strain Y supernatant was similar to oxygen consumption rate of control treatment. From this, it was suggested that strain Y reduced the competitive inhibition. This inhibition was released and strain R2 resumed their phenol-degrading activity after resource utilisation [2]. From RNA-seq analysis, we compared the three phases of DEGs between the collapse condition (phenol accumulation period) and strain Y under coexistence with strain R2.

Fig 1: Population densities of strains R2 and Y in a chemostat culture. Population density of strain R2;



blue squares, population density of strain Y; yellow circles, phenol concentration; orange triangles.

Above-mentioned analyses indicated that the collapse of strain R2 may trigger metabolic instability that caused imbalance between carbon and nitrogen metabolism. Obviously, TCA cycle relatively repressed about 68.9% and ammonium transporter, *amtB* was increased at 190-folds at the collapsed status. Only purine biosynthesis was found to be increased in strain Y expression level. Given that purine biosynthesis pathway emerges as a potential pathway that may lead to the mutualistic interaction, enabling metabolic cooperation for phenol biodegradation.

Keywords: cooperation, growth recovery, transcriptomic, chemostat, phenol biodegradation

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Molecular Cloning and Characterization of Lignin-Related *MYB* Genes from Oil Palm (*Elaeis guineensis* Jacq.)

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Extended Abstract

MYB (myeloblastosis) is a large family of proteins in all eukaryotes. These proteins primarily functionas transcription factors, regulating the transcription of genetic information from DNA to mRNA in the pathway toward protein translation. The structure of MYB TFs consists of two important regions, which are the N-terminal conserved MYB DNA-binding domain and the C-terminal modulator region responsible for regulating the protein's activities. Functional studies on MYB TFs have been extensively conducted, highlighting their wide role in plant metabolic systems, with various MYB functions reportedin different species. One of the functions of MYB TFs is regulating lignin biosynthesis, which is a key component in plant cells. Lignin has become a major focus in crop improvement due to its role in plant defense and adaptation to various stresses. Genome-wide analysis revealed a total of 159 *MYB* genes in the oil palm genome [1]. To date, only a few functional studies have been performed on these genes. Therefore, only limited information about their functions, particularly in lignin biosynthesis, is available. This study aimed to identify and study the selected *MYB* genes that are potentially involved in lignin biosynthesis in oil palm.

Bioinformatics analysis and transient expression were performed to identify and select oil palm *MYB* (designated as *EgMYB*) genes that are potentially involved in lignin biosynthesis. The amino acid sequences of EgMYB and MYB from other plant species were collected from an online database and a phylogenetic tree was constructed using the MEGA7 software to identify EgMYBs that potentially regulate lignin biosynthesis. Multiple sequence alignment was performed on the MYBs in each clade to compare the sequences. Through bioinformatics analyses, *EgMYB47* and *EgMYB48* were identified as potential lignin-related *MYB* genes and selected for further analysis. Total RNA was isolated from leaf tissues of oil palm (*Elaeis guineensis* Jacq var. *pisifera*) and converted into cDNA. Next, Polymerase Chain Reaction (PCR) was performed using a high-fidelity DNA polymerase to amplify the coding sequences of the *EgMYB47* and *EgMYB48*. Subsequently, the PCR products were cloned into pRI201AN binary vector, producing the transformation constructs (pRI201AN-*EgMYB47* and pRI201AN-*EgMYB48*). The ligation products were introduced into *E. coli* DH5α-competent cells usingthe heat-shock transformation method to produce the recombinant plasmids. Next, the recombinant plasmids were isolated from the *E. coli* cells and transformed into *Agrobacterium* LBA4404 competentcells.

To study the effect of the overexpression of *EgMYB47* and *EgMYB48* on the expression of the lignin biosynthetic genes, transient expression of *EgMYB47* and *EgMYB48* was performed in the tobacco (*Nicotiana tabacum*) leaves. The agroinfiltration of tobacco plants was performed according to the protocol developed by [2]. The leaves were harvested three days after infiltration and the expressions of selected lignin biosynthetic genes, including *NtPAL4*, *NtCAD2* and *NtPRX*, were studied using reverse transcription polymerase chain reaction (RT-PCR). The PCR products were subjected to gel electrophoresis analysis.

Based on sequence analysis, EgMYB47 and EgMYB48 were classified as the R2R3-type MYB. As shown in Figure 1A, the amino acid sequences of EgMYB47 and EgMYB48 displayed high similarities with several MYB TFs that suppress lignin biosynthesis in their respective hosts. It is worth noting that the EgMYB47 has the highest domain similarity with MusaMYB31 from banana and VvMYB4a from grapevine (98.1% and 96.2%, respectively). On the other hand, the R2R3 domain of EgMYB48 is identical to that of VvMYB4a. The coding sequences of *EgMYB47* and *EgMYB48* were successfully amplified from the oil palm cDNA as shown in Figure 1B.

Figure 1: (A) Multiple sequence alignment analysis of EgMYB47 and EgMYB48 amino acid sequences (B) Gel electrophoresis analysis of PCR products. DNA Ladder (M): ExactMark 1 kb DNALadder, 250 µg (1st BASE, Singapore). Lane 1: *EgMYB47*, Lane 2: *EgMYB48*

Gene expression analysis results showed that the expressions of *NtPAL4* and *NtCAD2* genes in tobacco plants reduced when either *EgMYB47* or *EgMYB48* was overexpressed. MYBs are transcription factors that will bind to the promoter sequence of lignin biosynthetic genes and regulate their transcription. Phenylalanine ammonia lyase (PAL) is the enzyme that controls the starting point of the metabolic process in the phenylpropanoid pathway and cinnamyl alcohol dehydrogenase (CAD) is the enzyme involved in the last step of monolignol biosynthesis by transforming the cinnamaldehyde into its respective alcohols [3,4]. The gene expression analysis results implied that both *EgMYB47* and *EgMYB48* might potentially suppress *NtPAL4 and NtCAD2* transcriptions, eventually compromising lignin formation in plants. We suggested that both of these transcription factors bind to the promoters of lignin biosynthetic genes and suppress the gene transcription, which results in reduced lignin accumulation in plants. It is also worth mentioning that *EgMYB47* and *EgMYB48* are close homologs ofseveral negative regulators of lignification, such as *LTF1* from poplar and *LlMYB1* from river tamarind[5]. Altogether, the results indicated that *EgMYB47* and *EgMYB48* could be potential negative regulatorsof lignin biosynthesis in oil palm.

In conclusion, *EgMYB47* and *EgMYB48* genes were cloned from oil palm genome and characterized by bioinformatics and molecular analyses. The results obtained suggested that *EgMYB47* and *EgMYB48* could be potential negative regulators of lignin biosynthesis in oil palm. These genes could be a molecular switch for manipulating lignin content in plants and could be utilized in crop improvement studies, especially in oil palm. However, further analyses are required to validate their roles in oil palm lignification. This study provides an informative insight into the MYB transcription factors in the oil palm.

Keywords: MYB, oil palm, lignin, genetic manipulation, agroinfiltration

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