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Climate Change Impact on the Sustainability of Agriculture, Forestry & Plantation

8-9 May 2023

Noble Resort Hotel, Melaka, Malaysia

Organised by :

Universiti Teknologi MARA | Faculty of Plantation and Agrotechnology

Nilai University – Enrichment For Life

Conference Manager :

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AGRICULTURE

002-002

MOLLUSCICIDAL ACTIVITY OF AQUEOUS EXTRACT FROM FIVE PLANTS SPECIES AGAINST GOLDEN APPLE SNAILS (*Pamocea canaliculata)*

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ABSTRACT

The quest for botanicals with molluscicidal activity became essential research when the Golden Apple Snails (*Pomacea canaliculata*) became a pest that invaded rice fields and resulted in a significant decrease in rice harvested in Malaysia. This study was conducted to screen the aqueous extracts of leaves of *Acacia mangium* (Fabaceae), *Allamanda cathartica* (Apocynaceae), *Catharanthus roseus* (Apocynaceae), *Euphorbia hirta* (Euphorbiaceae) and *Stachytarpheta jamaicensis* (Verbenaceae) as potential molluscicides. For each plant species, one kg of freshly crushed leaves was blended with 5000 ml of water and soaked at room temperature. After 24 hours, it was filtered, and this extract was named 100% aqueous extract. The two diluted concentrations of extracts, i.e., 10% and 50%, were prepared based on a 100% extract. Ten adult snails were treated at each concentration for molluscicide testing for 24 hours. Then it was replaced with chlorine-free water and left for 24 hours. Snails were considered mortal when they remained motionless if stimulated by a needle or if the body emerged from the shell or remained within it. The results showed that the most potent extracts were *Stachytarpheta jamaicensis* leaf extracts, followed by *Allamanda cathartica*, *Acacia mangium*, *Euphorbia hirta* and *Catharanthus roseus*. Therefore, this study suggested that *Stachytarpheta jamaicensis* warrants further investigation of the molluscicidal effect on controlling Golden Apple Snails.

Keywords: *Pomacea canaliculata*, molluscicidal, *Stachytarpheta jamaicensis*, pest.

INTRODUCTION

The non-native golden apple snail (*Pomacea canaliculata*) is a fresh water gastropod that has caused severe damage to Malaysia's rice industry by attacking and destroying the stems and young leaves of the plant and can eat up to 24 paddy saplings per day (Azmi *et al*., 2022). Damage to the snail significantly reduced paddy production. The problem becomes more severe because the snail population can increase rapidly in water and enough food. Chemical pesticides are widely used to control snails (Rohaizad Md Rejab *et al*., 2022). Although effective, using chemicals is not recommended as they have long-term toxicity effects on humans and the environment, polluting water resources and subsequently affecting ecosystems. Moreover, the costs associated with chemical molluscicides are unaffordable for farmers (Wang *et al*., 2022).

An alternative to nature's relatively "friendly" control of snails is to use biopesticides derived from naturally occurring plant compounds, which have a pronounced and affordable molluscicidal effect (Rosli *et al*., 2021). Ongoing efforts are still to find the most potent organic biological agents to minimize their invasion and attack. The strategy is to choose a plant that contains saponin, which can kill them (Bala & Singh, 2017). According to Akinpelu et al. (2012), plant derived saponins were targeted on muscles, hemolysis, bowel and hepatopancreas gland poison of the freshwater snail. Specifically, saponin able to inhibit the activity of acetylcholinesterase in the nervous system of the snail (Abubakar *et al*., 2017).

Saponin occurs in many local plants (Cheok *et al*., 2014). These plants include *Acacia mangium (*Rangra *et al*., *2019), Allamanda cathartica (*Khairun Nur *et al*., 2019*), Catharanthus roseus* (Pham *et al*., 2019), *Euphorbia hirta* (Nyeem *et al*., 2017) and *Stachytarpheta jamaicensis* (Egharevba *et al*., 2019). Therefore, this study aims to screen the particular plant with the activity of powerful molluscicids as a candidate for the development of a new natural molluscicidal agent against the golden apple snail.

MATERIALS AND METHODS

Golden apple snail

Adult Golden Apple Snails with shell lengths ranging from 25 to 35 mm were obtained from rice fields in the Ketereh District of Kota Bharu, Kelantan. The snails were raised in a chlorine-free 90-liter aquarium with fresh cabbage. Within a week, snails were assigned for molluscicidal testing.

Plants and extraction

One kg of leaves of *Acacia mangium*, *Allamanda cathartica*, *Catharanthus roseus*, *Euphorbia hirta* and *Stachytarpheta jamaicensis* were collected at Jeli District, Kelantan in July 2022, respectively. Separately, plant leaves were ground using an electric blender, extracted with 5000 ml of chlorine-free water for 24 hours, and filtered using filter paper. This liquid form of extract was named the 100 %(v/v) of extract, and used for molluscicidal essay within 24 hours.

Molluscicidal assay

The molluscicidal assay was conducted according to the method described by Prabhakaran *et al*., (2017). Snails were treated with three extract solutions, i.e., 10 % (v/v), 50 %(v/v) and 100%(v/v). Negative control only contains chlorine-free water. The final volume of extract and control was 300 ml. The assays were conducted in triplicate using a 500 ml aquarium with ten snails per extract concentration. Snails were left submerged in their respective extracts concentration for 24 hours. Then, the extract solution was removed, and the snails were washed three times using chlorine-free water and placed in 300 ml of chlorine-free water. After 12 hours, the number of dead snails were determined. The was considered dead if one or more of the following observations: (i) the snail's body remains in the shell, and usually, the non-dead snail will constantly move; (ii) the snail's body remains outside the shell when pierced slowly with a needle. The molluscicidal activity of the plant extracts were reported as median lethal concentration (LC_{50}) of snail sample. The LC_{50} was calculated by Probit analysis.

RESULT AND DISCUSSION

The molluscicidal potential of five different plant species was investigated in this particular study, using golden apple snails as the test subject.The strength of molluscicid activity of plant species was presented as the LC_{50} (Figure 1). Basically, the low LC_{50} indicates strong molluscicidal activity compares to the high LC_{50}. It was found that the most potent molluscicidal activity against golden snails was the extract of *Stachytarpheta jamaicensis* (3.76 ± 0.38 %(v/v)) followed by the extract of *Allamanda cathartica* (14.38 ± 1.31 %(v/v)), *Catharanthus roseus* (31.35 ± 6.36 %(v/v)), *Euphorbia hirta* (33.79 ± 1.53 %(v/v)) and *Acacia mangium* (51.50 ± 3.12 %(v/v)).

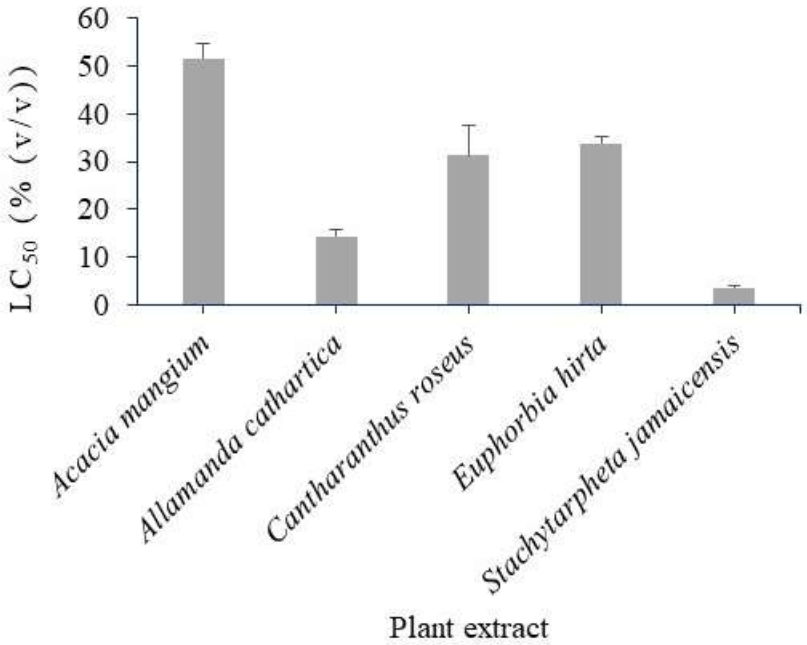

Figure 1: Molluscicidal activity (LC_{50} value) of five plants extract against golden apple snail.

This study was the first report the molluscicidal activity of water extract of leaves of *Stachytarpheta jamaicensis*, *Catharanthus roseus* and *Acacia mangium* . The molluscicidal activity of *Allamanda cathartica* toward golden apple snail was previously reported by the researcher from Thailand (Chobchuenchom *et al*., 2004); however, the study was shallow and no other reports were found. Sison *et al*. (2013) was reported the potential of *Euphorbia Hirta* ethanolic leaves extract as molluscicide against this snail adn the LC_{50} was 10.9 ppm. A study by Joseph *et al*., (2016) showed that the LC_{50} of the acacia mangium ground bark and water mixture to the golden snail was 25 mg/ml. No additional information on molluscicide activity of *Acacia mangium* is reported. In conclusion, these results have resulted in the selection of *Stachytarpheta jamaicensis* as a potential candidate for the continued development of natural molluscicides.

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005-004

DESIGN OF SIMPLE MECHANICAL TOOLS FOR PADDY LODGE – PROTOTYPING

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ABSTRACT

Paddy is an important crop in Malaysia and is essential for the country's food supply. Aside from that, the statistics show that Malaysia's paddy industry has generated consistent income for the country. Lodging is one of the problems that results in financial loss for farmers. Malaysia is one of the nations where rice is grown in high-yielding environments. Due to unforeseen weather conditions such as heavy winds and heavy rain which are frequently blamed for lodging during the grain loading time. To date, there is no such tool to be found in the market and made use by the farmer. In this project, a practical tool and most importantly cheap is going to be developed. Feedback from farmers and other stakeholders were considered in the design. A series of survey and trial sessions had been conducted before the design can be finalized. Finally, the prototype was fabricated and tested, in looking for design improvement. Manufacturability aspects not just on the design complexity but also the possibility of making mold will be considered in the future. The most challenging goal is on the cost as the product is going to be used by low-income farmers, the price of the tool must the lowest.

Keywords: lodged paddy, mechanical tool, low cost, practical, productivity.

011-005

DEVELOPMENT OF CROP CULTIVATION AND ALERT SYSTEM MOBILE APPLICATION

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ABSTRACT

Mobile application development is the process of creating software applications that run on mobile devices such as smartphones and tablets. The mobile application development process can vary depending on the type of app being developed, the platform it is being developed for, and the development methodology being used. These apps can be used for a wide range of purposes, including gaming, social networking, productivity, and more. In agriculture, the usage of mobile applications has also increased due to the awareness of the use of modern technology in the field of agriculture. Mobile applications can be very helpful in improving agricultural practices by providing farmers and agricultural workers with access to useful information and tools. Mobile application can be use in agriculture to manage crops, soil testing, livestock management, market information, education, and training. Mobile app development typically involves a combination of software engineering, user interface design, and testing. The

software development process is divided into five phases which are data collecting, application design, implementation, testing, and maintenance.

This project focus on developing a mobile application of information system for planting activities and alert system for crop planting. The system have 2 components which are a mobile app for user and also a web based administration page for administration purpose. This application helps farmers to plant and manage the crop from planting until harvesting. This application will send activity reminder to farmers as well as weather forecast data via app notification and SMS a day before each activity. This application will help farmers in maintaining their crop and to ensure that farmers follow the standard procedure during the planting process.

013-007

COMPLETE FULL FACTORIAL DESIGN OF THE EFFECTS OF COAGULANTS AND PROCESSING VARIABLES ON THE PHYSICOCHEMICAL QUALITY AND TEXTURE PROFILE ANALYSIS OF KENAF SEED TOFU

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ABSTRACT

Kenaf seed is a rich source of essential nutrients and has a potential for production of protein-based products. This study investigated the holistic effects of coagulants, kenaf seed-to-water ratio for extraction, and temperature of addition of coagulant on the physicochemical and texture quality of kenaf seed tofu. Randomized complete full factorial design was used to obtain different formulations of kenaf tofu production under 4 factors at different levels. Kenaf seed tofu production factors such as seed-to-water ratio for extraction of kenaf seed milky extract, coagulant types, concentrations and temperature of addition of coagulant and the interactions among the factors affected the quality of the tofu in a varied way. The main factors of coagulant types, seed-to-water ratio and temperature of addition of coagulant affected the yield, pH, crude protein, crude lipid, lightness yellowness and cohesiveness of the kenaf seed tofu while the redness of the tofu was affected by the coagulant types only. However, the hardness, chewiness and springiness of the tofu were affected by coagulant types and concentrations. Additionally, the 2-way interactions effects of coagulant types*coagulant concentrations, coagulant types*seed-to-water ratio, and the 3-way interaction of coagulant types*coagulant concentrations*temperature of addition of coagulant affected the hardness of the tofu. The chewiness and springiness of the tofu were affected by the 2-way interactions effects of coagulant types*seed-to-water ratio and coagulant concentrations*seed-to-water ratio, respectively. However, the 2-way (coagulant types*seed-to-water ratio, coagulant types*temperature of addition of coagulant and coagulant concentrations*temperature of addition of coagulant) and the 3-way (coagulant types*coagulant concentrations*temperature of addition of coagulant) affected the cohesiveness of the tofu. Though, the 4-way interaction has no significant effect on the texture characteristics of the kenaf seed tofu. This study also found that aluminium potassium salt and glucono-delta-lactone, with the use of 1:3 seed-to-water ratio and 70 or 80 ^{o}C temperature of addition of coagulant were better in terms of hardness and chewiness.

Keywords: Tofu, kenaf seed, physicochemical quality, seed-to-water, processing variables.

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008-009

OPTIMIZATION OF AB MIX FERTILIZER FOR *CAPSICUM FRUTESCENS* IN SOILLESS MEDIA USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT

In this study, optimization of AB mix fertilizer for enhanced growth and crop yield of *Capsicum frutescens* has been carried out using the wick fertigation technique. An appropriate amount of AB fertilizer concentration is crucial since lack of fertilizer may contribute to slow growth and lesser endurance towards plant disease whilst, an excessive application may result to burn effect and environmental pollution. Therefore, response surface methodology is used to determine the optimization growth of *Capsicum frutescens* through the central composite design of face-centered (k = 1) configuration and 13 triplicated runs. A quadratic model of three concentration levels of AB mix fertilizer (X_1: 1.8, 2.2, and 2.6 mS/cm) and wick length (X_2: 17, 19, and 21 cm) were used as factors. Results showed that X_1 and X_2 gave a significant influence on the selected response variables. Statistical analyses explained the coefficient of determination (R^2 < 0.9915), P-value (< 0.0001), F-value (163.54), and not-significant lack of fit values (> 1.14) supporting the validation of prediction models. The optimization condition of AB mix fertilizer for *Capsicum frutescens* has been identified with the maximum plant height recorded at 38.73 cm. This study demonstrates that an adequate amount of fertilizer with the appropriate length of wick used is crucial as they affect the plant's growth and yield.
Keywords: AB mix fertilizer, *Capsicum frutescens*, central composite design, response surface methodology

INTRODUCTION

The rapid growth of the world's population has led to an increasing demand for food supply. Many alternatives have been taken to ensure the fresh food supply is secured (Ahirwar & Hasan, 2018). *Capsicum frutescens*, (C. *frutescens*), also known as bird's eye chilli is one of the most important crops in Malaysia however, concern about the shortage of chilli supply for local's market demand has been prolonged and therefore, given rise to imported chilli supply from India, China and Thailand to fulfil the local demand. To increase the output with the increasing price of the input is a challenge; an appropriate amount of fertilizers and pesticides are important for food management resources to enhance the quality and quantity of crops. Conversely, excessive amounts and disproportionate use of fertilizers and pesticides can be harmful to the environment and cause serious pollution and health hazards. This includes the compilation of heavy metals in soils that are absorbed and accumulated in fruits, vegetables and grains which, therefore, affects food safety as the bio-concentrated pollutants enter organisms within the food chain. Literature reported that plants use up to 50% only of the applied fertilizer, 2 - 20% volatilized, 15 – 25% reacts with organic compounds in soil and 2 – 10% leach into groundwater and surface (Jadon et al., 2022). Large quantities of inorganic fertilizers application also led to severe water pollution where the excessive applied nitrogen, N may be potentially leached from the root and ends up in lakes, ponds, rivers and other water sources that results in an adverse effect. Therefore, it is important for the farmers/growers to follow the guidelines and recommended dose of fertilizers usage issued by the Malaysian Department of Agriculture since the outcome from an observation conducted showed that many of the farmers applied more than the recommended dose. Hence, it is important to optimize the application of fertilizers in order to sustain agricultural production, so that the impact towards the environment could be minimized.

Therefore, studies on the optimization condition of AB mix fertilizers on *C. frutescens* plants have been carried out using the wick fertigation technique (Nutri-pot) via response surface methodology, (RSM). However, this study involves from week 1 to week 7 only by utilizing a soft cloth thread that is used to absorb water and nutrients. RSM has been reported as an effective tool used by researchers to determine the optimization of a process. It is a

collection of statistical and mathematical systems that are used in developing, improving and optimizing different systems even when the independent variables have a combined effect on the desired response (Aslan, 2007). Chemicals used in this study are the inorganic fertilizers, known as AB mix fertilizers which are commonly used in urban farming. It consists of two (2) functional solutions: solutions A and B where both contain macro- and micro-components (Hidayanti & Kartika, 2019) that are immediately available in providing nutrients to crops.
In this paper, results on the optimum condition level of *C. frutescens* plants from week 1 to week 7 using the Nutri-pot system are reported. In this work, there are two (2) factors varied: i) the concentration level (EC) of AB mix fertilizers and ii) the wick length of the Nutri-pot. Comparison data between the simulated and the actual response of the plant's growth is also determined.

MATERIALS AND METHODS

Experimental design

Materials used for plant preparation were AB mix fertilizer, cocopeat as medium, *C. frutescens* seedlings, aluminium foil, 5-litre bottles and water. The fertilizers and seedlings are complimentary from E-Office Agrotech Plantation Sdn. Bhd. The Nutri-pots were first constructed as in Figure 1 by cutting the 5 litres bottles into half. The upper sides of the containers were filled with cocopeat whilst, the bottom parts were filled with AB mix fertilizer that was prepared at a different level of concentrations, (EC) of 1.8, 2.2 and 2.6 mS/cm. The cocopeat was prepared by washing it with water prior to the seedlings' transplant into the containers, provided with different lengths of wick: 17, 19 and 21 cm that will absorb the AB mix nutrients. Next, the fertilizer was poured into the bottom part of the containers and covered with aluminium foil to hinder algae growth, as shown in Figure 2. The experiment was carried out for seven weeks to acquire complete data on *C. frutescens* plant height.

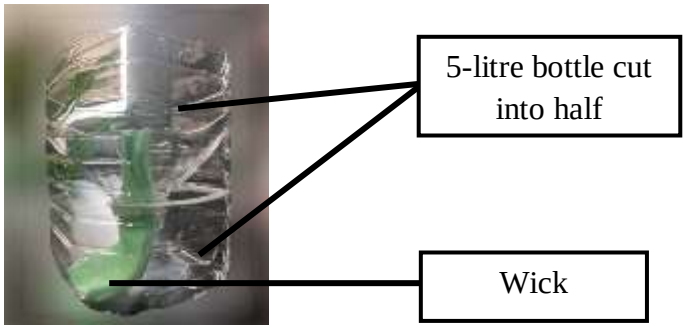


Figure 1: Nutri-pot system

Figure 2: Nutri-pot covered with aluminium

In the first four weeks, all seedlings were introduced and fed with lower EC concentrations at 1.0, 1.2 and 1.6 mS/cm, as shown in Table 1 to avoid stunted growth, plant diseases and excessive feeding to the tree. A mixture of organic pesticides was applied to the plants, 1 time per week to treat and protect the plants from whiteflies and pests.

Table 1: *C. frutescens* plants growth from week 1 - 4 with 19 cm wick length and maximum EC applied at 1.6 mS/cm. The height increased from 22.7 cm to 26.4 cm throughout the week.

Sample #10	Week 1	Week 2	Week 3	Week 4
Wick length: 19 cm				
EC Level (mS/cm)	1.0	1.2	1.6	1.6
Height (cm)	22.7	25.0	25.5	26.4

Mathematical Models and Analysis

Statistical methodologies in different fields of research have been used for optimization. A conventional method of RSM is useful in modeling and analyzing situations in which, several variables influence a response of interest and the objective is to optimize the responses. Hence, the goal of RSM is to explore a proper approximating relationship between the input variables and the output responses as well as, to find the optimum operating conditions for a system under investigation or within which operating requirements are satisfied (Srinivasan, 2012). The response surface can be expressed as follows:

$y = f(x_1, x_2, \ldots, x_k)$ (Eq. 1)

where y is the response and x_k is the independent variable (factor).

A central composite design (CCD) with two independent variables (X_1, EC values of AB mix fertilizers and X_2, wick length) at three levels was performed by applying the Design-Expert software package (Version 13.0.5, Stat-Ease Corp., US), whilst the crop height, Y_1; cm were studied as the response variable for the modelling. Each independent variable of three levels was coded as low (-1), centre point (0) and high (+1) with the two independent factors i.e. concentration level of AB mix fertilizer, X_1: 1.8, 2.2, and 2.6 mS/cm and wick length, X_2: 17, 19, and 21 cm were considered. To determine the number of runs of the CCD, the standard 2^k factorial with its origin at the centre is included. $2k$ points are fixed axially at a distance from the centre to generate the quadratic terms and replicate runs at the centre (r), where k is the number of variables. Hence, the total number of runs required for the two independent variables can be calculated using Eq. 2:

$2^k + 2k + r = 2^2 + (2 \times 2) + 5 = 13$ (Eq. 2)

Therefore, a total of 13 experimental runs were required for the two independent variables. Tables 2 and 3 provide a thorough explanation of the variable configuration along with their coded and actual levels of the EC values and wick length. The configuration of which model to use, the predictive models and their optimization were built by the chosen variables in Eq. 3 which expresses the equation of the second-order quadratic model:

$$Y = \beta_0 (\beta_i \times X_1) + (\beta_j \times X_2) + (\beta_{ij} \times X_1 \times X_2) + (\beta_i \times X_1^2) + (\beta_i \times X_2^2) \quad \text{(Eq. 3)}$$

where, Y is the response in terms of predicted plant height, β_0, β_i, β_j, and β_{ij} are the interactive regression coefficients, and X_1 and X_2 are the EC level of AB mix fertilizer and wick length, respectively.

Table 2: Experimental factors and level of CCD for different concentration levels (EC) of AB mix fertilizer and the wick length

Factors	Unit	Coded symbol	Coded levels		
			Low (−1)	Centre point (0)	High (+1)
EC value of AB mix fertilizer	mS/cm	X_1	1.8	2.2	2.6
Wick length	cm	X_2	17	19	21

Table 3: The coded and actual level of independent variables

No. of Runs	Coded label		Actual label	
	Factor X_1	Factor X_2	Factor X_1	Factor X_2
	EC level of AB mix fertilizer (mS/cm)	Wick length (cm)	EC level of AB mix fertilizer (mS/cm)	Wick length (cm)
1	0	0	2.2	19
2	0	-1	2.2	17
3	0	+1	2.2	21
4	+1	-1	2.6	17
5	-1	0	1.8	19
6	0	0	2.2	19
7	+1	0	2.6	19
8	+1	+1	2.6	21
9	0	0	2.2	19
10	0	0	2.2	19
11	-1	-1	1.8	17
12	-1	+1	1.8	21
13	0	0	2.2	19

The adequacy and the statistical significance of the variables in the model used were examined using ANOVA software by using the lack-of-fit test of different models. The coefficient of determination, R^2 was determined in order to assess the goodness and adequacy of the fitted model. Design Expert 13.0.5 software was used for regression analysis and graphical optimization.

RESULTS AND DISCUSSION

Effect of different EC values on *C. frutescens*' height

Table 4: Predicted and actual response values of *C. frutescens*' height

No. of Run	Factor X_1	Factor X_2	Response Y_1	
			Δ Plant Height (cm)	
	EC level of AB mix fertilizer (mS/cm)	Wick length (cm)	Actual Value	Predicted Value
1	0	0	39.80	39.40
2	0	-1	41.00	41.07
3	0	+1	34.30	34.61
4	+1	-1	39.90	39.64
5	-1	0	36.70	36.44
6	0	0	39.20	39.40
7	+1	0	33.30	33.94
8	+1	+1	25.50	25.12
9	0	0	40.20	39.40
10	0	0	39.00	39.40
11	-1	-1	33.90	34.09
12	-1	+1	35.60	35.67
13	0	0	39.20	39.40

Results of the *C. frutescens*' height after seven weeks of the experiment according to the 13 runs, at different EC levels of AB mix fertilizers and wick length as the factors, using CCD are shown in Table 4. It can be seen that the plant's height significantly varied as the factors were diversified. The actual plants' heights ranged from a minimum of 25.5 cm to a maximum of 41.0 cm. The lowest height, 25.5 cm was observed in the maximum (+1) level of EC and wick length values of 2.6 (mS/cm) and 26 cm, respectively whilst, the maximum height observed was at 41.0 cm as the EC level and wick length were at medium (0) level, with 2.2 mS/cm and 19 cm, respectively. All central points, (0, 0) had plant heights ranging from 39.0 cm to 39.8 cm whilst the axial (0, -1), (0, +1), (-1, 0), (+1, 0) and factorial (+1, +1), (+1, -1), (-1, -1), (-1, +1) points recorded lesser values. This revealed that the maximum height of *C. frutescens* can be achieved when both factors are at the appropriate amount of values. A plant's height is one of the crucial parameters that are often used as a measure to indicate the crop's development therefore, any independent variables need to be at the correct amount. The EC level of AB mix fertilizer with medium (0) treatment helps the plant during the nutrient uptake process; excessive or higher levels of EC value might contribute to brownish curled and shedding leaves (Soedirman et al., 2019). Overuse of inorganic fertilizers has caused serious environmental pollution including deterioration of soils' fertility and their natural properties, and groundwater pollution which, therefore, contributes to global warming issues (Rashmi et al., 2020). Similarly, the wick length of the Nutri-pot system used in this experiment is vital since it absorbs water and nutrients from the solution and supplies them to plants. This approach may be an effective substitute with lesser environmental damage to enhance the quality of the plants, enabling production with reduced labour and electricity or in regions with high air temperatures (FAO of the United Nations, 2015).

Model fitting

To examine the type of model to be used and the significance of each type of model, tests using different models namely linear, 2FI, quadratic and cubic have been carried out to find the relationship within the variables. As shown in Table 5, the coefficient values of linear and 2FI models were not significant as both show negative interactions from their values, whilst, for quadratic and cubic models, the values are significant. Based on the results, it can be observed that the quadratic model would be recommended as it gives positive values with the significant term in comparison with other models.

Table 5: Analysis of variance for different models

Source	Sequential *P-value*	Lack of Fit *P-value*	Adjusted R^2	Predicted R^2	
Linear	0.1376	0.0003	0.1930	-0.5937	
2FI	0.0266	0.0006	0.4957	-0.7081	
Quadratic	**< 0.0001**	**0.4345**	**0.9854**	**0.9568**	**Suggested**
Cubic	0.3447	0.4105	0.9867	0.8812	Aliased

After denoting that the best model to be used is quadratic, independent variables were fitted in the specified model and the effect of each variable was assessed. Therefore, several parameters were used as indicators to evaluate the adequacy of the fitted model, and the indicators were the coefficient of determination, (R^2), the adjusted determination coefficient, (adjusted R^2) and the predicted determination coefficient, (predicted R^2). Results shown in Table 6 indicate that the *F*-value tests performed for this model are 163.54. *F*-value is a measure of separation between various distributions during the experiment i.e. the variance of the data that can be analyzed and therefore, it is used to identify whether the test is statistically significant or vice versa. Therefore, the *F*-value of 163.54 implies that there is only a 0.01% chance that a model *F*-value this large could occur due to noise (Draman et al., 2021). It can be observed from Table 6 that the *F*-value of independent variables (*A*, *B*, *AB*, A^2 and B^2) were 35.12, 234.96, 242.74, 183.55 and 25.24, respectively which implied that the value of all parameters and interaction effect on dependent variable was significantly high. The *F*-value is indirectly proportional to the *P*-value where the *P*-value is a method used to quantify the probability that one can navigate the difference which could be the result of randomized tests. Generally, the statistical significance of the observed difference increased as the *P*-value decreased. A value less than 0.0500 indicates that the model term is significant. In this case, the independent variables of *A*, *B*, *AB*, A^2 and B^2 have a significant model term which is 0.0006, < 0.0001, < 0.0001, < 0.0001 and 0.0015, respectively. Equation 4 is the final equation in terms of actual factors fitting the model prediction.

$$\Delta \text{ Height} = - 401.703 + 208.310A + 24.2917B + (-5.03125AB) + (-26.3254A^2) + (-0.390517B^2) \quad \text{(Eq. 4)}$$

Table 6: Analysis of variance for the quadratic model

Sources	Sum of Squares	*DF*	Mean Square	*F*-value	*P*-value	
Model	218.30	5	43.66	163.54	< 0.0001	significant
***A* (EC value of AB mix)**	9.38	1	9.38	35.12	0.0006	significant
***B* (Wick length)**	62.73	1	62.73	234.96	< 0.0001	significant
AB	64.80	1	64.80	242.74	< 0.0001	significant
A^2	49.00	1	49.00	183.55	< 0.0001	significant
B^2	6.74	1	6.74	25.24	0.0015	significant
Residual	1.87	7	0.2670			
Lack of Fit	0.8608	3	0.2869	1.14	0.4345	not significant
Pure Error	1.01	4	0.2520			
Cor Total	220.17	12				
Std. Dev. (√RSE)	0.5167		RSE (%)	0.14		
R^2	0.9915		Predicted R^2	0.9568		
Adjusted R^2	0.9854		Adequate Precision	45.4496		

The *P*-value induces the R–squared, (R^2) value to be relatively high, 0.9915 as shown in Table 6. The value of 0.9915 denoted that approximately 99.15% of the variability observed in the target variable was explained by the regression model. If the value of R^2 is low, the model does not explain much about the data variation. R^2 is a statistical measurement which shows how well the model fits the data or how much variation was explained by the model (Draman et al., 2021). R^2 explains the extent to which the variance of one variable will be presented to the second variable even though the correlation explains the strength of the relationship between independent and dependent variables. The predicted R^2 value of 0.9568 was in reasonable agreement with the adjusted R^2 of 0.9854 where the difference is less than 0.2.

As for adequate precision value, it measures the signal-to-noise ratio where a ratio greater than 4 is desirable. As denoted in Table 6, the value of 45.450 indicates an acceptable signal. The lack of fit value, 1.14 denoted that the value is significant however, the non-significant lack of fit, 43.45 % denoted that the value of this large could occur due to the noise. Residual standard error, (RSE) data displayed 0.14 %, which indicates a smaller error percentage between the actual and predicted values.

The experimental or actual data of the plant's height were compared with the predicted values using the second-order quadratic model. It can be observed in Figure 3 that the actual values data fit well with the predicted data and there is a good correlation between the actual and predicted values. The fitting is relatively good which demonstrates that the CCD model with an experimental design can be effectively applied for optimization (Bhattacharya et. al., 2021).

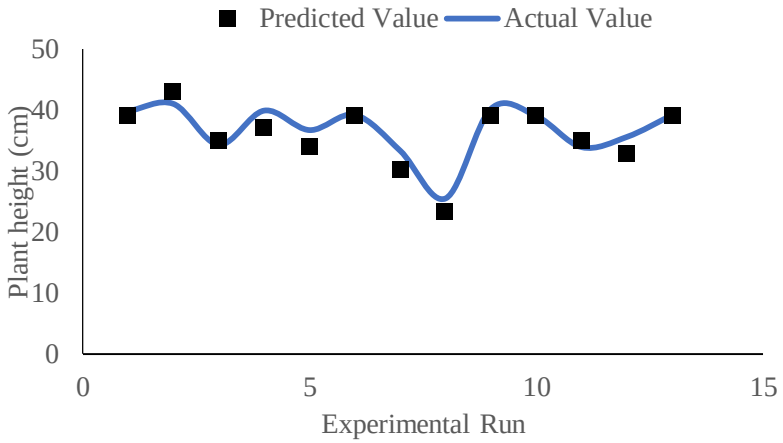
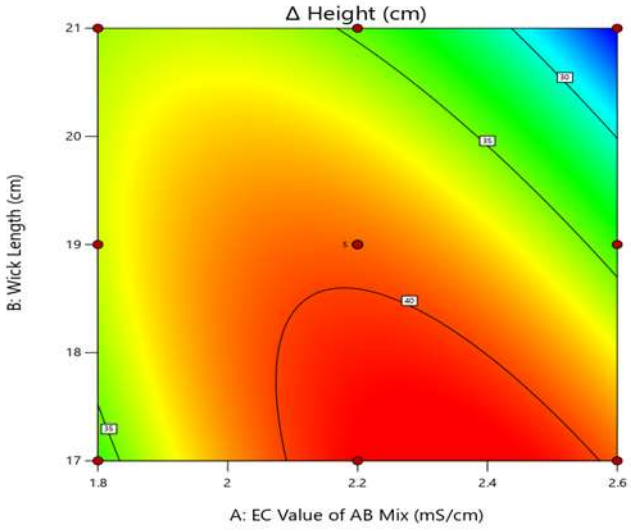
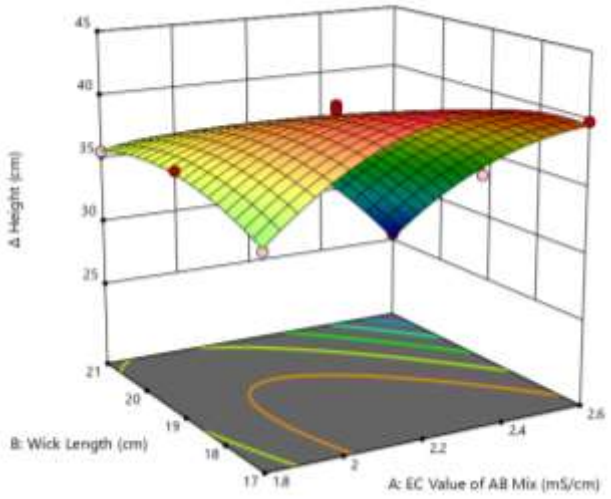


Figure 3: Run-wise predicted and actual values of *C. frutescens* growth

Figure 4 shows the response surface and their corresponding contours of the combined effect of the EC value of AB mix fertilizers and wick length on the height of the *C. frutescens* plant. It is observable that a sufficient amount of EC values and wick length can contribute to the height of the *C. frutescens* plant. Based on the contour plot graph in Figure 4 (a), darker orange-red regions possess maximum *C. frutescens* height (cm) whilst yellow, green and blue regions indicate a lower value of factors and response, consecutively. It can be observed that the maximum point of the graphs is when the EC value was 2.2 mS/cm and the wick length was 19 cm at which *C. frutescens* height recorded was 40.2 cm.



(a)



(b)

Figure 4 (a) Response Contour Plot and **(b)** 3D Surface Plot for interactive effects of EC level of AB mix fertilizer and wick length on *C. frutescens*' height

Based on the suggested quadratic model, Design-Expert software was used for optimizing the condition of AB mix usage on *C. frustescens* plant. The optimization studies were performed to evaluate the optimal experimental and predicted parameters. Table 7 compares the variables of the experiment along with the predicted and model-optimized values. The experimental / actual data recorded that the highest plant was at 40.20 cm, compared to the predicted value of 39.40 cm as the values of operating parameters were at 2.2. mS/cm and 19 cm for EC level and wick length, respectively. Under the same conditions, the maximum height of *C. frustescens* plant was predicted to be 39.40 cm. The slight difference between the predicted and actual values of the response has successfully verified the optimum point determined by RSM. The optimum values were found to be at the wick length and EC level of 18.15 cm, and 2.54 mS/cm, respectively where under the optimal conditions, the height of *C. frustescens* plant was expected to be 38.73 cm, which fitted well to the corresponding experimental value. According to the actual data, Table 4, Run 4 displayed the nearest value to the optimum condition under the operating parameters of 2.6 mS/cm and 17 cm for EC level and wick length, respectively.

Table 7: Comparison between the actual, predicted and optimized values from RSM for *C. frutescens* plant

Variables	Actual Value	Predicted Value	Optimized Value from RSM
EC level (mS/cm)	2.2	2.2	2.54
Wick length (cm)	19	19	18.15
Δ Plant Height (cm)	40.20	39.40	38.73
Plant Height Deviation %	–	2.03	3.80

020-012

EVALUATION OF PHYTOCHEMICAL, ANTIOXIDANT AND ANTIMICROBIAL PROPERTIES OF DIFFERENT ACCESSIONS OF *Persicaria minor* (KESUM)

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ABSTRACT

Persicaria minor (Huds.) Opiz. or locally known as *kesum* is an aromatic medicinal plant from the family Polygonaceae. It is originated from Southeast Asian countries such as Indonesia, Vietnam, Thailand and Malaysia. The plant leaf has many claims with regards to its traditional uses, but is popularly consumed as fresh vegetable (*ulam*), flavouring agent and food additive. Previous research showed that *P. minor* possessed antioxidant and antimicrobial activities. However, information on the effect of antioxidant and antimicrobial activities of different accessions of *P. minor* is still lacking. Therefore, the current work was undertaken to evaluate six different accessions of *P. minor* comprising MKSM002, MKSM004, MKSM006, MKSM011, MKSM013 and MKSM020. These accessions were obtained from various locations in Peninsular Malaysia and established in MARDI Headquarters herbal germplasm. The aerial parts of the plants were dried under a hot air oven at 50°C prior to extraction. From the results, MKSM002 and MKSM006 methanolic extracts were the most potent antioxidant due to the strongest ferric reducing (13.19 µmol Fe/g) and DPPH radical scavenging (IC_{50} 0.39 mg/mL) activities, respectively. Antimicrobial activity was determined against common pathogenic bacteria i.e, *Bacillus cereus, Staphylococcus aureus, Cronobacter sakazakii* and *Enterobacter aerogenes* using disc diffusion assay. Among the extracts, MKSM002, MKSM004 and MKSM006 were the most effective, being able to significantly ($P<0.05$) inhibited the growth of most of the bacteria tested. The most active inhibition was recorded against *E. aerogenes* with diameter of inhibition zones ranging from 14.12 mm to 15.75 mm ($P<0.05$). Phytochemical screening of the extracts showed that these extracts contained substantial amount of total phenolics and total flavonoids. Liquid chromatography-tandem mass spectrometry-quadrupole time-of-flight (LC–MS-QTOF) analysis of the selected extracts revealed the presence of various phytochemicals, with flavonoids and their derivatives being the most predominant ones. In conclusion, the selected *P. minor* accessions can be promoted as source of planting material source for breeding, conservation and commercial purposes. The findings are also important in the search for antioxidant supplementation and healthcare products in the future.

Keywords: herbs, bioactivities, methanol, LC-MS, profiling

021-013

EFFECTS OF NUTRIENT SOLUTION ON GROWTH, YIELD AND AROMATIC COMPOUND OF *PERSICARIA MINOR* CULTIVATED USING HYDROPONICS SYSTEM

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Abstract

Persicaria minor or locally known as kesum from the family *Polygonaceae* is a common herbal plant found in Malaysia. Hydroponic cultivation of kesum using deep water culture (DWC) system can be an alternative option for kesum growers in increasing crop yields. The deep-water culture system is a method in which liquid fertiliser solution is given directly to the plant roots without any medium and water flow. The study's main objective was to determine the effects of nutrient solution on growth, yield and aromatic compound of kesum cultivated using hydroponic system. Plants were grown under one of four nutrient solution regimes and the experiment was conducted under a side netted rain shelter. The four treatments comprised of 100%, 50%, 25% and 0% strength of the MARDI's nutrient concentrations typically used in commercial vegetables production. The experiment was arranged in Randomized Complete Block Design (RCBD) with 4 replications. Plants were selected randomly and harvested eight weeks after planting. Plants grown supplemented with 50% strength of nutrient concentration gave the best growth performance, biomass yield and aldehyde aromatic compound compared to the other treatments. They produced the highest plant height (78 cm), fresh biomass yield (174 g per plant) and aldehyde content (aldehyde C-10: 5.80% and aldehyde C-12: 12.23%). However, plants treated with 0% of nutrient concentrations exhibited major nutrients deficiencies symptoms and die after 3 weeks of planting. Hence, it can be concluded that the kesum plants cultivated using hydroponics' deep water culture system supplemented with 50% strength of MARDI's nutrient concentrations gave the highest plant growth, biomass yields and both aldehyde C-10 and C-12 compound.

Keywords: Hydroponics, nutrient solution, yield, aldehyde, *Persicaria minor*

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TREATMENT OF FISHPOND WASTEWATER USING HYBRID CONSTRUCTED WETLANDS IN MINNA, NORTH CENTRAL NIGERIA

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ABSTRACT

Musgola fish farm is an integrated farm located in Bosso Local Government of Niger State, North Central Nigeria. The farm uses large volume of freshwater for the purpose of fish husbandry. Wastewater generated from the fishpond leads to environmental pollution as it contains uningested food, fish dregs, faeces of different classes and chemical constituents. There is therefore the need for a study on environmental impact of these wastewaters and how it can be treated for safe disposal. This study was carried out to characterise the wastewater and thereafter evaluate the effectiveness of constructed wetlands (CWs) to treat it before discharging it into adjacent river. The results of fish pond effluent characterisation showed that the pH of the effluent ranges between 5.7 and 6.84, temperature was between 26 and 27 ^{0}C, electric conductivity ranges between 250 and 334 µs/cm, TDS ranges between 232 and 265 mg/L, BOD_5 was between 102 and 123 mg/L, NH_3 ranges between 1.23 and 1.92 mg/L, and Turbidity was between 9.9 and 11.2 NTU). These data were predetermined to use as baseline information for the wastewater entering the constructed wetlands. The developed hybrid CWs of two planted horizontal and vertical CWs with a corresponding two unplanted horizontal and verticals to act as control. The flow was continuous with calculated hydraulic flow rate of 20 L/day, hydraulic loading rate 15 L/day while hydraulic retention time for horizontal and vertical flow CWs were 5 and 4 days respectively. One way analysis of variance (ANOVA) at 95% significance level was used to examine the performance of the treatment. The treatment efficiency of the systems was calculated as the percentage of contaminant removal as measured from planted horizontal and vertical CWs compared with unplanted horizontal and vertical CWs. The comparison of hybrid CWs displayed removal efficiencies of 90.1 and 89.0 % for BOD_5, 44.9 and 58.2% for TDS, 60.7 and 77.7% for TSS, 48.9 and 57.4% for EC, 35.2 and 45.5% for Turbidity. *Sacciolepis africana*-planted hybrid CWs proved to be more efficient than unplanted wetlands in the treatment of fishpond wastewater. Planted hybrid CWs had final effluent concentrations that comply very well to the discharge limits of WHO and Nigerian FEPA standards. Hence, constructed wetlands is a viable alternative to address many of the water-management problems faced by the fish industry.

Keywords: *Sacciolepis africana*, constructed wetland, fishpond wastewater and environmental management.

INTRODUCTION

Agriculture has been backbone of Nigerian economy, contributing up to 85% of gross domestic product (GDP) before crude oil was discovered in commercial quantity in present day Bayelsa state (Samuel and Oje, 2012). Economic development of any nation depends on looking inwards to identify sectors of the economy where it has comparative advantage over other nations and seek to develop the identified sector. Jibrin (2016) carried out report on fish farming being the most practiced type of farming in Nigeria and has become an enterprise by Nigerians of various walks of life possibly due to its general acceptance by Nigerians with no restriction to ethnicity. Fish farming is the rearing of fish in an enclosed water bodies such as ponds, dams, cages, raceways, tanks, reservoirs under human management and has the same objective as agriculture to increase the production of food above the level that would be produced naturally (Olaoye, 2010). Fish farming remains the fastest growing agricultural industries globally, with an estimated total production of 66.6 million metric tonnes in 2012 (FAO, 2016). Intensification of fishponds production will require the use of more inputs, especially feed per unit area of land (Henriksson *et al.*, 2018), leading to an increase in wastewater generation from the production systems. Fish ponds wastewater contain a large number of physical, chemical and biological constituents from varying concentrations and levels (Jian-feng *et al*., 2005). It contains waste feeds and dregs which affect the receiving water bodies when discharged without proper treatment. The quantity of wastes generated from fishponds practices depends on the culture system, characteristics, choice of species, feed quality and management practices. Effective treatment is needed before these wastewaters are discharged into the environment or reused for irrigation (Badejo *et al.*, 2012).
The use of constructed wetlands (CWs) as natural and bases for economically low-cost effluent treatment cannot be over emphasised. Constructed wetlands (CWs) are treatment systems that have been designed and constructed to

utilize the natural process of physical, chemical, and biological synergistic action among substrates, plants and microorganisms, but do so within a more controlled environment (Jian-feng *et al*., 2005). They provide a less disturbance than the harsh conventional methods like incineration, thermal vaporization, solvent washing, or other soil washing techniques, which can destroy the biological component of the soil or change the chemical and physical characteristics of the receiving soil and water (Lin and Mendelssohn, 2009).

Hybrid constructed wetland is the combination of two flow systems, horizontal subsurface flow (HSSF) system and vertical subsurface flow (VSSF) system in stage manner to complement each other (Vymazal, 2002). This type of constructed wetland is well approved to remove BOD_5 and TSS from wastewater Zhang *et al*. (2012) experimented improve treatment of ammonium-N, TN, and TP from 4.37 to 0.94mg/l, 2.98 to 1.77mg/l and 3.14 to 1.95mg/l respectively. They concluded a significant decrease in organic nutrients using combination four stages CWs. Dong *et al*. (2016) demonstrated a high treatment of wastewater with hybrid CWs and recorded a significant decrease in 83% NH_4, 90% TSS, 76% BOD_5, 89% TP and 80% TN. Due to these reasons, there has been a growing interest in combined (hybrid) wetlands. Constructed wetlands are made up of four main components: plants, substrate media, microbial biomass and the aqueous phase (Vymazal, 2002). The sediment and gravel provide physical and chemical support in the root zone and. The root zone is the active reaction zone of CWs, where physicochemical and biological processes are induced by the interaction of the pollutants with the plants, microorganisms, and soil particles (Lee and Scholz, 2007). However, the ability of CWs to purify wastewater depends on naturally occurring physical, chemical and biological processes that take place within the system (Dhulap *et al.,* 2014). Constructed wetlands use natural geochemical, physical, and biological processes in a wetland ecosystem to treat contaminants of concern. Jian-feng *et al*., (2005) reported bioremediation of contaminants takes place during the passage of raw or pre-treated wastewater through the gravel layer and root zone of the constructed wetlands. The constituents of concern are removed by various mechanisms such as filtration and sedimentation of suspended particles, adsorption to suspended matter, photolysis, volatilization, plant uptake and precipitation by biogeochemical processes (Jian-feng *et al*., 2005). Savita, (2007) described the mechanisms for nitrogen removal in CWs are denitrification, plant uptake, volatilization, and adsorption.

The discharge of fishpond wastewater from Musgola fish farm Lapai Gwari into River Chanchaga tributary leads to; aquatic pollution and unhealthy environment, the need for proper disposal of the effluents is paramount to reduce the level of hazardous constituents into water bodies as well as soil. Fish farming sites are fast growing and need to be addressed by naturally, simple, and effective technology such as constructed wetlands especially in a developing country like Nigeria. The proper disposal of fishpond wastewater is of essence and to develop a hybrid constructed wetland that is simple ecologically friendly to treat fishpond wastewater before discharge will be an environmentally friendly and economically feasible option. The objectives of this study are therefore to characterise effluent from Musgola fish farms Lapai-Gwari, at the point of discharged into the river Chanchaga tributary. design and develop a hybrid constructed wetlands to treat fish pond effluent, and estimate the quantity of waste treated by hybrid CWs.

MATERIALS AND METHODS

The study area is Musgola fish farm Lapai-Gwari, located in Minna, Niger State, Nigeria. Niger state is situated in the Northern guinea savannah ecological zone of Nigeria. It lies between latitude 9°31'21.23" N and longitude 6°30'4.66" E of the prime meridian. The climatic condition is categorized by long dry and wet seasons. The rainy season begins in April and ends in October with an average rainfall of 1200 – 1300 mm annually, and the dry season starts in November and ends in March. The average temperature ranges from 22.5°C to 33.6°C annually with an average relative humidity of 50.2% (NIMET, 2006). Effluent generated from the Musgola fish farm flows through series of fishponds within the farm through a pipe whereafter it is discharged into River Chanchaga tributary. The physical and chemical parameters of this discharged effluent from the farm was examined to provide a base line information on the contaminants present in the discharged effluent. The aim is to have the baseline information of parameters of concern. The approaches were collection of fishpond effluent from the fish farm and analyse it for parameters of concern using APHA (2005) standard methods.

Experimental setup

The HSSF and VSSF CWs were constructed for the purpose of this research. It comprises of 8 cells, 4 horizontal cells and 4 vertical cells with HSSF CWs rectangular in shape with dimensions 100 x 75 x 37 cm, respectively for length, width and depth and the VSSF CWS was circular in shape 47 cm diameter, 57 cm height) made of plastics. Each horizontal cell had a volume of 278 L and vertical cells had a volume of 99 L, hydraulic retention time (HRT) of 6 and 3 days with hydraulic loading rate of 15 and 4 L/day. Two HSSF and two VSSF CWs were planted with *Sacciolepis africana* Two HSSF and Two VSSF CWs without plant to serve as the control. Figure 1.

Figure 1: Set up of a Planted and unplanted hybrid constructed wetland.

Fishpond wastewater was collected into 120 litres tank and allowed to flow into HSSF and VSSF CWs by gravity continuously through 50mm polyvinylchloride (PVC) pipe installed with control valves of porosity of 0.40. The control valves were inserted at the outlets of the dosing tank. The perforated pipes installed at the inlet and out of the cells were used to enable equal distribution of wastewater in and out of the wetlands. The influent tank 120 l was refilled every 6 days with fishpond wastewater.

After the completion of the construction and set up, the study seeks to investigate the suitability and effectiveness of *Sacciolepis africana* for the treatment of fish pond effluent. This was done by collecting

Sacciolepis africana from the natural wetland within Musgola fish farm and to transplanting them to the wetland cells. The macrophytes was transplanted to the wetland cells at an initial density of four plants per hole and allowed for the period of 3 weeks to be stabilized. The physicochemical and biological interactions were allowed take place in the root zone, with interaction of plants, microorganisms, the soil and pollutants. At the start of the planting, plant aboveground and belowground biomass was taken at wet and dry bases (biomass at day T0= 0), the 14th day (at T1=14), 28th days (at T2=28), 42nd days (at T3=42), to day173 (at X=173). Harvested biomass in replicates were taken to the laboratory, these plants were washed and sorted out into above ground (stems and leaves) and below ground (rhizomes and roots) parts. These harvested parts were washed dried and digested for analysis using Lin and Mendelssohn (2009) method.

After the establishment of the substrates, the wastewater was fed to the wetland from November 2019 to January 2020. The influent and effluent samples was taken every 6 days to analyse their treatment performance. On site analysis of physical - chemical parameters such as, pH, DO, temperature, conductivity was carried out on the field using a portable multi – parameter tester. After which the collected samples were carried to the laboratory to determine their parameters according to the methods described by Mustapha, (2018).

Results and Discussions

The results of the initial physico-chemical analysis of the fishpond effluent are presented in the table 1. The fishpond wastewater was composed of organic and inorganic compounds including salts, suspended solids and metals. The composition varied depending on feeds in the production chain.

Table 1: Average physico - chemical quality of the fishpond wastewater between October 2019 and March 2022

Parameters	Minimum	Maximum	Average	WHO Limits
Ec (µs/cm)	250	264.17	334	1000
DO (mg/L)	1.3	1.7791	1.99	<0.2
Turbidity (NTU)	9.9	10.709	11.2	5
TDS (mg/L)	232	251.21	265	500 - 2000

TSS (mg/L)	122	142.91	162	30 - 50
TS (mg/L)	155	377.69	420	
BOD_5 (mg/L)	102	115.65	123	25 - 10
NO3--N (mg/L)	0.03	0.0437	0.05	20 - 50
NH3+- N (mg/L)	1.23	1.6852	1.92	0.1 -1.0
SO4 (mg/L)	114	122.34	138	

The fishpond wastewater revealed that pH, temperature, TDS and nitrates were within the permissible limits. The nature of the fishpond wastewaters was such that it ranged between weakly acidic and weakly basic (6.5 ± 0.0 and 9.5 ± 0.1). A similar occurrence was reported for fishpond effluents by Naylor, (2003) Dissolved Oxygen, Turbidity, total soluble solids (TSS), biological oxygen demand (BOD_5), were above the permissible limits. High turbid water is often associated with the possibility of microbiological contamination (Igbinosa and Okoh, 2009). Also, if such effluent is discharged into water bodies, it will affect fish and other aquatic life. Discharge of effluents into the environment with high levels of BOD_5 imply that less oxygen is available for living organisms (Kaur *et al.,* 2010). In addition, this may indicate toxic conditions and the presence of biologically resistant organic substances in the effluent (Yusuff and Sonibare, 2004). Nutrients are required by plants for growth; however, high concentrations of nutrients are largely responsible for eutrophication, depletion of dissolved oxygen and pollution of water bodies (Chang *et al.,* 2010). This study showed that it is paramount to treat and brings these contaminants to non-hazardous levels to protect the aquatic ecosystem and people in the downstream end of the river who use the river as source of water for domestic and agricultural purposes.

Treatment efficiencies of the hybrid wetlands (BOD_5, DO)

Mean values of the various pollutants' concentration and water quality parameters in the influent wastewater and effluent discharge of all the respective wetlands configurations were taken and compiled for comparison. The sample space comprised of 23 sample points. Planted wetlands had higher efficiency compared to unplanted in improving the BOD_5 and DO of the wastewater figure 4.2 and figure 4.3. For BOD_5, average efficiency of 90% and 89% was recorded for planted horizontal and planted vertical wetlands, compared to lower efficiencies of 70.3% and 79.1% from unplanted horizontal wetland and unplanted vertical wetlands respectively. DO average efficiencies 70.3 % and 68.7% compared to unplanted were also recorded 30.0% and 24.6%. Table 2 Mustapha (2011) also reported on performance of constructed wetland compared to unplanted wetland in Morocco also noticed similar performance.

Table 2: Removal efficiency of various wetlands configurations in treatment for BOD_5, and DO

	BOD_5			**DO**		
Wetland Configuration	**Influent Average**	**Effluent Average**	**Efficiency (%)**	**Influent Average**	**Effluent Average**	**Efficiency (%)**
Planted Horizontal	115.7 ± 0.5^{a}	11.5 ± 0.8^{a}	90.1 ± 0.4^{c}	11.8 ± 0.3^{a}	3.5 ± 0.3^{a}	70.3 ± 0.2^{b}
Planted Vertical	115.7 ± 0.5^{a}	12.7 ± 0.4^{a}	89.0 ± 0.0^{c}	11.8 ± 0.1^{a}	3.7 ± 0.3^{a}	68.7 ± 0.3^{b}
Unplanted Horizontal	115.7 ± 0.3^{a}	34.4 ± 0.8^{d}	70.3 ± 1^{a}	11.8 ± 0.0^{a}	8.5 ± 0.3^{a}	30.0 ± 0.6^{a}
Unplanted Vertical	115.7 ± 0.6^{a}	24.2 ± 0.6^{c}	79.1 ± 0.7^{b}	11.8 ± 0.1^{a}	8.9 ± 0.1^{a}	24.6 ± 0.9^{a}

Values are Means of two replicates (n=2), value followed by same superscript alphabet are not significantly different at (P<0.05) along the column, as assessed by LSD, Tukey (HSD).

Figure 2: BOD_5 Treatment Efficiency of various wetlands configurations

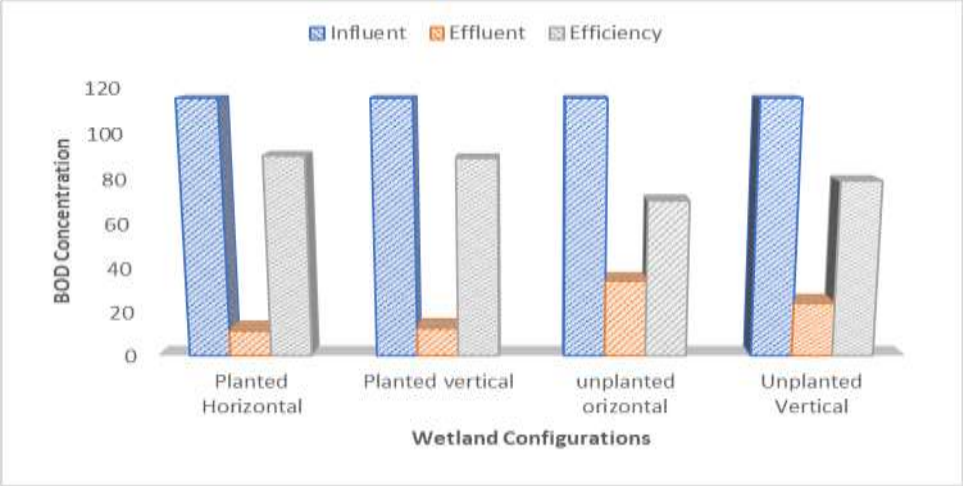
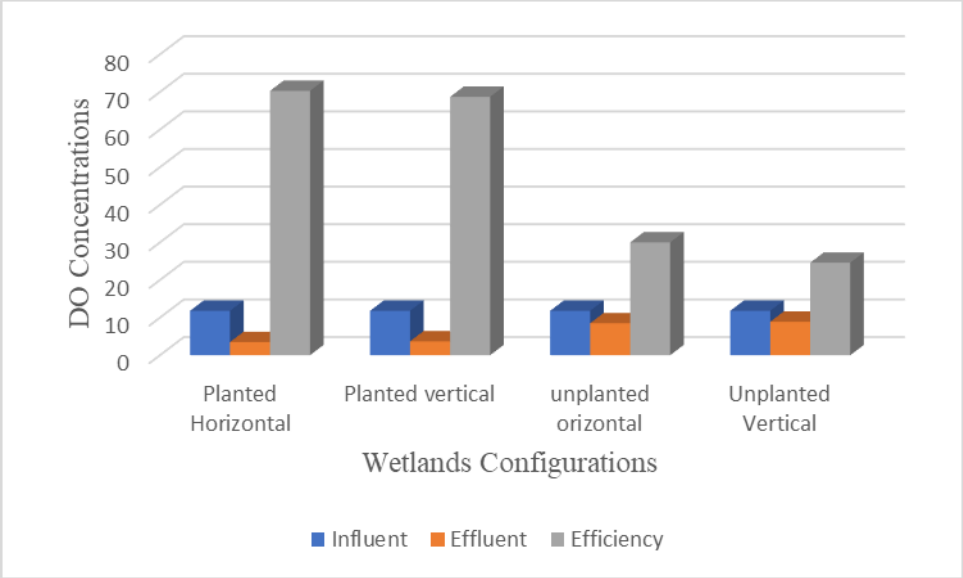


Figure 3: DO Treatment Efficiency of various wetlands configurations.



Treatment efficiencies of the hybrid wetlands (TDS and TSS)

As shown in table 3, for planted wetlands (horizontal and vertical), treatment efficiencies for TSS were 60.7% and 77.7%, while for unplanted wetlands (horizontal and vertical) efficiencies of 60.2% and 76.9% were gotten, significant differences of the constructed wetlands were reviled. For TDS, planted wetland performed better than unplanted wetlands with treatment efficiencies of 44.9% and 58.2% for planted Horizontal and Planted Vertical, compared to lesser efficiency values of 32.2% and 37.5% for unplanted horizontal. Similar high performance of planted wetlands over unplanted for TS was also found. Planted Horizontal and vertical wetlands had TS removal efficiencies of 49.7% and 63.1%, compared to lower efficiencies for unplanted horizontal and vertical wetland of 41.5% and 50.9%. Figures 4 and 5. Hybrid constructed wetlands has been seen to be able to treat the effluent from fishpond to a level that will allow it to be disposable into water courses without any nuisance.

Table 3: Removal efficiency of various wetlands configurations in treatment for TSS and TDS

	TSS			TDS		
Wetland Configuration	**Influent Average**	**Effluent Average**	**Efficiency (%)**	**Influent Average**	**Effluent Average**	**Efficiency (%)**
Planted Horizontal	142.9±0.1[a]	56.2±0.2[c]	60.7±0.2[a]	251.2±0.7[a]	138.4±0.2[b]	44.9±0.3[b]
Planted Vertical	142.9±0.4[a]	31.8±0.2[a]	77.7±0.3[b]	251.2±0.5[a]	105.1±0.1[a]	58.2±0.3[c]
Unplanted Horizontal	142.9±0.3[a]	56.8±0.4[c]	60.2±0.2[a]	251.2±0.6[a]	170.3±0.4[d]	32.2±0.4[a]
Unplanted Vertical	142.9±0.4[a]	33.0±0.3[b]	76.9±0.2[b]	251.2±0.5[a]	156.9±0.5[c]	37.5±0.3[a]

Values are Means of two replicates (n=2), value followed by same superscript alphabet are not significantly different at (P<0.05) along the column, as assessed by LSD, Tukey (HSD).

Figure 4.: TSS Treatment Efficiency of various wetlands configurations

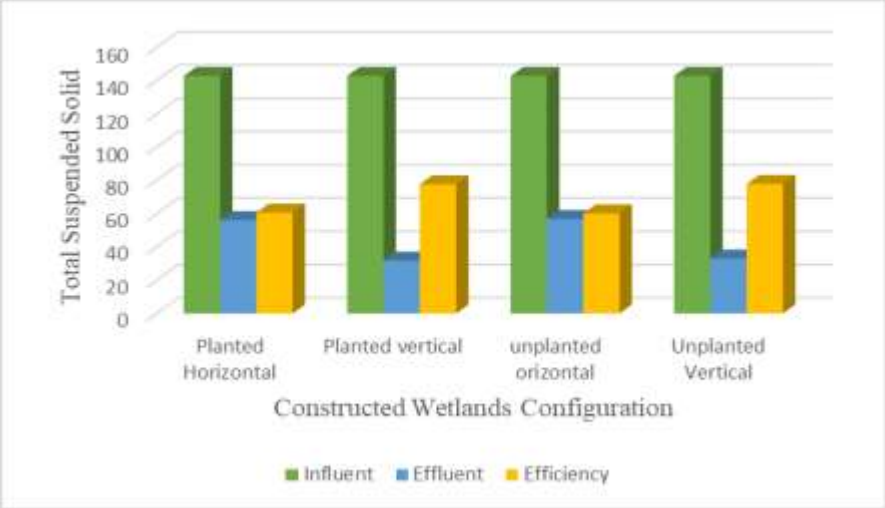
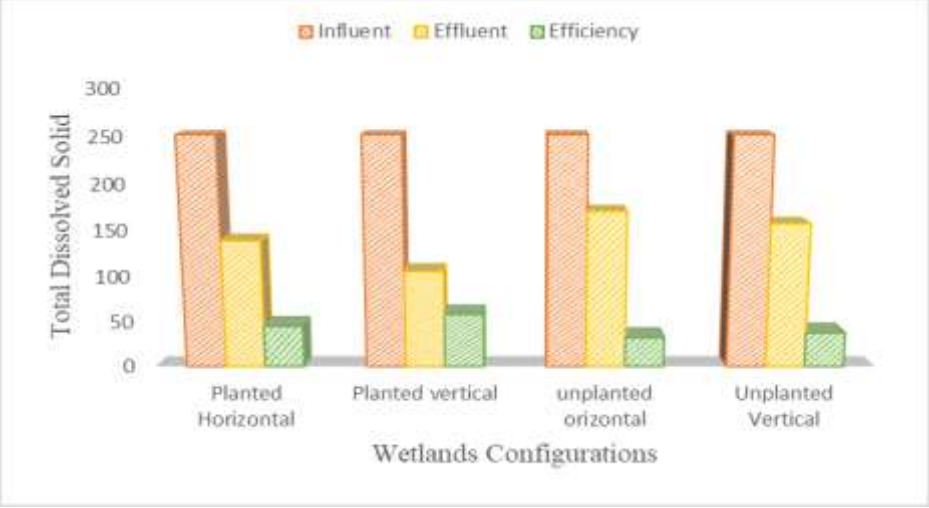


Figure 5: TDS Treatment Efficiency of various wetlands configurations



CONCLUSION AND RECOMMENDATION

The *Sacciolepis africana*-planted hybrid CW are more efficient than unplanted wetlands in the treatment of fishpond wastewater. Planted hybrid CWs had final effluent concentrations that comply very well to the discharge limits of WHO and FEPA (Nigeria), such values of 5 NTU for turbidity, 30 mg/L for TSS, 10 mg/L for BOD_5, 40 mg/L for COD and 5 mg/L Plants are important components of wetland and their roles can be seen when you compare the performance of planted vs unplanted wetlands. Sediments of planted wetlands trapped more elements from the wastewater compared to sediments of unplanted wetlands. This is because of the presence of plant (*Sacciolepis africana*) in the wetlands. The elements taken up by the plants are deposited in the sediment after they die, these lead to accumulation of these elements overtime. With little availability of locally materials, both horizontal and vertical hybrid/planted wetlands should be run alongside each other to combine the benefits and efficiencies of both configurations put together.

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023-017

PRELIMINARY STUDY OF PERFORMANCE EVALUATION OF 6-ROWS AUTONOMOUS RICE TRANSPLANTER

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ABSTRACT

Rice is the most widely consumed staple food in Asia, accounting for roughly 90% of global rice production. Malaysia has a total cultivated area of 730,016 hectares, with a total output of approximately 3.3 million metric tonnes in 2016. Rice is usually planted by manual sowing, transplanter, or direct sowing. This study explores the performance and operation of an autonomous rice transplanter machine compared to a conventional rice transplanter machine. Performance testing was conducted at the MARDI Seberang Perai, Penang rice study plot. The transplanter used in this study is a 6-row autonomous rice transplanter and a 6-row conventional rice transplanter. The settings for both transplanters are set at the same scene to ensure the same plant growth rate between them. According to the results of the autonomous rice transplanter's performance, it achieved 58 percent farm efficiency with a work rate of 3.49 hours/ha. The conventional rice transplanter recorded a work rate of 4 hours/ha with farm efficiency at 50 percent. The theoretical work rate for these two tractors is set at 2 hours/ha by maintaining the tractor's speed at the same rate of 2.75 km/hour. The study shows that an autonomous rice transplanter can accelerate rice planting up to 12.75 percent faster than a conventional rice transplanter. Results of rice cultivation with an autonomous rice transplanter also demonstrate straighter crops and uniformity when compared to a conventional rice transplanter. Using a weeding tool equipped with a fertilizer applicator, weeding and fertilizing tasks in the row are made simpler due to the plant's straightness.

Keywords: Paddy, performance, autonomous rice transplanter, conventional rice transplanter

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GROWTH, LEAF QUALITY AND EPIDERMAL BLADDER CELL SIZE OF ICE PLANT (*MESEMBRYANTHEMUM CRYSTALLINUM* L.) UNDER DIFFERENT CONCENTRATIONS OF NUTRIENT TREATMENT AND LED HEIGHT TREATMENT

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ABSTRACT

This study was conducted to determine the optimum nutrient treatment and LED height on the growth, leaf quality and epidermal bladder cells size of ice plant (*Mesembryanthemum crystallinum* L.) in an enclosed plant system – the Farm Box. The plants were grown using nutrient film technique systems in five different nutrient concentrations (EC = 0%, 25%, 50%, 75% and 100%), under three different LED height treatments (30cm, 35cm and 40cm height from plant, mean light intensity were 222, 213, 198 PPFD, respectively) for 40 days.

For plant growth, among the different nutrient concentration treatments, the 100% nutrient concentration showed the highest growth characteristics (leaf number, shoot number, plant height, leaf width, total fresh weight, leaf fresh weight, root fresh weight, stem fresh weight, total dry weight, leaf dry weight, root dry weight, stem dry weight and leaf area). At 100% nutrient concentration, the total fresh weight, leaf fresh weight and stem fresh weight were significantly ($P<0.05$) higher than all nutrient concentrations in both 30cm and 35cm LED height. Among different LED height treatments, 30cm LED height showed the highest growth (leaf number, shoot number, plant height, leaf width, leaf length, total fresh weight, leaf fresh weight, root fresh weight, stem fresh weight, total dry weight, leaf dry weight, root dry weight and stem dry weight) and was significantly ($P<0.05$) higher than 40cm LED height for total fresh weight, stem fresh weight and stem dry weight.

Among the different nutrient concentration treatments, plants cultivated using 50% nutrient concentration showed the highest chlorophyll *a*, chlorophyll *b* and carotenoids in all LED height treatments. Chlorophyll *a* was significantly ($P<0.05$) higher than the 100% nutrient concentration (30cm LED height); chlorophyll *b* was significantly higher than the 25% nutrient concentration (all LED height); carotenoids were significantly higher than the 75% and 100% nutrient concentrations (30cm and 35cm LED height).

Higher nutrient concentrations affected the epidermal bladder cells size (EBC) more, 75% nutrient concentration produced the largest EBC size on abaxial and adaxial leaf surfaces and stems. At 75% nutrient concentration abaxial leaf's EBC (30cm LED height) and adaxial leaf's EBC (30cm and 35cm LED height) were significantly ($P<0.05$) larger than all other nutrient concentrations.

This study recommended the use of the 100% nutrient concentration and 30cm LED height treatment as the optimum growth condition for early planting stages (40 days) of *M. crystallinum.*

Keywords: Farm box, light intensity, plant pigment.

027-020

PRIMILARARY STUDY OF COFFEE HARVESTING TOOL FOR LIBERICA VARIETY COFFEE

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ABSTRACT

Coffea Liberica, which is primarily grown in Southeast Asia. It is currently the most significant Coffea species cultivated in Malaysia and the Philippines. The major problem in harvesting Liberica coffee is that the mature growth isn't even and the higher strength of coffee cherry stem on tree branches. The coffee cherry can't be picked by shaking the tree because they don't fall off easily. Twisting and stripping coffee cherry is a harvesting technique which encourages the development of new coffee bud seeds. In this study, a tool for harvesting coffee cherry is used to pick coffee cherry from the tree branch by using rotating and stripping technique. This is a tool that already exists on the market and has been modified to suit the Liberica variety of coffee. It has two arms that rotate in opposite directions and are covered with Thermoplastic Polyurethane (TPU) material with the shape of a drill to protect the branch of the coffee tree from injured. The concept and designs of the covered TPU drill shape were made using computer-aided design software in the third dimension (3D), which simulated the functions. The covered was then made using a 3D printer machine. Actual experiment were conducted by establishing the mechanism of the concept and observing its actual function. It has been determined the physical parameters of Liberica cherry, the strength of coffee cherry stem on tree branches, and the comparative performance of conventional harvesting and harvesting with tools. The results indicate that the strength of mature Liberica coffee cherry stem on tree branches is stronger than that of unripe stem; therefore, the concept of shaking cannot be utilized in the design of harvesting machinery. Results also show that using tool to harvest coffee cherry is more productive than harvesting by hand. Extensive research, development, and improvement are required.

Keywords: Liberica, Coffee cherry, Mechanical harvesting tool, Manual harvesting, Performance Evaluation

030-023

OBSERVATION ON AGRO-MORPHOLOGICAL, FIELD PERFORMANCE AND CLONAL FIDELITY ASSESSMENT OF TISSUE CULTURE GENERATED COCOA CLONE

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ABSTRACT

A comparative observation on the phenotypic and field performances of a mature tissue culture tree generated from cocoa clone staminode, was carried out to evaluate the differences between a tissue culture generated cocoa and cocoa clone generated through conventional propagation method. Both the tissue culture generated cocoa and conventional propagated cocoa clone were DNA fingerprinted with the MCB cocoa SNP panel to assess the clonal fidelity of the tissue culture generated plant in relation to the expected cocoa clone. From the DNA fingerprinting results, the tissue culture generated cocoa tree was verified as a true-to-type clonal tree exhibiting the same profile with the clonal planting material generated conventionally through grafting, even though it was not the original mother plant. Observation results on the agro-morphology of tissue culture generated cocoa compared to the cocoa clone generated conventionally through grafting shown some significant differences in the phenotypic and field performance. Tissue culture generated cocoa has jorquette branches, the usual characteristic of hybrid cocoa trees propagated from seeds, which make the tree taller than cocoa clone generated through conventional method. Cocoa trees generated from tissue culture technique also observed to have smaller girth circumference measurement compared to the conventionally propagated cocoa tree. However, early flowering was observed with tissue culture cocoa trees at approximately 12 months after planting compared to the conventionally propagated cocoa tree which is about 18 - 36 months.

Keywords: tissue culture cocoa, *Theobroma cacao*, agro-morphological traits, clone verification; SNP genotyping.

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THE BENEFITS OF FERTIGATION FOR SMALLHOLDER FARMERS IN SARAWAK RURAL COMMUNITY

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ABSTRACT

A fertigation system is one of the features of precision agriculture activities that are often used by farmers nowadays. Fertigation is defined as the implementation of liquid fertilizer or permeable solid fertilizers through drip irrigation systems which is straightway to the region utterly plant roots develop. Smallholder farmers in rural areas are trying to bend over backward to produce enough yields and to meet the food demand to support their families' essential needs. Providing these rural communities with the legitimate tools to boost the production process and to ease adversity could help to support rural communities and unlock their potential to face the increase in global food demand. Therefore, the current study was carried out to identify the benefits of fertigation for the farmers in Sarawak. The data was collected from 12 farmers in Sarawak by employing a random sampling technique through a random process where each person in the population has the same probability of being selected for the sample. This research employed an open-ended questionnaire to collect the data was analyzed through Thematic Analysis (TA). The method applied in this research was using the promotional approach to smallholder farmers. The result turns out impressively that the adaptation of precision farming which is fertigation, the new way of farming activity, enables farmers to maximize their yield and produce a high-quality yield as well as high net income of the farmers to cater to the demands in the market and people as compared to the conventional methods.

Keywords: Fertigation, Smallholder Farmers, Rural Area, Thematic Analysis, Promotional Approach

1. Introduction

The fertigation system is a common farming practice and is widely used by farmers around the world. It has become a brilliant practice or approach of fertilization for every crop that is planted by farmers in this modern agriculture system to apply inputs, especially water, and fertilizers. According to Hakkim et al. (2016), fertigation is defined as the implementation of liquid fertilizer or permeable solid fertilizers through drip irrigation systems which is straightway to the region utterly plant roots develop. Besides, Xiukang et al. (2016) defined fertigation as the technology of agricultural water management which supplies fertilizer and water simultaneously in a drip irrigation system, by injecting soluble fertilizer into the water and the irrigation system transporting the fertilizer into the root region of the crop.

In addition, for the past few years, productive and fertile soils are the major aspect to be considered for the development of balance societies and civilizations. As stated by Sureshkumar et al. (2017) healthy and good soils not only aid in the growth and development of a plant that human beings consumed as food but it is also important for energy and water security for the ecosystem. Precision agriculture technology such as fertigation systems is very important for smallholder farmers in this developing world but is often presumed as bizarre. Loon et al. (2018) prove that low-resource rural communities are the most affected by the negative changes in the environment.

Sarawak Government had provided and initiated a lot of initiatives to transform the State into a net food exporter by the year 2030. In this case, the farmers must take a chance to snatch the opportunity given to establish a better farm and the productivity of their crop to generate income from the crop produce. For example, to help farmers in rural areas, the state government has handed out RM9 million under Agriculture Community Outreach

Programme (AgriCOP) and Deputy Chief Minister Datuk Amar Douglas Unggah Embas said that it was an aid to emphasize agriculture activities to accelerate food production in Sarawak. Besides, the state government also hopes more farmers and youth participate in agriculture activities because the state government also wishes to become a net food exporter by the year 2030 (Achoi, 2020).

Despite, the agriculture sector also changed its trend effect from the development of the agriculture sector itself and the consumption pattern, smallholder farmers begin to seek a maximum yield and tend to produce high-quality food-based products to meet the food demand. As stated by Abdullah (2017), the need and the opportunity expand when rural areas and rural population are facing changes affected by external influences such as urbanization. Providing these rural communities with the legitimate tools to boost the production process and to ease adversity could help to support rural communities and unlock their potential to face the increase in global food demand. Therefore, the current study was carried out to identify the benefits of fertigation for the smallholder farmers in Sarawak whether they tend to improve their livelihood through this farming activity because they are therefore set to play an increasingly bigger part in the agricultural sector in Sarawak.

2. Materials and methods

2.1 Fertigation in Sarawak

Fertigation which is the combination of 'fertilization' and 'irrigation' now has briskly spread all over the world in the last 40 years. In order to minimize the consumption of water in agriculture, the evolution of fertigation systems seems to be quick in many areas of the world, which the desire arose from the insufficiency of water due to the increasing of urban demands. Besides, the evolution of fertigation system also rise by the increase in labor costs, demands in reducing pollution and to reduce soil erosion, increase the dependence on saline water sources, and also for wind conditions and unfavorable the quality of soil in certain area (Kafkafi, 2005).

As mentioned, fertigation is a process in which the fertilizers are being applied or used along with the irrigation water (fertilization + Irrigation). These fertilizer solutions are being prepared in the stock tanks and the solution is injected into the irrigation water. Hence, the fertilizers are then dissolved at appropriate concentrations where the nutrients and water in needed quantity at a right time placed in root zone. This will enhance the maximum absorption of applied water and nutrients in order to achieve more crops per drop of water. As Amy Grant (2021) said in her article, fertigation usually used by commercial farmers or growers which is a person, a firm or a corporation engaged primarily in crop production and plating purposes for trade or sale.

The state government has presented more modern agriculture systems such as the Internet of Things (IoT), aquaponic, hydroponic, and fertigation systems to support agriculture activities in Sarawak. The Internet of Things (IoT) is a type of emerging system which integrates many technologies from different areas. According to the report by Ling (2018), Sarawak had brought up a new practice or approach to their agriculture sector which is more competent and modern. Moreover, this modern practice also helps the youths and encourages them to participate in the agriculture sector, as mentioned by the Deputy President of Dewan Negara, Senator Datuk Seri Abdul Halim Abdul Samad.

In a study by Abdul Hakim Bujang (2017), one of the farmers in Sarikei who uses the fertigation technique, claims that he has zero experience in modern farming and he used recycled items that can be found in the backyard to minimize the cost. With help from his friends, he tried to plant rock melon and installed the piping system. He said that it was too easy to install and fertigation system might create high opportunities for rural people to generate their income and he stressed that fertigation farming is a future for backyard farming. This shows that the farmers perceived the fertigation system as very convenient, easy to use and cheap.

2.2 Advantages of fertigation

Fertigation farming brings many benefits and advantages to our ecosystem, nature, and animals. Hakkim et al. (2016) list several advantages of the fertigation systems as seen below:

a) Fertilizer can be applied directly to the effective root zone of plant growth via drip fertigation. The amount and form of nutrient supply is adjusted according to the needs of the essential growth phases of the plant, and fertilizer administration is synced and optimized with plant needs.

b) Nutrients can be applied at any time during the growing season based on crop needs, resulting in a reduction in the amount of fertilizer used and less leaching due to unseasonal weather.

c) Reduce labor and energy cost due to the automation of control.

d) Available and simple to use and suit automation

e) Timely application of small and exact amounts of fertilizers directly to the root zones, which enhance the usage of fertilizer efficiency and prevent nutrient leaching below the root zone

f) Provide a consistent flow of water and nutrients to prevent crop damage.

g) Smaller amounts of fertilizer required to solve any deficiency issues and highly mobile nutrients such as nitrogen can be carefully managed to secure rapid crop uptake.

h) Safer utilization method, as it eliminates the danger affecting roots due to higher dose.

i) Prevent soil erosion.

2.3 Sampling and selection

This study employed a random sampling technique which is using a random number of fertigation farmers that exist in the entire area of Sarawak. This allows for the possibility that each person in the population has the same probability of being selected for the sample. This type of sampling provides benefits to the researcher by drawing out or gaining information from the participants, especially when dealing with the farmers, as they are more knowledgeable in the field. In this research, at least 12 farmers were selected to undergo a series of interview sessions.

2.4 Methods

2.4.1 Data collection

The 12 respondents were interviewed using a set of open-ended questionnaire. The open-ended questions required the respondents to provide answers or responses in their own words. All interview sessions were recorded and transcribed verbatim. Furthermore, the items in the questionnaire were designed to get their responses related to fertigation and their experiences in the field when handling this type of farming activity. The questions are mostly open-ended questions, such as why they choose fertigation, their experiences in fertigation, the problems they faced, and the benefits of fertigation. Before the interviews, the participants were contacted by phone to give them information about the study and their scheduled interviews. During year the 2021, due to the Movement Control Order (MCO) in Sarawak, on-site discussions and interview could not be conducted face-to-face. Therefore, the researcher opted to conduct online interviews.

2.4.2 Thematic analysis

This research employed Thematic Analysis (TA) as the method to analyze the qualitative data. As argued by Braun and Clarke (2006), TA can be an analytic method and be seen as a major qualitative analysis approach than other qualitative research methods. There are six-phase approaches that guided the researcher when doing the analysis. The first phase focuses on understanding the data where it was transcribed, read, and re-read to develop basic codes. The second phase covers setting up the basic codes where the data was coded and collated with relevant and interesting features of data systematically. The third phase is involves theme selection in which the data collated and compiled to derive potential themes. The fourth phase involves the review of the themes to check whether it works in relation to the coded extract to develop a thematic map. The fifth phase comprises the procedure of naming the themes. Finally, the sixth phase is on producing the report to answer the research questions posted at the start of the research.

2.5 Promotional approach

A promotional approach is a plan that can be implemented to alter the other farmer's perceptions about fertigation, and attract and increase more potential farmers to engage in the fertigation system. As stated by Claudia (2022), the concept of promotional strategy refers to the long-term planning and actions taken by any firm to reach specific goals. There are four functions of promotional approach that are considered to be the most important:

a. Build awareness

This will raise the level of awareness among the farmers about the fertigation technique. Identify the farmers that are already engaged in this fertigation and undergo an interview by asking a few related questions. The data collected from the participants can be one of the promotional strategies to help other farmers.

b. Foster interest
Once the research is completed, it will make other farmers intrigued and interested in fertigation because they can differentiate between both conventional and modern way of farming methods.

c. Generate demand
By sharing the great features and experiences of the participants that already engaged in fertigation, other farmers will start relating emotionally to it by seeing something that may benefit them and their livelihood.

d. Induce prospects to take action
Paper publishing will benefit the reader about fertigation and more researchers will study and start doing research about fertigation that can help other farmers in the rural areas in Sarawak.

3. Results and discussion

The result has disclosed that all six participants declared that they have stated more than one benefit of fertigation. The main themes include an increase in income and profit, reduced labor and energy costs, simplicity and effectiveness, automation and control, and enhance production and crop quality.

3.1 Theme 1: Increase income and profit

Most farmers mentioned in the interview that fertigation indeed helps them to increase their income and provide profit. King (2021) stated that the fertigation system can be quite expensive, yet the majority of the farmers will see a return on their investment within just one year and agreed that fertigation farming increase bottom-line profits while it lowers the costs.

One of the participants declared that fertigation gives a huge impact on the farmer's profit when there is a large amount of yield produced:

"Thus, if the yield is increasing; our margin increases as well, which means that our income also increases. It is because, we usually apply this fertigation, this system, with the aids of irrigation system, efficient fertilization, the reduction of labor cost together with the production of numerous of fruit from one plant". (Farmer 1)

Other than that, two participants claim that the crops that they planted through fertigation bring an additional and outstanding income for them and their families after they sold it.

"Okay, first things first this fertigation provides me an additional income for me and my family, okay". (Farmer 2)

"So, if we look at it in terms of benefits or the profits, it currently appears a very bright future, extremely bright. This means that if we are able to sell in 5 to 6 Months or 6 to 7 months if we estimate it roughly from the first of our training, we are able to produce an income of more than 10,000 plus (RM10,000+). I guess that if the income that we get for 6 months is already 2 to 3 thousand (RM2000-RM3000) per month. We feel very lucky in terms of income, in terms of leisure time, because... it is not just for me, but also for my children". (Farmer 3)

One participant shared the reason why she engaged in fertigation because she is a retired person and has nothing to do at retirement. She stated that the profit that they get through fertigation is acceptable.

"The profit is good. At this point, the harvest's net profit is 30 percent (%), 30% and 40%". (Farmer 4)

Farmer 5 informed that the profit that he gained through fertigation was worth his effort and he was very satisfied with the crops that he planted.

"In terms of profit, obviously we get some income through it. After that, it provides a relax lifestyle because of what we have planted, we gain profit through what we have grown ourselves, right? We get the profit and we will be very satisfied with the crops that we planted". (Farmer 5)

Moreover, farmer 6 said that fertigation provides a lot of profit when he made a rough calculation of his earnings over six months.

"So the profit, if in theory, okay, absolutely; because if in theory, you surely can get profit for example if 1 green house is typically 70 feet long, the width is 110 feet, okay, there are 1,000 trees inside. Yes, for instance I grew chili, okay. If 1 tree in 1 polybag has one for example 2 Kilos (2 Kg) or 3 Kilos (3 Kg), easy to say 3 Kilos (3 Kg). 3 Kilos (3 Kg) times 1,000 trees (3 Kg x 1,000), means that 3,000 Kilos (3,000 Kg). Okay, you multiply with, if 1 Kilo (1 Kg) the price is for example 10 ringgit (RM10.00), okay? It will be 30,000 (RM30,000) for 6 months". (Farmer 6)

3.2 Reduce labor and energy cost

By using fertigation and the automation of the system, the farmers simply can supply both nutrients and water to the plants. Although fertigation is an automatic technology and it does not require a lot of maintenance, the farmers still need a few workers on hand to handle the labor-intensive works such as fertilizing, weeding, and harvesting which help the farmers save money on the worker's wages. Fertigation is indeed attributed to energy savings which employed lower fuel, less labor, and reduced fertilizer costs compared to the conventional methods (Bandyopadhyay et al., 2020).

Most of the participants highlighted that fertigation farming does not require a lot of energy to operate.

"If we have lowered the labor expenses, it also benefits us because these labor costs can be directly included in our income, and our profits". (Farmer 1)

"Indeed, the fertilizers you just need to mix it up, do not require anything else. Then, you can minimize employee salary. Yes, because if you want to do fertilizing, as we do here, one workers for morning fertilizing. There are 3 workers here, one person is 40 (RM40.00). If in the morning I count it as half day, half day for 20 (RM20.00), works with the fertilizers 60 (RM60.00)". (Farmer 2)

"We do not need a lot of energy to water each polybag. Okay, as compared with the conventional method, we need to water it one by one, okay". (Farmer 3)

Three other participants stated that they manage to minimize both labor and energy cost on their farms.

"As far as you know, only 3 of us handle this fertigation. It does not involve a lot of workers". (Farmer 4)

"In that case, we can reduce the energy to carry out this fertigation". (Farmer 4)

"Okay, this fertigation does not require energy". (Farmer 5)

"One, the maintenance costs... is a little bit lower in terms of labor. For example if I have 4 green house, I just need 2 workers only, 2 workers that are really devoted to their work". (Farmer 5)

"First of all, good morning. Less human power and then you no need a poison, no need a major poison". (Farmer 6)

"So that to minimize your cost, all this". (Farmer 6)

3.3 Simple and Effective

Fertigation is a timely application of small and exact amounts of fertilizers directly to the root zones, which enhances the usage of fertilizer efficiency and prevents nutrients from leaching below the root zone. As stated by Ranjan et al. (2021), nutrient loss by leaching is much less likely as compared to the conventional method, resulting in losses of 40-55% of nutrients.

All participants agreed that this fertigation is very simple to operate and effective as well.

"We can see that we also need to switch from the standard system to the irrigation system which is more efficient. The term fertigation refers to; an irrigation system that is significantly more effective as the water is continuously infused with fertilizers for the plants". (Farmer 1)

"The first one, this fertigation farming, the reason why I choose this fertigation farming is because it is the easy way of farming for me". (Farmer 2)

"So, very simple, you need to like maybe 2 or 3 days, you have a daily visit. So, you no need a youngster to help, the old man also can do". (Farmer 3)

"Yes, performing this fertigation is very simple, because it is long-term, as it can be harvested 2 times in a year". (Farmer 4)

"In this fertigation, even we women also can perform this fertigation because the work needs to be done is not that heavy because everything in there is already set by the timer". (Farmer 5)

"Thus, there is no other problem and also no difficult tasks. Young women even elderly women also do not have any issues because one, you do not need to water it. You will only have the tanks, the system, more than that you have the IoT (Internet of Things) and you just monitor it". (Farmer 6)

3.4 Automation and control

Farmers can control the crops by automatically managing the water and fertilizer. Fertilizers can be applied at any time during the growing season based on crop needs, resulting in a reduction in the amount of fertilizer used. The amount and form of nutrient supply are adjusted according to the needs of the essential growth phases of the plant, and fertilizer administration is synced and optimized with plant needs. Neto et al, (2014) stated that the automatic control system of fertigation worked well by adjusting the frequency of the fertigation cycle which minimize environmental issues related to effluent disposal and improved the efficiency of fertilizer and water resources.

Farmer 1 justifies that fertigation is an automated process of watering and fertilizing system that has caught his attention to use it.

"One, it simplifies the watering and fertilizing system. Yes, the main focus of this system is consistent fertilization and watering of the plant, which is direct to the root zone of the plant. That is one of the reasons why we choose it". (Farmer 1)

Another farmer admits that it is a bit more modern than the conventional method of farming.

"The crops, the system of watering, the fertilization, for the time being, we utilize auto work, everything is automatic". (Farmer 2)

In addition, other participants spoke that they can apply water and fertilizer at any time that they want.

"Planting as much as we can, okay? With the aid of the system or the modern way of farming especially this fertigation system, we can water it according to certain time we want, okay". (Farmer 3)

"So, everything is controlled by using smart phone only. We program it, okay? We can set when we want to water our crops, the NPK (Nitrogen + Phosphorus + Potassium) fertilizer proportion; that is why it is good". (Farmer 4)

"If fertigation? No salary, it works automatically. Yes, the salary is given. Like us here now, fertigation is not automatic. Okay, it is a manual function, the workers just need to mix the fertilizers for 5 minutes only. After 5 minutes, he can leave". (Farmer 5)

Farmer 6 differentiates the system of fertigation from the conventional method where he finds that both have a huge difference.

"When compared to the conventional system, it is quite different. I declare that the outcome is superior to the conventional system because the fertilization is more organized, and then it can be said enough food and nutrient intake by plants". (Farmer 6)

3.5 Enhance production and crop quality

The most important aspect of fertigation is that it produced a robust and nutritious plant of a consistent size because the fertilizers and water are both given directly to the roots, where it is more convenient and effectively

absorbed by the plants. As mentioned by Labbate (2018), fertigation generates better crop production and quality compared to conventional practices because the micronutrients are supplied at a precise amount which can deliver higher yields.

Moreover, some of the participants mentioned that their end product and the crop quality were quite impressive after applying the fertigation system on their farm.

"I also try to do an experiment as well, I plant conventionally first followed by fertigation. So, it feels different. Thus, I can see that the nutrient that is provided to the plant is truly adequate and the result is quite good. I can say that lucrative oftentimes far than the conventional method". (Farmer 1)

"Therefore, if the crops obtain an adequate amount of fertilizers, a proper amount of nutrients, it means the crops are healthy and productive. When the crops are healthy and productive, the outcomes, or the end-product, the production of the fruits; as for example, a watermelon can produce a higher yield". (Farmer 2)

"Why did I choose this fertigation? The first is to boost my ginger's productivity". (Farmer 3)

"Thus, now the crops that are available, those that have been sold that day are rock melon, cucumbers, and Bentong ginger. Generally, the outcome is quite good because if there is a profit, we will try to increase it more and more". (Farmer 4)

One of the farmers mentioned that he adhere to some SOP (Standard Operating Procedure) of planting so that his crops will be in a good condition, productive and free from pest and disease.

"This way, we should follow the SOP (Standard Operating Procedure) to protect our crops so that our crops will be productive, free from diseases, pests and fungus, okay? If for the pests we do not have an issue with it because we follow the SOP for the sustainability of our crops". (Farmer 5)

Farmer 6 stated that the crops that he planted produced a lot more than he expected but the total amount of crop that he harvested was still not enough for local consumption in his area.

"I observe that for this first batch, there is still insufficient for our usage in Kapit. I mean just like my friend that day he plants 500 chillies, still not enough for us in Kapit. I mean just for local usage". (Farmer 6)

4. Conclusion

Fertigation has established itself as an essential component of contemporary agricultural systems, and it has played and will continue to play a significant role in advancing the use of precision agriculture. Sarawak Government has come up with a lot of initiatives such as providing better infrastructure and services, funds, and other means of support to help and aid the livelihood of rural communities. The findings have found that the new way of farming activity enables farmers to maximize their yield and produce a high-quality yield as well as contribute to high net income of the farmers to cater for the demands in the market and people as compared to the conventional methods.

Conflict of interest

The authors hereby stated that there is no conflict of interest.

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THE EFFECT OF FLOW RATE ON PHYSICOCHEMICAL AND MICROBIAL PROPERTIES OF AERATED COMPOST USING SPENT MUSHROOM SUBSTRATE AND COW MANURE.

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ABSTRACT

Composting is a method of organic waste treatment by microorganisms that can be improved by aerated composting. This study investigates the effect of different air flow treatments (0, 10, 15, 20, 25ml/min) on the physicochemical and microbial properties of aerated compost using spent mushroom substrate and cow manure. The microbial properties of the compost were studied through bacteria isolation, CFU counting and biochemical tests. Physicochenical properties of compost include temperature, moisture content, oxygen content, pH, electrical conductivity, C/N ratio, potassium, and calcium content were investigated.
The microbial community of the 25ml/min showed the highest population of beneficial microbes (*Azotobacter* sp.:113.0 x 10-6, and *Rhizobium* sp.:176.8 x 10 -6). Control treatment (0 ml/min) had highest number of harmful microbes (*Escherichia coli*:61.6 x 10 -6 , *Enterococcus faecalis* :6.4 x 10-6 and *Pseudomonas* sp.: 46.0 x 10-6). *Salmonella* sp. was not detected in all treatments but it was found to increase in control treatment at the end of composting. 25ml/min compost also recorded the highest oxygen level (15.2%) and potassium content (806ppm); had ideal moisture content (66%), pH (9.3), and electric conductivity (2.0 mS/cm); and had the lowest temperature (29.4Cº) at the end of the composting indicated the maturity of the compost. The highest calcium level was observed in compost at 10ml/min (95.4ppm). The CN ratio of all treatments ranges from 11.3 - 11.6. This study suggests that 25ml/min of aerated compost could benefit the agricultural industry.

Keywords: Composting, Air flow, Microorganism.

039-030

PROPAGATION OF SYZYGIUM MALACCENSE THROUGH SEED FRACTIONATION TECHNIQUE

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ABSTRACT

Syzygium malaccense belonging to the large family of Myrtaceae produces medicinal plant parts and edible fruits which contain high nutritional values and antioxidants. However, the limited occurrence of this fruit species within Malaysia has hindered its commercialization potential. Large scale planting is necessary in promoting this indigenous fruit. Timely supply of sufficient planting materials is needed for this purpose. To date, this tree species is mainly propagated by seeds while stem cutting and grafting techniques are less successful. Although whole seed has a single plumule-radicle axis, preliminary work showed that a seed could produce more than one plant with its fragmented portions. The cotyledonary fraction devoid of embryo could become regenerative leading to the formation of an entire plant. This phenomenon in S. malaccense could be associated with polyembryony documented in many other members within Myrtaceae. The present study explored seed fractionation as a non-conventional method in propagation of S. malaccense. The seeds cut systematically into separated halves and quarters were studied for in vivo sprouting potential in moistened sand medium. The experiment was carried out on germination racks in laboratory. The results indicated that the reduced reserve did not impact the development of full plant from the seed fractions. The quarter seeds were comparable to the half seeds with a full plant regeneration rate of up to 1.5 while the intact whole seeds had a rate of 0.93. Thus, this simple seed fractionation technique is useful for the multiplication of S. malaccense. Moreover, most of the remaining seed fragments rooted simultaneously but their shoots were yet to be visible by the end of the study period of five months. Attempts that facilitate the shoot development after adventitious rooting from the fractions through the manipulation of some environmental factors would be beneficial for the propagation of this fruit species. The genetic fidelity of the plantlets originating from a single seed is another research focus in sourcing an alternative for clonal planting materials.

Keywords: Adventitious, cotyledon, regeneration, root, sprouting

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EFFECT OF COMBINATION NAPHTHALENE ACETIC ACID (NAA) AND 6-BENZYLAMINOPURINE (BAP) ON *IN VITRO* MICROPROPAGATION OF RICE (*Oryza sativa* L.) cv. MR269

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ABSTRACT

Rice (*Oryza sativa* L.) is one of the world's most important food plants, that has a relationship with the other cereal species, which is a staple food, that consumed by more than 50% of the global population. Tissue culture technique is an efficient approach to improve the rice regeneration by optimization of plant growth regulators. This study is carried out to developed an efficient combination hormone NAA and BAP *in vitro* micropropagation of rice (*Oryza sativa* L.) cultivar MR269 in MS basal medium treated with different concentration (1.0 mg/L BAP + 0.1 mg/L NAA, 2.0 mg/L BAP + 0.2 mg/L NAA, 3.0 mg/L BAP + 0.3 mg/L NAA, 4.0 mg/L BAP + 0.4 mg/L NAA and 5.0 mg/L BAP + 0.5mg/L NAA) using matured seeds. The cultures were incubated for 4 weeks in the growth chamber. The observation revealed that there were significant results of height of plantlets, number of shoots number of roots, length of roots and fresh weight towards the treatments. The maximum number of roots (15.25±1.89), length of roots (1.8±0.25cm) and height of plantlets (13.88±0.47cm) were obtained in MS media supplemented with 1.0 mg/L BAP and 0.1 mg/L NAA. The highest number of shoots (7.5±0.29) and fresh weight (0.21±0.05g) were observed in MS media supplemented with 3.0 mg/L BAP + 0.3 mg/L NAA and 5.0 mg/L BAP + 0.5 mg/L NAA respectively. The best combination of hormone for the efficient of rice regeneration was in the MS supplemented with 1.0 mg/L BAP and 0.1 mg/L NAA. However, the MS media with 0 mg/L BAP and 0 mg/L NAA, which act as a control showed the most efficient media for the plant regeneration of rice especially in the roots and the shoots induction.

Keywords: Rice, *Oryza sativa*, MR269, NAA, BAP

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042-032

EFFECTS OF ROOT ZONE TEMPERATURE AND LIGHT INTENSITY ON PLANT GROWTH, FLOWERING AND FRUIT QUALITY OF PLANT FACTORY 'FESTIVAL' STRAWBERRY (*Fragaria X ananassa Duch.)*

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ABSTRACT

Plant factory strawberry growth and production is highly affected by environmental factors such as light and temperature. Recent interest in the plant factory production of strawberries in soilless substrates has triggered concern about possible effects of Root Zone Temperature (RZT) and light intensity on plant growth and fruit yields. In hypothesis RZT and light intensity can increase the plant growth performance and affect inflorescence production. This study was aimed at investigating the effects of RZT and light intensity towards growth and reproductive performance of strawberry. Root zone of 'Festival' strawberry plant was exposed to temperature of 15^{o}C at night and without RZT, as control, under two different light intensities which is 200 mmolm^{-2}-s^{-1} and 300 mmolm^{-2}-s^{-1}. Root and crown temperature in Root Zone Cooling (RZC) was achieved at 15-21^{o}C. Leaf number was significantly affected by the interaction between RZT and light intensity. Crown diameter in the RZC treatment (13.27 cm) group was higher than in the control (12.06 cm). Chlorophyll content was significantly elevated by higher light intensity 356.9 mmolm^{-2}-s^{-1}. Flower production in RZC was 52% higher than in the Control. Enumeration of growth organs and inflorescence increased in RZC suggesting the induction of reproductive growth by low root zone temperature. However, light intensity received by plant and interaction between RZC and light intensity did not have any effect on inflorescence production. Fruit size and soluble solid concentration were not affected by RZT, light intensity and interaction of RZT and light intensity. The increase in flower production is attributed to the lower plant temperature specifically at the crown which was at 10-12^{o}C. In conclusion RZC can induce growth and reproductive performance and ultimately increase fruit yield of hydroponically planted factory strawberry.

Keywords: Root temperature, crown temperature, Inflorescence, Light intensity, LED

043-033

THE EVALUATION OF BROTH-MEDIA EFFICIENCY AND RELATIVE RISK ASSOCIATED WITH *SALMONELLA* IN CULLED LAYERS AND THEIR ENVIRONMENT

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ABSTRACT

Salmonellosis is a type of food poisoning that has been implicated in many foodborne outbreaks globally, characterized by acute gastroenteritis with short incubation period, and is caused by Gram negative bacteria belonging to the genus *Salmonella.* Our preliminary studies have shown the overall prevalence of *Salmonella* was 14.0% (66/470) from 470 culled layers including environmental samples (feed, faeces, litter and drinking water) isolated from culled layers from farms and wet market in Penang and Kedah, Malaysia. Following to that, we were interested to investigate the efficiency of several enrichment broths and selective media used during the experiment. Interestingly, the isolation of *Salmonella* was observed more effective with higher isolation rate at 66.7% and 57.6% from Rappaport-Vassiliadis (RV) enrichment broth and Xylose Lysine Tergitol-4 (XLT-4) selective media, respectively. In addition, the incorporation between *Salmonella* prevalence data from previous study and relative risk (RR) value for culled layers and their environment was also evaluated to determine risk factors. In this study, RR value was calculated based on the ratio of incidence between layer farms and wet market to indicate risk of disease more likely or less likely to occur. From the prevalence study, there was a significant difference between farms and wet market ($p<0.05$) and RR value was found higher at wet market comparable to farms. Therefore, the exposure assessment tracks the pathogen from farm to the point of retail within this study, taking into account RR value. Our findings provide clearer perspective on the most efficient method of *Salmonella* isolation for detection accuracy. Furthermore, this study indicated baseline information on the distribution of *Salmonella* relative risk in culled layers and environment to form a basis for risk assessment and future interventions.

Keywords: *Salmonella*, efficiency, relative risk, culled layers, environment.

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024-035

PERFORMANCE EVALUATION OF A ROOT BALL PEDESTRIAN TYPE TRANSPLANTER ON GINGER PLANTING

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ABSTRACT

This article reports on the performance evaluation of a pedestrian type transplanter on ginger planting. The tests were carried out on mineral soil at Engineering Research Center Plot in MARDI Serdang, Selangor. The shortage of labours was a main problem thus the need for mechanization arises. Conventional method of ginger planting was using manual hand to plant the seeds into soil. To overcome this issue, a root ball pedestrian type transplanter was introduced and tested. The machine performed well when operated on planting bed. Based on the performances test, the results showed that the planting rate was 88% for the machine. On average, the machine required 10 hours to complete planting ginger in 1 hectare while manual planting took about 13.5 hours to complete the planting process based on 2 men operating respectively. The results showed that the field efficiency was 95.65% and machine required 20man.hr/ha while manual planting required 27man.hr/ha. This result indicated that labour usage reduced by 26% compared to the conventional method. For future research, it would be good to analyse on the ginger growth performance and yield based on the machine used.

Keywords: ginger planting; transplanter; machine performance; field efficiency; ginger planter

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019-036

GROWTH AND YIELD RESPONSES OF SHALLOT (*ALLIUM ASCALONICUM* L.) ON VARIOUS PLANTING DISTANCES AND FERTILISER RATES

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Keywords: shallot, planting distance, fertiliser rate, yield, sandy clay

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048-040

PREDICTIVE MODEL FOR MOISTURE CONTENT OF *Coffea liberica* SEEDS SUBJECTED TO AMBIENT AIR DRYING

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ABSTRACT

Determination of seed moisture content (MC) is a destructive method according to International Seed Testing Association (ISTA) where the seeds are dried at 103±2 °C for 16±1 hours in convection oven to know the amount of water within seeds. The present work analysed the relationship between weight and MC of *Coffea liberica* seeds so that the seeds with MC estimates themselves could subsequently be applied as planting materials or for storage. From the fully ripe fruits, single seeds, two seed units, three seed units and four seed units were studied for suitability in developing a predictive model for MC. In each context, seeds of varying MCs for model building were obtained with air drying at ambient temperature of 28±2 °C and relative humidity (RH) of 55±5% in laboratory for 0, 2, 4, 6, and 8 days. Prior to desiccation treatments, the seed units were tagged and noted for fresh weight (FW), length and breadth. After desiccation treatments, weight after desiccation (DesW) was recorded and the actual MC of seed was determined with the oven drying method. Plots of MC - desiccation period showed that ambient air-drying reduced MC of seeds progressively and consistently. With the initial MC of 0.4 g H_2O g^{-1} Wt on wet weight (Wt) basis, air drying of the seeds in laboratory for up to 8 days reduced their MC to 0.15 g H_2O g^{-1} Wt. Subsequent correlation analysis revealed that MC had positive relationship with DesW, but was negatively associated with (Loss of water), which is the difference between FW and DesW. Stepwise linear regression analysis implied that MC of *C. liberica* seeds could best be estimated as MC = 0.185 + 0.118 FW – 0.412 (Loss of water) using two seed unit. The model was statistically significant ($P < 0.001$) with appropriate R^2 and SE_E values of 0.95 and 0.0187 g, respectively.

Keywords: Correlation, desiccation, regression, weight

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044-042

EFFECTS OF LAYER AND PLANTING DISTANCE ON GROWTH OF FAN PAK CHOY (*Brassica rapa L. subsp. chinensis*) ON A MULTILAYER PLANTING SYSTEM

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ABSTRACT

Vertical or multilayer farming is getting popular and more attention in Malaysia due to its effectiveness of space optimization. Planting density also another focus to maximize the production capacity with compromise of growth and yield. However, uneven lighting and shading was an issue on multilayer planting system in a greenhouse. Therefore, a study on the effect of layer and different planting distance on growth of Fan Pak Choy in a multilayer planting system was studied. This study was conducted in greenhouse at the Malaysian Agricultural Research and Development Institute (MARDI) using two factor factorial Randomized Complete Block Design (RCBD). The first factor is layer (L) which consists of 3 levels, namely below (L1), middle (L2) and top (L3). The second factor is planting distance (S) which consists of 3 distances arranged with 13cm (S1), 18cm (S2), 23cm (S3) in a single row. Parameters observed were plant height, number of leaves, leaf area, plant fresh weight, relative chlorophyll content, air temperature, relative humidity, light intensity and air speed. Top and middle layers show better results compared from below layer on plant height, number of leaves, leaf area, plant fresh weight and relative chlorophyll content. Planting distance of 13cm, 18cm and 23cm was not significantly different for all parameters except for plant fresh weight and leaf area which is 18cm (327.06g, 2482.77m²) gives better results followed 13cm (299.46g, 2181.91m²) and 23cm (229.70g, 1875.67m²) respectively. In summary, combination between layer and planting distance was significantly affect on yield of Fan Pak Choy.

Keywords: Fan Pak Choy, green house, multilayer, planting distance.

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049-043

MONITORING OF INCUBATION QUAIL EGGS WITH LEARNING DATA AND INTERNET OF THINGS (IOT) SYSTEMS

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ABSTRACT

Compared to chicken or duck, the breeding of quils was not famous in Malaysia. Besides that, the hatching success rate still become a big issue. The objective of this project is to develop an incubator monitoring system that can independently control the incubator's temperature, humidity, and eggshell size hence increase the hatching success The experiment proceeds to identify the relationship between temperature and size of quail eggs on the hatching rate of quail eggs. The DCF Incubator is used as the primary incubator and equipped with a thermostat for temperature control. The ESP32, DHT11, and ThingSpeak is used as the monitoring system for temperature and humidity. A Raspberry Pi 3 and Camera Pi is used for size detection of quail eggs using open python. The data collected from the monitoring system was sent to a ThingSpeak channel for analysis. The ideal temperature for quail egg incubation is around 37.5 degrees Celsius. The size of the quail egg also affect the hatching rate. The project collected data on the hatching rate of quail eggs after 16 days in an incubator, finding that smaller eggs had a higher hatching rate of 80%, compared to medium-sized eggs at 66.67% and large eggs at 63.16%. The data suggests a potential correlation between egg size and hatching rate, with smaller eggs having an advantage in regulating temperature. In conclusion, the results of this project provide valuable insights into the incubation process, allowing for greater control and precision.

Keywords: Quail Egg, Monitoring System, Learning Data, Internet of Things (IoT) and Incubator

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VARIABILITY OF FRUIT MORPHOLOGY, YIELD, AND QUALITY IN THE TAGNANAN POPULATION AS MATAG POLLEN SOURCE

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ABSTRACT

The male parent of the MATAG hybrid, Tagnanan, is an allogamous tall type, with substantial variation and thus, contributing to the possible inconsistency in MATAG hybrid production and consequently lowering the efficiency of genuine MATAG production. Therefore, the selection and improvement of homogeneous Tagnanan individuals as pollen sources must be made to ensure the production of high-quality MATAG. This study aimed to describe the variation and evaluate the Tagnanan population currently utilized as the main pollen source for MATAG production based on fruit yield and quality components. A quantitative descriptive study of the growth and coconut yield attributes was done on the 13-year-old Tagnanan population at DOA Teluk Bharu, Perak. Phenotypic performances were characterized by colour, shapes (polar and equatorial view), the number of fruits and variation in traits related to yield and quality of fruits. From the polar and equatorial views, fruits in this population were mainly round-shaped. The PCA generally explained 49% of the variances, with PC1 accounting for 35.9% of those variations and positively correlating with all other parameters. PC2 made up 13.8% of the variations, with traits including the length of the stem with 11 leaf scars, the thickness of the shell, the size of the fruits, the weight of the husk, and the weight of the fruits indicating distributions. The dry matter, stem circumference at 20 cm, meat weight, and the association between fruit size and husk weight were all positively correlated. Regardless of the colours of the Tagnanan fruit, palms of round shape fruits could be selected for the future generation of MATAG. MATAG coconut showed a potential for rejuvenation of the coconut industry.

Keywords: fruit morphology, fruit quality, Tagnanan tall, variability, PCA

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052-047

PRODUCT DEVELOPMENT OF WHEATGRASS BREAD

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ABSTRACT

Wheatgrass (*Triticum aestivum*) is a young wheat plant that is harvested when the length of the grass reached 15-18cm where the nutrient content at this stage is the highest. Wheatgrass is a rich source of vitamins, minerals, amino acids, enzymes, chlorophyll, and dietary fiber and its health benefits are well known. In this research, fresh wheatgrass-pandan extract was incorporated into breadmaking to develop a new functional food product. The dough was subjected to proofing (60 mins, 35^{o}C, 80% RH) before baking at 160^{o}C for 30 mins. The sensory qualities of the bread were evaluated by 50 untrained panelists using a 7-point hedonic scale. Proximate analysis, color (L*, a*, b*), and antioxidant assay were performed on the product. The overall acceptability score for the wheatgrass bread was 5.96 out of 7 with an acceptance index of 85%. The mean scores for various sensory attributes were: aroma (6.04), taste (5.68), color (5.54), and texture (5.44). Wheatgrass provides a refreshing appearance to the bread and increases its nutritive value. The addition of pandan leaf extract gave the wheatgrass bread extra fragrance which increases the overall acceptability of the bread. A total of 94% of the panelists liked the product. The wheatgrass bread contains 42.93% carbohydrates, 15.62% protein, and 4.96% fat. With 15.6% protein content, the wheatgrass bread met the criteria for a “high protein” nutritional claim. In summary, a new functional food - wheatgrass bread with good sensorial quality and a unique wheatgrass-pandan flavor combination was developed. Wheatgrass bread provides a healthy bread alternative for consumers.

Keywords: Wheatgrass bread, pandan, functional food, sensory evaluation.

INTRODUCTION

Non-communicable diseases such as heart disease, cancer, diabetes, and obesity are the leading cause of death worldwide and pose a global health threat. Poor nutrition intake has a detrimental association with non-communicable diseases. The demand for functional food products has been increasing over the years due to the growing number of health-conscious consumers. The development of functional foods aligns with the global sustainable development goal SDG 3 – promote good health and well-being.

Wheatgrass is a well-known superfood as it provides numerous health benefits to humans mainly contributed by its chlorophyll content. According to Jain and Jain (2014), wheatgrass juice contains 70% chlorophyll which creates an unfavorable environment for the growth of bacteria in the body, hence effectively enhancing the body's immune system that increasing resistance to illness. The high amount of chlorophyll in wheatgrass provides several health benefits such as blood clotting, wound healing, body detoxification, improve digestion, easing the pain of rheumatism, anti-aging, and anti-microbial effects (Johnson, 2015). Besides, wheatgrass is a multivitamin source as it contains vitamins A, B, C, K, and E and minerals such as phosphorus, magnesium, iron, calcium, and magnesium (Sukhoterina, 2015). Wheatgrass is rich in antioxidants such as enzyme superoxide dismutase and cytochrome oxidase which can scavenge free radicals to inhibit DNA damage due to oxidative stress (Gore et al., 2017).

Functional foods are foods that provide health benefits beyond basic nutrition. The demand for functional foods is increasing with a market worth USD281 billion in 2021 and is predicted to grow at a CAGR of 9.5% between 2021 and 2028 (Statista, 2023). In recent decades, there was a paradigm shift in consumers’ perception of health care, switching from disease treatment to disease prevention. Many are willing to spend on food supplements and functional foods for good health. However, food supplements in the form of capsules and pills are not appetizing or aesthetically pleasing. Contrarily, the concept of functional foods is widely accepted as consumers can take in health-promoting ingredients through delicious foods.

Despite the forementioned health benefits of wheatgrass, there are limited varieties of wheatgrass food products in the market. Wheatgrass products are mostly sold in the form of powdered food supplements or wheatgrass drinks.

Hence, this study aims to develop a new functional food - wheatgrass bread using wheatgrass extract as a functional ingredient; to conduct a sensory evaluation of the bread; and to determine the physicochemical properties of the product. Bread was chosen as a carrier to deliver the health-beneficial compounds of wheatgrass to consumers as bread is one of the staple foods worldwide and it is affordable to most consumers.

MATERIALS AND METHODS

Materials and Equipment

Ingredients that were used in this study included fresh wheatgrass, high-protein flour, salted butter, eggs, salt, white granulated sugar, yeast, pandan leaves, and water. Chemicals that were used for analytical procedures included petroleum ether, sulfuric acid, sodium hydroxide, boric acid, catalyst (K2SO4, CuSO4.5H2O), methanol, Folin-Ciocalteu reagent, gallic acid, sodium carbonate, ethanol, ascorbic acid, and 2,2-diphenyl-1-picrylhydrazyl (DPPH). Apparatus and equipment used throughout the whole study included a food mixer, fermenting box, baking oven, hot air oven, water activity meter, crude fiber system, Kjeldahl protein, muffle furnace, colorimeter, and UV-VIS spectrophotometer.

Preparation of Wheatgrass Bread

A 100 g fresh wheatgrass and 26 g pandan leaves were washed to remove the dirt. After that, pandan leaves were boiled with 400 mL of water until flavorful pandan extract was obtained. Wheatgrass extract was prepared by blending it with the pandan extract. The wheatgrass-pandan extract was used in the mixing process of the bread dough. All the ingredients were prepared and weighed according to the formulation: 58% high-protein flour, 10% whole eggs, 6% white granulated sugar, 4% salted butter, 0.5% yeast, 0.5% salt, and 21% wheatgrass-pandan extract. Firstly, all the dry ingredients were mixed uniformly in a large bowl, then the wheatgrass-pandan extract was added to the mixture. The duration of mixing was 10 mins at 218 rpm until the dough was formed. The bread dough was kneaded for another 15 mins. After that, the bread dough was transferred to fermenting box and fermented for 60 mins at 30°C, 75% RH. After the first fermentation, the dough was removed from the fermenting box and kneaded to remove the gases from the dough, and left aside to rest for 15 mins. Then, the rested dough was subjected to second fermentation which is known as dough proofing for 60 mins at 35°C, 80% RH. Next, the leaven bread dough was baked in the oven for 30 mins at 160°C. The wheatgrass bread was formed and packed into a sealed bag when it was cooled down to room temperature.

Sensory Evaluation

Sensory attributes (texture, color, aroma, taste, and overall acceptability) of wheatgrass bread were evaluated by 50 untrained panelists using a 7-point hedonic scale (1: dislike extremely to 7: like extremely). A briefing on the evaluation procedure and sensory attributes was given to the panelists. A 7-point hedonic scale is commonly used for affective sensory evaluation to determine the acceptability of a product. The Acceptance Index (AI) of the sample was calculated using the formula: AI = (Mean overall acceptability score/7) × 100.

Physicochemical Analysis

Proximate analysis was conducted according to the AOAC (2000) standard procedure to determine the moisture content, ash content, crude fat content, crude protein content, and total carbohydrate content of the wheatgrass bread. Lovibond spectrocolorimeter was used to determine the color characteristics of wheatgrass bread.

2,2-diphenyl-1-picrylhydrazyl (DPPH) Test. The scavenging activity of DPPH radicals was determined according to the methodology described by Lu et al. (2014). Briefly, 0.1 mL of sample extract was mixed with 3.9 mL of 0.06 mM DPPH solution in a test tube. The mixture was wrapped with aluminium foil, and incubated in a water bath (30°C, 30 mins). After incubation, the absorbance of the sample was read at 517 nm using a UV-Vis spectrophotometer against a prepared blank. The Radical scavenging activity (%) was calculated using the equation below:

$$\text{DPPH scavenging activity (\%)} = \frac{AB-AA}{AB} \times 100\%$$

where,
AB = Absorbance of blank sample
AA = Absorbance of sample

Determination of Total Phenolic Content (TPC). A series of gallic acid standard solutions with different concentrations were prepared. A 0.5 mL of each standard solution was pipetted into a test tube and mixed with 2.5 mL of 10% Folic-Ciocalteu reagent. The mixture was incubated at 37°C for 5 mins and then 2.0 mL of 7% sodium carbonate solution was added into each test tube before incubation at 37°C for 30 mins. Then, the absorbance of

each standard solution was read at 765nm using a UV-Vis spectrophotometer. A calibration curve was prepared by plotting the absorbance at 765 nm versus different concentrations of gallic acid solution. For the TPC determination of the sample, 0.5 mL of the standard solution was replaced by 0.5 mL of diluted sample extract. The concentration of gallic acid equivalent (GAE) was calculated by using the formula below:

$$\text{TPC (mg GAE/g)} = \frac{\text{R (mg/ml)} \times \text{Total Volume of sample extract (ml)} \times \text{Dilution factor}}{\text{Weight of sample (g)} \times \text{Volume of sample extract used (ml)}}$$

Statistical Analysis

All analyses were done in triplicate and the measurements were reported as the mean ± standard deviation. The data were analyzed by t-test, ANOVA, and Pearson correlation test. The significance was defined at $p < 0.05$. The data analysis was performed using IBM SPSS software version 23.0.

RESULTS AND DISCUSSION

Sensory Evaluation

An affective test was used to determine the degree of liking of a product by the panelists. The sensory results were shown in Figure 1. Based on the overall acceptability score, it was concluded that 94% of the panelists liked the wheatgrass bread. A total of 88% of them liked the refreshing color of the bread however, 2% of them dislike slightly on the color because it was not green enough. With regards to the aroma, 94% of the panelists liked the fragrance of the bread and commented that the bread was redolent with the scent of wheatgrass. Nevertheless, 2% of them disliked the aroma slightly because the bread smelled like matcha instead of wheatgrass which led to a little disappointment. A total of 88% and 86% of the panelists liked the taste and the texture of the bread, respectively. Some panelists suggested that the product could be improved by adding some fillings such as red bean paste, almonds, nuts, or raisins.

Figure 1. Percentage distribution against sensorial attributes of wheatgrass bread

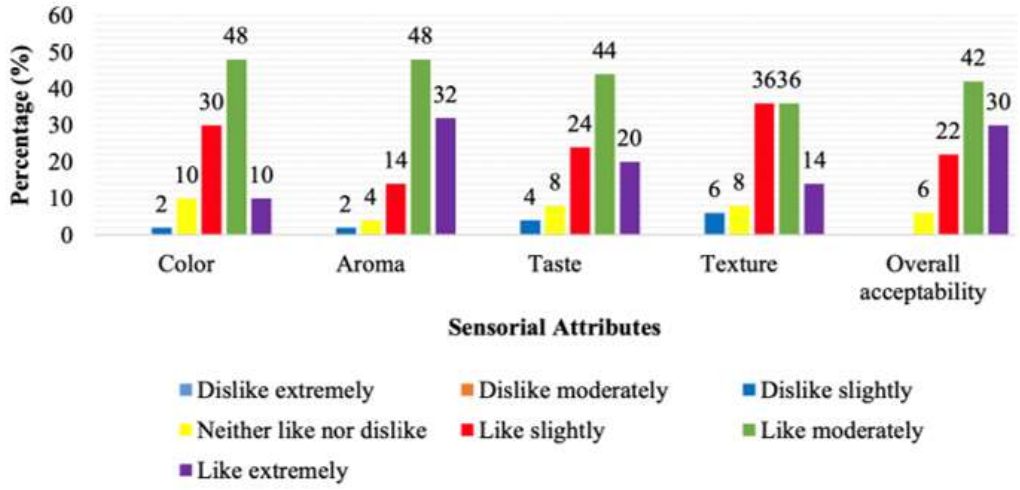


Table 1 shows the mean scores of the color, aroma, taste, texture, and overall acceptability of the wheatgrass bread. The mean values illustrated that the majority of the panelists liked the wheatgrass bread product as all the means exceeded 5.00. The aroma score (6.04) was the highest, indicating that most of the panelists liked the wheatgrass-pandan flavor combination. The undesirable grassy note of wheatgrass was covered by the addition of pandan extract. Pandan contains isoprene esters, tannins, glycosides, alkaloids, and richly scented essential oils; and serves as a natural flavoring and coloring agent. The overall acceptability score for the wheatgrass bread was 5.96 out of 7 with an acceptance index of 85%.

Table 1. The mean score of various sensory attributes of wheatgrass bread

Description	N	Minimum	Maximum	Mean score
Color	50	3	7	5.54±0.89
Aroma	50	3	7	6.04±0.90

Taste	50	3	7	5.68±1.02
Texture	50	3	7	5.44±1.03
Overall acceptability	50	4	7	5.96±0.88

Table 2. Pearson correlation between overall acceptability and sensory attributes

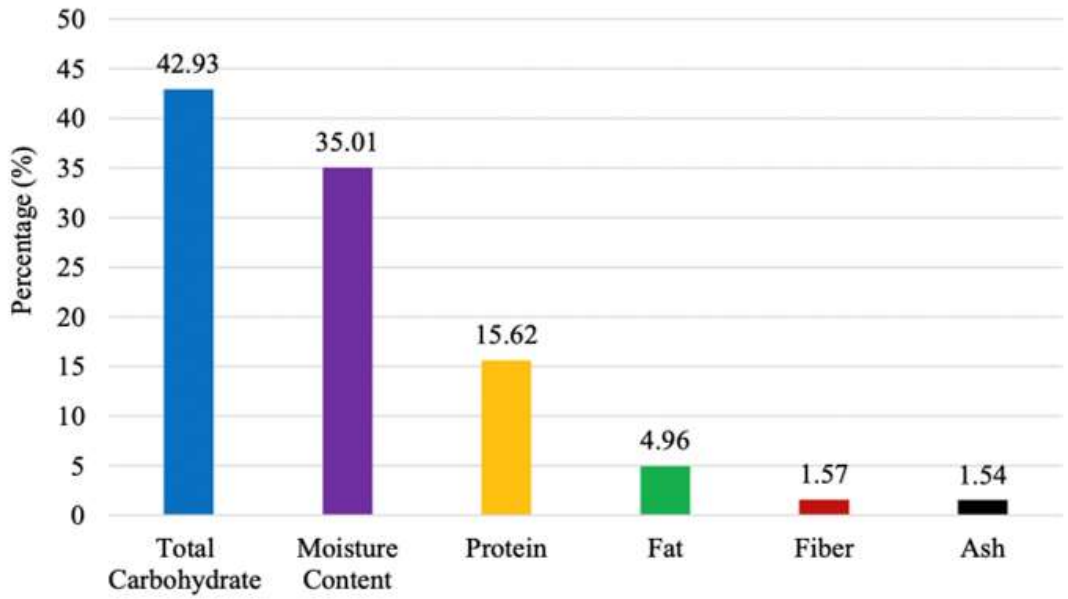
Overall acceptability * Attribute	r-value	Association
Overall acceptability * Texture	0.716	Strong correlation
Overall acceptability * Taste	0.691	Strong correlation
Overall acceptability * Color	0.631	Strong correlation
Overall acceptability * Aroma	0.490	Moderate correlation

The correlation between overall acceptability and various sensory attributes of wheatgrass bread was analyzed using the Pearson correlation test (Table 2). Different sensory factors affect the acceptability of the product to different extents. The overall acceptability of the product is affected by texture, taste, color, and aroma in the descending order of significance. A t-test was run to compare the mean overall acceptability scores between male and female panelists. The result showed that there was no significant difference ($p>0.05$) between males and females in terms of their overall acceptability score, suggesting that both genders are potential customers for the wheatgrass bread. In addition, one-way ANOVA analysis showed that there was no significant difference ($p>0.05$) among races (Chinese, Malay, and Indian) in terms of their overall acceptability of wheatgrass bread. Similarly, no significant difference ($p>0.05$) was found among the different age groups in terms of their overall acceptability score on the product.

Proximate Analysis

The proximate composition of the wheatgrass bread was shown in Figure 2. The high carbohydrate content (42.93%) is mainly attributed to high-protein flour and sugar (Scazzina et al., 2013). Sugars, starches, and fiber in the formulation are the sources of carbohydrates. The wheatgrass bread contains 15.62% protein which is primarily contributed by the high-protein flour. With 15.62% protein content, the wheatgrass bread met the criteria for a "high protein" nutritional claim. Wheatgrass is rich in protein and contains 17 amino acids (Sukhoterina, 2015). Salted butter was used in wheatgrass bread baking which contributed to the fat content (4.96%) in the finished loaf. Additional fats in bread formulation are required to tenderize the bread loaf. Fats such as margarine, shortening, and butter exhibit tenderizing effects which give the desired texture of bread loaf. The crude fiber content and ash content of wheatgrass bread were 1.57% and 1.54%, respectively. The calorie density of the wheatgrass bread was 282 kcal per 100 g product.

Figure 2: Proximate composition of wheatgrass bread



The total phenolic content of wheatgrass bread was 76.00±0.08 mg GAE/100g sample, while DPPH radical scavenging activity was 7.55±0.02%. The antioxidant potential of wheatgrass is contributed by its high content of bioflavonoids such as quercetin, apigenin, and luteolin which aid in blood flow, digestion, and detoxification of the body. Wheatgrass is also a good source of tocopherols that possess high vitamin E potency (Chauhan, 2014). Great amounts of vitamins, minerals, and phenolic compounds including flavonoids in wheat sprouts are synthesized during germination. Thus, wheatgrass has the maximum antioxidant potential (Suriyavathana et al., 2016). Wheatgrass also contains antioxidants such as enzyme superoxide dismutase and cytochrome oxidase which can scavenge the free radicals to inhibit DNA damage due to oxidative stress (Gore et al., 2017).

The color profile of the wheatgrass bread: L*=73.8 ± 0.31, a*= -7.3 ± 0.21, b*=41.9 ± 0.17, C*=42.5 ± 0.31 and h*=98.5 ± 0.21. L* represents lightness, -a* and b* represent green and yellow, respectively. C* and h* values represent color components chroma and hue, respectively. Overall, the wheatgrass bread has a pleasant light green color.

CONCLUSION

A new functional food - wheatgrass bread with good sensorial quality and a unique fragrance of wheatgrass-pandan flavor combination was developed. The high-protein wheatgrass bread is packed with micronutrients and it provides a healthier choice for consumers.

ACKNOWLEDGEMENTS

The authors would like to thank Tunku Abdul Rahman University of Management and Technology for the financial and technical support.

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006-048

RELATIONSHIP BETWEEN PHYSICAL AND MECHANICAL PROPERTIES OF PINEAPPLE FOR THE DEVELOPMENT OF A MECHANICAL HARVESTER

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ABSTRACT

Pineapple has been identified as one of the tropical fruits that can increase the Malaysian economy. Increase in demand will cause the pineapple cultivation to shift its focus to use mechanization, specifically in harvesting. Physical and mechanical properties of the pineapple are very important to develop a pineapple harvester. Essential parameters such as fruit weight, length, maximum diameter, maximum circumference, stem length, stem diameter and crown length were collected and recorded from matured pineapples freshly harvested in peat soil area, MARDI Pontian. The force required to separate matured pineapple from its stem was also measured using a digital force gauge. Relationship between the physical and mechanical properties were observed to identify strong correlations. All the physical and mechanical properties of pineapple show strong correlations except for stem length. These parameters and their correlations will be used to develop a pineapple harvester.

Keywords: Pineapple, Harvester, mechanization, pineapple properties

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060-052

DRYING CHARACTERISTICS AND PHYTOCHEMICALS RETENTION OF SELECTED CLONES OF LIBERICA COFFEE GROWN IN MALAYSIA

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ABSTRACT

Coffee is one of the world's most well-known and popular beverages, and the trees can be found in many countries, including Malaysia. Coffee beans have been used in a variety of foods and beverages since ancient times due to their unique and tasty flavour. Arabica and Robusta are the two most widely grown clones, with Liberica being the most underutilized. Liberica clones have recently gained popularity in Malaysia due to their distinct flavour profile. In view of this, the current study of assessing the drying characteristics of selected clones of Liberica coffees and the influence of drying temperatures on phytochemicals retention was conducted. Coffee beans from selected clones of 211, 213, 222, 224, and MKL7 were harvested at an optimum maturity and dried in a convective oven at 50°C, 60°C, and 70°C. The drying periods for all clones were observed at 15 hours, 8 hours, and 6.5 hours when drying at 50°C, 60°C, and 70°C respectively. The Page model is the best mathematical model for determining the drying kinetics of the beans for all drying temperatures. Clones 211, 213, and 224 showed high antioxidant activity when subjected to oven drying at 60°C with values ranged from 0.997 IC50 (mg/ml) to 1.622 IC50 (mg/ml) for DPPH method and 0.099 µmol/mg to 0.145 µmol/mg for FRAP method respectively. Clone 224 retained the most total phenolics content after drying at 60°C, with a final concentration of 21.94 mg GAE/g. Drying at 50°C and 60°C resulted in the highest retention of total flavonoids content for clones 211, 213, 222, and 224, with concentrations ranging from 5.11 mg RE/g to 10.77 mg/RE, whereas total flavonoids content for clone MKL 7 remained stable at 7.30 mg RE/g, 7.71 mg RE/g, and 8.43 mg RE/g for all drying temperatures. Clone 224 retained the most chlorogenic acid and caffeine content when dried at 60°C. The study demonstrated that drying at 60°C is the recommended temperature for preserving total phenolics, total flavonoids, total antioxidants, chlorogenic acid, and caffeine content in Liberica coffees.

Keywords: Drying, Caffein, Chlogenic acid, *Liberica* coffee, Total antioxidant activity

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056-053

YIELD OF SHALLOT (*ALLIUM CEPA* VAR. *AGGREGATUM* L.) FROM DIFFERENT HARVESTING AGE

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ABSTRACT

Experiment was conducted to see the effect of different harvesting time on shallot yield. Shallots were planted using consumption bulb of Indian Variety in open research plot in MARDI Serdang. The bulbs were harvested at 45, 55, 65, 75 and 85 Days After Planting (DAP). The experiment was arranged in a randomized complete block design with 4 replications. Each of the harvesting time has four beds of 20 meters in length with 530 bulbs planted in each bed. The bulbs were planted at a distance of 15cm x 15cm between bulbs in 4 rows in every bed. Analysis of variance was done using *Proc GLM procedures of SAS version 9.4. Post hoc test was conducted using Duncan New Multiple Range Test (DNMRT) to measure specific differences between pairs of means.* The results obtained show that the highest yield was obtained from 65 DAP with dried bulb of 13.3kg per plot which is equivalent to 6.6 t/ha. Harvesting earlier than 65 DAP gives low yield as the bulb still in growing stage or late to germinate. Later harvesting stage up to 85 DAP also gave low yield as the number of rotten bulbs increased. In this study it was also found that the harvested shallots are divided into two categories, namely single type and aggregate type at a ratio of almost 50% for each. In terms of bulb size, aggregate bulbs are smaller than single bulb. Harvests of 75 DAP and 65 DAP provide the heaviest and widest bulb for both categories. However, the length of the 75 DAP harvest is longer than the 65 DAP harvest. This study provides a clearer perspective on the yield performance of consumption shallot bulb harvest at different harvesting age. Shallot from Indian variety are best harvest at 65 DAP for good yield (6.6t/ha). Harvest earlier and beyond 65 DAP will give significant reduction. Planting materials using consumption bulb may give two forms of shallots that is aggregate and single shallot.

Keywords: yield performance, shallot, bulb, harvesting time

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055-054

COMPLETE PLANTLET GENERATION AND ACCLIMATIZATION OF THE MEDICINAL HERB *ZINGIBER OFFICINALE VAR. RUBRUM*

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ABSTRACT

Zingiber officinale var. rubrum, also known as red ginger, is a perennial herb that is widely used in traditional medicine. The rhizome extract of Z. *officinale var. rubrum* has been reported to have antioxidant activity, anti-inflammatory activity, anti-nausea/antiemetic activity, anti-bacterial activity, cytotoxic activity, and antidiabetic activity. Using tissue culture techniques, the mass propagation of red ginger is studied. In a previous experiment, the red ginger shoot multiplication medium was determined, which is Murashige and Skoog (MS) media with 1.0 mg/L BAP supplementation. Even though the plantlets were able to establish a root system during the shoot multiplication stage, an experiment to study the effect of rooting hormone on the red ginger was conducted. The effects of two types of auxin, IBA and NAA, at different concentrations on the root induction of red ginger have been studied. Plantlets, measuring 3–4 cm in length, were cultured in MS media supplemented with IBA or NAA at different concentrations. Media without hormones was used as a control. After 1 week, all plantlets generated a root system in all medium experiments, with the highest number of roots per explant in the medium without hormone. The complete plantlets were acclimatized in four different media in a weaning chamber. The mixture of top soil, baked soil, and peat moss (2:1:1) had the highest survival rate, with 100% survival, and the mixture of peat moss and sand (1:1) had the lowest, with 50% survival. The plantlets that survived were placed in a polybag filled with mixed soil, top soil: baked soil and peat moss (2:1:1), placed under 50% shade, and watered three times daily. After 2 months, the average growth is 5 cm. The protocol developed can be applied for mass production of *Z. officinale var. rubrum*.

Keywords: tissue culture, halia bara, root induction, hardening

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063-055

TOWARD INTELLIGENT CROP PRODUCTION MANAGEMENT DECISION SUPPORT SYSTEM THROUGH DATA FUSION

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ABSTRACT

Integration of data from various sources provide farmers with useful information and recommendations for managing their crops. Data fusion techniques can be used to combine data from different sources such as weather forecasts, satellite imagery, soil sensors, and crop growth models to create a holistic view of the crop's growing conditions. An intelligent system can use this information to provide farmers with real-time recommendations on things like irrigation, fertilization, pest control, and harvest timing. By using data fusion, the system can improve the accuracy of its predictions and recommendations, resulting in better crop yields and reduced costs for farmers. The data can also be analyzed by agronomists and researchers to improve crop management practices and develop new crop varieties. Toward this end, a system is being developed to fuse data from multiple sensors and multiple sites for two crops, namely pineapple in the open field and leafy vegetables planted indoors. It is hoped that the developed system can help farmers to make more informed decisions, improve crop yields, and increase their profits while helping to conserve resources such as water and fertilizer.

Keywords: Industry 4.0, Internet-of-Things, Smart agriculture, Indoor farming, Pineapple

1. Introduction

Agriculture is a crucial sector of the global economy, providing food, fuel, and raw materials for various industries. With the global population projected to reach 9.7 billion by 2050, there is an urgent need to increase agricultural productivity to meet the growing demand for food (Lowenberg-DeBoer, Franklin et al. 2021). At the same time, farmers face several challenges, such as climate change, water scarcity, soil degradation, and pests and diseases (Bregaglio, Titone et al. 2016).

To overcome these challenges and increase agricultural productivity, farmers need access to accurate and timely information on their crops' growing conditions. In recent years, there has been an explosion of data sources available to farmers, including weather forecasts, satellite imagery, soil sensors, and crop growth models. The challenge is to integrate this data from multiple sources to provide farmers with useful information and recommendations for managing their crops (Ip, Ang et al. 2018, Lioutas, Charatsari et al. 2022).

Data fusion techniques can be used to combine data from different sources and provide a holistic view of the crop's growing conditions. An intelligent system can use this information to provide farmers with real-time recommendations on things like irrigation, fertilization, pest control, and harvest timing (Busemeyer, Mentrup et al. 2013, Sa, Ge et al. 2016). By using data fusion, the system can improve the accuracy of its predictions and recommendations, resulting in better crop yields and reduced costs for farmers.

The integration of data from multiple sources has been increasingly used in various fields, including agriculture, to improve decision-making and performance. In recent years, data fusion techniques have been used to combine data from various sources, such as weather forecasts, soil sensors, satellite imagery, and crop growth models, to create a holistic view of the crop's growing conditions (Yaqoob, Hashem et al. 2016, Shakoor, Northrup et al. 2019).

Several studies have investigated the use of data fusion techniques in agriculture. For example, Zhu, Cai et al. (2018) developed a data fusion-based system for predicting rice yield and water use efficiency using data from unmanned aerial vehicles (UAVs), ground-based sensors, and meteorological data. The system achieved higher accuracy in yield prediction compared to traditional models.

Similarly, Ahmad, Nasirahmadi et al. (2022) developed a data fusion-based system for monitoring and managing crop growth and soil moisture in greenhouse agriculture. The system combined data from wireless sensor networks

and crop growth models to provide real-time recommendations on irrigation and fertilization. The system achieved significant improvements in crop yield and water use efficiency compared to traditional methods.

In the field of precision agriculture, data fusion techniques have been used to optimize crop management practices. For example, Abu Bakar, Muslimin et al. (2021) developed a data fusion-based system for precision fertilization using data from satellite imagery, soil sensors, and crop growth models. The system achieved significant improvements in fertilizer use efficiency and crop yield compared to traditional fertilization methods.

The integration of data from various sources through data fusion techniques has been shown to be a promising approach to improve agricultural productivity and sustainability (Wolfert, Ge et al. 2017). The use of data fusion-based systems can provide farmers with real-time recommendations on crop management practices, optimize resource use, and reduce costs. Further research is needed to develop and refine data fusion-based systems for various crops and growing conditions to realize the full potential of this approach in agriculture.

Moreover, the data collected by the system can be analyzed by agronomists and researchers to improve crop management practices and develop new crop varieties. Thus, the integration of data from various sources can not only help farmers improve their yields and profits but also contribute to the development of sustainable agricultural practices.

Toward this end, a system is being developed to fuse data from multiple sensors and multiple sites for two crops, namely pineapple in the open field and leafy vegetables planted indoors. The system aims to help farmers make more informed decisions, improve crop yields, and increase their profits while helping to conserve resources such as water and fertilizer.

In this work, we describe the methodology used to develop the data fusion-based system, including data collection, data fusion techniques, real-time recommendations, system testing, data analysis, and system improvement. The results of the system's performance evaluation are discussed, and the implications of the system for sustainable agriculture are examined.

2. Materials and methods

This section describes the methodology used to develop the data fusion-based system that integrates data from multiple sensors and multiple sites for two crops, namely pineapple in the open field and leafy vegetables planted indoors. Figure 1 depicts a typical architecture for IoT systems. It shows the information exchange architecture for a Thingsboard® platform.

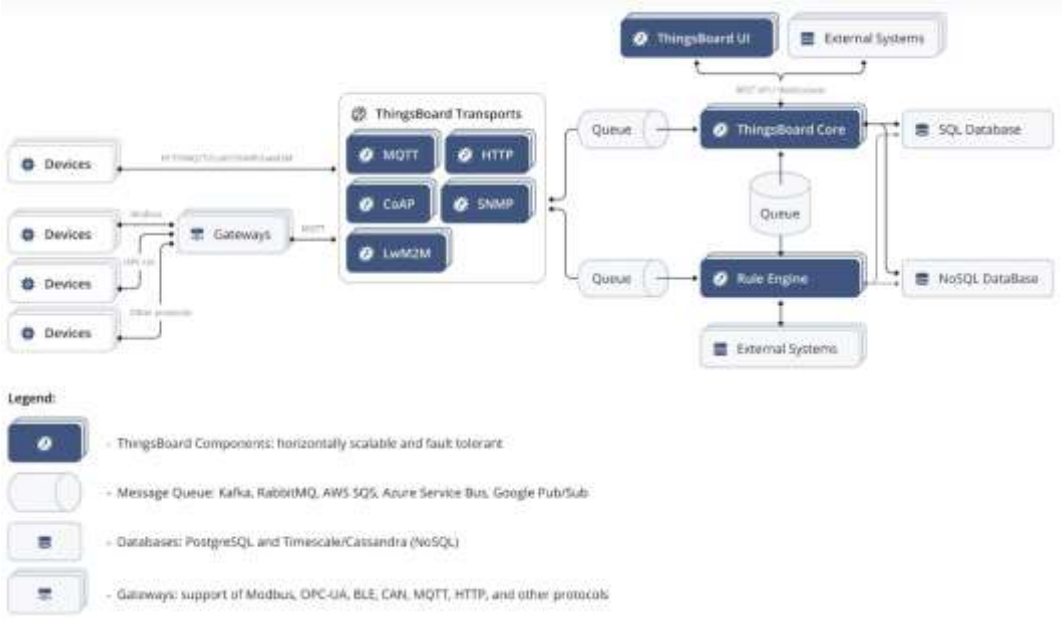


Figure 1: Thingsboard® IoT platform architecture for integrating sensors and smart devices.

Data Collection:
The first step in developing the system was to collect data from various sources such as weather forecasts, satellite imagery, soil sensors, and crop growth models. The data collection was carried out using a combination of automated systems and operator input through mobile devices that collected data from multiple sensors located at different sites. The Thingsboard® IoT platform was used to visualize the data collected by the sensors.

Data Fusion:
The next step was to fuse the data collected from various sources using data fusion techniques. At the moment, data fusion is only limited to the gathering of various sensors in one platform, namely the Thingsboard IoT platform.

System Testing:
To ensure that the system was functioning correctly, it was tested in real-world conditions. The system was tested on multiple sites for both crops, and the data collected was analyzed to evaluate the system's performance.

3. Results and discussion

The developed data fusion-based crop production management decision support system was evaluated using data collected from two crops, namely pineapple in the open field and leafy vegetables planted indoors. The system was able to fuse data from multiple sensors and multiple sites, providing a holistic view of the crops' growing conditions. Figure 2 and figure 3 shows the Thingsboard® platform with the two sites from which data were gathered.

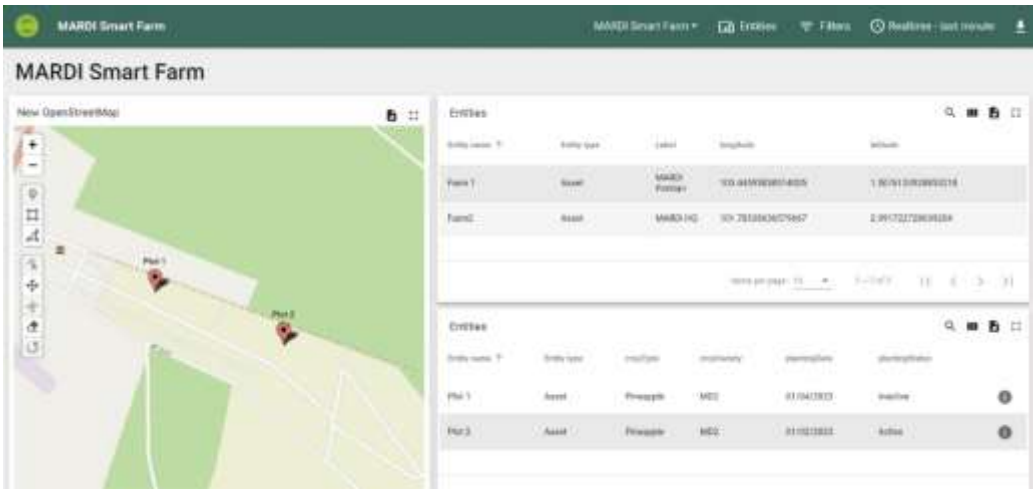


Figure 2: Farm site 1 located at a MARDI Pontian station in the state of Johor, Malaysia

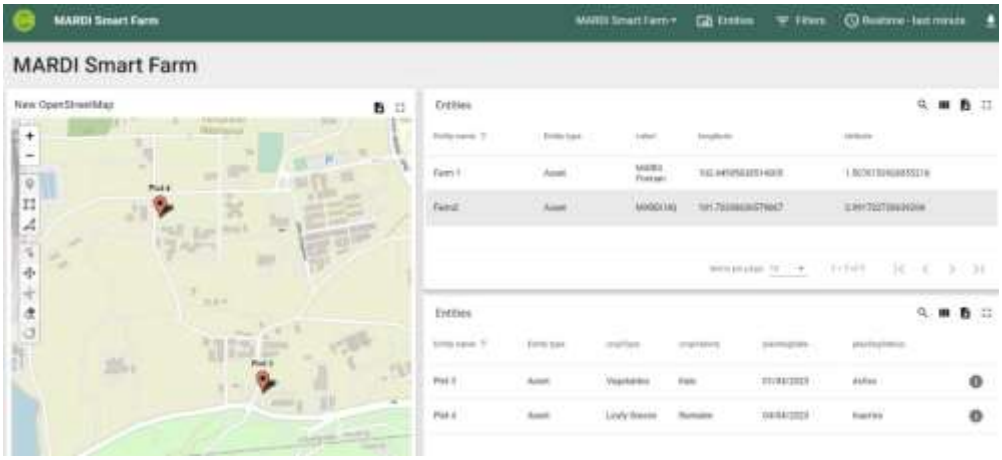
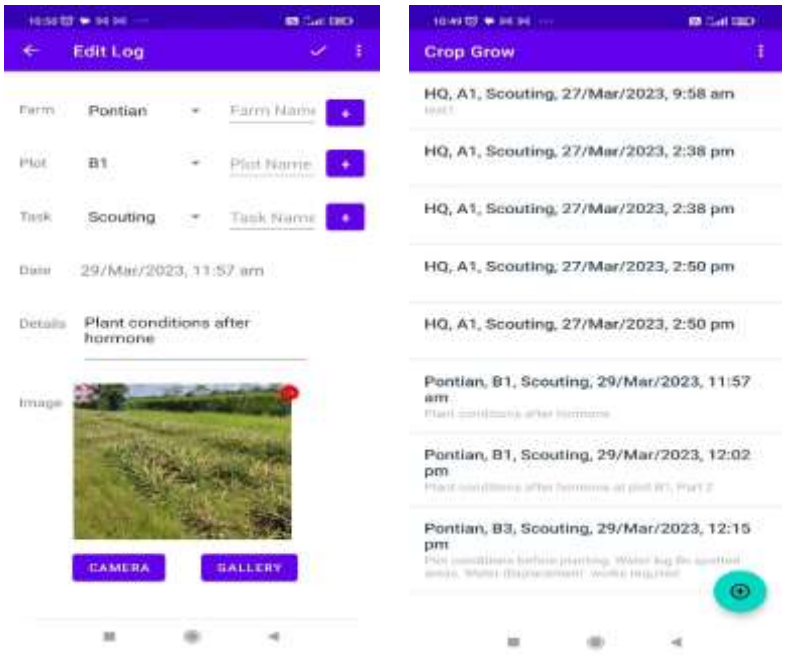


Figure 3: Farm site 2 located at a MARDI Serdang station in the state of Selangor, Malaysia

Figure 4 shows how users can input data to be sent to a Thingsboard® platform. A mobile application was developed to allow users i.e. farm workers/operators to key in related information regarding a task. After all information are entered, it is logged as a farm activity related to crop production such land preparation, scouting and fertilizer application. The log is sent automatically to the Thingsboard® platform when a connection to the internet is present. All images acquired through the mobile application are sent to a cloud storage separate from the IoT platform. Only the link is sent to thingsboard.



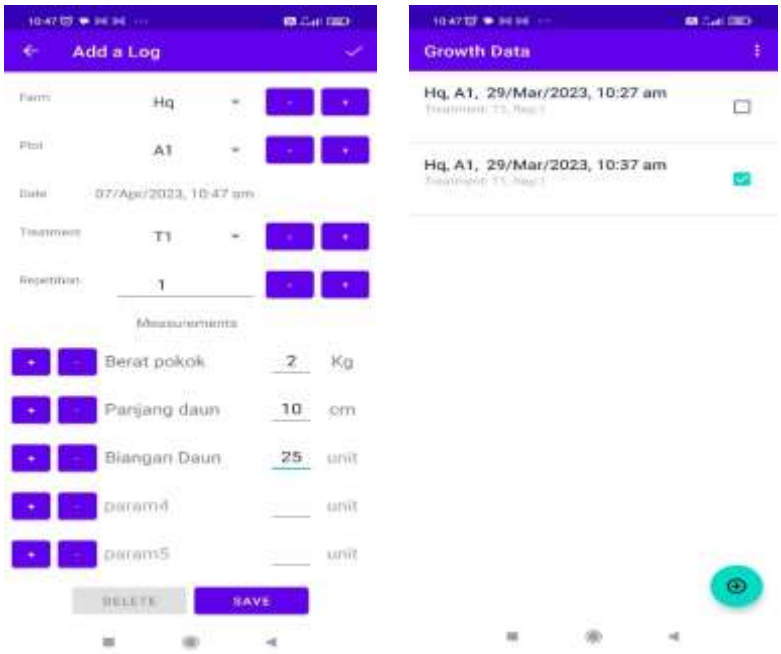
(a) (b)

Figure 4. A screenshot of a worklog app developed to allow users to report and log activities related to crop production such land preparation, scouting and fertilizer application. Subfigure (a) depicts an interface for users to key in all relevant information relating to a task. Subfigure (b) shows the list of tasks or worklogs that were entered.

The developed mobile application also allows users to collect data relevant to crop growth parameters. The interface is shown in figure 5. Users are able to enter measurements related to crop growth parameters during field work. Once the measurements are entered, the information is saved in a list and sent automatically to the IoT platform when an internet connection is present.
All information that was sent to the IoT platform by the mobile application are saved in a server located in the cloud. Figure 6 depicts all task logs that were sent to the platform.

For the task log module as shown in figure 5, from tests done in the field it was observed that when there was a strong internet connection, on average a duration of between 1 to 10 seconds was needed to upload the data in the cloud. The time taken depended on the size of the image that had to be sent to the cloud.

The crop growth parameter data input module showed a better performance in terms of time taken to upload data to the cloud. The average time taken to upload a single data entry was only 1.5 seconds whereas multiple data upload took on average 5 seconds. This was due to the fact that only strings and numbers were transferred which only has a size of a few kilobytes as opposed to images which is a factor of 1,000 to 10,000 times bigger.
The results of this study demonstrated the potential of data fusion techniques in crop production management decision support systems.



(a) (b)

Figure 5: A module to record Crop growth parameters while taking field measurements. Subfigure (a) shows an interface where users are allowed to enter measurements of crop growth parameters. Subfigure (b) shows a list of measurements that were entered.

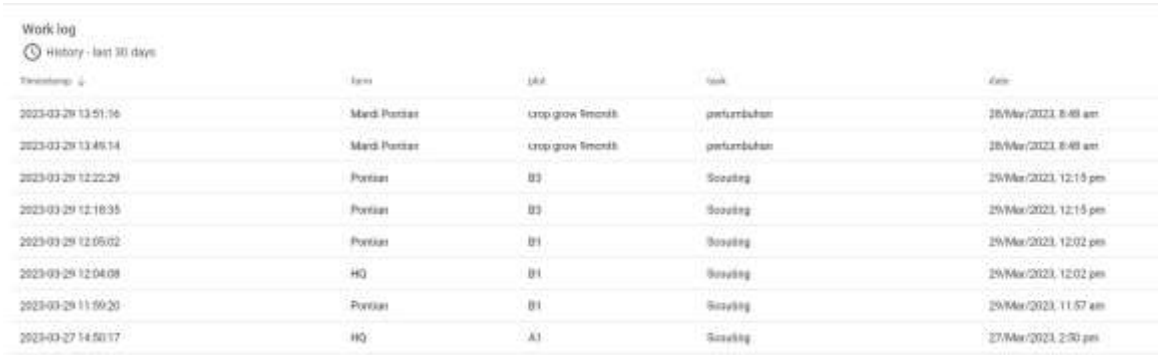


Figure 6: Data from mobile device that were sent to the IoT platform.

This work demonstrated the system's ability to allow information/data input by human operators. This is crucial since data embedding human intuition provides more insight in the data analysis phase. In conjunction with other sensor data, the system has the potential of making more effective decisions for crop production.

4. Conclusion and further works

The development of an intelligent system that integrates data from various sources through data fusion techniques can improve crop management practices. The system can provide real-time recommendations on irrigation, fertilization, pest control, and harvest timing, resulting in improved crop yields, reduced costs, and conservation of resources. The data analysis capabilities of the system also benefit agronomists and researchers in developing new crop varieties and improving crop management practices. The developed system can help farmers make more informed decisions, increase their profits, and help conserve resources like water and fertilizer. The ability to make informed data centric decisions could lay the foundation for a macro level economic policy by the Malaysian government regarding agriculture. It would foster Malaysia's realization of the National Agrofood Policy 2.0 in adopting smart agricultural production The current work discussed how data can be collected to enable data fusion. This step is often overlooked as most work assume that data collection is trivial which is never the case. Further work is needed to make sense of the fused data in order to fully utilize the potential of IoT platforms. A fully

functional platform would be able to optimize data based crop production. Additionally, the development of user-friendly interfaces and mobile applications would improve the accessibility and usability of the system for farmers.

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065-057

CFD SIMULATION IN HIGH-DENSITY PLANTING SYSTEM INSIDE A CONTAINER-TYPE PLANT FACTORY

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ABSTRACT

Computational fluid dynamics (CFD) plays an increasingly important role in designing the agriculture control environment structure in the past few years. A plant factory is a fully enclosed controlled environment agriculture structure developed to create optimum growing conditions for crops. Previous studies have proven that the CFD technique was able to analyse and predict the internal climate of the plant factory in the designing stage before the actual plant was built. This study was conducted to analyse the changes in air flow characteristics and temperature distribution in high-density planting inside a shipping container-size plant factory with different inlet and outlet locations. Uniformity of airflow and temperature distribution is important in plant factories as it is responsible for creating an optimum and uniform growing condition for crops. Three alternative designs of the inlet and outlet locations i.e location 1, 2 and 3 were simulated to improve the uniformity of airflow and temperature distribution. Finally, the location of the inlet and outlet that produced the optimum airflow and temperature distribution inside the plant factory was identified.

Keywords: CFD simulation, plant factory, airflow distribution, temperature distribution

066-058

OVEREXPRESSION OF ANTIHYPERTENSIVE PEPTIDE GENE ENCODING GG-7PAH USING *AGROBACTERIUM TUMEFACIENS* AS MEDIATED FOR TRANSFORMATION IN RICE PLANTS (*ORYZA SATIVA* L.)

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ABSTRACT

Peptides derived from food protein have the potential to become antihypertensive agents with relatively few adverse side effects. The Gg-7pAH gene encoding antihypertensive is a gene that contains Cys-Met-Try-Leu-Ala-Ser-Gly (CMYLASG) heptapeptide from Melinjo (*Gnetum gnemon* L) seeds, which are Angiotensin-converting enzyme (ACE) inhibitor peptide. This study aimed to investigate the expression of the tandem repeat heptapeptide (10x peptides, Gg7-pAH) gene and increase plant tolerance to herbicides. The Gg7-pAH gene was constructed in the *p*Green II 0229 vector under the control of the Glu4 promoter and transformed in rice callus using an agrobacterium vector. The transgenic rice plants showed a better ability to apply the herbicide, which was applied by applying screening on media and lubricating method to the leaves, compared to the non-transgenic plants. The screening was carried out with specific herbicide phosphinothricin (ppt) in various concentrations: 0, 20, 50, and 100 ppm. Then, the screening efficiency was evaluated by calculating the putative planlet percentage. As a result, 16 putative plantlets, with a presentation of 29,6% (0 ppm ppt), 6 putative plantlets on (20 ppm ppt) presentation of 14,3%, and no plantlets produced at 50 and 100 ppm ppt, presentation of 0%. PCR analysis confirmed the Gg-7pAH gene in putative transgenic rice plants. PCR results showed that there were two positive plants with antihypertensive gene insertion. The two transgenic strains were tested and compared with non-transgenic. Hydrolyzed recombinant protein isolates showed better ACE inhibitory activity in T4 and T7 rice plants with IC50 of 1.47 µg/mL and 2.35 µg/mL compared to control plants (IC50 = 3.96 µg/mL). These findings reveal a reasonably good potential in the recombinant Gg-7pAH gene, which is transformed into rice plants to produce rice plants that can treat hypertension.

Keywords: recombinant Gg-7pAH, transformation, heptapeptide, hypertension, *A.umefaciens*.

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PROCESS OPTIMIZATION OF DRIED GINGER (*Zingiber officinale*) PULP

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ABSTRACT

Ginger (*Zingiber officinale*) is a popular food and spice. With the increase in consumption of ginger-based products, there will also be an increase in the production of their waste pulp. Therefore, this study aimed to evaluate the quality of ginger pulp to optimize its fiber content for food and industrial application. The study investigated the effects of different process variables on the quality of ginger pulp using Response Surface Methodology to optimize its process conditions. Under these optimized conditions, the following optimized values were obtained: water activity of 0.3827, minimum bulk density of 0.0769 g·mL-1, maximum bulk density of 0.1296 g·mL-1, maximum ash content of 0.64%, lowest water retention capacity of 4.295 g·g-1, highest water retention capacity of 7.32 g·g-1, lowest oil binding capacity of 2.973 g·g-1, maximum oil binding capacity of 4.663 g·g-1, and fiber content of 69.13%. In addition, the fiber content of the dried ginger pulp was found to be higher compared to other natural sources of food fibers.

Keywords: Drying, Ginger, Optimization, Pulp, RSM.

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069-060

PHYTOCHEMICAL CONTENT AND ANTIOXIDANT POTENTIAL OF *PSIDIUM GUAJAVA L.* LOHAN (GIANT GUAVA)

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ABSTRACT

Fruits have long been known for their health promoting benefits and this has been attributed to their antioxidant possessing bioactive compounds. *Psidium guajava* is a popular fruit grown locally in Malaysia. However only the pulp is most frequently consumed. Due to its hard texture, the seeds and skin of the fruit are usually discarded and end up as food waste with economic, environmental and social consequences. The main aim of this study was to determine if guava fruit waste has the potential to be utilised as functional foods. The antioxidant and phytochemical content (flavonoid, polyphenol, vitamin C) of the waste (seed + skin), pulp and whole fruit of three samples of *Psidium guajava L. Lohan* (giant guava) were determined via the 1, 1-diphenyl-2-picrylhydrazyl- DPPH, the aluminium chloride, the Folin Ciocalteu and the ammonium molybdate colourimetric assays respectively. Results indicate that there was no significant difference ($p > 0.05$) in the phytochemical content of the different sections. The waste and pulp contained 0.140µg QUE /mg dry weight sample while the whole fruit contained 0.19 ± 0.012µg QUE /mg dry weight sample. TPC values ranged from 1.902 ± 0.193µg GAE/mg dry weight sample to 2.479 ± 0.015µg GAE/mg dry weight sample. The vitamin C content averaged 0.62µg vitamin C /mg dry weight sample. Moreover, all three sections exerted similar free radical scavenging effects with an average EC_{50} value of 0.358mg/mL sample. The study has shown that guava fruit waste has the potential to be utilised effectively; as food packaging, nutraceuticals or even animal feed, rather than ending up in landfills.

Keywords: *Guava, Phytochemical content, Antioxidant potential*

INTRODUCTION

The *Psidium guajava L.* (Guava) plant is a native of Mexico but is now also available in Central and South America, Europe, Africa and Asia since it is able to grow in tropical and subtropical areas (Gutierrez *et al*., 2008). The guava fruit is generally ovoid or pear shaped and depending on the cultivar, the diameter can vary in size from 2.5 to 10cm, and the weight ranges from 50 to 500g (Yusof, 2003). The flesh comes in a variety of colours, viz: pink, white or yellow, and it may be seeded or seedless (Yusof, 2003). It is considered a common man's fruit and is called the 'apple of the tropics' (Chopda and Barrett, 2001).

In Malaysia it is grown both commercially and in many home gardens. It is known locally as "Jambu Batu". The most popular guava varieties grown in Malaysia are the GU8 (Kampuchea *variety)* followed by the GU16 *(Lohan or Giant variety) (Anim Agricultural Technology, 2014).* The Lohan guava is a cloned variant with seeds and is much bigger in size. Cultivation of the Lohan guava started in Malaysia in 2010 *(Anim Agricultural Technology, 2014).*

Guava fruit has been used in traditional medicine to treat ulcers, wounds and diarrhea in the Philippines and anorexia, diarrhea, digestive problems, inflammation and ulcers in Brazil (Gutierrez *et al*., 2008). The leaves, pulp and seeds are used to treat respiratory and gastrointestinal disorders. They possess antispasmodic, anti-inflammatory, anti-diarrheic, anti-cancer properties and it has been used as a cough sedative, in the management of hypertension, obesity and also in the control of diabetes mellitus (Barbalhol et al., 2012). The seeds have been used for their antimicrobial, gastrointestinal, anti-allergic and anticarcinogenic activity (Barbalhol et al., 2012).

Some people choose to remove the seeds and skin of the guava fruit, consuming only the juicy flesh. This is because of the assumption that simply washing the fruit is not as effective as peeling it, in terms of removing pesticide residues. While it is not dangerous to eat these seeds, it is unpleasant because there are numerous seeds and they are usually very hard. Since the fruit is not consumed it its entity, the resources that went into growing, harvesting, transporting and packaging it is wasted. Moreover, if guava waste goes into landfill and rots, it produces methane, a greenhouse gas, that contributes to air pollution. Food waste will also influence the demand of the fruit, which will drive up its cost and limit its availability to all consumers.

Many governments and organisations around the world have committed to reducing food waste which will benefit sustainable production and consumption; goal 12.3 of the sustainable development goals adopted by the United Nations in 2015 (Champions 12.3.org, 2016). Thus, researchers are now focusing on utilising these food wastes into useful, sustainable products. The aim of this research was therefore to determine the phytochemicals and antioxidative property of guava food waste (seed and skin) and to compare them to the whole fruit and pulp. This is to ascertain if the waste has the potential to be utilised as functional foods rather than ending up in landfills.

METHODOLOGY

Chemicals

The following chemicals were used in this study. 2,2-diphenyl-1-picrylhydrazyl (DPPH), Gallic acid, Quercetin, Folin-Ciocalteu reagent, Ascorbic acid, methanol, sulfuric acid, sodium carbonate, sodium hydroxide, aluminium chloride, sodium nitrite, sodium phosphate, and ammonium molybdate. All chemical used were obtained from Nilai University laboratory and were of laboratory grade.

Plant materials

Three fruits of *Psidium guajava L. Lohan* (Giant guava) were purchased from Aeon supermarket, Nilai, Malaysia.

Preparation of samples

The fruits of *Psidium guajava L. Lohan* were washed under running tap water, followed by distilled water to remove any dirt and soil residues. The samples were patted dry with a clean towel to remove excess water. The guava fruits were cut into two equal portions. One half was used in its entirety and labelled as WF (whole fruit), while the skin and seeds (waste) of the other half portion were separated from the pulp and labelled as S+S (skin and seeds) and P (pulp) respectively. All guava sections were then cut into small pieces with a kitchen knife.

Preparation of extracts

The various samples (WF, S+S and P) were mixed with distilled water in the ratio 1:2 and homogenised with a food blender. The phytochemicals in the homogenate were extracted on an orbital shaker for 1 hour at, room temperature, at a speed of 15,000 rpm. The homogenate was then filtered using a Whatman filter paper and the filtrate was collected and poured into pre-weighed petri dishes covered with tin foil punched with small holes. The petri dishes were then dried in the oven at 60^{o}C to evaporate off the solvent and until a constant dry weight was achieved. The weight of the residues in each petri dish was recorded and the dishes were placed, covered, at 4^{o}C until needed for analysis. Upon analysis, a stock solution of each extract was made by reconstituting the residue in the petri dish with distilled water to a final concentration of 10mg/mL.

DPPH assay

DPPH radical scavenging activity of the extracts was determined using the method of Gülçin, et al., (2010) with some modification. Briefly, different concentrations of the diluted extract were mixed with 80% of methanol until the total volume achieved was 1.5mL, followed by the addition of 0.5mL DPPH (0.1mM). The mixture was left for 30 minutes in the dark, after which the absorbance reading was taken at 517nm using a spectrophotometer. All trials were performed in triplicates; 80% methanol was used as the blank and a mixture of 80% methanol and 0.5mL DPPH was used as the negative control and vitamin C (1mg/mL) was used as the positive control. The percentage scavenging effect of the DDPH radical was calculated using the equation:

$$\% \text{ Scavenging } = \frac{Absorbance\ control - Absorbance\ test}{Absorbance\ control}\ x\ 100\%$$

Total phenolic assay

The total phenolic content was determined using a modified Folin-Ciocalteu colourimetric method of Kaur and Kapoor (2002). Briefly, 100µL of the diluted extract (1mg/ml) was mixed with 100µL of Folin-Ciocalteu reagent (50% v/v), followed by 800µL of sodium carbonate (5% w/v). The solutions were mixed using a vortex mixer and incubated at 40 °C for 20 minutes. The absorbance of the mixture was measured at 760nm after 20 minutes, using a spectrophotometer. All trials were performed in triplicates. A mixture of distilled water with Folin-Ciocalteu reagent and sodium carbonate was used as the blank. Gallic acid was used as the reference polyphenolic compound and a standard curve was plotted by measuring the absorbance of Gallic acid in the concentration range 10-100µg/ml. Means and standard deviation were obtained from triplicate absorbance measurements and the results are expressed as microgram gallic acid equivalent per milligram dry weight sample (µg GAE/mg DW sample).

Total flavonoid assay

The total flavonoid content was determined by using a modified method of Pekal and Pyrzynksa (2014). Briefly, 1.0mL of diluted extract (1mg/mL) was mixed with 0.3mL $NaNO_2$ (5%) and left for 5 minutes. After 5 minutes, 0.5mL $AlCl_3$ (2%) was added to the mixture and left for 6 minutes. 0.5mL NaOH (1mM) was added to the mixture and left for a further 10 minutes at room temperature. The absorbance of the mixture was then measured at 510nm by using a spectrophotometer. All trials were performed in triplicates. A mixture of 1mL distilled water with 0.3mL $NaNO_2$, 0.5mL $AlCl_3$ and 0.5mL NaOH was used as the blank. Quercetin was used as the reference compound for flavonoids and the absorbance of Quercetin in the range of 20-100µg/mL was measured and used to generate a standard curve. Means and standard deviations were obtained from triplicate measurements and the results are expressed as microgram quercetin equivalent per milligram dry weight sample (µg QE/mg DW sample).

2.3.4 Vitamin C assay

The vitamin C content of the extract was measured using the method of Papoutsis, et al., (2016). A mixture of 500ml sulfuric acid (0.6M), 5.32g sodium phosphate and 2.47g ammonium molybdate was prepared. Next, 3ml of the prepared solution was then mixed with 0.3mL of diluted samples before being incubated for 90 min in a 90°C water bath. The mixture was then left for 30 minutes at room temperature. The absorbance was measured at 695nm using a spectrophotometer. All experiments were performed in triplicates. Distilled water was used as the blank while the absorbance of vitamin C in the concentration range 0-100µg/mL was used to generate a standard curve. All results are expressed as microgram vitamin C per milligram dry weight sample (µg Vit.C/mg DW sample).

2.4 Statistical analysis

Results are expressed as mean ± standard deviation. An independent Anova single factor test was used to compare the means of three replicate measurements, with a significance level of $p < 0.05$.

RESULTS AND DISCUSSON

DPPH radical scavenging

The average DPPH radical scavenging activity of the extracts of three different fruits of *Psidium guajava L. Lohan* (Giant guava) are depicted in Table 1. EC_{50} value is the concentration required to obtain 50% scavenging effect (Chen et al., 2013). According to Suriyatem et al., (2017), the lower the EC_{50} value, the stronger the antioxidant potential and so, the more effective the reducing power of the sample. In this study, waste extracts (skin + seed) and whole fruit extracts of guava exhibited EC_{50} values of 0.367 mg/mL and 0.310mg/mL respectively. This indicates that the antioxidant effect of the whole fruit might be contributed by the waste (S+S) that was left intact in the WF sample. The pulp extract exhibited a higher EC_{50} value of 0.395 mg/mL. The absence of the waste lowered the antioxidant potential of the pulp. Although the results indicate that the antioxidant potential of whole fruit > waste > pulp, the values are not significantly different ($p > 0.05$). Thus all 3 samples possessed comparable antioxidant activity.

Table 1: EC_{50} (mg/mL) values of *Psidium guajava L. Lohan* (Giant guava)

Sample	EC_{50} (mg/mL)
Skin and seed (S+S)	0.367 ± 0.199^a
Pulp (P)	0.397 ± 0.055^a
Whole fruit (WF)	0.310 ± 0.128^a

Values are means ± SD of the extracts of three fruit samples. Each sample extract was analysed in triplicates at 6 different concentrations to obtain the EC_{50} value. Subscripts with the same letter indicate that the values are not significantly different from one another ($p > 0.05$).

Earlier studies have shown that guava waste and whole fruit extracts possess higher antioxidant activity compared to pulp extracts. In 2006, Lim et al., reported that the antioxidant activity of guava with intact peel was higher than the fruit without peel (Lim et al., 2006). Removal of the peel from the fruits results in loss of antioxidant activity. According to the study by Suwawong and Boonpangrak (2021), the guava peel extract has higher antioxidant activity than the pulp extracts due to the presence of polyphenolic phytochemicals in the fruit peel which has proven to possess antioxidant properties. Similar findings were also reported by Marquina et al., (2008), who demonstrated that the peel extract's antioxidant capacity was ten times greater than that of the pulp extract.

The results of the current study differ from previous studies in that all three guava extracts show comparable antioxidant potential. Thus, the presence of the peel (in the S+S and WF samples) does not contribute significantly to the antioxidant activity of the extracts. The difference can be explained by a number of factors including the variety of guava investigated, the ripeness of fruit at harvesting, climatic conditions, as well as extraction conditions (Wang & Lin, 2000; Gull et al., 2012).

Total phenolic content

The total phenolic content (TPC) of the different extracts of *Psidium guajava L. Lohan* (Giant guava) are shown in Figure 1. The pulp extract contained the highest polyphenolic content of 2.480 ± 0.124µg GAE/mg DW sample, followed by the whole fruit extract with 2.204 ± 0.149µg GAE/mg DW sample, while the waste extract exhibited the lowest polyphenolic content of 1.902 ± 0.439µg GAE/mg DW sample. Statistical analysis has however shown that the polyphenolic content of all three portions of the guava fruit is comparable ($p>0.05$).

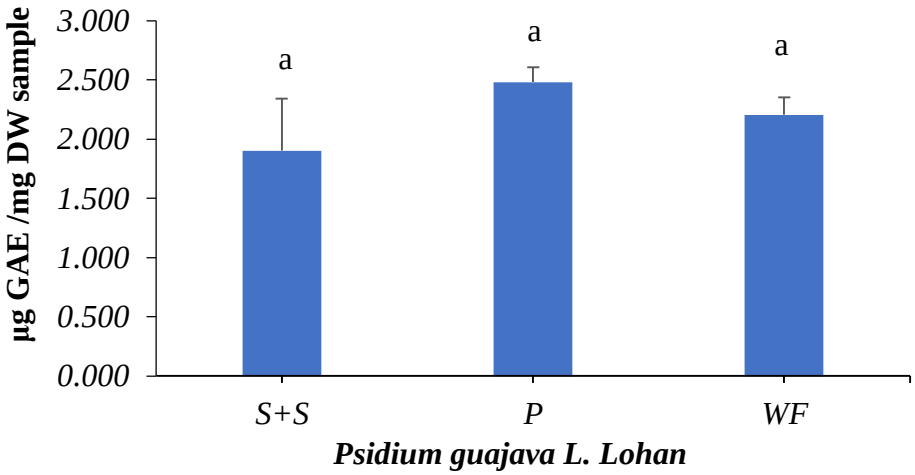

Figure 1: Total phenolic content (TPC) of different extracts of *Psidium guajava L. Lohan*

Values are the means of 3 fruit samples with each sample being assayed in triplicates. Subscripts alphabets with the same letter indicate that the values are not significantly different from one another ($p > 0.05$).

Bioactive compounds from plant sources, especially polyphenols have been proposed to exhibit strong antioxidant effects. The antioxidant activity of guava has also been shown to be due to the polyphenols found in the peel and the immature fruits (Jiménez-Escrig, 2001). Guava contains carotenoids and polyphenols, two main antioxidant pigments, which have high antioxidant potential in plant food (Jiménez-Escrig, 2001; Flores et al., 2014; Uzzaman et al., 2018;). These pigments contribute to the colour of the peel and the pulp.

The current study has however shown that the antioxidant activity (Table 1) and the polyphenolic content (Figure 1) of the waste is comparable to the whole fruit and the pulp. Studies have shown that the antioxidant activity and phytochemical composition of P. *guajava* vary significantly according to the cultivar and pulp colour, as well as development stage of the fruit at harvesting (Flores et al., 2014; Wang & Lin, 2000).

Total flavonoid content

The total flavonoid content of the different extracts obtained from 3 different *Psidium guajava L. Lohan* (Giant guava) fruits are summarised in Figure 2 below. The whole fruit extract exhibited the highest amount of flavonoid (0.193 ± 0.108µg QE/mg DW sample) compared to the waste and pulp extract which possessed similar TFC values of 0.14 ± 0.030µg QE/mg DW and 0.14 ± 0.040µg QE/mg DW respectively. The total flavonoid content of the waste, whole fruit, and pulp extract were comparable and not significantly different ($p > 0.05$) from one another.

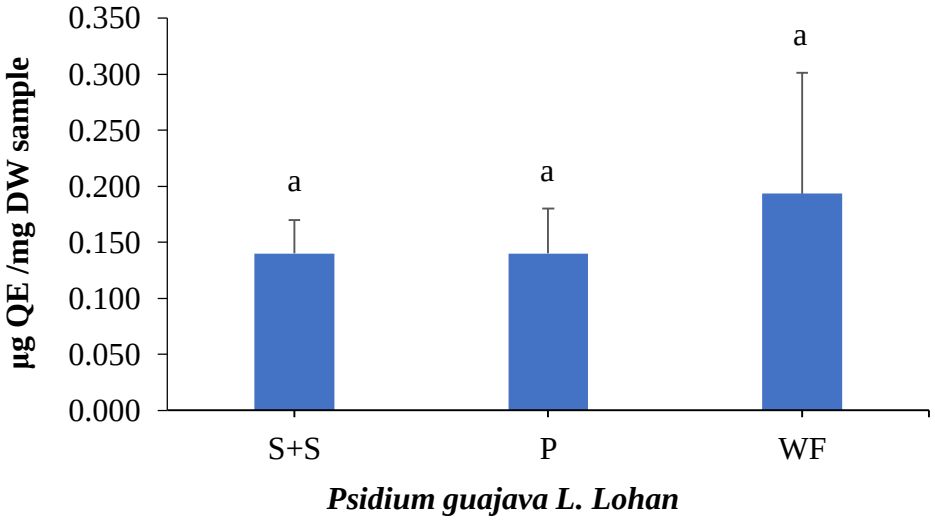

Figure 2: Total flavonoid content of different extracts of *Psidium guajava L. Lohan*

Values are the means of 3 fruit samples. Each trial was carried out in triplicates. TFC results are expressed in µg QAE/mg DW sample. Subscripts with the same letter indicate the values are not significantly different from one another ($p > 0.05$).

A study by Shukla et al., (2021), quantified the bioactive compounds in 5 different cultivars of Indian guava at different ripening stages. They determined that Quercetin was the major flavonoid present in the fruit, and the highest amount was found in unripe Safeda (3.22 mg/100 g) and the lowest in the ripe stage of Surkha (0.11 mg/100 g). It was also found that the level of Quercetin decreased with maturity in all three stages: unripe, semi-ripe and ripe stages (Shukla et al., 2021).

This study has shown that although the waste and pulp contained slightly lower flavonoid content than the whole fruit extract (Figure 2), the TFC values are not significantly different ($p>0.05$) from one another. Thus, all three sections (WF, S+S and P) of the guava fruit exhibited comparable ($p>0.05$) antioxidant potential, polyphenolic and flavonoid content. This indicates a positive relationship between the TPC and TFC values and the antioxidant activity in all extracts.

3.4 Vitamin C content

Vitamin C in humans must be ingested through their diet. Citrus fruits like oranges, grapefruits, lemons and lime are well known for their high vitamin C content. Guava has however been shown to possess higher vitamin C content than citrus fruits (Kumari et al., 2013). Vitamin C is an electron donor, and this property accounts for all its known functions. It has proven to be a potent water-soluble antioxidant in humans. Antioxidant effects of vitamin C have been demonstrated in many experiments in vitro (Padayatty et al., 2003).

The current study therefore investigated the vitamin C content of the waste, pulp and whole fruit of three guava samples. As seen from Figure 3 below, the pulp contained slighltly higher amounts of vitamin C compared to the waste with values of 0.647 ± 0.237 µg Vit C /mg DW sample and 0.553±0.145 µg Vit C /mg DW sample respectively. The whole fruit extract exhibited the highest vitamin C content of 0.660±0.099 µg Vit C /mg DW sample. Since the whole fruit comprises both the peel and the pulp, it is not surprising that it possesses slightly higher ascorbic acid content. However, the ascorbic acid content of all three extracts (S+S, P, WF) is not significantly different from each other ($p > 0.05$).

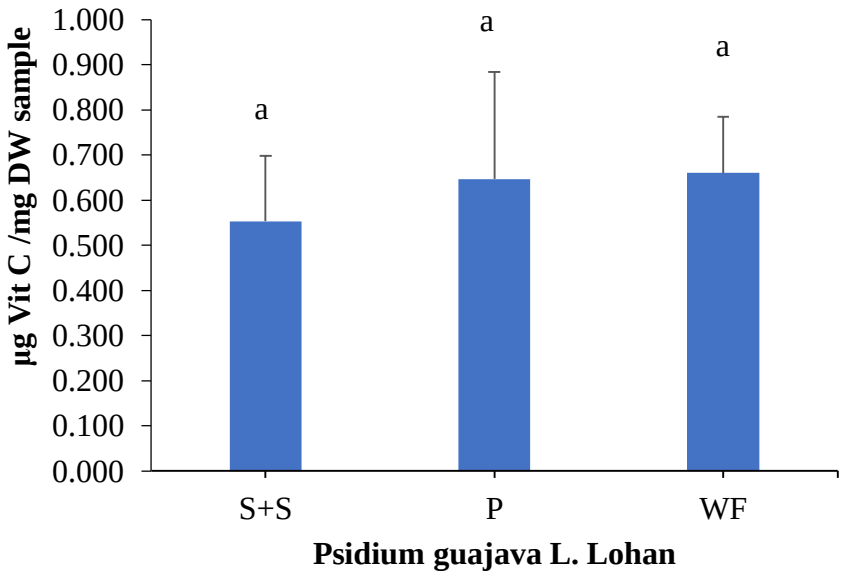

Figure 3: Vitamin C Content of different extracts of *Psidium guajava L. Lohan*

Values are the means of 3 fruit samples and each sample was assayed in triplicates. Subscripts with the same letter indicate the value are not significantly different with one another ($p > 0.05$)

In 2003, a study by Bashir and Abu-Goukh found that, the peel of guava contains higher amounts of ascorbic acid than the pulp (Bashir & Abu-Goukh, 2003). This is generally true for most fruits. However, it is also known that ascorbic acid may be destroyed by heat (Naseer et al., 2018). This might explain the findings of the present study which showed that the skin (exposed to strong sunlight) contained slightly lower amount of vitamin C than the pulp. Moreover, it has been proven that different stages of maturation and geographical locations had profound effects on the antioxidant activity and vitamin C contents of guava fruit (Gull et al., 2012).

CONCLUSION

The guava fruit contains oleanolic acid, ascorbic acid, citric acid and the flavonoids guaijavarin and quercetin (Naseer et al., 2018), all of which will contribute to the total phenolic content of the fruit. Thus, when compared to the total flavonoid and vitamin C content, the polyphenols were present in the highest amount in all 3 samples.

While the whole fruit, which comprises the waste and the pulp, was shown to possess slightly higher vitamin C and flavonoid content, the TPC, TFC and Vitamin C content of all three extracts were not significantly different from one another ($p > 0.05$). This results in all three sections exerting similar free radical scavenging effects with an average EC_{50} value of 0.358mg/mL sample.

Some people, for a variety of reasons, discard the seed and skin when consuming guava. This fruit waste will ultimately end up in landfills, leading to economic, environmental and social consequences. The current study has shown that guava fruit waste possesses antioxidant properties comparable to that of the whole fruit and pulp. The TPC, TFC and Vitamin C content of the waste contributes to its potent antioxidant potential. As such, guava fruit waste has the potential to be utilised as food packaging, nutraceuticals and animal feed. Further investigation is therefore needed to develop guava fruit waste into a beneficial functional food.

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SCREENING FOR THE POTENTIAL NATURAL COMPOUNDS AGAINST SARS-COV-2 SPIKE PROTEIN USING COMPUTATIONAL APPROACH

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ABSTRACT

Covid-19 is a respiratory tract infection caused by a novel coronavirus, known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Current drugs and vaccines lack clarity in terms of their efficacy and safety. Besides, the mechanism of inhibition between the binding of SARS-CoV-2 and angiotensin-converting enzyme 2 (ACE2) is not well explained. These have prompted us to screen natural compounds for potential inhibitors of the SARS-CoV-2 spike protein and to investigate the effects of molecular interactions on binding affinity using an in silico approach. Phytochemicals from 15 medicinal plants with anti-viral, anti-inflammatory or anti-bacterial properties were docked with the receptor binding domain (RBD) of the SARS-CoV-2 using YASARA AutoDock program. The docking protocol was further validated by superposition between the deposited 3D-crystal structure of SARS-CoV-2 in complex with inhibitor, which was obtained from the Protein Data Bank, and the YASARA predicted docked SARS-CoV-2 with inhibitor. Among the 28 phytochemicals, Theaflavin showed a high binding energy of 7.23 kcal/mol with respect to the SARS-CoV-2 spike RBD. It forms substantial hydrogen bonds with Lys417 and Asn460; hydrophobic interactions with Lys417, Asp420, Leu455, and Phe456; π-π interaction with Phe456; as well as cation-π interaction with Lys417 at the RBD. The molecular docking protocols were successfully validated as the superposition value of root-mean-square deviation (RMSD) was 0.49 Å, which was below 2.0 Å. Taken together, Theaflavin may be a promising potential anti-viral drug candidate for inhibiting the binding of the SARS-CoV-2 spike protein to the ACE2 receptor on the host cell. Theaflavin can be further investigated in vitro and in vivo as a lead compound against SARS-CoV-2.

Keywords: SARS-CoV-2 spike RBD, Molecular docking, YASARA, Phytochemicals.

INTRODUCTION

Coronavirus disease 19 (COVID-19) was first reported in Wuhan, China, in December 2019 (Lin et al., 2021). Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) are viruses that possess RNA genomes that are single-stranded (Huang et al., 2020). Its genome encodes structural proteins such as spike (S), membrane (M), envelop (E), as well as nucleocapsid (N), non-structural proteins, and accessory proteins (COVID-19 Treatment Guidelines Panel, 2022). The transmembrane glycoprotein spike, which is found on the SARS-CoV-2 surface, is vital for viral entrance into host cells because it facilitates the recognition of virus receptors as well as the fusion of membranes. Spike protein comprises the S1 subunit, which essentially deals with the receptor on target cells, and the S2 subunit, which is in charge of fusing the viral and cellular membranes. The receptor binding domains (RBDs) at the S1 subunit assist in the stability of the membrane-anchored S2's pre-fusion state, which involves fusion activity. The S1 subunit attaches directly to the angiotensin-converting enzyme 2 (ACE2) receptor on target cells, enabling the infection to take hold in the cells (Sruthi et al., 2020). From the information above, the most efficient approach to prevent SARS-CoV-2 infection of host cells is to inhibit SARS-CoV-2 spike protein binding to ACE2.

Several drug compounds have been reported as candidates to inhibit SARS-CoV-2. However, the efficacy and safety of these compounds in COVID-19 patients are still unclear because there is no clinical study that can prove the drugs have no side effects on the patients. Furthermore, the mechanism of SARS-CoV-2 spike protein inhibition is still unclear due to a lack of information regarding the inhibitory properties that are responsible for the inhibition. Therefore, the objectives of this study are to screen for potential inhibitors of the SARS-CoV-2 spike protein from natural compounds by using bioinformatics tools and to identify the effects of molecular interactions on binding affinity.

METHODOLOGY

Receptor and ligands preparations

Docking is a molecular modelling technique that is used to predict how a protein interacts with small molecules (Singh et al., 2022). In this study, docking experiment was performed with the SARS-CoV-2 spike protein, which served as a receptor, and the phytochemical (Table 1), which served as ligands. Based on the research by Xian et al. (2020), 15 indigenous medicinal plants that possessed anti-viral, anti-inflammatory, and anti-microbial properties were selected for this in-silico study. The structures of SARS-CoV-2 spike protein (PDB ID: 7DZW) and natural compounds were obtained from Protein Data Bank database (https://www.rcsb.org/) and PubChem database (https://pubchem.ncbi.nlm.nih.gov/), respectively. After that, energy minimization of receptor and ligands was done to optimize the hydrogen bonding network, remove unfavorable interactions, and obtain as low energy in the system as possible (Henrik and Maria, 2018).

Table 1: List of 15 plants and their corresponding selected phytochemicals

No.	Plants	Phytochemicals
1	*Glycyrrhiza glabra*	Glycyrrhizin
		Isoflavone
2	*Polygonum cuspidatum*	Resveratrol
3	*Panax ginseng*	Ginsenoside-Rb1
		Glucoside
4	*Rauvolfia serpentina*	Reserpine
5	*Boenninghausenia sessilicarpa*	Leptodactylone
		Coumarin
		Rutamarin
6	*Lycoris radiata*	Lycorine
7	*Salvia miltiorrhiza*	Dihydrotanshinone
		Cryptotanshinone
8	*Stephania tetrandra*	Tetrandrine
		Fangchinoline
9	*Stephania japonica*	Cepharanthine
10	*Rheum palmatum*	Emodin
		Chrysophanol
		Physcion
		Rhein
11	*Triterygium regelii*	Celastrol
		Tingenone
		Iguesterin
12	*Alnus japonica*	Hirsutenone
13	*Camellia sinensis*	Theaflavin
14	*Myrica rubra*	Myricetin
15	*Scutellaria baicalensis*	Scutellarein
		Wogonin
		Baicalein

Molecular docking simulations

YASARA, a bioinformatic tool that implements AutoDock program, was used to conduct this molecular docking simulations. This docking process was performed using a pre-made script that had been downloaded from the link, dock_run.mcr. According to Solo and Arockia (2021), the most probable active site of the spike protein was identified in the receptor binding domain (RBD), which is located at 319 to 541 amino acids. Hence, the simulation cell was placed around the active site to focus docking with the selected natural compounds listed in Table 1. The prepared receptor, SARS-CoV-2 spike protein, and the ligands, phytochemicals, were then docked together. The binding energy and the molecular interactions of each ligand were observed and tabulated.

Validation of YASARA docking protocols

SARS-CoV-2 3CL, a main protease of SARS-CoV-2, was used to validate the YASARA docking protocol because there was no deposited crystal structure of SARS-CoV-2 spike RBD in complex with inhibitor in any database to date. To begin the validation process, the receptor, which is SARS-CoV-2 3 CL (PDB ID: 7JST), the ligand, which is inhibitor EB54 (PubChem CID: 163201238), and the deposited crystal structure of SARS-CoV-2 3CL in complex

with inhibitor EB54 (PDB ID: 7TIW) were retrieved from the Protein Data Bank database and PubChem database, respectively. The energy minimization and molecular docking between the SARS-CoV-2 3CL and the EB54 was then carried out using the same protocol in 2.2. However, since the active sites of the SARS-CoV-2 3CL were His41 and Cys145, the simulation grid box was set to focus on these residues (Kneller et al., 2020). Following that, superposition, which also known as structure alignment, between both the YASARA simulated structure and the deposited complex structure was carried out using MUSTANG alignment. The output of the superposition value is given in root-mean-square deviation (RMSD).

RESULTS AND DISCUSSION

Molecular docking analysis

Twenty-eight medicine plants derived compounds, which include glycyrrhizzin, isoflavones, resveratrol, ginsenoside-Rb1, glucosides, reserpine, leptodactylone, coumarin, rutamarin, lycorine, dihydrotanshinone, cryptotanshinone, tetrandrine, fangchinoline, cepharanthine, emodin, chrysophanol, physcion, rhein, celastrol, tingenone, iguesterin, hirsutenone, theaflavin, myricetin, scutellarein, wogonin, and baicalein, as well as the target receptor, SARS-CoV-2 spike RBD, were used for the docking studies. The binding affinities and molecular interactions between each ligand and the receptor were investigated in detail and enumerated in Table 2.

Table 2: Results of docking between the spike protein of SARS-CoV-2 and the 28 phytochemicals

Comp. No.	Phytochemicals	Binding Energy (kcal/mol)	Contacting Receptor Residues	No. of Hydrogen Bond	No. of Hydrophobic Interaction	No. of π-π Stacking	No. of Cation-π Interaction
1	Glycyrrhizin	5.96	**LEU A 455** **PHE A 456** TYR A 473 ALA A 475 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488 TYR A 489	2	6	-	-
2	Isoflavones	6.89	GLN A 474 GLY A 476 SER A 477 THR A 478 PRO A 479 CYS A 480 ASN A 481 VAL A 483 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488	-	10	1	-
3	Resveratrol	7.26	ARG A 454 **PHE A 456** ARG A 457 LYS A 458 GLU A 471 ILE A 472 TYR A 473 GLN A 474 PRO A 479 CYS A 480 ASN A 481 GLY A 482 PRO A 491	2	8	2	1
4	Ginsenoside-Rb1	2.88	ARG A 403 **LYS A 417**	2	8	-	-

			GLY A 446 GLY A 447 ASN A 448 **TYR A 449** TYR A 451 TYR A 453 **GLN A 493** SER A 494 **TYR A 495** **GLY A 496** PHE A 497 **GLN A 498** **ASN A 501** **TYR A 505**				
5	Glucosides	6.12	VAL A 350 ARG A 403 GLU A 406 ILE A 418 TYR A 451 LEU A 452 TYR A 453 **GLN A 493** SER A 494 **TYR A 495**	4	3	-	-
6	Reserpine	5.44	**LEU A 455** **PHE A 456** TYR A 473 ALA A 475 GLY A 476 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488 **TYR A 489** PHE A 490 LEU A 492 **GLN A 493** SER A 494	1	9	3	-
7	Leptodactylone	6.79	GLN A 474 GLY A 476 SER A 477 THR A 478 PRO A 479 CYS A 480 VAL A 483 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488	-	6	1	-
8	Coumarin	5.71	GLN A 474 ALA A 475 GLY A 476 SER A 477 THR A 478 PRO A 479	1	8	-	-

			CYS A 480 VAL A 483 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488				
9	Rutamarin	5.41	LYS A 444 GLY A 446 GLY A 447 ASN A 448 **TYR A 449** ASN A 450 LEU A 452 PHE A 490 LEU A 492 **GLN A 493** SER A 494	2	9	1	1
10	Lycorine	8.15	GLN A 474 ALA A 475 GLY A 476 SER A 477 THR A 478 PRO A 479 CYS A 480 VAL A 483 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488	3	7	1	-
11	Dihydrotanshinone	7.20	GLN A 474 GLY A 476 SER A 477 THR A 478 PRO A 479 CYS A 480 VAL A 483 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488	-	9	1	-
12	Cryptotanshinone	6.38	**PHE A 456** LYS A 458 GLU A 471 ILE A 472 TYR A 473 GLN A 474 PRO A 479 CYS A 480 ASN A 481 GLY A 482	-	9	1	-
13	Tetrandrine	6.29	**LYS A 417** **LEU A 455** TYR A 473 ALA A 475 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488 TYR A 489 PHE A 490 **GLN A 493**	-	6	1	-

14	Fangchinoline	6.64	**LYS A 417** **LEU A 455** TYR A 473 ALA A 475 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** **CYS** A 488 TYR A 489 **GLN A 493**	-	6	1	-
15	Cepharanthine	8.09	THR A 415 GLY A 416 **LYS A 417** ASP A 420 TYR A 421 ARG A 454 **LEU A 455** **PHE A 456** ARG A 457 LYS A 458 SER A 459 ASN A 460	-	10	1	-
16	Emodin	8.06	GLN A 474 ALA A 475 GLY A 476 SER A 477 THR A 478 PRO A 479 CYS A 480 VAL A 483 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488	2	7	1	-
17	Chrysophanol	7.83	GLN A 474 ALA A 475 GLY A 476 SER A 477 THR A 478 PRO A 479 CYS A 480 VAL A 483 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488	-	9	1	-
18	Physcion	7.81	GLN A 474 ALA A 475 GLY A 476 SER A 477 THR A 478 PRO A 479 CYS A 480 VAL A 483 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488	-	9	1	-

19	Rhein	7.12	**LYS A 417** ILE A 418 ASP A 420 TYR A 421 TYR A 453 ARG A 454 **LEU A 455** **PHE A 456** ARG A 457 LYS A 458 SER A 459 ASN A 460 LEU A 461	2	4	2	-
20	Celastrol	7.67	GLN A 474 THR A 478 PRO A 479 CYS A 480 ASN A 481 VAL A 483 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488	1	7	1	-
21	Tingenone	6.89	**LEU A 455** **PHE A 456** TYR A 473 ALA A 475 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488 **TYR A 489**	-	7	2	-
22	Iguesterin	6.54	**TYR A 449** LEU A 452 GLU A 484 **TYR A 489** PHE A 490 LEU A 492 **GLN A 493** SER A 494	-	7	3	-
23	Hirsutenone	7.43	**TYR A 449** LEU A 452 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488 **TYR A 489** PHE A 490 LEU A 492 **GLN A 493** SER A 494	3	5	3	-
24	Theaflavin	7.23	**LYS A 417** ASP A 420 TYR A 421 TYR A 453 **LEU A 455** **PHE A 456** ASN A 460 TYR A 473	3	4	1	1
25	Myricetin	5.83	VAL A 350	3	4	4	1

			ARG A 403 GLU A 406 ILE A 418 TYR A 451 LEU A 452 TYR A 453 **GLN A 493** SER A 494 **TYR A 495** **TYR A 505**				
26	Scutellarein	5.75	**TYR A 449** LEU A 452 GLU A 484 **TYR A 489** PHE A 490 LEU A 492 **GLN A 493** SER A 494	3	3	3	-
27	Wogonin	7.71	GLN A 474 ALA A 475 GLY A 476 SER A 477 THR A 478 PRO A 479 CYS A 480 ASN A 481 VAL A 483 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488	1	8	1	-
28	Baicalein	6.87	ALA A 475 GLU A 484 GLY A 485 **PHE A 486** **ASN A 487** CYS A 488 **TYR A 489** PHE A 490	3	5	2	-

Note: Contacting receptor residues in bold are the active site residues of SARS-CoV-2 spike RBD.

From the results in Table 2, Resveratrol (3), Lycorine (10), Dihydrotanshinone (11), Cepharanthine (15), Emodin (16), Chrysophanol (17), Physcion (18), Rhein (19), Celastrol (20), Hirsutenone (23), Theaflavin (24), and Wogonin (27) showed remarkable binding affinity with SARS-CoV-2 spike RBD, which ranged between 7.12 kcal/mol and 8.15 kcal/mol. Besides, Glycyrrhizin (1), Resveratrol (3), Ginsenoside-Rb1 (4), Glucosides (5), Reserpine (6), Coumarin (8), Rutamarin (9), Lycorine (10), Emodin (16), Rhein (19), Celastrol (20), Hirsutenone (23), Theaflavin (24), Myricetin (25), Scutellarein (26), Wogonin (27), Baicalein (28) showed hydrogen bonding with the abovementioned residues Asn487, Gln493, Lys417, Phe490, Ser494, Tyr449, and Tyr505 of the SARS-CoV-2 spike RBD. Moreover, all 28 phytochemicals showed hydrophobic interactions with the SARS-CoV-2 spike RBD. Furthermore, referring to Table 2, all 28 phytochemicals have a π-π stacking with the aromatic ring of SARS-CoV-2 spike RBD except for Glycyrrhizin (1), Ginsenoside-Rb1 (4), Glucosides (5), and Coumarin (8). Finally, Resveratrol (3), Rutamarin (9), Theaflavin (24), and Myricetin (25) were shown to exhibit cation-π interaction with SARS-CoV-2 spike RBD residues Arg403, Arg454, Lys417, and Lys444.

Best-fitted phytochemical

Theaflavin was chosen for further investigation as the best-fitting compound among the 28 phytochemicals due to its high binding energy, presence of more than one hydrogen bond, hydrophobic interaction, π- π stacking, and cation-π interaction with the SARS-CoV-2 spike RBD.

Binding energy

The docking scores obtained are preliminary estimates of the absolute free energy of binding in which the receptor and ligand are kept rigid, based on the experimentally determined structures by Andrade et al., 2020. It is generally believed that the more negative stabilization energy, the greater the possibility of receptor-ligand binding action. However, the YASARA used in this study has a built-in protocol for calculating binding energies (Derek et al., 2015). The following equation is used to compute the binding energy that results:

Binding Energy = EpotRecept + EsolvRecept + EpotLigand + EsolvLigand – EpotComplex – EsolvComplex (1)

Energy in the YASARA binding energy function was calculated as the difference between the total potential and solvation energies of the separated compounds as well as the total potential and solvation energies of the complex. Hence, a more favourable binding in the context of the selected force field is indicated by the higher positive binding energies obtained in the results (Aamir et al., 2018).

Figure 1 shows the docking of theaflavin towards the SARS-CoV-2 spike RBD. Theflavin obtained a 7.23 kcal/mol docking score against SARS-CoV-2 spike RBD, which is considered a high binding affinity compared to the other phytochemicals. High binding affinity for the theaflavin-spike RDB complex indicates that the complex ois likely to be stable and that the ligand is tightly bound to the spike protein. Based on the in silico research carried out by Mohamed et al. (2021), YASARA was used to screen for the potential reactivator against malathion-inhibited human AChE. High binding energy, which was 6.45 kcal/mol, formed between the docking of 4-hydroxybenzohydrazide and malathion-inhibited human AChE showed a stable and strong receptor-ligand interaction. In short, high binding energy values have been demonstrated in the literature to indicate a well-fitted protein and ligand complex structure, which is consistent to the result obtained in this study.

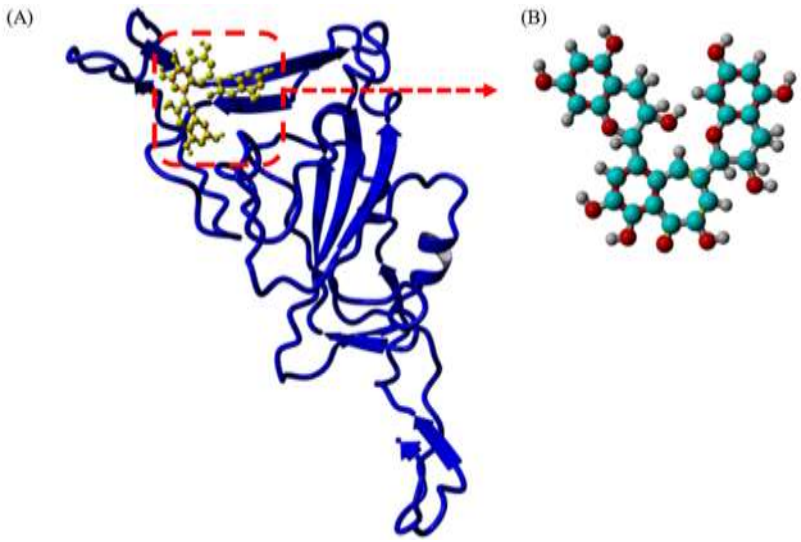

Fig. 1. (A) Docking of Theaflavin (24) towards SARS-CoV-2 spike RBD. Blue colour represents SARS-CoV-2 spike RBD while yellow colour denotes theaflavin; (B) 3D compound structure of Theaflavin (24). Light blue colour represents carbon, red color signify oxygen, and grey colour indicates hydrogen.

Hydrogen bond

In nature, hydrogen bonds are ubiquitous and are typically throught to facilitate the binding of proteins and ligands (Chen et al., 2016). This electrostatic interaction usually occurs between the partially positively charged hydrogen atoms of the protein and the partially negatively charged atoms of the ligand, such as oxygen or nitrogen atoms. They are important in the docking process because they contribute to the stability of the protein-ligand complex. They also play a crucial role in the specificity and affinity of ligand binding to the protein because they can form only when the ligand is positioned in the correct orientation and conformation relative to the protein. The complex's formation will be stronger and the docking outcome will be more accurate when there are more intermolecular hydrogen bonds (Wu et al., 2012).

According to Figure 3.2, the chromane ring of theaflavin formed a hydrogen bond with Lys417 (2.105 Å). The dihydroxyphenyl ring of theaflavin showed hydrogen binding with Lys417 (1.953 Å) and Asn460 (2.019 Å). The donor-acceptor distance for a strong hydrogen bond typically falls within the range of 1.5 to 2.5 Å. This range is based on experimental measurements and theoretical calculations, and it is supported by numerous studies of

hydrogen bonding in a variety of chemical and biological system (Jeffrey, 1997). In short, since all hydrogen bonds formed between the theaflavin and the spike RBD are consistent with the range stated by Jeffrey (1997), these hydrogen bonds are showing a strong interaction.

Based on the research article published by Veeramachaneni et al. (2020), the Lys417, Gln493, Gln498, Asn487, and Tyr505 residues in the SARS-CoV-2 spike RBD were identified as the major hot spot amino acids involved in the protein-ligand binding. The researchers discovered that throughout the computational simulation, the hydrogen bond interaction percentage for residue Gln492 showed 100%; Gln498 showed 90%; Asn487, Tyr505, and Lys417 showed 80%; Tyr489, Asn501, and Tyr453 showed 60%; and Ala475 showed 50%. As a result, this indicates the hydrogen bonds between theaflavin and SARS-CoV-2 exhibit a strong interaction.

Based on previous study by Hatmal et al. (2020), Veeramachaneni et al. (2020), Wang et al. (2020), and Badhe et al. (2021), Lys417 is one of the key amino acids that contributed from the SARS-CoV-2 spike RBD side in the hydrogen binding activity. This is because a salt bridge was observed between the ACE2 residue, Asp30, and the spike RBD residue, Lys417, across the binding groove, resulting in the establishment of a strong electrostatic interaction. Hence, theaflavin, which formed strong hydrogen bond and hydrostatic interaction with residue Lys417 may be feasible to inhibit the binding of SARS-CoV-2 spike protein and ACE2.

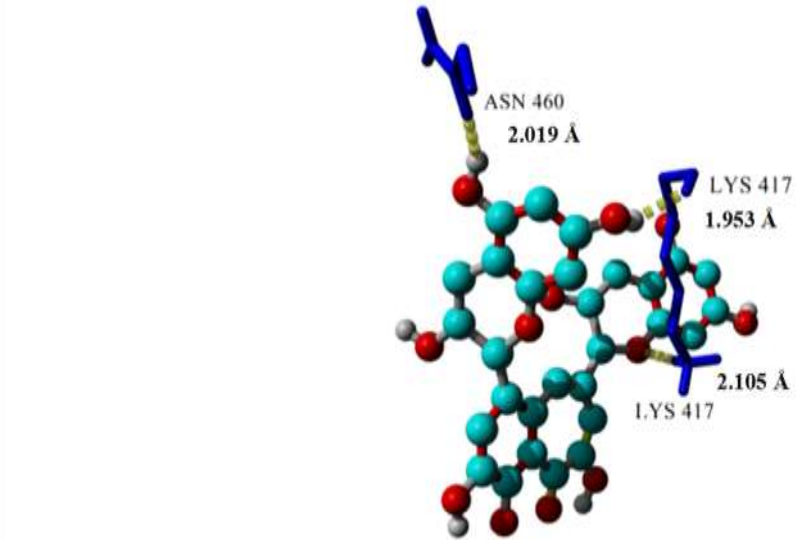

Fig. 2. Hydrogen bonding between Theaflavin (24) and Asn460 and Lys417 residues of SARS-CoV-2 spike protein. Residues involved in the protein-ligand complex are highlighted. Blue colour represents residues of SARS-CoV-2 spike protein. Yellow dotted line denotes hydrogen bonding.

Hydrophobic interaction

Hydrophobic interactions form through the close proximity between non-polar amino acid side chains of the protein and hydrophobic groups on the ligand (Klebe, 2013). The shape of the ligand, which is mostly made up of hydrophobic carbons, determines whether it can even reach the active site. The well-fitting of these hydrophobic carbons with the active site geometry ensures that there will be no unintended ligand interactions with target proteins similar to the target. Patil et al. (2010) found that the biological activity of the drug is further increased by an increase in the amount of hydrophobic in the active site of the drug-target interface. In short, hydrophobic interaction plays a major role in stabilizing the ligands at the binding interface and specifying the protein-ligand complex.

In Figure 3, the dihydroxyphenyl ring showed hydrophobic interaction with Asp420 (3.640 Å). The chromane ring of theaflavin showed hydrophobic interaction with Lys417 (3.539 Å). The catechol ring showed hydrophobic interaction with Leu455 (3.523 Å) and Phe456 (3.453 Å). According to University of Massachusetts Amherst (n.d.), the typical range for carbon-carbon distances in hydrophobic interactions is between 3.3 Å to 4.0 Å, which is consistent with the data obtained in this study. Besides, Veeramachaneni et al. (2020) used interaction analysis to discover that the major hot spot amino acids involved in SARS-CoV-2 spike RBD receptor-ligand binding include Gln492, Gln498, Asn487, Lys417, and Tyr505. By comparing the results obtained with the significant hot spot found by Veeramachaneni et al. (2020), the theaflavin-spike RBD complex was proven to exhibix good hydrophobic interactions.

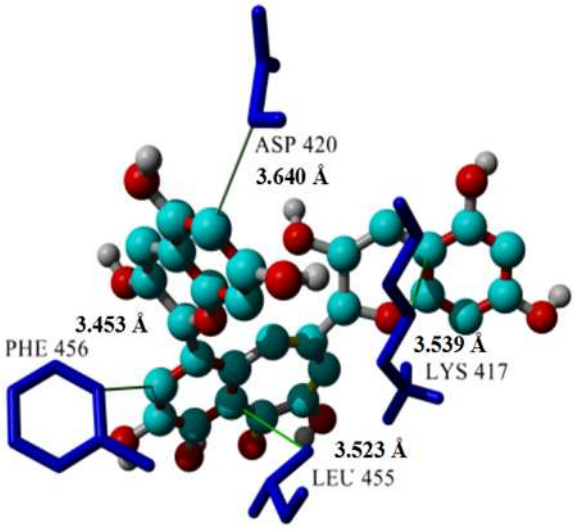

Fig. 3. Hydrophobic interaction between Theaflavin (24) and Asp420, Leu455, Lys417, and Phe456 residues of SARS-CoV-2 spike protein. Green line denotes hydrophobic interaction.

π-π stacking

π-π stacking refers to the attractive interaction between the π-orbitals of aromatic rings on the protein and ligand. Aromatic rings contain π-electron clouds above and below the ring that can interact with π-electrons in other aromatic rings. When the π-electron clouds of aromatic rings are parallel and in close proximity, they can interact through van der Waals forces and form a π-π interaction. Although π-π interaction is assumed to be weak and is less common than hydrophobic interactions, it has been showed to play a significant role in folding and thermal stability of protein, as well as in the binding of protein to ligands (Stornaiuolo et al., 2013).

Figure 4 showed a π-π interaction between the catechol ring of theaflavin and Phe456 (4.222 Å). According to Liao et al. (2013), π-π interaction typically occurs between the side chains of the aromatic amino acids, which include phenylalanine (Phe), tyrosine (Tyr), tryptophan (Trp), and Histidine (His). According to Teli et al. (2021), the phenyl ring of compounds such as acetoside and epitheaflavin monogallate showed π-π stacking with Tyr449; the aromatic phenyl ring of hypericin, quercetagetin, and astragalin exhibited a more favourable π-π stacking with His163; and the catechol ring of quercitrin and procyanidin formed a π-π interaction with Try505, resulting in the formation of a more stable protein-ligand complex. In short, the non-covalent interaction between the side chains of the aromatic amino acids, which include Phe, Tyr, Trp, and His, were examined by Teli et al. (2021) to show a strong π-π stacking interaction. Therefore, the association between theaflavin and SARS-CoV-2 spike RBD was shown to be stable since theaflavin was observed to bind with one of the aromatic amino acids, which is Phe.

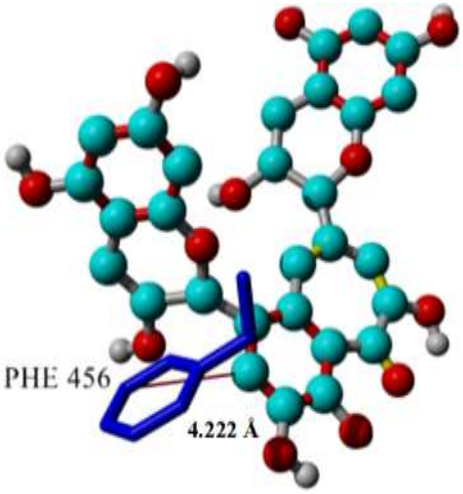

Fig. 4. π-π stacking between Theaflavin (24) and Phe456 residue of SARS-CoV-2 spike protein. Red line indicates π-π interaction.

Cation-π interaction

Cation-π interaction is a non-covalent molecular interaction between an electron-rich π system, such as benzene, acetylene, or ethylene, and a positively charged cation, such as Na^+ or Li^+. Cation-π interactions can be particularly

important in the binding of ligands to proteins that contain aromatic residues in their actives sites, such as lysine (lys), arginine (arg), or histidine (His). These amino acids have an aromatic ring structure tat can interact with the positively charged cations via their π-electron clouds, which can provide additional stabilization to the protein-ligand complex (Gallivan and Dougherty, 1999).

In Figure 5, the chromane ring of theaflavin showed strong and favourable cation-π interaction with Lys417 (3.446 Å). This is due the fact that cation-π interaction, which typically occur between the cationic sidechains and the aromatic ligands, are among the strongest non-covalent interactions (Gallivan and Dougherty, 1999). Salonen et al. (2011) stated that the cation-π interaction is one of the strongest driving forces in biological complexation processes. This is because the cation-π interaction was found to contribute 2.6 kcal/mol to the binding interaction. Thus, the cation-π interaction observed between theaflavin and spike RBD was proven to be strong and stable.

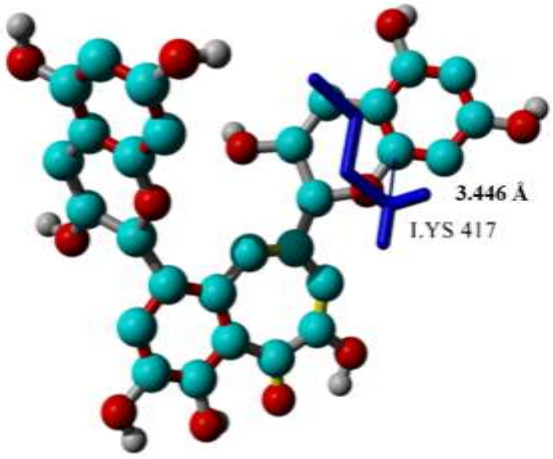

Fig. 5. Cation-π interaction between Theaflavin (24) and Lys417 residue of SARS-CoV-2 spike protein. Blue line indicates cation-π interaction.

Validation of YASARA docking protocols

The molecular docking protocols and parameters were validated by redocking, prior to superposition. Figure 6 depicts the overlaid conformation of the redocked ligand with reference to the crystal structure of the downloaded ligand. The superposition between the deposited crystal structure of SARS-CoV-2 3CL in complex with inhibitor EB54 and the YASARA simulated docked structure showed root-mean-square deviation (RMSD) value of 0.49 Å over 301 aligned residues with 100% sequence identity. According to Singh et al. (2017), a successful docking is defined as having an RMSD value of less than 2.0 Å between the crystallographic ligand and the docked ligand. Therefore, the YASARA docking protocols was successfully verified.

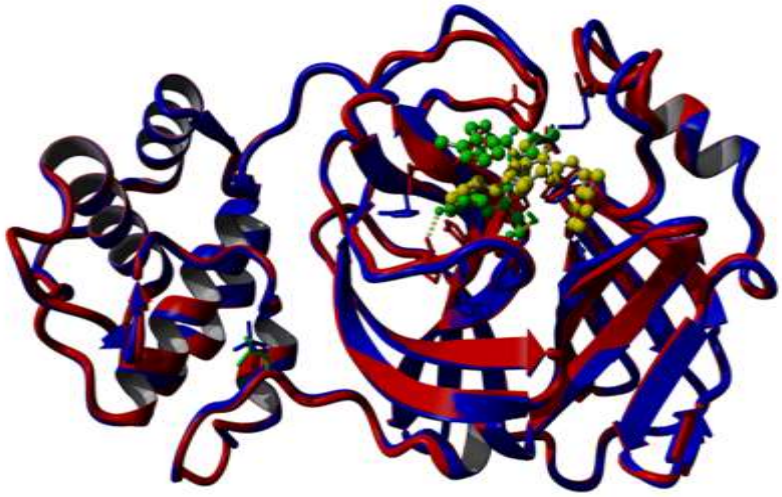

Fig. 6. Structural alignment between the deposited complex crystal structure from PDB with the docked structure simulated using MUSTANG alignment by YASARA. Red colour refers to the deposited crystal structure, blue color indicates the predicted docked structure, green colour denotes the crystallographic ligand, and yellow colour depicts the docked ligand.

CONCLUSION

In this study, the potential inhibitors were screened based on their binding affinity, molecular interactions, and the distance of the nucleophilic attack of the phytochemicals towards the SARS-CoV-2 spike RBD by using the YASARA. The hydrogen bond, hydrophobic interaction, van der Walls interactions, and the conformational entropy of the ligand were each identified with a distinctive physicochemical contribution to the binding free energy. Thus, theaflavin, which obtained a high binding energy value and consists of multiple molecular interactions with the residues of SARS-CoV-2 spike RBD can fit well and bind more tightly to the active site of the SARS-CoV-2 spike RBD. In short, theaflavin could be used as a lead compound for developing a SARS-CoV-2 inhibitor that targets the spike RBD. In vitro and in vivo studies are needed to confirm on the inhibition mechanism of theaflavin towards SARS-CoV-2 spike RBD.

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074-065

DEVELOPMENT OF CACAO POD HUSK CHIPS USING QUALITY FUNCTION DEPLOYMENT METHOD

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ABSTRACT

Cocoa Pod Husk (CPH) contributes 67% of fresh cocoa mass. Even though it is rich in protein, fiber, and bioactive components, the utilization of CPH has not been optimal. The purpose of developing chips with the addition of CPH using Quality Function Deployment is to measure the level of consumer needs and desires for CPH chips, evaluate the quality attributes of CPH chips based on consumer wants and needs, and design its prototypes as the results of CPH chips. The utilization of CPH as a raw material for making chips is expected to be a functional snack due to its fiber content which is beneficial for health. The consumer target for CPH chips is 17-25 years old, which is a teenager who likes to consume snacks. CPH chip development is carried out using QFD starting with the production of CPH flour. After obtaining CPH flour, CPH chips are made by mixing the ingredients into the dough, flattening the dough, molding the dough, and frying it using the deep-frying method. The questionnaire distribution of CPH chips development was carried out using the Accidental Sampling method to measure the Product Performance Levels (PPL) and Consumer Need Levels (CNL) of CPH chips with the existing formula as a benchmark. The quality attributes of the CPH chips that were evaluated were the aroma, taste, texture, and color. The PPL and CNL questions on the measurement attributes questionnaire of the initial CPH chips showed valid results (r count > r table) and reliable (r Cronbach'a alpha > alpha value). Consumer evaluation of CPH chips development shows that consumers want products that have a distinctive CPH chips aroma, yellowish brown color, crunchy texture, and tasty taste. Furthermore, CPH chips are improved using CPH flour which is pretreated with soaking in 3% citric acid to produce the attributes that consumers want. Based on the results, developed CPH flour which was pretreated with 3% citric acid soaking showed a higher Whiteness Index value ($p < 0.05$) which was 43.20 ± 0.88 compared to initial CPH flour which was made without citric acid pre-soaking treatment, which was 38.90 ± 0.39. The Browning Index value of initial CPH flour was higher (6,556.20 ± 262.61) than developed CPH flour (5,383.72 ± 209.54). The product performance test showed that the developed CPH chips showed better product performance as compared to its initial CPH chips. The total dietary fiber content of developed chips was 16.10 ± 0,032 % so it could be categorized as a fiber-rich product due to its dietary fiber content of more than 6%.

Keywords: CPH, chips CPH, dietary fiber, QFD

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075-066

PERFORMANCE OF LEMONGRASS (*Cymbopogon citratus*) CULTIVARS INTEGRATED IN DOUBLE AVENUE OIL PALM PLANTING AREA

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ABSTRACT

The lemongrass (*Cymbopogon citratus*) or Serai makan is classified as herb crop under gramineceace family. It's is common herb consumed by Malaysian people as edible consumption and exploited for food, flavouring, medicine, perfume, cosmetic, pest repellent and etc. Lemongrass very suitable to cultivate in Malaysia because of hot and dry climate throughout the year, can be grown in many types of soil and high demand potential. In Malaysia, three common cultivars of lemongrass were cultivated such as *Kampong*, *Peha Ayam* and *Gajah* in monoculture system. To date, planting lemongrass integrated with other crop such as oil palm was rarely found. Therefore, the purpose of this study is to determine the performance of three lemongrass cultivars (*Kampong*, *Peha Ayam* and *Gajah*) integrated in double avenue oil palm planting system in order to optimize and maximize the land use and thus improving the socioeconomic among oil palm smallholder. Result shown lemongrass good growth and it's has suitable and potential to integrate with oil palm. Nonetheless, *Peha Ayam* cultivar gave highest in growth, yield and economic in double avenue oil palm planting system followed with *Gajah* and *Kampong* cultivar.

Keywords: Lemongrass, peha ayam cultivar, integration, oil palm

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081-067

PERFORMANCE EVALUATION OF MODIFIED RICE STRAW BALER AT WET SOIL CONDITION

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ABSTRACT

Rice straw is produced during the harvesting process of rice and available abundantly available at the field. Nowadays, rice harvesting is conducted using a combine harvester and the rice straw will be left behind on the stubble. Basically, the rice straw can be collected during the dry season together with the stubble but most farmers have managed the rice straw through open burning because it is easy and cheaper. However, the rice straw generated during the wet season it will remain at the field and incorporated into soil on the next planting season. In 2021, around 3.0 million tonnes of rice straw was generated by 647,859 hectares of rice planted area. Therefore, in order to benefits the natural resource that is freely available, the collection of rice straw to fulfill demand for various applications is necessary. Calculation of the rice straw quantity is performed prior to machine evaluation. The modified mini rice straw baler that attached to 3 points link of a tractor is evaluated to determine its performance and capability at the speed of 1.6 km/hour. Collection of the rice straw during the wet season is conducted without slashing the stubble and the rice straw is collected on the stubble by the machine through mechanically adjustment of feeding tine position. The bale of rice straw is collected at a discharged structure for quality analysis and measurement with the size of 50cm (diameter) and 70cm (length). The result indicated that 1.75 tonnes of rice straw is produced by a hectare of rice at the distribution of 0.175 kg/m^2. The statistical analysis of the rice straw distribution has shown no significant difference which means the crop is evenly grown in the experimental plot. This factor has resulted accumulation quantity of rice straw on the stubble is consistent. The mini baler is capable to collect 0.656 tonnes/hour of rice straw at the performance rate of 90.6%. Utilization of the modified mini baler to collect the rice straw at wet soil conditions able to increase its production towards sustainability of the rice industry.

Keywords: Rice Straw, Mini Baler, Machine Performance, Field Mechanization, Rice Industry

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082-068

WASTE MANAGEMENT OF DOMESTIC COOKING OIL IN PERLIS: SOAP MAKING BASED FROM USED COOKING OIL

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ABSTRACT

Domestic cooking oil (DCO) is a huge waste production in Malaysia. Nowadays with the increasing demands for cooking oil, the waste level is increasing. Waste from DCO is also a good candidate as a material for making soap. It is typically cheaper than other oils. In this study, we have investigated the operation of produced soap from waste cooking oil. The objectives of this study are (i) investigating and producing organic soap based on a mixture of residual domestic cooking oil, ornamental plants, herbs, and edible plants and (ii) assessing the efficacy of organic soap in cleansing and sustaining good skin. The operating temperatures is 60℃ and 4% content of moisture is the optimum technology of degumming. The most favorable decoloring agent is activated kaolinite clay, DCO and activated clay ratio of 100:5 at 60℃ with 30 min treated time. The optimal technology of saponification is that the mass ratio of sodium bicarbonates and WCO is 0.3:1, and saponification temperature is 70℃. The final products are three different types of soaps that can generate income for the local community.

Keywords: Domestic cooking oil, soap, kaolinite clay, waste, environment

1. Introduction

The disposal of domestic cooking oil poses a significant environmental challenge due to its potential to clog sewage systems, contaminate water sources, and harm wildlife. Despite the development of various solutions for the proper disposal of cooking oil, many households continue to pour it down the drain or dispose of it in the trash, leading to negative impacts on the environment. This problem is further compounded by the fact that domestic cooking oil is often used in large quantities in households, particularly in developing countries where cooking oil is a staple ingredient in many meals. Therefore, there is a need for effective and sustainable solutions to address the environmental impacts of domestic cooking oil disposal. Recycling domestic waste cooking oil into organic products can protect the environment, particularly the hygienic water supplies. The presence of residual hydrophobic cooking oil generates oil globules that can harm soil microorganisms and aquatic organisms. In light of the Sars-CoV-2 pandemic, this study aims to develop an organic and anti-bacterial soap from leftover cooking oil and high anti-oxidant ingredients to preserve skin moisture and health, especially for eczema sufferers. Nowadays, with the increasing demands for cooking oil, the waste level is increasing. The discharging of cooking oil residues into the water contaminates the flora and fauna of rivers and lakes, as this is floating on the surface and does not allow oxygenation, preventing the passage of sunlight and suffocating the photosynthesis, causing the death of aquatic animals and plants (Okafor, 2011; Omodanisi et al., 2011) A spill of used oil as tiny as 1 L can contaminate a million litres of fresh water.

So, the recycling of waste cooking oil is becoming a viable alternative in mitigating environmental and ecological problems (Singh-Ackbarali et al., 2017; Sanaguano et al., 2017). And it will also become an income generation for the community that produces eco-friendly products from this waste. The production of soap from used oil largely contributes to the economic improvement of local communities in Indonesia (Septiowati et al., 2019). The study by Kusumaningtyas & Qudus (2019) shows that the manufacture of this soap has helped to improve the economy of the residents of Sekaran Village, Gunungpati District, Semarang, Indonesia. This was successfully produced starting with the high awareness of the villagers to save the environment from the growing waste of cooking oil. Similarly, a

study by Septiowati et al., 2019) found the involvement of housewives in Bambu Apus Pamulang, Indonesia in the production of used oil so that they can improve the household economy. Whereas the study by Susanti & Priamsari (2019) it has also studied the manufacture of this soap in the Sidorejo area of Semarang Regency, Indonesia.
Production of soap from waste cooking oil showed that the soap produced had good quality and met the standards for commercial soap (Al-Qodah et al., 2008). Production of soap from waste oils and fats using response surface methodology showed that waste cooking oil was a suitable feedstock for soap production and that the optimal conditions for soap production could be achieved using a combination of waste cooking oil and other waste oils and fats (Hamedi et al., 2013). Preparation of soap from spent bleaching earth and waste cooking oil as feedstocks for soap production. The results showed that the soap produced had good quality and met the standards for commercial soap (Al-Shannag et al., 2015). This study investigated the use of spent bleaching earth and waste cooking oil Production of soap from used cooking oil and comparison with commercial soap had similar quality and fatty acid composition to commercial soap and could be produced at a lower cost (Jafari et al., 2019).

This study approach were divided into 5 phases. Phase 1: Collection and re-screening of waste domestic cooking oil. Phase 2: Identification of ornamental plants, herbs, and edible plants that are ideal for integrating with mixtures, bentonite clay, and waste domestic cooking oil. Phase 3: Use-safe cold process soap was produced through a saponification reaction to differentiate the oil into butyric acid and glycerol, followed by a solidification reaction and curing process to neutralize the alkali. Phase 4: Hydrolysing cold process soap in boiling water tends to produce liquid organic soap. Phase 5: Marketing and accumulating testimonials. The final phase were knowledge sharing with B-40 concerning product development and marketing. The study approach were expected to be sufficient to provide organic hygienic care products that are environmentally friendly, preserve skin moisture, are anti-bacterial and are anticipated to be a viable alternative to synthetic soaps that are non-biodegradable. In addition, it is anticipated that both B-40 and UiTM will garner profits as a result of the findings of the study.

2. Materials and methods

2.1 Study area and dataset

UiTM Perlis, Arau been choose as study area that located at (6° 25' 46.9488" N, 100° 16' 11.4384" E). Perlis is Malaysia's smallest province, situated on the northern tip of Peninsular Malaysia's west coast. Majority of Malays stay in Arau with a medium population density. There are 3 institution in Arau that makes Arau become a strategic location to spread awareness about recycling of domestic cooking oil among the community. Total municipal waste contribution (including domestic cooking) by Perlis is 200 tonnes per month. For small state it is a huge problems. Recycling the domestic cooking oil as side income can help the communities to increase their income as well.

This study used dataset which is questionnaire paper from customers. First dataset get by measured and calculate sample size of this study is 60 sample of residents at UiTM Perlis Branch by follow rule Krejcie & Morgan. (1970). The questionnaire been distributed by google form and hand to hand answer.

2.2 Soap Preparation

The soap was prepared according to the ingredient formulated from the Completely Randomized Design (CRD) A x B x C where A = types of DCO or Soap, B percentage of Kaolinite clay/sodium bicarbonates + soda carbonates and C = essential oil/water.

3. Results and discussion/Results

In this study the physical condition of cooking oil was first observed. Production of soaps with unique properties needs a careful selection of oil types. The criteria for the selection of oil for industrial or domestic application in soap making includes the presences of natural characteristic aroma and natural colour and also the effectiveness, skin effect and the quality product after using it (Araújo et al., 2013 ; Okoye et al., 1999).
Quality parameters to be considered are general appearance (including soap density, luminous, abrasive), good solubility, good foaming and stable, high cleaning power, foaming, resistant to rancidity,good in soft water, good stability (related to color). Based on the literature, differences in oil and fat produce a soap with different qualities, for example color, foaming consistency, and cleaning power (Ahmad, 1981).
Most of the customers give the highest satisfaction for liquid soap and powder soap as shown in Figure 2 and Figure 3. Mostly for all level. This shows that organic soap making from DCO can become a substitutes for chemical soap in the market.

Readability test for level of satisfaction for all types of soap.

To validate the data had been perform in SPSS software for examine the level of satisfaction for all types of soap at Arau, Perlis are using reliability test. The reliability test was used to examine the internal consistency and validity of each scale (Jangra et al. 2021). This is because to identify the data that been process are good data and the accuracy

of the result can be guaranteed. The following table describes the range values of Cronbach's alpha (Zach. 2021). For data collected, overall data consistency and Cronbach Alpha reliability coefficient computed is 0.904 for 25 indicators. Since, the value of test is exceed 0.6, it show the data is in good condition.

4. Discussion

A green prospective based on the reuse of waste materials such as domestic cooking oil to manufacture soap is presented. In other country, thousands of tons of waste are generated from used cooking oil and production of nut shells' residues is growing every year. The management of domestic cooking oil waste varies across countries and regions, depending on factors such as cultural practices, economic conditions, and environmental regulations.

In the United States, many households and businesses can recycle used cooking oil through local recycling programs. The recycled oil is often used to produce biodiesel fuel, animal feed, or other industrial products. Some cities also have drop-off locations for used cooking oil, and some waste management companies offer curb side pickup for used oil.

The European Union has implemented regulations on the disposal of domestic cooking oil waste, requiring the proper collection and disposal of used oil. Many EU countries have implemented collection and recycling programs, and some have established penalties for improper disposal of used cooking oil.

In Japan, households are encouraged to collect used cooking oil in special containers and dispose of it at designated collection sites. The collected oil is often used to produce biodiesel fuel or recycled into other industrial products.

In many developing countries, the management of domestic cooking oil waste is a significant challenge due to limited waste management infrastructure and economic resources. Used cooking oil is often disposed of in the trash or poured down the drain, leading to negative impacts on the environment and public health. Some organizations and governments have initiated programs to promote the proper disposal and recycling of used cooking oil in these countries, but implementation and enforcement remain a challenge.

In conclusion, the management of domestic cooking oil waste varies across countries, with some countries having established collection and recycling programs, while others still struggle with proper disposal and recycling due to limited resources and infrastructure. It is important for governments, organizations, and individuals to work together to promote sustainable waste management practices for domestic cooking oil waste to reduce environmental impacts and promote public health (Global Waste Index, 2019).

In addition, the additional of kaolin clay and essential oil in making the soap, may increase the quality of the product. Therefore, it is necessary to diversify reuse mechanisms of these wastes, in order to make them back into raw materials. Complying with this trend, this work was carried out by processing and treating used oil, formulating and producing soap, and performing an acceptance study of the final product. Results validated a high potential of the idea in the environmental education and economic aspect. It can also be useful for waste management, and it can support the development of community projects on an ecological approach. The chemical nature of the lipophilic part of soap plays the largest role in determining the performance of finished soap (Viorica, 2011).

5. Conclusion

In this research, the process experimental of degumming, decoloration and saponification of DCO were determined by standard experiment, the experimental conditions were optimized. Our results showed the following:
1) The highest satisfaction for effectiveness of bar soap are Bar A and Bar C, for liquid is liquid A and liquid B, for powder soap are powder C and powder D.
2) The sample color and scent for liquid and powder soap both types of soap get the highest satisfaction from the customers.

Conflict of interest - Disclose any potential conflict of interest appropriately.
The authors declare no conflict of interest.

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Table 1. **Treatment for soap Making (bar, liquid and powder)**

Combinations	**Description**
$\mathbf{A_1B_1C_1}$ $\mathbf{A_2B_1C_1}$ $\mathbf{A_1B_2C_2}$ $\mathbf{A_2B_2C_2}$	DCOa + 5%Kaolinite clay + Lemon DCOb + 5%Kaolinite clay + Lemon DCOa + 10%Kaolinite clay + Lavender DCOb + 10%Kaolinite clay + Lavender
$\mathbf{A_3B_3C_3}$ $\mathbf{A_4B_3C_3}$ $\mathbf{A_3B_4C_4}$ $\mathbf{A_4B_4C_4}$	4% SoapA + 32% Sodium bicarbonates + 32% soda carbonates + 32% borax 4% SoapB + 32% Sodium bicarbonates + 32% soda carbonates + 32% borax 10% SoapA + 30% Sodium bicarbonates + 30% soda carbonates + 30% borax 10% SoapB + 30% Sodium bicarbonates + 30% soda carbonates + 30% borax
$\mathbf{A_5B_5C_5}$ $\mathbf{A_6B_5C_5}$ $\mathbf{A_5B_6C_6}$ $\mathbf{A_6B_6C_6}$	50% SoapA + 5%Vinegar +45% water 50% SoapB + 5%Vinegar +45% water 40% SoapA + 10%Vinegar +40% water 40% SoapB + 10%Vinegar +40% water

Figure 1. Types of soap from Domestic Cooking Oil

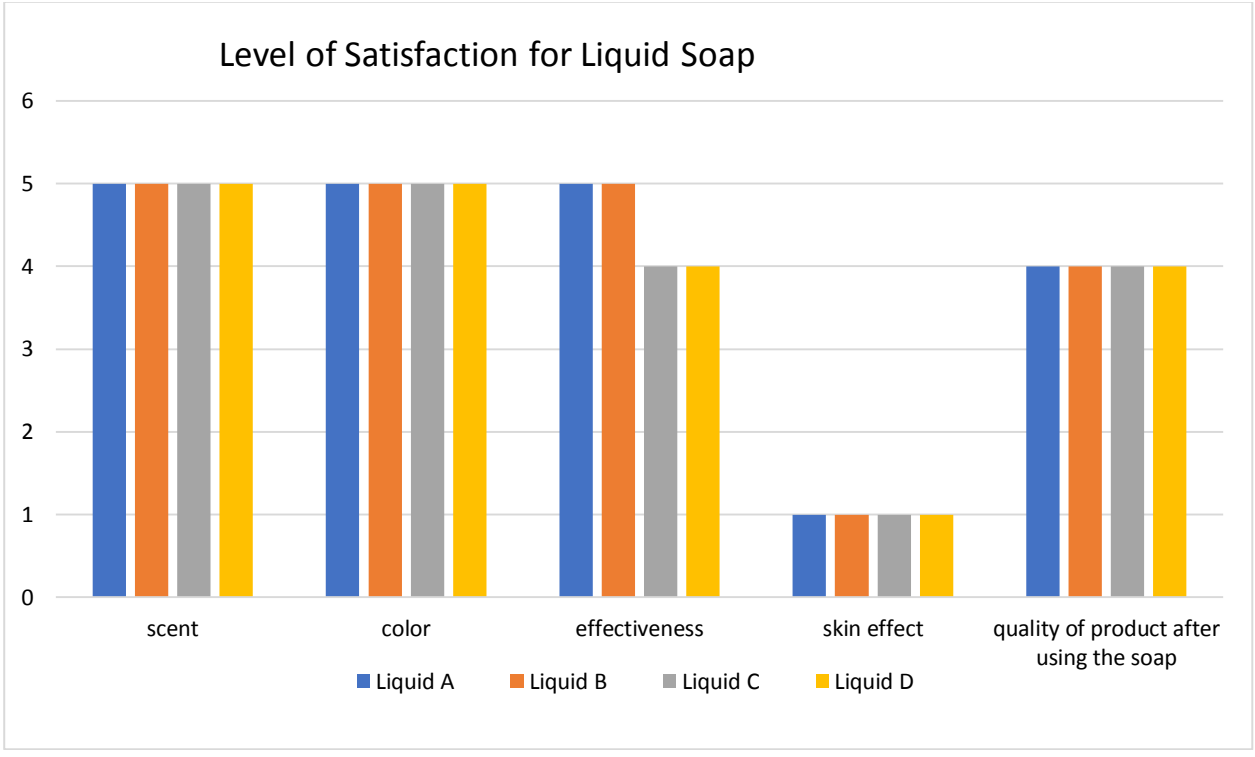

Figure 2: Level of satisfaction for liquid soap

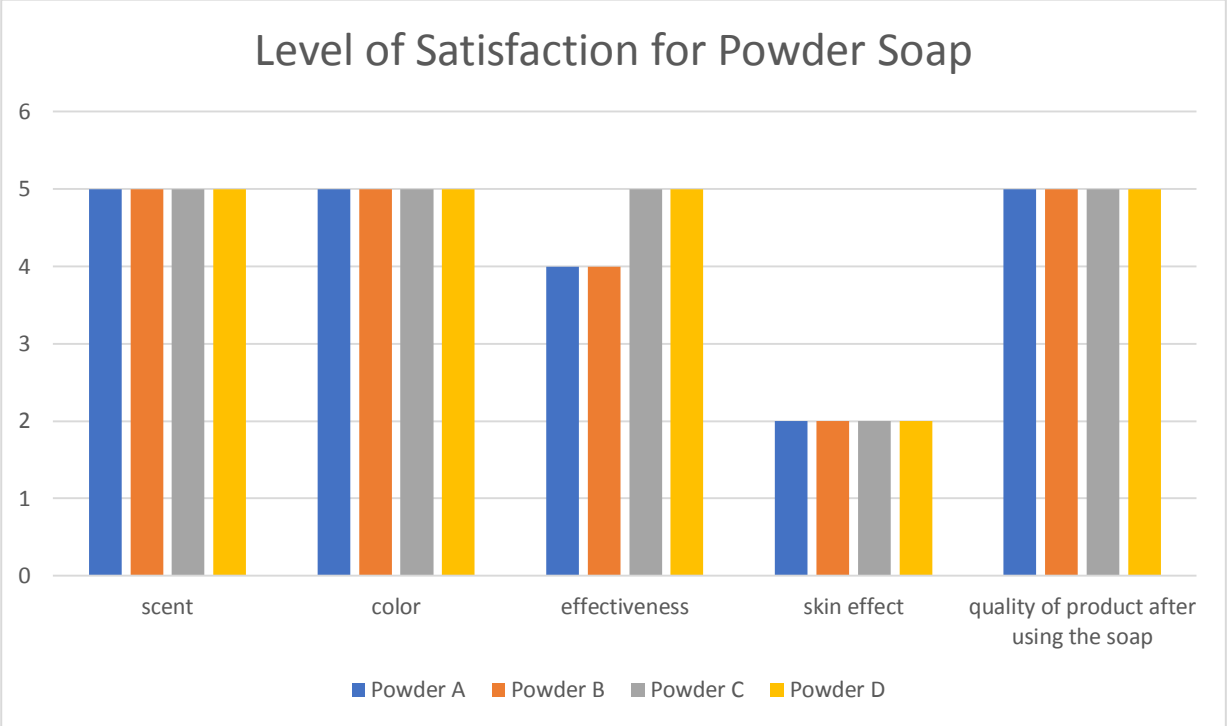

Figure 3: Level of satisfaction for powder soap

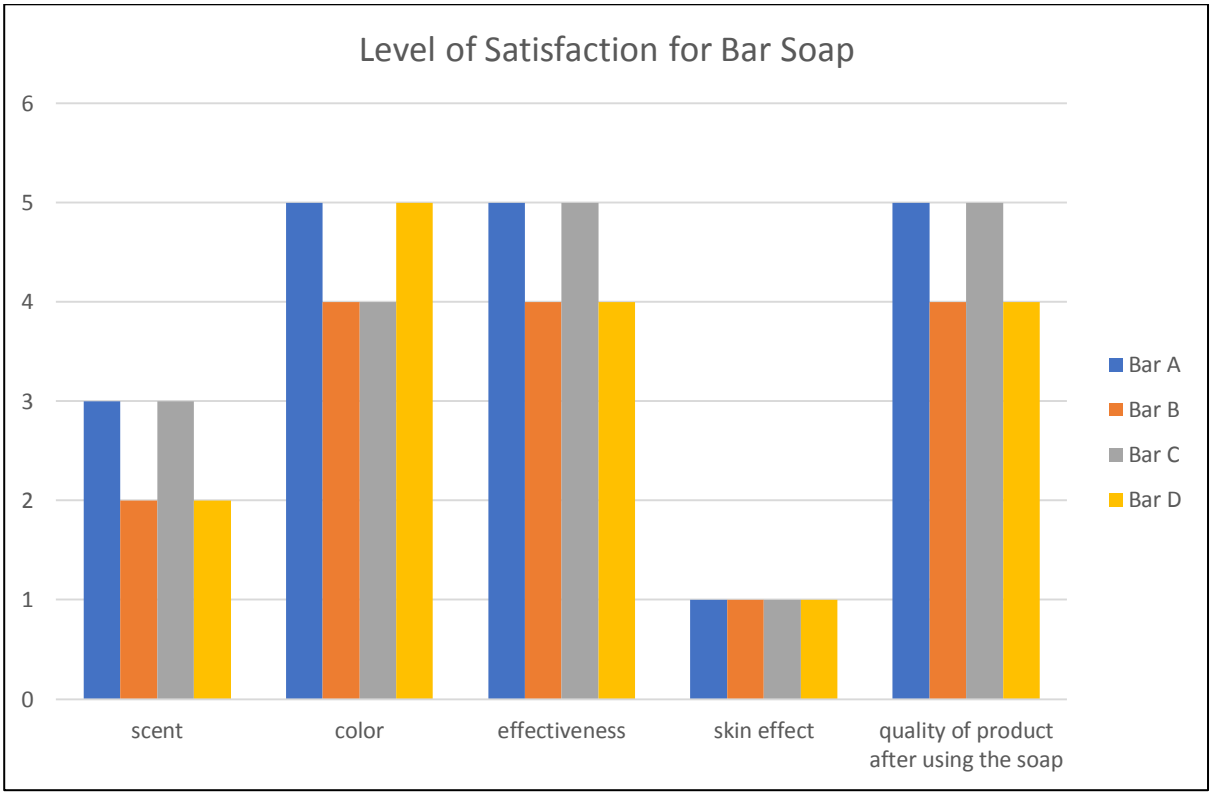

Figure 4: Level of satisfaction for bar soap

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BLACK SOLDIER FLY LARVAE FRASS PRODUCTION FOR MANAGING WATER HYACINTH ENCROACHMENT

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ABSTRACT

Water hyacinth (WH) is one of the most invasive and toxic aquatic weeds which detrimentally affects freshwater quality and ecosystem *via* hindering sunlight from reaching aphotic zone and depleting oxygen level in water bodies. An attempt was made to mitigate WH invasion by producing frass using the invasive aquatic plant as feeding substrate for rearing black soldier fly larvae (BSFL). The objectives of this study were to: (i) produce frass from BSFL using WH as feeding substrates and (ii) characterize the agronomic properties of the frass produced from BSFL after being fed on WH. The frass production was carried out by rearing BSFL using WH at a feeding rate of 200 mg larvae^{-1} day^{1} for 48 days. Water hyacinth was fully digested by BSFL at 48 days after which the frass produced by the larvae and sieved to pass a 2 mm sieve for physical, biological, and chemical properties. The BSFL frass colour was dark, and the odour became earthy, suggesting that the frass had reached maturity. The BSFL frass is a slightly alkaline material (pH =7.64), and its electrical conductivity (6 µS/cm) was in the range of permissible level as an organic fertilizer. The BSFL frass could be considered as an organic fertilizer with an appropriate range of organic matter (50.31%), organic carbon (29.18%), 2.18% total N, 1270 mg kg^{-1} ammonium, 1370 mg kg^{-1} and nitrate. The C/N ratio of BSFL frass produced from WH was 13 suggesting that the frass can decompose rapidly to release essential nutrients for crop uptake. The BSFL frass resulted in 100% germination and showed 86.46% germination index of maize seeds revealing that the frass had no toxic effect, but rather promoted seedling growth. The BSFL frass produced from WH has potential to be used as organic fertilizer to promote crop growth and soil productivity. A pot experiment study is in progress to determine the effect of BSFL frass from WH on soil productivity and crop growth.

Keywords: digestion, environmental conservation, organic fertilizer; plant growth enhancer, waste management

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086-070

DETERMINATION OF HARVESTING TIME AND QUALITY OF KESUM (*PERSICARIA MINOR*) IN DIFFERENT CULTIVATION SYSTEMS

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ABSTRACT

Various planting techniques and systems have been studied and practised to produce quality crops with high yield. Among the cultivation systems that are widely used in agriculture are open field planting, fertigation and hydroponic systems. Harvesting at optimal maturity stage is a vital approach to obtain crops with high quality and nutrient content. Kesum (*Persicaria minor*) is an aromatic herb that is very native to Southeast Asian countries and is synonymous with Asian cuisine because its ability to enhance flavour in dishes and is also used as a traditional medicine. This study was conducted to evaluate optimal harvesting time and quality of kesum in different cultivation systems which were open field planting, fertigation and hydroponic system (controlled and semi-controlled environment). In open field and fertigation system, kesum were planted on soil but with different fertilizer rate and application. While for hydroponic system, kesum were planted in 156cm x 63cm polystyrene boxes filled with water in a controlled and semi-controlled environment (closed and opened rain shelter structure respectively). Samples were harvested at different maturity stage which were 8, 12, 16 and 18 weeks after planting. Postharvest quality of the samples was measured at every harvest time. The plant fresh weight was found to increase at every harvesting week whereas kesum in the fertigation system reached optimal weight of 887.41g and 1076.51g at week 16 and 18 after planting, at 18 week in the open field system (855.63 g), at 16 and 18 week in semi-controlled hydroponic system (509.45g and 493.26g) and at 18 week in controlled hydroponic system (424.00g). Phenolic content was found to be higher in kesum from the fertigation and open field systems which were 384.72mg/g and 391.64mg/g respectively at week 16, while in the controlled environment hydroponic, the phenolic content reached highest value of 207.43mg/g at week 16 and at week 12 in semi-controlled hydroponic systems (183.47mg/g). Ascorbic acid and water content showed a decreasing trend throughout the harvesting weeks, in contrast to the total soluble solids content, total titratable acidity and pH value which increased in all four cultivation systems. Based on the data obtained, the optimal harvesting time for kesum in fertigation, conventional and controlled hydroponic systems is at week 16 after planting, while for semi-controlled hydroponic systems as early as week 12.

Keywords: fertigation, herb, hydroponic, soilless planting

087-071

COMPARISON OF METHANE EMISSION FROM CONVENTIONAL AND AGROECOLOGICAL RICE APPROACH IN KELANTAN MALAYSIA

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ABSTRACT

Methane (CH_4) is a potent greenhouse gas that contributes to climate change, and its emission from agricultural activities is a significant source of concern, particularly in rice cultivation in Malaysia, where rice is a staple crop. Numerous studies have shown that conventional rice cultivation methods result in higher methane emissions compared to agroecological approaches. Thus, a study had been conducted to estimate methane emissions from two different locations at Bachok and Kadok, Kelantan during the main and off-season from July 2018 until Jun 2019. Treatments comprising two methods of crop establishment viz., conventional (CM) and system of rice intensification (SRI) as the agroecological approach (AE) was laid out in randomized complete block design with four replications and plot size of 5 x 5 m. MARDI fragrant rice (Oryza sativa L) variety 'MRQ 76' seeds were direct seeded in the conventional treatment plots with flooded conditions while in SRI, 12-day-old seedlings were transplanted in the SRI treatment plots with saturated conditions were maintained. Methane gasses were sampled during 40, 70, and 100 days after sowing. Results of the study indicated that among the methods of crop establishment, the C method had the maximum cumulative CH_4 emission followed by SRI. Methane emission using the SRI method in Bachok was 64% lower with an average value of 3.06 mg/m^2/hr compared to the conventional technique with 8.47 mg/m^2/hr. The SRI method also showed a 63% lower value in Kadok with 2.90 mg/m^2/hr compared to the conventional with 7.90 mg /m^2/hr. Emission of CH_4 was higher in the early stage of the crop at 40 days after sowing and declined at 100 days after sowing in all two methods.

Keywords: Agroecological Approach, Conventional, Methane, Rice, Kelantan

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THE POTENTIAL OF USING VERMIWASH ON PAK CHOY PLANTED IN NFT SYSTEM

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ABSTRACT

Pak Choy is one of the most popular leafy herbs in Malaysia. It is famously cultivated in a greenhouse by providing ideal environmental conditions to boost crop production. Nowadays, the excessive use of chemical fertilizer could cause serious effects on the environment while the increase in crop demand could increase crop production. Hence, this study aimed to assess the potential of using vermiwash as an organic fertilizer on Pak Choy grown in the NFT system compared to AB solution. The study was conducted using a Randomized Complete Block Design (RCBD) with two treatments and three replications. The result reveals that the use of vermiwash significantly affects the growth of Pak Choy as compared to AB solution. The result presented here suggests the use of vermiwash as the growing solution of Pak Choy in the future as it is environmentally friendly and could give a higher quality of Pak Choy.

Keywords: Pak Choy, vermiwash, Nutrient Film Technique (NFT system), hydroponic, plant growth.

INTRODUCTION

Nowadays, Pak Choy has been widely grown in the greenhouse to increase crop production. Greenhouses may provide optimum climate conditions for plant growth and produce a good quality Pak Choy. The hydroponic system is a sustainable way of growing plants using soilless media as it could conserve 90% of water usage (Sharma et al., 2019). It can produce uniform plant growth which is less susceptible to pest and disease infestation while fertilizer plays a major role in incrasing the plant productivity. Vermiponic is a soilless cultivation technology that combines hydroponics and dissolved vermicompost leachate in the form of a nutrient solution which is also known as vermiwash. Vermiponic is using waste recycling by using worm casts for feeding plants. There have been several studies in the literature reporting that leachate as an organic fertilizer that give a positive effect on root projection in green leafy plants as compared to other inorganic fertilizers (Loera-muro et al., 2021). The study conducted by Rasool et al. (2008) obtained a significant effect on the leaf area and shoot dry weight from the use of vermiwash as the nutrient solution. Verma et al. (2018) also claimed that vermiwash have a significant effect on the growth and productivity of paddy and Zea Mays. Tadayyon et al. (2018) obtained a higher plant growth rate on fenugreek. However, when high concentrated vermiwash is used, it will reduce the plant growth rate.

So far, there has been little discussion on the growth of Pak Choy planted in the hydroponic system using vermiwash. This paper aims to determine the potential of using vermiwash in Pak Choy growth compared to AB nutrient solution. The findings of this study will lead to the selection of the best-growing solution for Pak Choy.

METHODOLOGY

The experiment was conducted at Universiti Teknologi MARA (UiTM), Perlis branch. The study area was characterized by a warm humid tropical climate with an average temperature of 24.6 to 33.8°C, total monthly rainfall of 10 to 50 mm, and relative humidity of 25 to 60 %. The experiment was set up in a Randomized Complete Block Design (RCBD) consisting of two (2) treatments and three (3) replications. Firstly, in the preparation of seedlings, Pak Choy seeds were sown in a germination tray. Pak Choy seedlings were transplanted into the NFT system after 14 days when the Pak Choy reached about 3 to 4 inches in height. Prior to transplanting, the hydroponic system was prepared with two types of nutrient solution. The first solution was prepared using a common AB fertilizer while the second one used vermiwash. Pak Choy growth was monitored for 14 days, 28 days, and 42 days after transplanting. The parameters such as plant height were measured using a ruler, the number of leaves was

counted manually, and fresh weight was measured using an electronic balance. Statistical analysis was conducted using IBM SPSS software version 16.0. The growth response of Pak Choy grown in the NFT system was determined using an independent sample t-test with a significance of 5% at a p-value less than 0.05.

RESULT AND DISCUSSION

The Pak Choy growth analysis conducted using an independent sample t-test for parameters such as the plant height, number of leaves and fresh weight of Pak Choy grown under vermiponic and hydroponic system was shown in Table 1.

Table 1: Independent samples T-test for number of leaves, plant height and fresh weight of Pak Choy

	t	df	Mean Difference	Std. Error Difference
Number of Leaves	-3.724	78	-1.892	0.508
Plant Height	-15.450	78	-7.388	0.478
Fresh Weight	-9.099	78	-66.350	7.292

An independent samples t-test was conducted to determine the significant difference in treatment and parameters. The number of leaves was normally distributed, as assessed by the Shapiro-Wilks test ($p>0.05$) while plant height and fresh weight were not normally distributed, as assessed by the Mann-Whitney U test. The results indicated that Levene's test for equality of variances indicated no statistical significance ($p>0.05$) on the number of leaves, while significant plant height and fresh weight of Pak Choy was obtained using vermiponic solution compared to AB hydroponic solution. Thus, the hypothesis that vermiwash will increase the growth of Pak Choy was supported.

Effect of Vermiwash and AB Nutrient Solution on Plant Height

The mean height of Pak choy grown in the hydroponic NFT system was 16.3cm while in the vermiponic system was 23.6cm. From the analysis, it was shown that the mean value of the Pak Choy's leaves number grown in vermiwash was higher than the mean value of the Pak Choy's plant height in the AB nutrient solution. The vermiwash contains a variety of dissolved nutrients including essential amino acids that could contribute to a significant increase in plant growth (Bhagat et al., 2022). Similar findings were obtained by Hamed et al. (2022) and Sundararasu (2016) on lettuce and chili respectively, which obtained a significant increase in plant height. Furthermore, the other growth performance such as shoot growth, the total number of leaves, leaf area, and wet weight of *Amaranthus viridis* also shown considerably greater in the wermiwash compared to the common hydroponic nutriet solution (Deepthi, 2021). Aside from macro and micronutrients, the vermicompost leachate contains plant growth promoters such as auxin, cytokinins, ethylene, enzymes, and vitamins which were excreted from the earthworms and through the process done by useful microorganisms like bacteria (Ansari, 2001).

Effect of Vermiwash and AB Nutrient Solution on The Number of Leaves

The mean number of Pak Choy leaves grown in the AB nutrient solution system was 20 units leaves while in the the vermiwash was 22 units of leaves. From the analysis, it was shown that the mean value of the Pak Choy's leaves number in the vermiwash was not significant with the mean value of the Pak Choy's leaves number grown in the AB nutrient solution. This study was contradicted by Hameed et al. (2022) and Sundararasu (2016) which obtained significant increases in the number of leaves. Even though the number of leaves have no significant different, it was observed that the size of Pak Choy leaves planted in the vermiponic system was larger and greener compared to the hydroponic system. This finding was supported by Harahap et al. (2020) that claimed translocation of nutrients may occur to other parts of the plants.

Effect of Vermiwash and AB Nutrient Solution on Fresh Weight

The mean fresh weight of Pak Choy grown in the AB nutrient solution was 66.73g while in the vermiwash was 133.08g. From the analysis, it was shown that the mean value of fresh weight in the vermiwash was higher than the mean value of plant height in the AB nutrient solution. Similar findings were obtained by Hameed et al. (2022) and Sundararasu (2016). According to Choi et al. (2012), the application of vermiwash may considerably enhance the quantity of nitrogen (N) in plant tissue, plant height, and diameter of Pak Choy stem base. In addition, vermicompost leachate was found to have much more nutrients than aquarium water, which may have impacted the development and metabolic indices of plants, especially on *Amaranthus viridis* (Deepthi, 2020).

CONCLUSION

In conclusion, Pak Choy grown in vermiwash gives better quality of Pak Choy produced from the plant height, number of leaves, and fresh weight measurement compared to AB nutrient solution. This is because the vermiwash contains readily available plant nutrients that improve plant growth responses and yield production. Furthermore, it was observed that the yield of Pak Choy grown in the vermiwash was greater than the number of plants grown in the AB solution. This research visualizes the potential of using vermiwash in Pak Choy growth by providing a higher yield and better quality of produce compared to AB nutrient solution and directly promotes the use of organic fertilizer in plant production. This finding supports the national agenda on food security and achieving the sustainable development goals of responsible consumption and production.

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SEA LEVEL RISE AND THREATS TO THE GROWTH OF INFRASTRUCTURE IN BANGLADESH'S COASTAL CITIES

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ABSTRACT

The coastal cities in Bangladesh have been vulnerable due to their establishment in riverbanks and low facilities for the community and society. The sea level has been increasing in Bangladesh resulting to higher negative impacts on coastal cities, community and society. The infrastructure development of the country has been affected by sea level rises with the interruption for pure water supply, sewerage system, drainage, electricity and power system. Also, coastal cities in Bangladesh have been dealing with flood, salinity, earth-quake, cyclones, climate change, land-sliding, water-logging and erosion etc. These challenges have been affecting lives of the people in the coastal cities.

Keywords: Bangladesh, sea-level rise, coastal cities, infrastructure development, vulnerability threats

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THE IMPACT OF MIX MARKETING STRATEGIES ON THE SALES OF AGRICULTURAL PRODUCTS: A CASE STUDY IN JOHOR

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ABSTRACT

This research was conducted to understand the impact of 7Ps Marketing Mix Strategies (i.e., product, price, promotion, place, people, physical evidence, and process) on the sales of agricultural products. The retailers' perspective of the influence of the strategies on their sales was analyzed to fully understand the effect that each element has on sales improvement. Since each of the seven Ps of the marketing mix has a different impact on sales, which varies from product to product and market to market, each P has a unique level of influence on sales. This study employed descriptive analysis and multiple linear regression to achieve the research objectives. The data was collected from 150 agricultural product sellers from different stores in Johor by employing a closed-ended survey questionnaire. The respondents were selected using convenience sampling, and the data were analysed through multiple linear regression analysis. It was found that the majority of the retailers were particularly new in the business with 64.9% of them having 2 to 4 years of experience. The findings also revealed that among the 7Ps marketing mix strategies, only two strategies, namely place, and people were found not significant in influencing sales. Moreover, among the five strategies that significantly influenced sales, the promotion strategy showed the highest influence compared to others. This study can help sellers or relevant agencies to understand the most efficient strategies for increasing sales of agricultural products, especially in the post-pandemic business environment.

Keywords: marketing mix, agricultural products, sales, pandemic

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PRODUCT DEVELOPMENT OF CHOCOLATE CUBES USING VALUE ENGINEERING METHOD

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ABSTRACT

Cocoa is one of the plantation commodities that has an important role in economic activities, namely as a foreign exchange earner besides oil and gas. Indonesia is ranked first in Asia with the highest consumption of chocolate, which is 7.3 kg per capita. Chocolate is seen by consumers as comfort food or stress relief. For consumers who buy chocolate for their consumption, consuming chocolate in small quantities rather than one large size causes consumers to act more impulsively to consume larger quantities. Consumption of chocolate in small sizes (one bite size) gives the impression that the product has a premium image and is of higher quality. The purpose of this study was to identify the characteristics of chocolate that influence product purchasing decisions and to develop one-bite-sized chocolate cubes based on consumer needs using the Value Engineering method. The study used 433 respondents with the criteria of chocolate consumers aged 15-40 years. Based on the research results, it is known that chocolate bars and molded chocolate are the types of chocolate most often consumed with a frequency of 2-3 times a month. Consumers have the highest complaints when consuming chocolate, namely melted chocolate which makes hands dirty with large chocolates and is too hard to bite. Based on the desire analysis, consumers want the development of milk chocolate cubes with nuts filling. Four alternative concepts of milk chocolate cubes with a mass percentage of 50% cocoa were prepared using 2 variations of the amount of cocoa butter (10% and 15%) and 2 variations of the type of nuts (almonds and cashews). Based on the hedonic test results, milk chocolate cubes with a formula of 10% cocoa butter and cashew nut filling had the highest product value of 0.13 compared to other formulas. Chocolate color and ease of eating are the attribute weights with the highest weights. So it can be concluded that the milk chocolate cube formula is 40% cocoa beans; 10% cocoa butter, and cashew nut filling is the selected formula for the chocolate cubes.

Keywords: Chocolate Cubse, One Bite Size, Value Engineering

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ANTIFUNGAL ACTIVITY OF COPPER OXIDE NANOPARTICLES AGAINST *FUSARIUM* SP. AND *ASPERGILLUS BRASILIENSIS*

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ABSTRACT

Copper oxide nanoparticles gained importance in agriculture for their antifungal action on various fungal plant pathogens. In this context, the biosynthesised CuONPs were compared with chemically obtained CuONPs to investigate the effect of the preparation method on the antifungal properties. The poisoned food technique was used to test the antifungal activity of chemical and green CuONPs against two phytopathogenic fungi, *Fusarium sp*. and *Aspergillus brasiliensis*. Chemically fabricated CuONPs had more potent antifungal activity than green CuONPs against *Fusarium sp*. However, chemical and green CuONPs had a similar inhibitory effect on *A. brasiliensis*. This result is essential to show the impact of the synthesis method on enhancing the potential of antifungal activity of metal oxide nanoparticles.

Keywords: Copper oxide nanoparticles, synthesis method, antifungal activity, *Fusarium sp.*, *Aspergillus brasiliensis*

INTRODUCTION

The use of nanotechnology in agriculture has grown significantly over the past few decades, leading to a new field known as nano agriculture (Ibarra-Laclette et al., 2022). Various nanoparticles have been used in this field, but copper-based nanoparticles have become increasingly popular due to their excellent antimicrobial properties (Abd-Elsalam, 2022). Chemical synthesis, which is expensive and produces toxic byproducts that harm the environment, is unsuitable for food applications, medicine and cosmetics (Augustine and Hasan, 2020; Malhotra and Alghuthaymi, 2022). Conversely, biosynthesis is advantageous due to its low-cost production, simplicity, and environmental safety (Kuppusamy et al., 2016).

In a previous study (Valan et al., 2022), copper oxide nanoparticles were biosynthesised by adding aqueous leaf extract of *Aquilaria malaccensis* into copper sulphate (CuSO4·5H2O). The nanoparticles' characteristics were evaluated by field emission scanning electron microscopy (FESEM), energy-dispersive X-ray spectroscopy (EDX), Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and transmission electron microscopy (TEM). FESEM and TEM analysis showed they were spherical with a 6 to 32 nm size range. The elemental composition of the nanoparticles was confirmed to be copper (Cu) and oxygen (O) using EDX analysis, with weight compositions of 55.5% and 21.0% and atomic percentages of 21.86% and 32.88%, respectively. FTIR confirms the functional group in the *Aquilaria malaccensis* leaf extract biomolecules responsible for forming CuONPs. In contrast, XRD confirmed the CuONPs primitive structure with an average crystallite size of 1.08 nm. The biosynthesised CuONPs were found to be potential as an antibacterial agent. They showed potent inhibition activity towards *Bacillus subtilis* as 20 µL and 40 µL of 70 µg/µL inhibits the bacteria with average inhibition zone measuring 24.43 ± 0.10 mm and 27.31 ± 0.13 mm, respectively.

Fusarium sp is a significant group within the family of Tubercullariaceae, and they commonly infect plants (Lahmar et al., 2017). These fungi are responsible for significant problems, such as plant wilting, due to their ability to spread on plant tissue and enter xylem vessels, impairing the water transport system (Yadeta and Thomma, 2013; Servin et al., 2015). The wilting of the host plant is also due to the production of various toxic substances by *Fusarium* species (Viet et al., 2016). Additionally, *Fusarium* is a well-known and devastating fungal disease that affects economically significant vegetables like potatoes and tomatoes (Chehri, 2016). Similarly, the *Aspergillus*

genus is also responsible for causing secondary rot in various plants due to the accumulation of mycotoxins (Perrone et al., 2007).
In a previous study by Viet et al. (2016), spherical copper nanoparticles (CuNPs) synthesised using a chemical reduction method with a size range of 20-50 nm were evaluated as an antifungal agent against *Fusarium sp.* The results indicated that CuNPs inhibited the fungal strain by 93.98%. Subsequently, CuNPs with a size range of 5-10 nm and spherical were synthesised using Cetyl Trimethyl Ammonium Bromide and isopropyl alcohol and evaluated for their antifungal activity against *Fusarium oxysporum* using the Kirby-Bauer disc diffusion method. The results showed that at a concentration of 20 µg, CuONPs inhibited the fungal strain with a zone of inhibition measuring 24 ± 0.5 mm (Kanhed et al., 2014). Additionally, green synthesised CuONPs using *Eichhornia crassipes* with a nanoparticle size measuring 28 ± 4 nm and spherical exhibited the highest zone of inhibition, measuring 21.26 ± 1 mm against *Fusarium culmorum* utilising a concentration of 100 $\mu g/mL^{-1}$ (Vanathi et al., 2016).

Similarly, CuONPs synthesised using *Stachys lavandulifolia* extract resulted in nanoparticles less than 80 nm in size and demonstrated a 90% inhibitory effect towards *Fusarium solani* at a concentration of 80 µg/mL (Khatami et al., 2019). These studies suggest that chemically and biosynthesised copper-based nanoparticles are potent antifungal agents against *Fusarium sp.* However, a side-by-side comparison is essential to study the efficiency of biosynthesised metal nanoparticles compared to chemically synthesised metal nanoparticles in inhibiting fungal strains. Furthermore, no studies have been conducted on the antifungal effects of Cu/CuONPs nanoparticles against the fungus *A. brasiliensis*.

Fusarium sp. and *A. brasiliensis* are phytopathogenic fungi that cause significant problems in agriculture. Hence, this study aimed to compare the inhibitory efficiency of *A. malaccensis* biosynthesised CuONPs and chemically fabricated commercial CuONPs as antifungal agents against these two fungi using the food poisoning method. The inhibitory effect was evaluated every two days intervals for four days. This study also provides important insights into the antifungal application of *A. malaccensis* biosynthesised CuONPs, which have not been previously reported.

MATERIALS AND METHODS

Collection and preparation of fungal strain

The fungal strains investigated in this study were *Fusarium sp.* and *Aspergillus brasiliensis* (ATCC 16404). *Fusarium sp.* was acquired from Dr Erneeza Binti Mohd Hata at the Faculty of Agriculture, University Putra, Malaysia. The culture was maintained at 4°C on potato dextrose agar (PDA) (HiMedia, India). *A. brasiliensis* was obtained from the Department of Applied Sciences collection at Nilai University. A subculturing method was employed, involving the excision of a piece of agar from the existing fungal culture using a sterile scalpel, then transferring it onto freshly prepared PDA. The plates were sealed and incubated at room temperature (26°C to 30°C) for 5 days for *Fusarium sp.* and 4 days for A. *brasiliensis*.

Preparation of treatments

Suspensions of biosynthesised CuONP and commercially obtained 30 – 50 nm chemically synthesised CuONP (Alfa Aesar, Massachusetts) were prepared separately with sterile distilled water at 300, 380, and 450 ppm. Homogenisation was performed for 20 minutes at 1000 rpm using a mechanical blender (Xinganbangle, China). Subsequently, PDA agar powder was incorporated into each suspension, and the mixtures were autoclaved at 121 °C/15 psi (Tomy, Japan) for 15 minutes. At the same time, the PDA solution was supplemented with 0.02g/mL of *A. malaccensis* leaf extract and autoclaved. The resulting autoclaved PDA treatments were poured into sterile plates and prepared for antifungal bioassays.

Antifungal bioassay

The antifungal bioassay method employed in this study was adapted from the protocols described in previous studies by Lipsa et al. (2020) and Wahyuni et al. (2021). PDA plates without any treatments served as the control, while *A. malaccensis* leaf extract was employed as the negative control. A 6 mm diameter disc of Fusarium sp. obtained from a 5-day-old actively growing culture was inoculated onto the PDA plate with different treatments to conduct the bioassay. Similarly, a 6 mm diameter disc of *A. brasiliensis* obtained from a 4-day-old actively growing culture was inoculated onto the PDA plate with different treatments. The fungal disc was placed at the centre of the PDA agar plates, followed by incubation at room temperature (26°C to 30°C) for 4 days. Fungal colony diameter was measured every 2 days until day 4.

Statistical analysis

The data obtained in this study were presented as means ± standard deviations (S.D.). Statistical analyses were conducted using analysis of variance (ANOVA), and significant differences between means were determined using Tukey's honest significant difference test at a significance level of P=0.05.

RESULTS AND DISCUSSION

Antifungal activity against Fusarium sp.

This study investigated the antifungal activity of biosynthesised CuONPs and chemical CuONPs against the plant pathogenic fungus *Fusarium sp*. using an *in vitro* antifungal assay. The inhibitory activity of the CuONPs was determined based on the radial growth of *Fusarium sp*. on the plates containing different treatments. Fungal growth diameters were recorded on days 2 (Fig. 1) and 4 (Fig. 2) after inoculation and compared with the control group.

On day 2 (Fig.3), the control plate without any treatment showed a mean diameter of 18.04 ± 0.07 mm for the *Fusarium sp* colony. The colony size was significantly reduced on plates containing different treatments. The diameter of the colony on the plate with *A. malaccensis* leaf extract was 17.04 ± 0.04 mm, while 300 ppm chemical CuONPs showed a diameter of 7.04 ± 0.14 mm. The plates treated with 380 and 450 ppm chemical CuONPs did not support any fungal growth. Furthermore, the growth diameter of the fungal colony on the plates treated with 300, 380, and 450 ppm biosynthesised CuONPs was 15.32 ± 0.10 mm, 14.08 ± 0.08 mm, and 13.12 ± 0.09 mm, respectively. The colony diameter on plates with different treatments was significantly lower compared to the control without any treatment.

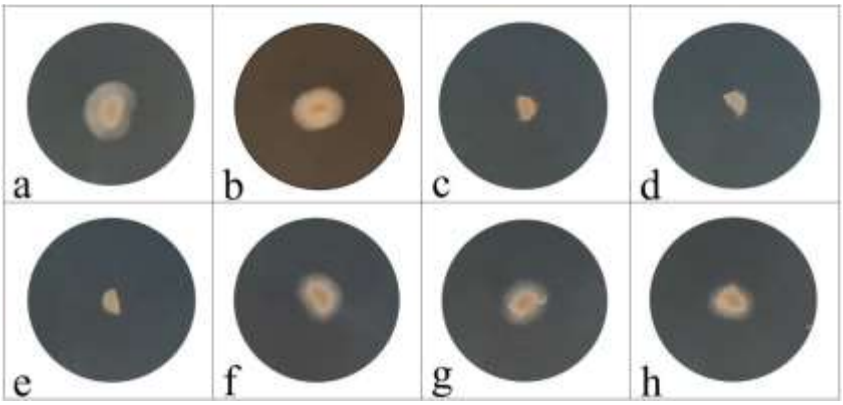

Figure 1. Antifungal activity of a) control, b) *A. malaccensis* leaf extract, c) 300 ppm chemical CuONPs, d) 380 ppm chemical CuONPs, e) 450 ppm chemical CuONPs, f) 300 ppm biosynthesised CuONPs, g) 380 ppm biosynthesised CuONPs, and h) 450 ppm biosynthesised CuONPs against *Fusarium sp* (Day 2)

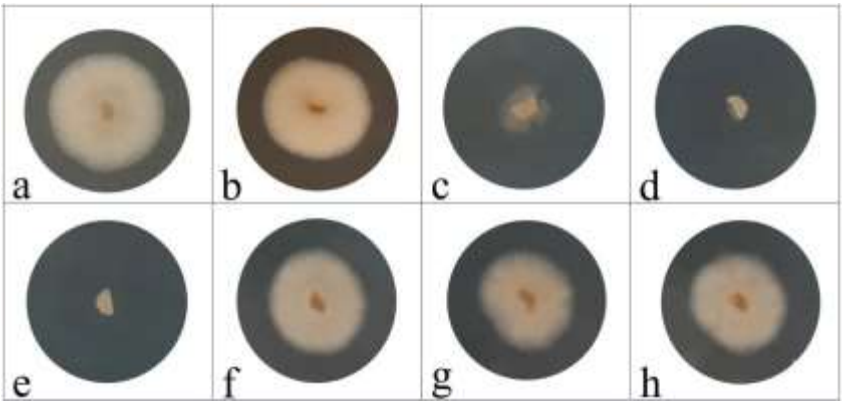

Figure 2. Antifungal activity of a) control, b) *A. malaccensis* leaf extract, c) 300 ppm chemical CuONPs, d) 380 ppm chemical CuONPs, e) 450 ppm chemical CuONPs, f) 300 ppm biosynthesised CuONPs, g) 380 ppm biosynthesised CuONPs, and h) 450 ppm biosynthesised CuONPs against *Fusarium sp* (Day 4)

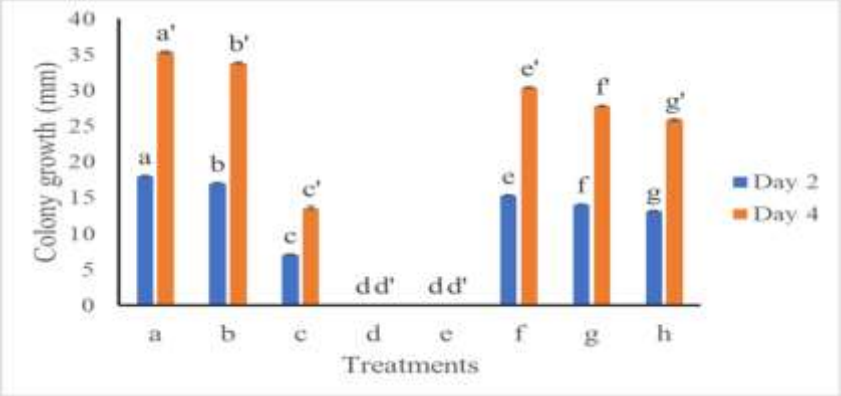

Figure 3. Antifungal activity of a) control, b) *A. malaccensis* leaf extract, c) 300 ppm chemical CuONPs, d) 380 ppm chemical CuONPs, e) 450 ppm chemical CuONPs, f) 300 ppm biosynthesised CuONPs, g) 380 ppm biosynthesised CuONPs, and h) 450 ppm biosynthesised CuONPs against *Fusarium sp*. Means with the same letter are not significantly different at $p<0.05$

On Day 4 (Fig. 3), the growth of the *Fusarium sp.* colony on the untreated control plate was observed, and the mean diameter was recorded as 35.36 ± 0.15 mm. The colony diameter on the plate treated with *A. malaccensis* leaf extract was 33.84 ± 0.15 mm. However, the plate treated with 300 ppm chemical CuONPs exhibited a smaller colony diameter of 13.56 ± 0.24 mm. As observed on day 2, plates containing 380 and 450 ppm chemical CuONPs did not reveal any fungal growth. Furthermore, the growth diameter of the fungal colony on the plates containing 300, 380, and 450 ppm biosynthesised CuONPs was recorded as 30.40 ± 0.13 mm, 27.80 ± 0.14 mm, and 25.88 ± 0.15 mm, respectively. On day 2, it was observed that the colony diameter on the plates with different treatments was significantly lower compared to the control without any treatment. Based on the results obtained, it can be concluded that a concentration higher than 450 ppm of CuONPs is needed to inhibit the growth of the fungus completely.

The concentration of nanoparticles is a critical factor that affects their efficacy in inducing oxidative stress and reactive oxygen species (ROS) production. As the concentration of nanoparticles increases, the availability of these particles also increases, leading to a higher potential for inducing oxidative stress and ROS (Raffi et al., 2010). Moreover, it has been reported that at high concentrations, CuNPs can release more Cu^{2+} ions, penetrating the fungal cell and causing cell death. Additionally, the incubation duration also plays a crucial role in determining the antifungal activity of nanoparticles. Longer incubation times provide more opportunities for the nanoparticles to release ions, which can subsequently inhibit fungal growth. Therefore, it is essential to consider both the concentration and incubation time when assessing the antifungal potential of nanoparticles.

A. malaccensis was found to have minimal antifungal properties, potentially due to certain biocompounds in the leaf extract that inhibit the colony growth of *Fusarium sp. Aquilaria* spp, such as *Aquilaria crassna* essential oil, has moderate antifungal properties, although higher dosages are required to function similarly to conventional drugs (Dahham et al., 2014; Jok et al., 2015). Additionally, linoleic and hexadecenoic acids found in the essential oil of *A. malaccensis* possess antifungal properties against certain pathogenic fungi in plants (Abubacker and Deepalakshmi, 2013). The growth inhibition of *Fusarium sp*. colony growth found on the plate containing *A. malaccensis* leaf extract indicates that the extract exhibits antifungal properties, albeit with lower efficacy than biosynthesised CuONPs using the same extract. From this observation, the *A. malaccensis* leaf extract may only help to reduce and stabilise metal ions. *A. malaccensis* leaf extract's antifungal effect is likely due to linoleic and hexadecenoic acid. In contrast, CuONPs have a potent antifungal mechanism due to their ability to induce ROS, penetrate the cell membrane, and interfere with the metabolic pathway of fungi. The bioactive compound from the leaf extract may be present in trace amounts on the surface of the nanoparticles produced, potentially enhancing the antifungal effect of CuONPs.

The high toxicity levels of chemical CuONPs against *Fusarium sp.* compared to biosynthesised CuONPs may be attributed to the chemical synthesis method and the nanoparticle size, typically 30 to 50 nm. In contrast, the lower antifungal activity of biosynthesised CuONPs against *Fusarium sp.* indicates that they are less toxic than chemical CuONPs. However, the antifungal activity of synthesised CuONPs may vary depending on the synthesis route used. The surface modification of synthesised nanoparticles with surfactants or metal salt can alter the surface chemistry of the nanoparticles, potentially influencing their antifungal properties (Alghuthaymi et al., 2015; Cruz-Luna et al., 2021).

Al-Rajhi et al. (2022) conducted a study showing that the sporulation percentage decreased as the concentration of CuONPs increased. The researchers used the spore counting technique and microscopic analysis to analyse this observation. Similarly, Pariona et al. (2019) reported that CuNPs, synthesised with sodium citrate tribasic dihydrate and sized between 200 to 500 nm, changed the colour, morphology, texture, density, and form of *Fusarium solani*, *Neofusicoccum sp*, and *Fusarium oxysporum*. The CuNPs caused significant alterations in the cell organelles and hyphae of *Fusarium solani* and *Fusarium oxysporum.* The toxicity of CuONPs causes oxidative stress, leading to disturbances in enzymes and metabolic pathways (Al-Rajhi et al., 2022).

Furthermore, Ashraf et al. (2021) reported that CuONPs induced ROS on the cell wall surface, causing destruction. Therefore, biosynthesised CuONPs exhibit antifungal properties on *Fusarium sp*. However, ultimately inhibiting the growth of the fungus requires a concentration of CuONPs higher than 450 ppm. It is important to note that increasing the concentration of nanoparticles also increases the availability of these particles to induce oxidative stress and ROS.

Antifungal activity against Aspergillus brasiliensis.

The antifungal effect of biosynthesised CuONPs and chemical CuONPs against the plant pathogenic fungus *Aspergillus brasiliensis*, using a similar method to *Fusarium sp.*, was also investigated. Similarly, fungal growth diameters were recorded on day 2 (Fig. 4) and day 4 (Fig. 5) after inoculation and compared with the control group. On the second day of the experiment (Fig. 6), the mean diameter of the *A. brasiliensis* colony on the untreated control plate was 18.48 ± 0.10 mm. In contrast, the growth of the *A. brasiliensis* colony was inhibited on plates containing the various treatments. Specifically, the growth diameter of the colony on the plate containing *A. malaccensis* leaf extract was 17.56 ± 0.10 mm. 300, 380, and 450 ppm chemical CuONPs, the diameters of the colonies were 14.20 ± 0.08 mm, 13.96 ± 0.04 mm, and 13.48 ± 0.10 mm, respectively. Furthermore, 300, 380, and 450 ppm biosynthesised CuONPs exhibited diameters of 14.00 ± 0.00 mm, 13.76 ± 0.09 mm, and 13.12 ± 0.07 mm, respectively. Statistical analysis revealed insignificant colony diameter on Day 2 on plates containing 380 ppm chemical CuONPs and 300 ppm biosynthesised CuONPs. Plates with 450 ppm biosynthesised CuONPs showed the lowest colony diameter (13.12 ± 0.07 mm) of *A. brasiliensis.*

On day 4 of the experiment (Fig. 6), the mean diameter of the *A. brasiliensis* colony on the untreated control plate was 36.52 ± 0.12 mm. The colony diameter on the plate containing A. malaccensis leaf extract was 34.56 ± 0.10 mm. Meanwhile, for 300, 380, and 450 ppm chemical CuONPs, the diameters of the growing colonies were 28.20 ± 0.08 mm, 27.36 ± 0.11 mm, and 26.24 ± 0.17 mm, respectively. Finally, 300, 380, and 450 ppm biosynthesised CuONPs exhibited diameters of 27.92 ± 0.05 mm, 27.08 ± 0.15 mm, and 26.12 ± 0.12 mm, respectively.

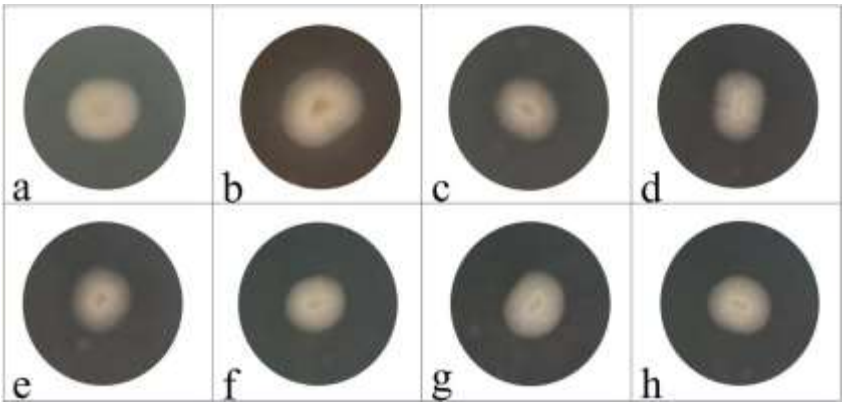

Figure 4. Antifungal activity of a) control, b) *A. malaccensis* leaf extract, c) 300 ppm chemical CuONPs, d) 380 ppm chemical CuONPs, e) 450 ppm chemical CuONPs, f) 300 ppm biosynthesised CuONPs, g) 380 ppm biosynthesised CuONPs, and h) 450 ppm biosynthesised CuONPs against *A. brasiliensis* (Day 2)

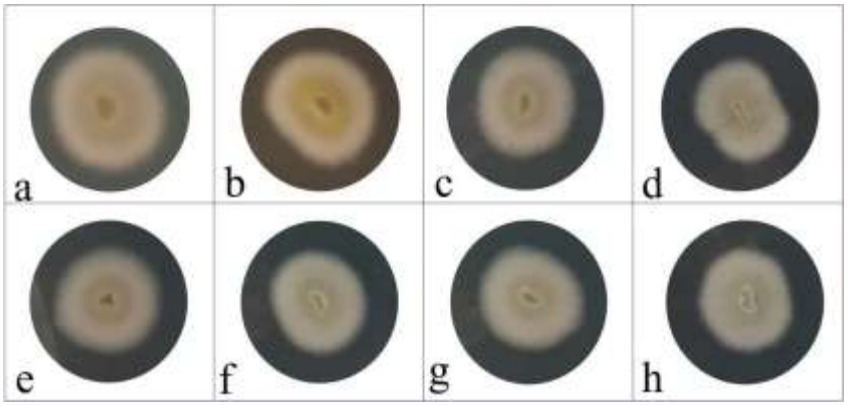

Figure 5. Antifungal activity of a) control, b) *A. malaccensis* leaf extract, c) 300 ppm chemical CuONPs, d) 380 ppm chemical CuONPs, e) 450 ppm chemical CuONPs, f) 300 ppm biosynthesised CuONPs, g) 380 ppm biosynthesised CuONPs, and h) 450 ppm biosynthesised CuONPs against *A. brasiliensis* (Day 4)

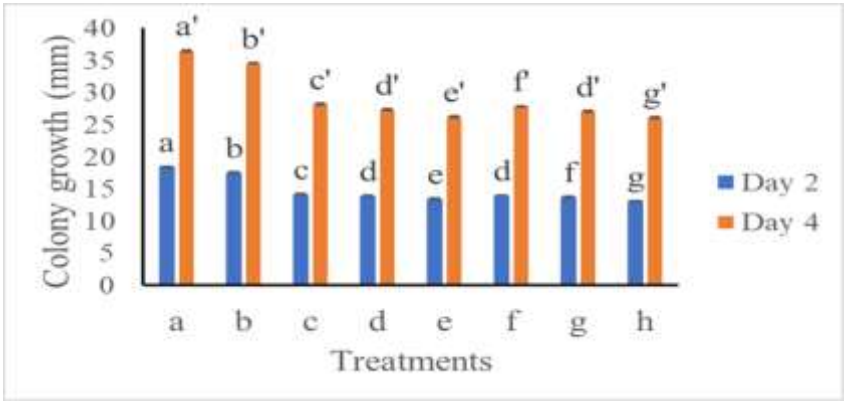

Figure 6. Antifungal activity of a) control, b) *A. malaccensis* leaf extract, c) 300 ppm chemical CuONPs, d) 380 ppm chemical CuONPs, e) 450 ppm chemical CuONPs, f) 300 ppm biosynthesised CuONPs, g) 380 ppm biosynthesised CuONPs, and h) 450 ppm biosynthesised CuONPs against *A. brasiliensis*. Means with the same letter are not significantly different at $p<0.05$

The study's results indicated that the diameter of the fungal colony on 300 ppm chemical CuONPs was significantly higher than on 300 ppm biosynthesised CuONPs. The results suggest that biosynthesised CuONPs at 300 ppm exhibit better antifungal activity than chemical CuONPs. Furthermore, the antifungal effect of chemical CuONPs and biosynthesised CuONPs at 380 ppm were insignificant. Additionally, at 450 ppm, the CuONPs synthesised by either method were found to be negligible. The similar effects of CuONPs of different sizes of nanoparticles and methods of synthesis cannot be explained.

The study revealed that *A. malaccensis* has an antifungal effect on *A. brasiliensis*, which may be attributed to linoleic and hexadecenoic acid in the leaf extract responsible for the antifungal effect. Furthermore, Chen et al. (2014) reported that cucurbitacin (I), present in the shoot and callus of *A. malaccensis*, possesses antifungal activity. However, it was observed that biosynthesised CuONPs using *A. malaccensis* leaf extract exhibited a higher antifungal effect than *A. malaccensis* leaf extract alone.

Previous studies have reported that copper nanoparticles are commonly spherical and have a remarkable effect on many fungi due to their ability to quickly penetrate the cell membrane and initiate cellular inhibition by accessing cellular enzymes (Ouda, 2014; Bramhanwade et al., 2016). The concentration of CuNPs also plays a crucial role in the mortality rate of fungi by distorting the mycelium and inducing high levels of oxidative stress (Hermida-Montero et al., 2019). CuNPs at a concentration of 1000 ppm have been found to inhibit different phytopathogens, such as *Botrytis cinerea*, *Alternaria alternata*, *Monilinia fructicola*, *Colletotrichum gloeosporioides*, *Fusarium solani*, *Fusarium oxysporum*, and *Verticillium dahliae* (Malandrakis et al., 2019). CuNPs have an antifungal effect that can inhibit plant-based pathogens intracellularly and extracellularly (Cruz-Luna et al., 2021). The inhibitory effect is size-dependent, as it is easier for small nanoparticles to enter cells and release ions that affect intracellular organelles compared to larger nanoparticles that have difficulty penetrating the cell membrane. The mechanism of copper-based nanoparticles against fungus is that CuNPs release ions that damage certain groups of proteins essential for the membrane and reduce the membrane permeability (Huerta-Garcia et al., 2014; Mikhailova, 2020). The ions also alter the electron transport channels, oxidise the proteins, induce ROS that causes high levels of gene

transcription, interfere with many metabolic pathways, and destroy DNA (Kumari et al., 2017; Zhao et al., 2018; Rana et al., 2020). This study has shown that biosynthesised CuONPs can inhibit phytopathogenic fungi such as *A. brasiliensis*.

The inhibitory effect of biosynthesised CuONPs on the growth of *A. brasiliensis* was evident from the significant decrease in mean colony diameter compared to the control plate. Similarly, the colony diameter of the *Fusarium sp* was significantly reduced in the presence of biosynthesised CuONPs compared to the untreated control plate. These findings suggest that biosynthesised CuONPs have the potential to inhibit the growth of various phytopathogenic fungi, including *A. brasiliensis* and *Fusarium sp*. The CuONPs could be used as an alternative to chemical CuONPs for plant disease management.

CONCLUSION

In this study, the comparison of the antifungal properties of biosynthesised CuONPs and chemical CuONPs was successfully investigated. Results showed that green-synthesised CuONPs exhibited an inhibitory effect towards *Fusarium sp.* and *A. brasiliensis* but with a lower antifungal effect on *Fusarium sp.* compared to chemical CuONPs. However, biosynthesised and chemical CuONPs had a similar inhibitory effect on *A. brasiliensis*. The underlying reason for this similarity needed to be clarified. The *A. malaccensis* leaf extract used as a negative control showed antifungal activity due to active biocompounds, but no antibacterial activity was observed. Overall, it was found that biosynthesised CuONPs are less potent antimicrobial agents than chemical CuONPs. However, biosynthesised CuONPs are less costly, less toxic and more environmentally friendly than chemically synthesised CuONPs.

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092-081

EVALUATION OF MULTIPLE WELL SYSTEM IN SHALLOW AQUIFERS FOR PADDY IRRIGATION

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ABSTRACT

Groundwater from the first layer of the shallow aquifer is important to develop a sustainable water resources supply for paddy irrigation, especially in an area which is vulnerable to climate change and lack of surface water sources and facilities. The volume of groundwater is significant data to estimate the coverage area on paddy plantations and future development. Utilizing groundwater for irrigation can be an alternative to maximize grain production. Instead of reduction of risk due to climate, with sustainable water sources, farmers will increase production to maximize their income since the era of pandemics and disasters which impact food security. The yield of groundwater can be a reference to farmers for crop growth decision-making. Discharge of groundwater is depending on the subsurface characteristic and lithology at the specific area.

Keywords: Groundwater, Tubewell, multiple well systems, shallow aquifers

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THE EFFECT OF DROUGHT STRESS AT THE FLOWERING STAGE ON MORPHOLOGY, PHYSIOLOGY AND YIELD OF MALAYSIA RICE

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ABSTRACT

The selection of drought-tolerant rice varieties in Malaysia has limitations because of the less availability of climate-ready rice varieties and there is less utilization of genetic resources in Malaysia rice germplasms that were readily available in the gene bank. To screen and identify climate-ready rice varieties, this experiment was conducted in Glasshouse Unit, Fakulti Pertanian, UPM for two planting seasons to allow an appropriate setting for the imposition of drought stress conditions. A Split Plot Design with three replications was used and the main plot is the water stress treatment consisting of T1: Drought and T2: Control conditions. For T1:drought stress, all plants were irrigated until 65 days after planting and drought stress was imposed during the reproductive stage (panicle initiation stage) for 21 days until the rice leaves were tightly rolled and showed tip damage then reirrigated for recovery, and for T2:control, the plants were irrigated every two days. The subplot is the rice genotypes (G) consisting of 21 rice genotypes comprising traditional Malaysia's Oryza sativa lines including checks from MARDI. The physiological data was measured two times during the peak drought conditions on day 86 and the recovery conditions on day 93 by using LICOR-6400. The chlorophyll content was measured during the drought stress at day 79 by using a SPAD meter. Among the studied traits, it was measured that for morphological traits, there is a significant difference between varieties with reduced leaf length, number of tillers, panicle length, and dry biomass but there is a significant difference between varieties and treatments for plant height as the plants in drought treatments were recorded higher. For physiological traits, the plants exposed to drought have lower photosynthetic rates, and stomatal conductance but higher chlorophyll content. In the yield component traits, accessions exposed to drought reduced the number of grains per panicle, 1000-grain weight, and harvest index. Thus, drought stress at the flowering stage can have significant effects on the morphology, physiology, and yield of rice plants in Malaysia. The evaluation of selected rice genotypes to acquire variety-specific rice morphological and physiological characteristics is a sustainable approach for identifying the climate-ready rice varieties for the development of drought-tolerant rice in Malaysia.

Keywords: Rice, Drought Tolerance, Morphology, Physiology, Yield Component

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ACID AND ALKALI TREATMENT ON NATURAL FIBERS FOR BETTER TENSILE STRENGTH OF EPOXY COMPOSITES

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ABSTRACT

Natural fiber which known are from agricultural waste, fruit skin, stalks, and so on is considered recyclable also creating great demand as they come at a very low cost, is biodegradable, and has low density. However, natural fibers are hydrophilic in nature, so it tends to absorb water. Chemical treatments can usually overcome this problem. Usually, acid and alkali treatments are very popular among researchers. In this study, we focused on seeing the differences in the natural treatment of acidic and alkaline using citric acid (vinegar) and sodium bicarbonate (soda) of certain three types of selected fibers. The 24 hrs treatments were studied on coconut coir, banana stem fiber, sugarcane bagasse, and corn stalk fiber. All the fibers acted as fillers in epoxy composites. The tensile strength has been investigated and compared between untreated and treated as well. All fibers were observed highest tensile strength after being treated with alkali compared to acid. Treatment with alkali is more suitable for natural fiber in order to clean the fiber surface, thus helping to get better fiber-matrix interaction. These are the reason for the highest tensile strength.

Keywords: Natural fiber, acid treatment, alkali treatment, tensile strength

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CURING TECHNIQUE AFFECTS PHYSICOCHEMICAL CHANGES OF SHALLOT

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ABSTRACT

The curing technique is the first postharvest handling process that is carried out after the shallots are harvested. Curing is a drying process intended to dry off the necks and outer scale leaves of the bulbs to prevent the loss of moisture. The drying process may take 7-10 days. Good quality shallot had around 80-84% of moisture content of bulbs after curing occurs. The optimum curing process is expected to improve the shallot's storage to extend its shelf life of shallots. Therefore, the purpose of this research was to evaluate the effects of curing techniques on shallot quality. The result showed that the in-door drying treatments with temperatures 30-32°C and 65-70% RH gave the best quality than other treatments. The in-door drying process is three days faster compared to the direct sun-drying and in-door ambient drying conditions (28±1°C and 65-70% RH). There were drastic decreases in moisture content from 84.0% to 82.0% in three days of drying that had been the optimum moisture content in shallot, respectively. It could minimize damage and weight loss, maintaining hardness and colour until 16 weeks of storage and is significantly better than direct sun-drying treatment.

Keywords: conventional curing, mechanical curing, postharvest quality, moisture content

102-089

MECHANIZATION SYSTEM PACKAGE FOR GRAIN CORN CULTIVATION IN MALAYSIA

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ABSTRACT

Around 50 to 60 percent of the ingredients used to create animal feed are made of grain corn. Based on the present production of 5.8 tonnes of grain corn for one hectare of farmland in Malaysia, 4.01 million tonnes of animal feed worth RM6.15 billion were imported into the nation in 2020, with two million tonnes of grain corn contributing for the other half of that figure. Malaysia is seeking to decrease its reliance on imports by 30% by producing 600,000 tonnes of grain corn for livestock feed over the next ten years. Land preparation, planting, crop care, irrigation, and harvesting are the five key mechanised processes used in the production of grain corn. Mechanization is crucial for ensuring the sustainability and increasing the productivity of grain corn production, particularly on a large scale. Plantation operations become more productive through mechanisation, involving fewer labour, and increasing uptime. When grain corn production is mechanised, the various machines should be chosen in accordance with their suitability and the planting site's conditions. Mechanized planting techniques require a 1.5 ha/hour work rate. With a work rate of 3.5 ha/h, the work efficiency for spraying using machinery is between 50 and 70 percent. Although the work rate for fertilization with mechanised equipment is 1.0 ha/h with a work efficiency ranging from 70% to 80% according to the condition of the soil surface and the farm's layout.

Keywords: Grain corn, mechanization, planting, spraying, work rate, work efficiency.

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095-090

SOLAR POWERED WIRELESS ROUTER – DESIGN AND DEVELOPMENT FOR AGRICULTRE USE

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ABSTRACT

Agriculture cultivation area usually located in the rural, out of power grid and lack of internet network infrastructure especially in the developing countries. These are major obtascle for farmers to utilize IoT technology as it has the potential to revolutionize the industry by enabling farmers to make data-driven decisions that optimize crop yields, reduce waste, and improve sustainability. Generally, the development of off the grid wireless network technology have been a focus and developed by network provider in the world, however it is not available and accessable by the small farmers especially in Malaysia. This work presents the design and development of solar powered wireless router for agriculture use with a low development cost and affordable for small farmers. LTE 4G router with a sim card slot is used as main internet source for the system. An outdoor CPE device been setup to extend and provide wireless access point node for all the IoT device in the field for a better coverage area in the field.

Keywords: Agriculture, solar, wireless, internet of things

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067-091

RESTRUCTURING AGRO-WASTE THROUGH NANOTECHNOLOGY

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ABSTRACT

The disposal of agricultural waste poses adverse effects on ecosystems due to the indiscriminate dumping of agricultural waste into waterways and landfill. When not used productively, this waste becomes a health and environmental hazard. Untreated waste releases toxic fumes that increase greenhouse gas emissions, which in turn exacerbate climate change. It is currently estimated that about 21–37% of greenhouse gases are produced by the agricultural sector. This new reality has provoked concerns in recent years that call for substantial shifts in conventional agricultural methods and to consider waste re-utilization. It is therefore clear that significant interventions are required for the proper management of agro-waste. Agro-waste can be restructured to generate sustainable energy and create value-added bioproducts. The promising relevance of agro-residues has resulted in the generation of novel bioproducts which are produced through valorization techniques. The accumulation of toxic residues from fertilizers and pesticides due to intensive agriculture could be reduced by using nanoagrochemicals in the form of nanofertilizers and nanopesticides as alternatives that are more target-specific and which cause minimal environmental discharge. Diverse nanoparticles have also been engineered to adsorb and remove pollutants discharged from agricultural sites through nanobioremediation. This review discusses the comprehensive potential of nanotechnology to manage and restructure agricultural waste.

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052-092

DEVELOPMENT OF YEAST BREAD USING NATURAL PIGMENTS

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ABSTRACT

Due to high demand for natural products by health-conscious consumers, natural food colorants are gaining popularity and interest in food and beverage sectors. Beetroot (*Beta vulgaris*) is a good source of folate and potent antioxidant betalain pigments, while green tea is rich in polyphenols catechin. In this study, beetroot juice and green tea were used as natural pigments in the development of a watermelon look-alike bread. Other ingredients include flour, sugar, unsalted butter, egg, milk, yeast, and raisin. The dough was subjected to proofing (70 mins, room temperature) before baking at 180^{o}C for 25 mins. Sensory qualities of the bread were evaluated by 50 untrained panelists using a 9-point hedonic scale. Proximate analysis, color (L*, a*, b*), textural properties, and antioxidant assay were determined. The overall acceptability score for the bread was 7.48 out of 9 with an acceptance index of 83%. The mean scores for various sensory attributes were: aroma (6.62), taste (7.16), color (6.48) and texture (7.14). The bread contains 46.50% carbohydrate, 13.43% protein and 5.34% fat, 1.53% ashes, and 1.50% crude fiber. With 13.43% protein content, the functional bread met the criteria for "high protein" nutritional claim. The colour profile of the inner part of the bread: L*=51.56±2.79, a*=24.41±3.77, b*=21.20±3.15 and the outer part of the bread: L*=52.56±4.11, a*=-19.28±1.39, b*=35.42±1.55. The radical scavenging capacity DPPH was 18.19%, and total phenolic content was1.22 mg GAE/g. In summary, a watermelon look-alike yeast bread with good sensorial quality and high protein content was developed. The product provides a healthy bread alternative for consumers.

Keywords: Beetroot, green tea, natural pigments, antioxidant activity, functional food.

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104-096

ARTIFICIAL INTELLIGENCE VIRTUAL MOUSE USING HAND GESTURES AND FINGERTIPS DETECTION

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ABSTRACT

The increasing role of Human-Computer Interaction (HCI) in various real-life applications such as medical, academic, entertainment as well as in agriculture, provides possibilities for the development of virtual devices. In recent years there has been growing interest in developing virtual mouse that uses hand gestures and fingertip movements to provide a more intuitive user interface. Prevailing studies noted that the existing virtual mouse systems using hand gestures are capable of identifying a several hand gestures and fingertips in various light conditions and translate them into corresponding cursor movements and actions. However, they are unable to recognize fast hand gestures or fingertips movements due to the high framerates, leading to an increase in error rates. Additionally, mouse click events that occur when the finger is held in a specific location cause the user to make constant finger movements to avoid false alarms. Thus, this project proposed an artificial intelligence virtual mouse that relies on a combination of computer vision techniques and machine learning algorithms to detect and interpret user hand gestures and fingertip movements. The system captures a video stream of the user's hand and fingers using a camera and applies image processing algorithms to identify and track their position, orientation, and movement. The system then maps these movements to corresponding cursor movements and actions. The proposed system demonstrates an accuracy of over 96%. It has the potential to be useful specially for those who require a more efficient and convenient input method for their computing tasks.

Keywords: Human Computer Interaction, virtual mouse, hand gestures and fingertip movements, computer vision, machine learning.

111-097

THE IMPACT OF HIGH TEMPERATURE AND DROUGHT ON PHOTOSYNTHESIS RATE AND STIGMA CONDITION DURING ANTHESIS STAGE USING RICE (*Oryza sativa* MR253) AS A MODEL PLANT

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ABSTRACT

Rice is one of the most important crops in the world, after wheat and corn. This plant is consumed by over 7 billion people worldwide. Until now, rice has dominated the Asian continent because it is a plant that does best in warm and humid climates. The rice industry began to feel the effects of El~Nino after its occurrences in 1997–1998 and 2014–2016 because of prolonged hot and dry conditions. The flowering stage is the most crucial stage for determining rice yield. High temperature and water stress or drought may have an effect on rice flowering. It will indirectly affect the yield of rice production. This research seeks to ascertain how abiotic stress, such as intense water stress and high temperature affects rice plant flowering. For this study, the MR 253 variety was used. Plants were subjected to water stress (WS), a high temperature (HT) of 38 °C and a normal (C) temperature 27-34 °C as treatments and controls. The study was conducted under a rain shelter using plant containers and a simulation chamber. The water in the container of WS container was drained out 14 days before flowering to create drought conditions until temporary wilting. The high-temperature simulation was controlled over three days, from 1000h to 1400h with 70% humidity and CO_2 at 400ppm, in a phytotron chamber. The results of this observation demonstrated that dry conditions and 3 consecutive days of high temperatures were sufficient to interfere with rice's flowering process, resulting in burned-dry stigma and low photosynthesis rate. Observations revealed that the HT and WS that occurred during the rice flowering phase resulted in a 2.0 to 3.5 t/ha decrease in yield compared to the average national yield (4.5 t/ha).

Keyword: flowering, high temperature, photosynthesis, water stress, rice, stigma

100-099

ANTIMIRCOBIAL PROPERTIES OF GREEN SYNTHESISED METAL NANOPARTICLES

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ABSTRACT

Metallic nanoparticles are gaining popularity due to their application potential in various industries. The emphasis on potential antibacterial applications of nanoparticles originates from the emergence of resistance in many deadly infections to conventional antiseptics and drugs. While many processes exist to generate metallic nanoparticles, the biological synthesis using plant sources are sustainable, cost-effective, and environmentally friendly. This paper summarises the use of various plant-based materials for nanoparticle production, the antibacterial properties of metal nanoparticles, and their prospective applications. The production of metal nanoparticles using extracts and solutions derived from various plant species is described. Additionally, this paper examines the factors affecting the synthesis of nanometal oxides from a diversity of green resources, and also their uses. Since biosynthesized nanoparticles have been shown to have antimicrobial, antifungal, and even antiviral capabilities, they are extensively studied, with silver, zinc and copper nanoparticles being the most investigated and having the greatest promise for therapeutic applications. Other sectors in which biosynthesized nanoparticles can be used are also mentioned, such as wastewater treatment and UV protection. This review sheds lights on the current trends in metallic nanoparticle synthesis and applications for the growing research community.

Keywords: *leaf extracts, fruits, metal oxide nanoparticles, antimicrobial agent*

106-100

DMAIC-BASED LEAN MAINTENANCE FRAMEWORK TOWARDS A SUSTAINABLE PALM OIL MILL OPERATION

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ABSTRACT

Sustainable manufacturing practices stand as a pragmatic approach transforming palm oil mill operation into a more efficient and cleaner production, reducing potential risks on the environment while increase growth and global competitive advantage. Substantial benefits of implementation sustainability practices not only perceived in environment conservation, but also financial profits and social welfare. In this transformation, the efficiency of the production system is directly related to the equipment performance. The adoption of lean maintenance performs analysis of root cause failure, failed part, maintenance procedure effectiveness, predictive maintenance, condition monitoring results providing appropriate conservation strategy as well as appropriate methods and tools to support the decision-making process in this area. It emphasis on the elimination maintenance related wastes and non-value added activities including unexpected failures and unnecessary maintenance that generate significant impact on costs and production losses. It is essential to improve the operation efficiency of palm oil mills to attain the rising customers demand worldwide. Define, Measure, Analyse, Improve, and Control (DMAIC) as a six-sigma tools offers proven quality tools to achieve breakthrough performance. Therefore, this study aims to develop a systematic lean maintenance framework based on DMAIC specific to the palm oil production. The framework not only suggests the selection of appropriate maintenance strategy, but also the use of appropriate tools to support the decision making process and allows continuous improvement for the sustainability of palm oil mill operation. This framework enables engineers to define, measure and analyse failures of production. It also assists engineers in implementing proactive actions and continuous improvement.

Keywords: Sustainability, Palm Oil Production, Lean Maintenance, DMAIC, Six-Sigma

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113-101

AN EXPLORATION OF ALTERNATIVE FEEDS FOR *MYOPOPONE CASTANEA* ANTS (HYMENOPTERA: FORMICIDAE) WITH VARIOUS INSECTS SPECIES IN THE LABORATORY

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ABSTRACT

The abundance of organic matter in the rejuvenation area of oil palm causes it to increase pest population of O. rhinoceros making it increasingly difficult to control. Insecticide use continuously make pests resistant and leave residues in the environment. Wrong One way to control this pest can be done by using predatory insects such as M. castanea ants are capable of consuming 2.8 - 3 O. rhinoceros larvae in 5 days. Control by using ants has not been fully implemented because lack of large numbers of colonies requiring mass rearing. This technique constrained by the difficulty of continuous feeding in large quantities. Alternative solution the mass propagation of these ants is by using cheap and easy-to-obtain feed. The aim of the study was to find out alternative feeds for M. castanea ants which are larval predators of O. rhinoceros. Held in October to December 2020 at Laboratory of Plant Pests, Faculty of Agriculture, University of North Sumatra with altitude ± 25 m asl. Using a completely randomized design (CRD) with 5 treatments and 4 replications adopted. The power consumption results show that Omphisa fucidentalis larvae are potential alternative feed for the propagation of predatory ants M. castanea. This is because the consumption power reaches 8 tails and is always the highest starting from the 1st week to the 1st week the 10th, and able to produce 109 and 98 new tillers respectively in the first and second replicates

Keywords: *alternative feed, R. ferrugineus, O. fuscidentalis, H. illucens*

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088-102

EVALUATING THE IMPACTS OF CLIMATE CHANGE ON THE COASTAL REGIONS OF BANGLADESH FROM SOCIETAL AND ECONOMIC PERSPECTIVES

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ABSTRACT

In the data collection process, both the quantitative and even qualitative methods agave been used here. The research is even based on an "inductive research approach", and even the "positivism research philosophy" has been taken here. Data analysis is even done through Readsh, Metabaase, and even Lokker. In the literature review section, the overview of the impact of climate change on the coastal areas of Bangladesh is evaluated by identifying the problems or risk factors for these natural disasters in the coastal regions. The anthropogenic and geographic processes are mainly responsible for the increment of the sea level. According to the IPCC report, one-fifth of the population lives in the coastal region of Bangladesh. The research area of the study depicts the hazards related to environmental changes in the coastal region of Bangladesh. The research zone covers Physiographic factors that affect climate change such as water logging, low elevation in the coastal regions, increase salinity, and rise of sea level.

Keywords: Bangladesh, Coastal Regions, Socio-Economic Conditions, climate change, Inflation

015-103

EFFECT OF HEAT GENERATED BY AIR-CONDITIONING COMPRESSOR TOWARDS THE SURROUNDING ENVIRONMENT: A CASE STUDY USING GREEN LEAVES PLANTS

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ABSTRACT

Hot-air generation complicates the energy efficiency. The heat energy can affect thermal heating emission reduction efforts in buildings. In this study, the effects of heat generated from air-conditioning compressor on various physical properties of green leaves plants were investigated. Three different type of green leaves crops were selected which were *Brassica rapa subsp. chinensis, Brassica oleracea var. alboglabra and Ocimum basilicum*. These crops were cultivated in two separate greenhouses receiving exhaust from two different compressors in 8 hours/day for a duration of 55 days. The evaluation factors included seed germination rate (%), crops survival rate (%), plants height, number of leaves and dimension of leaves. The result showed that the increase of heat capacity release from the air-conditioning compressor will decrease the growth rate of green plants significantly. This work aims to provide insights to the public of the effect of heat generated from air-conditioning compressor as thermal heat.

Keywords: Air-conditioning compressor, Heat stress, Plants growth; Thermal heat.

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052-105

DEVELOPMENT OF STEAMED CAKE USING RED WINE DREG AS A NATURAL COLORANT

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ABSTRACT

Red yeast rice is a fermented rice that acquires its red color from being cultivated with the yeast *Monascus purpureus*. It is widely used to produce various fermented foods in China, Japan, and East Asia. Red yeast rice has been reported to lower cholesterol, improve digestion, and possess antioxidant activity. Red yeast rice is a main ingredient in Foochow red wine. This study aimed to develop steamed cake by using Foochow red wine dreg as a natural food colorant. The steamed cake was prepared by mixing self-rising flour, sugar, raisins, water, and red wine dreg extract, and then steamed at high heat for 20 mins. The sensory qualities of the steamed cake were evaluated by 50 untrained panelists using a 7-point hedonic scale. The physicochemical properties and antioxidant activity of the product were determined. The overall acceptability score for the steamed cake was 5.80 out of 7 with an acceptance index of 83%. The mean scores for various sensory attributes were: color (5.56), aroma (5.52), taste (5.72), and texture (5.26). The color profile of the steamed cake: L*=64.10±0.34, a*=11.46±0.37, b*=21.94±0.68. The radical scavenging capacity DPPH was 53.47% with total phenolic content of 2.35 mg GAE/g, and total flavonoid content of 1.70 mg CE/g. The steamed cake contained 12.55% sugar and alcohol was not detectable. Red wine dreg provides an attractive color to the cake. In summary, a healthier steamed cake with acceptable sensory quality and enhanced antioxidant activity was developed.

Keywords: Red yeast rice, red wine dreg, steamed cake, natural colorant.

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117-106

AUTOMATIC PADDY LEAF DISEASES RECOGNITION USING IMAGE PROCESSING

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ABSTRACT

Rice is a staple food in Malaysia. By planting rice leaves, farmers can produce rice crops that can help feed the growing population and ensure food security. In addition, the cultivation of paddy leaves is important to support the population by providing economic development, nutrition, environmental sustainability, and also preserving cultural practices. Total rice production in Malaysia in 2021 amounted to approximately 2.43 million metric tons, an increase compared to approximately 2.34 million metric tons in the previous year. However, current studies and statistics indicate the impact of plant diseases exacerbates the challenge of increasing rice yields and the current food supply deficit. In addition, rice crops are often grown in large fields, making it difficult and time-consuming to manually inspect each plant for signs of disease and requiring plant disease expertise. This highlights the need for an automated and efficient method to detect paddy leaf diseases. In this research, an Automatic Paddy Leaf Disease Detection System using Image Processing techniques is developed. This research includes image acquisition, image segmentation, feature extraction, and classification. The developed system achieves 95% accuracy and can serve as an aid to farmers for the early detection and control of diseases and therefore can prevent losses and the further spread of diseases.

Keywords: Paddy Leaves Detection, Plant Diseases, Image Processing

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119-107

COMPARISON DIFFERENT SOIL SERIES AFFECTING ON SACHA INCHI (*PLUKENETIA VOLUBILIS*) GROWTH PERFORMANCE IN UNIVERSITY COLLEGE OF AGROSCIENCE MALAYSIA

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ABSTRACT

Sacha inchi plants (Plukenetia volubilis L.) is recognised as an herbal plant that originated from the Amazon Forest in Peru which is region of South America. In recent years, it was used as a source of medicine and health by the Inca community in Peru. This research is focusing on the comparison between different soil series which effecting the sacha inchi growth performance. This study was conducted at University College Agrscience Malaysia (UCAM) in Alor Gajah, Melaka. All the sacha inchi seeds were planted into polybags with different soils series with same rate as treatments. The basic elements for all plants to growth were given with the rate such as water, fertilizer, and light. Thus, 14 days are required for germination of sacha seeds before transferring into the polybags. This is because the sacha inchi are off-types variety of seeds. The Completely Randomized Design (CRD) is applied as an experimental designed. It consists of six (6) treatments and seven (7) replications in each treatment. The data then was collected for 8 weeks and had been analysed in a one-way ANOVA at 5% significant level with using Statistical Package for the Social Sciences (SPSS) software. The results showed that significant difference at all treatment with all the growth and physiological performance parameter for sacha inchi plants (Plukenetia volubilis L.). The results also recorded that the T4 treatments (Padang Besar series (PBR_2) can be used as potential media soil series for commercial sacha inchi planting with proper management.

Keywords: Sacha inchi, soil series, growth performance.

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123-109

THE POTENTIAL EFFECTS OF CLIMATE CHANGE AND INSECT PEST DISTRIBUTION IN THE HIGHLAND REGION

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ABSTRACT

Climate change and global warming have adversely impacted Malaysian agriculture sectors. Changes in the pattern of climate parameters such as minimum and maximum temperatures, precipitation, and humidity, impact agricultural production. Temperature rise also affects insect dynamics and causes insect outbreaks, particularly in highland areas. According to records from the Malaysian Meteorological Department (MET) showing an increase in temperature in the Cameron Highlands from 1985 until 2020. This data has been supported by recording temperature data in the field using a data logger. The interpolation analysis method in ArcGIS 10.5 is used in this study to determine the distribution of climate parameters and insect pests in cabbage farms. The findings revealed that the primary cabbage pest, *Plutella xylostella*, had multiplied in areas with higher temperatures and more rainfall. In fact, insect movement has increased to high-elevation areas. According to preliminary interpretations, insects have become increasingly adapted to high temperatures, high humidity, high rainfall, and changes in the atmosphere's chemical composition due to insecticide use. Climate-resilient species will impact highland agricultural activities and the country's food security. Effective pest management measures must be implemented to control the population of pest insects in highland areas.

Keywords: climate change, pest, beneficial, brassica, agriculture

124-110

DEVELOPMENT OF A MECHANICAL WEEDING AND FERTILIZING MACHINE FOR WATERMELON PRODUCTION

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ABSTRACT

Watermelon weeding and fertilizing are currently done manually. These two operations are usually carried out separately, which consumes much time and energy. Most watermelon farmers in Malaysia use a knapsack sprayer to apply herbicides during the weeding operation. It requires approximately seven hours to complete the weeding operation for one hectare. After weeding, the farmers will spread N.P.K. fertilizer on the watermelon plants according to the predetermined rate. This process takes between 23 to 24 hr/ha. Therefore, this paper describes the development and evaluation of a mechanical weeding and fertilizing machine for watermelon planting. The study's objective was to design and fabricate a prototype machine that can be used for these two operations, specifically for open-field cultivation. The main criteria considered during the design and evaluation of the prototype machine are its reliability in terms of working mechanism, field capacity, and field efficiency. In addition, the mechanical weeding technique and uniformity of fertilizer rate are also evaluated in this experiment by comparing it to the existing method. This prototype was developed from a rotavator structure as the basis of the chassis. Afterward, the fertilizer tank and its fertilizing mechanisms were added to the main structure, allowing two operations (fertilizing and mechanical weeding) to be carried out simultaneously. This prototype machine needs to be connected to a 4-wheel tractor and uses the power from the tractor's power take-off (P.T.O.) to move the mechanism that has been installed on the prototype machine. According to the evaluation, the prototype machine's field capacity is 0.32ha/hour, with a field efficiency of 91.4 % for both operations. In addition, the use of fertilizer can also be saved up to 18% compared to existing methods due to uniform distribution.

Keywords: watermelon, mechanical weeding, mechanical fertilizing, field capacity, field capacity

101-111

COMPARATIVE EFFICACY OF SOME INSECTICIDES AGAINST RICE BROWN PLANTHOPPER

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ABSTRACT

The control of insect pests, brown planthopper (BPH) by using chemical is preferred by farmers compared to other methods that are more environmentally friendly. The method is easier to use in addition to being easily available in the market. However, there are many options with different brands and formulations that confuse farmers to decide. Therefore, a study was conducted to evaluate the effectiveness of some selected insecticide against BPH. The study was carried out in the entomology glasshouse, MARDI Seberang Perai, using 30 days old MR297 rice variety and planted in several pots according to the study treatments. The insecticide that has been identified is sprayed on the plant and then 20 third-instar nymphs of BPH are released on it. The data then records the survival of third-instar BPH nymph from all the treatment pots daily until all nymphs or adults died. As a result, this assessment recorded that all the seven insecticide products are able to kill the BPH. However, there are various time of efficiency of the product to kill the BPH. The fastest time mortality of BPH was observed in Triflumezopyrim 10% which records 48 hours of all BPH to died. It was followed by Fenobucarb 50% that took 72 hours and Buprofezin 46.3% took 120 hours. The rest was slowest reaction until 192 hours for the BPH to die. The results of this study are only part of the many insecticides on the market. The need for this study is to continue to be conducted so that farmers get the latest information for them to make decisions on insect control activities.

Keywords: BPH, insecticide evaluation, rice cultivation

125-112

A STUDY OF HEAT INSULATION METHODS FOR ENHANCING THE INTERNAL TEMPERATURE ON ARTIFICIAL STINGLESS BEE HIVE

ABSTRACT

The honey of stingless bees has gained a large popularity among the beekeepers, particularly in tropical and subtropical regions such as the Americas, Africa, and Southeast Asia. They are referred to as "stingless" because they do not sting and do not harm humans. Additionally, the honey of stingless bees has a distinct flavor and is highly valued in some cultures for its medicinal qualities. The problem with employing traditional stingless bee hives made from wooden logs is that they are highly weak and susceptible to enemy attacks from the outside. These attacks can come from either predators or parasites, and they have the potential to trigger the Colony Collapse Disorder (CCD) if they are not eradicated. Thus, in replace of the traditional hive, an artificial hive made of PVC, 3D-printed PET-G, and acrylic has been developed. However, based on previous study, the stingless bees particularly vulnerable to the high temperature that was exceeded 38°C. As such, this paper's primary objective is to report the results of studies designed to identify the most effective insulating method for the artificial hive. Clay, wood powder, polystyrene, bubble aluminum foil, and a water-cooling system are among the insulating techniques that have been tested over the course of roughly a month and a half. As for results, the average difference between the outside and inside temperatures for artificial hive with bubble aluminum foil (0.39°C) is the closest value to traditional hive (0.44°C). Without any material or method of heat insulation, the average temperature difference between the exterior and interior of the artificial hive was only 0.09°C. In conclusion, bubble aluminum foil can aid in enhancing the heat resistance more compared to other materials or methods. This is due to the multiple layers of air-filled bubbles that serve as insulation in bubble aluminum foil. In addition, bubble aluminum foil is less expensive and easier to implement than other insulation materials or methods that has been test.

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105-113

PINEAPPLE GROWTH PERFORMANCE, YIELD AND FRUIT QUALITY INFLUENCED BY FOLIAR FERTILIZATION ON CLAY SOIL

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ABSTRACT

Small scale pineapple farmer conducting fertilization programme for pineapple with application of granular fertilizer. Meanwhile, large scale pineapple plantation conducts fertilization programme through foliar feeding to accommodate usage of plastic mulching for weed suppression and high-density planting requirement. Thus, this study was conducted to evaluate different treatments of foliar fertilizer by comparing pineapple growth performance, fruit quality and expected yield. This study was conducted on clay soil using MD2 pineapple planted on completely randomized block design with application of five foliar fertilizer treatments with four replications. Granular fertilizer treatment was chosen as control. Foliar fertilizer application was conducted every month before flowering induction. Based on growth performance on plant height, D-leaf length and width and number of functional leaves, significant difference was observed during early growth stage but eventually did not differ toward end of vegetative stage. Based on pineapple fruit quality, lowest total soluble solid (TSS) and crown to fruit ratio were recorded on T6 and differed significantly compared to other treatments. Meanwhile, other parameters such as total titratable acid (TTA), TSS/TTA ratio, fresh fruit weight, fresh plant weight were differed insignificantly. Insignificant difference was recorded for expected yield in which the highest value produced by T6. Based on data on agricultural input calculation and expected yield, T3 was recorded as the best foliar application for pineapple due to its low-cost input with optimum yield and good fruit quality.

Keywords: Foliar fertilizer, MD2 pineapple, total soluble solid

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SCREENING AND IDENTIFICATION OF *GARCINIA ATROVIRIDIS* GENOTYPES WITH HIGH HYDROXYCITRIC ACID

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ABSTRACT

One of the potential food ingredients with anti-obesity benefits is hydroxycitric acid (HCA), which a derivative of citric acid. It was reported that HCA can be obtained from groups of Garcinia fruit. In Malaysia, Garcinia atroviridis or commonly named as asam gelugur is a very popular fruit used as a flavouring agent in cooking and to promote health traditionally. It was also reported that the *G. atroviridis* fruits contain hydroxycitric acid (HCA) and flavonoids that have been shown to possess remarkable hypolipidemic effects, promoting weight reduction by reducing lipogenesis and enhancing glycogen formation. Due to the benefits, researchers from Forest Research Institute Malaysia (FRIM) intend to screen and identify *G. atroviridis* genotypes in several populations in Peninsular Malaysia with high contribution of HCA. In this study, the fruits from selected genotypes were collected from four populations such as i) Tapah, Perak (AGA); ii) Yan, Kedah (AGY); iii) Bukit Gantang, Perak (AGBG) and iv) Jeli, Kelantan (AGJ). The ripe fruits were sliced and dried in an oven for 50 °C for three days. Moisture content of dried fruits must be below 10% and were finely ground before proceed with High Performance Liquid Chromatography

(HPLC) analysis. The amounts of HCA showed a variation from nondetectable to detectable quantities and provided the average HCA content in the range of 18.02-28.36 % w/w (AGA), 21.91-27.03% w/w (AGY), 5.35-46.66% w/w (AGBG) and 31.65-57.21% w/w (AGJ). Selection and identification of *G. atroviridis* genotypes from every population were made based on the yield of HCA percentage. The selected genotypes were then propagated to get its clones for future breeding activities.

Keywords: asam gelugur, flavouring agent, HPLC, high yield, breeding activities

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118-115

EVALUATION OF *Strobilanthes crispus* STEM CUTTINGS FROM DIFFERENT POPULATIONS FOR THE PRODUCTION OF HIGH QUALITY PLANTING MATERIALS

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Introduction

Strobilanthes crispus (L.) Bremek is a woody shrub belongs to the Acanthaceae family. It is one of the most widely used local herbal products in Malaysia for both domestic and international use. According to Burkill et al. (2002), *S. crispus* is natively found in Madagascar as well as the Malay Archipelago. It is commonly known as 'pecah beling' or 'pecah kaca' in Malay and 'Hei Mian Jiang Jun' (Black-faced General) in Chinese dialect. This plant normally grows alongside the river or in uninhabited fields (Noraida, 2005). It can spread and grow up to 1.5 metres in height. The leaves' upper surface is rough, darker green in colour, and covered in short hairs. The flowers of *S. crispus* are yellow in colour and have short, dense, and panicled spikes (Sunarto, 1977).

Traditionally, this plant is consumed as a water decoction or tea, which is believed to be effective in treating kidney stones, diabetes, and general health. Many studies have reported that *S. crispus* contains numerous phytochemicals, and the identified compounds have been proven scientifically to possess various favourable medical properties, such as anti-oxidant (Ismail et al., 2000; Qader et al., 2011), anti-microbial (Muskhazli et al., 2009), anti-diabetic (Norfarizan et al., 2009; Fadzelly et al., 2006), anti-ulcerogenic (Al-Henhena et al., 2011), as well as wound healing (Norfarizan et al., 2009). Most importantly, according to a review by Ng et al. (2021), this plant also exhibited anti-cancer features. The plant's extracts have shown potent anticancer effects against a wide range of cancers, including breast cancer, liver cancer, and colon cancer, through numerous in vitro and in vivo studies.

Looking at the potential of this plant in the pharmaceutical industry, it is important to have a sustainable supply of high quality planting material of *S. crispus* as most of the raw materials supplied to the industry are being wildly collected or imported from other countries with uncertain quality (Zurinawati, 2004). The breeding programme of *S.crispus* is currently being carried out by the Forest Research Institute Malaysia, and this paper reports on the stem cutting performance of *S. crispus* collected from different populations in Peninsular Malaysia with the aim to select the high quality mother trees.

Materials and Methods

Collection of mother trees

The collection of *S. crispus* mother trees was conducted in four regions (central, northern, southern, and east coast) of Peninsular Malaysia. The distribution of the collection is shown in Figure 1. The collections took place between October 2022 and May 2023. Only vigorous, healthy plants with a plant height of more than 1 metre were selected for the mother trees. About 30 mother trees were collected from each region. Each accession was coded with a different number and locality. Morphological data such as plant height and leaf density (high, medium, or low) were recorded for each accession, and the mean for each variable is presented in Table 1. The stems and leaves of selected mother trees were collected and brought back to the Forest Research Institute Malaysia (FRIM) for cultivation and phytochemical analysis.

Table 1. Means of plant height and leaf density of *S.crispus* in each accessions

Region	Accessions code	Plant height (cm)	Leaf density (Score: High=3, Medium=2, Low=1)
Central	BPB	136.7 ± 6.84ab	2.79 ± 0.08a
South	NPB	172.1 ± 6.35a	3.00 ± 0.00a
	MPB	171.4 ± 5.49a	2.73 ± 0.14ab
	JPB	172.0 ± 8.10a	2.80 ± 0.11a
North	KPB	149.4 ± 12.4ab	2.68 ± 0.12ab
	PPB	162.8 ± 8.59a	2.30 ± 0.15bc
	APB	122.0 ± 8.00b	2.00 ± 0.00c
East coast	DPB	n.a	n.a
	TPB	n.a	n.a
	CPB	n.a	n.a

Means followed by different alphabet were significant different at p <0.05

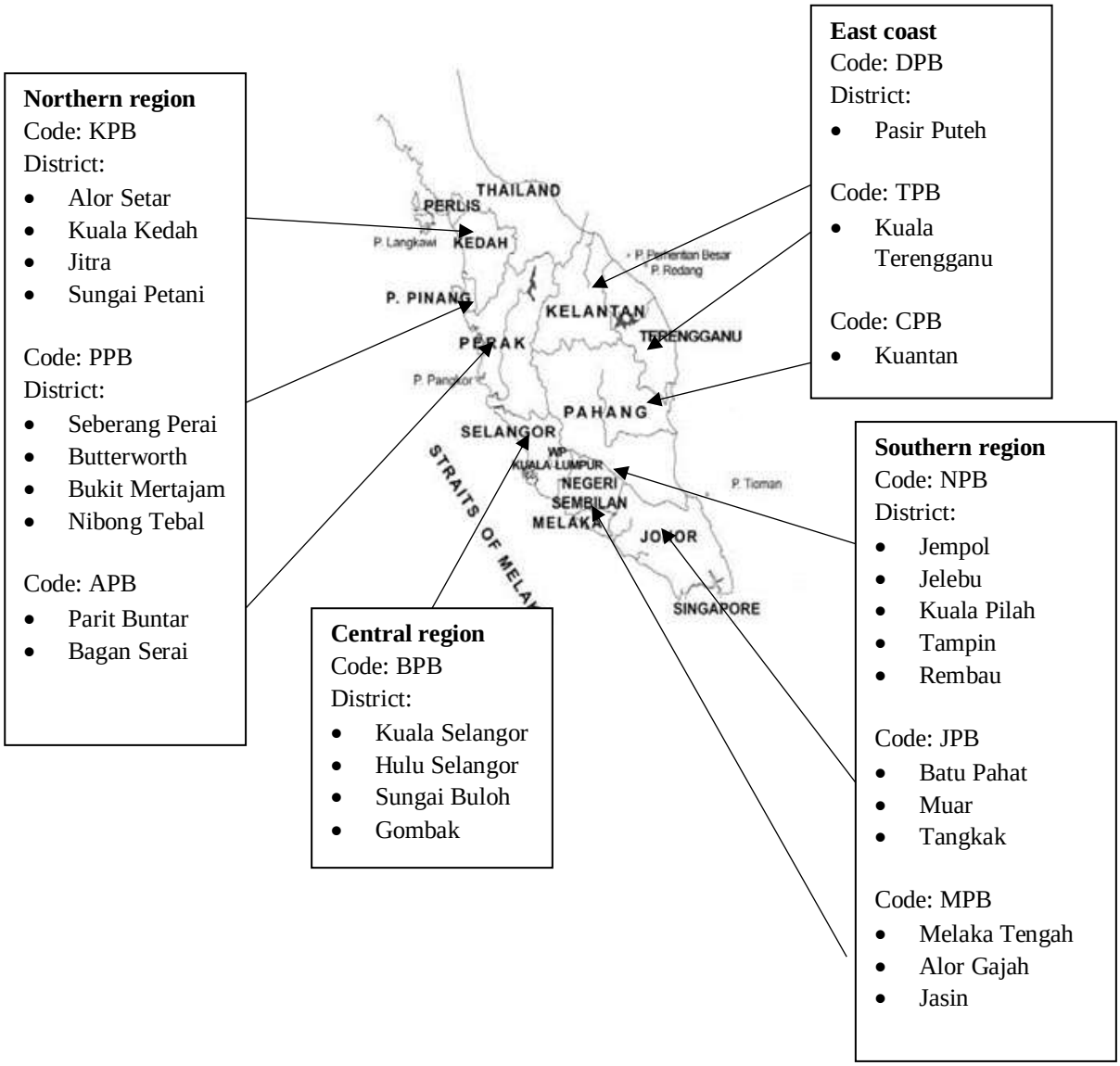

Figure 1: Distribution of *S. crispus* mother trees collection in Peninsular Malaysia

Propagation of mother trees

Preliminary assessment

A preliminary assessment was conducted to study the effects of different Indole Butyric Acid (IBA) concentrations on the rooting performance of *S. crispus* stem cuttings. The cutting materials were sourced from *S. crispus* stock plants grown at the nursery of the Herb and Tree Improvement Branch, FRIM, Kepong. Stem cuttings were cut at 10 cm in length with 1 or 2 nodes per cutting. The base of the stem cuttings was immersed in different concentrations of IBA (0 mg/L, 0.5 mg/L, 1 mg/L, and 2 mg/L) and Seradix 2 (0.8% IBA) for 2 minutes before being quickly planted in rooting media. The n number for each treatment is 30 and is replicated three times. The cuttings were misted three times daily for 10 minutes each session at 8 a.m., 12 p.m., and 4 p.m. Cuttings were grown in a Randomised Complete Block Design (RCBD). The cuttings were evaluated after 40 days. The variables measured were cutting survival rate, percentage of rooted cutting, number of roots, and root length.

Mass propagation

Each accession was propagated through stem cuttings using the above approach for mass propagation. As a rooting hormone, the commercial rooting hormone Seradix 2 (0.8% IBA) was used since it provided the best cutting survival rate and rooting performance. The survival rate of cuttings from the central and southern regions was reported in this study, and the evaluation was performed after 40 days of experiment.

Statistical analysis

All data were submitted for ANOVA using SPSS. Differences between means were compared using the Duncan Multiple Range Test (DMRT).

Results & Discussion

Based on preliminary analysis, different IBA concentrations significantly affect *S. crispus* stem cuttings' survival rate, rooting percentage, number of roots, and root length at $p<0.05$ (Table 2). Cuttings treated with 2 mg/L IBA had the lowest survival rate (76.67%), while Seradix 2 (0.8% IBA), a commercial rooting hormone, had the best survival rate (90%). Cuttings treated with Seradix 2 (0.8% IBA) had the highest rooting rates, number of roots, and root length. The lowest root length and least number of roots were seen in stem cuttings from the control treatment (0 mg/L). IBA concentrations' efficacy was arranged as follows: Seradix 2 (0.8% IBA) > 0.5 mg/L > 1.0 mg/L > 2.0 mg/L > 0 mg/L. In the current study, it was discovered that almost all treatments, including the control, were initially capable of inducing rooting in cuttings. However, the percentage of rooting varied with treatment, and IBA was found to be very effective in promoting root induction especially in the usage of Seradix 2 (0.8% IBA). IBA has also been shown to be more effective for root induction in stem cuttings of other medicinal plants, including *Andographis paniculata* (Hossain et al. 2021) and *Ginkgo biloba* (Aseesh et al. 2011).

Table 2: The effect of different IBA concentration on survival rate and rooting performance of *S.crispus*

Treatment	Survival rate (%)	Rooted cutting (%)	No. of root	Root length (cm)
0 mg/L	83.3b	58.3c	2.24 ± 0.37c	1.54 ± 0.23c
0.5 mg/L	80.0b	71.7c	4.10 ± 0.50b	2.66 ± 0.28a
1.0 mg/L	80.0b	63.3bc	3.31 ± 0.39bc	2.35 ± 0.28ab
2.0 mg/L	76.7c	58.3c	2.54 ± 0.33c	1.89 ± 0.22bc
Seradix 2 (0.8% IBA)	90.0a	80.0a	6.56 ± 0.72a	2.89 ± 0.27a

Means followed by different alphabet were significant different at $p<0.05$

In the mass propagation study, Analysis of variance (ANOVA) revealed a significant difference in the percentage of cutting survival amongst the populations (BPB, NPB, MPB, and JPB) at $p<0.05$ (Figure 2). Accessions collected from the southern region (JPB) recorded the highest percentage of survival at 80.5 ± 5.26%, followed by the central region (BPB) at 63.7 ± 4.32%. Whereas the remaining accessions from the southern region, MPB and NPB recorded the lowest percentage of survival at 52.3 ± 10.1% and 44.3 ± 11.4% respectively.

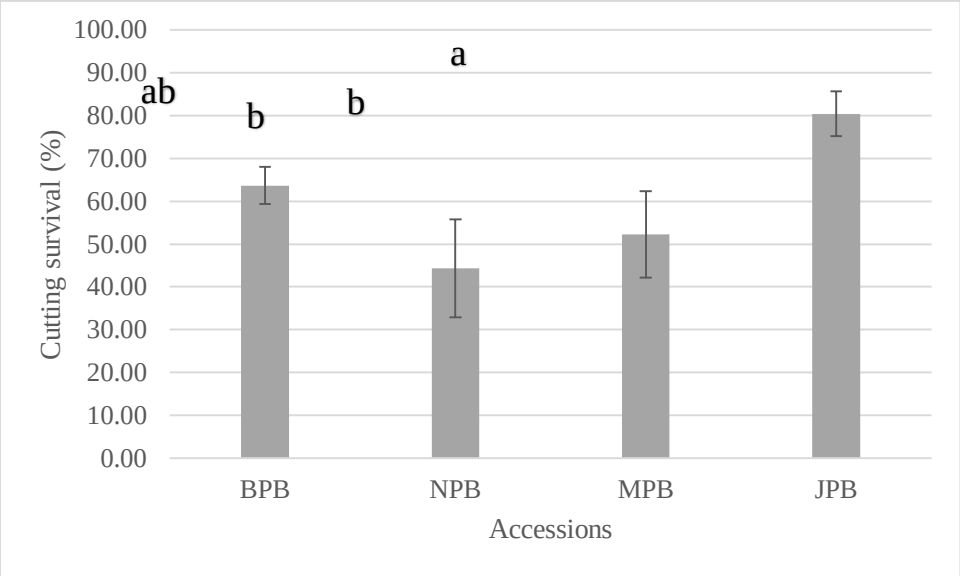

Figure 2: Percentage of *S. crispus* cuttings' survival from the central and southern regions

Several factors, including the environment and the quality of the stock plant, can have an impact on the overall success of cuttings. Cuttings material from the southern region (JPB) could be obtained from a well-treated stock plant. Other than health, age and productivity may play an essential part in assuring the success rate of cuttings, since juvenile shoots are preferable because they regenerate and create adventitious roots faster than mature plants (Preece, 2008). In future studies, the rooted cuttings from all accessions will be evaluated for growth performance, biomass, and phytochemical analysis. Several accessions with good growth performance, high biomass, and high quality chemical compounds will be tested for clonal trial before being promoted to the industry for plantation and the supply of high quality raw materials.

Conclusion

The use of IBA had a substantial effect on the survival percentage and root performance of *S. crispus* stem cuttings in this investigation. To improve root induction in *S. crispus* stem cuttings, the application of commercial rooting hormone Seradix 2 (0.8% IBA) is advised. In terms of mass propagation, accessions collected in the southern region (JPB) have the highest proportion of survival, followed by accessions obtained in the central region (BPB). In order to determine the superior accessions of *S.crispus*, additional evaluation such as plant growth, biomass, and chemical compound screening are necessary.

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PROTEIN AND AMINO ACID PROFILE IN *MORINGA OLEIFERA*

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ABSTRACT

Moringa oleifera or locally known as "merunggai" or "gemunggal" is well known traditional medicinal plant in Malaysia. Traditionally, *M. oleifera* are widely used in cancer treatment, anti-inflammatory and anti-Buruli ulcer activity, enhance fertility, and lifestyle-related diseases, such as hypertension and diabetes mellitus. The leave extract was studied by evaluating total protein and amino acid using Kjeldahl method and ACCQ Tag Waters method using high pressure liquid chromatography (HPLC) with fluorescence detector. It was found that *M. oleifera* leaves and seed has the amount of 26.89 ± 0.25 g/100g and 27.9 ± 0.89 g/100 g, respectively. Essential amino acid in leaves higher compared to seeds with the most abundant amino acid in leaves is leucine, and arginine in seeds.

Keywords: Moringa, amino acid

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PHYSICAL, CHEMICAL AND NUTRITIONAL ANALYSES OF COCONUT HAUSTORIUMS

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ABSTRACT

Coconut haustorium is a part of embryo embedded in the endosperm nearer to the coconut germination pores. This young sponge part will grow to form a cotyledon structure known as a haustorium. The coconut haustorium will growth and finally fulfilled the entire coconut water cavity within 20-24 weeks after germination. A matured coconut haustorium contains high moisture content range between 79.99-86.40 % and it is rich in various nutrients and minerals. The carbohydrate, crude fat, crude protein and ash contents were at recorded at 9.34-15.58 %, 0.62-2.15 %, 1.34-1.84 % and 1.61-2.30 % respectively. The coconut haustorium also has a potential to be developed as a health supplement products. In relation to that, a physical-chemical and nutritional quality study of coconut haustorium were carried out to develop MARDI coconut haustorium products. The interest nutritional content in the coconut haustorium is high in a lysine and other essential amino acids. Thus fresh haustorium can be used as a high value added of superfood ingredient for health and wellness supplements and specially focus for increasing a food intake (appetite) especially for children supplement.

Keywords: Haustorium, coconut, physical, chemical, nutritional and amino acids

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099-120

COMPARISON OF NANOCELLULOSE EXTRACTED FROM *COCOS NUCIFERA, SACCHARUM OFFICINARUM L.* AND *CYMBOPOGON*

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ABSTRACT

Agricultural residues that was not well-managed will lead to environment deterioration. Nevertheless, they can be used as alternative source for the production or application in various industries due to their fascinating properties in absorption ability, mechanical properties and biodegradability. In recent advancement, agricultural residues are broadly used to form nanocellulose. In this study, nanocellulose was extracted from plant leaves of coconut, sugarcane and lemongrass which are abundant agricultural waste. Chemical pre-treatment was carried out by boiling of dried leaves at 80 °C in NaOH. The homogenization was conducted at the speed of 1000 rpm for 30 min to produce nanocellulose. The samples were characterized for surface morphology, Fourier transmission using FTIR and water absorption. The properties that displayed by the formed nanocellulose were analysed and compared for further recommendation. These materials are high potential to be used in different fields towards a sustainable future.

Keywords: Extraction; homogenization; agricultural waste; morphology.

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057-121

PRELIMINARY STUDY ON TRAY SEEDING MACHINE IN RICE NURSERY CENTRE IN MARDI PARIT

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ABSTRACT

Mechanical transplanting is an important part of the rice seed production process. A good rice seedling mat is required for good and smooth transplanting in the paddy fields. The activity of preparing a rice seedling mat begins with the selection of good quality seeds, germination tests that produce a germination percentage of more than 80 percent, the soaking process for 24 hours, the tossing process for 24 hours, the process of sowing medium and rice seeds in trays, and storage for seedling germination and growth in the nursery until they are ready for transplanting. The purpose of this preliminary study on a rice tray seeding machine in a rice nursery centre is to identify and prioritise ergonomic risk factors and hazards for musculoskeletal disorders (MSDs) in the nursery industry. After the preliminary survey was completed, the project team and cooperators prioritised jobs or tasks for intervention. As a result, two specific priority intervention tasks have been identified: Task 1 is the repetitive refilling of the media and seed in the hoppers, and Task 2 is the repetitive delivery of a load of five sets of rice trays from stacking station to pallet. The interventions recommended to reduce hazards and improve ergonomic risk factors.

Keywords: rice tray seeding machine, ergonomic, musculoskeletal disorder, intervention

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131-125

EFFECT OF IODINE CONCENTRATION ON GROWTH AND IODINE UPTAKE OF LETTUCE (*Lactuca Sativa* L.) BIOFORTIFIED WITH IODINE IN NFT HYDROPONIC SYSTEM

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ABSTRACT

According to the National Iodine Deficiency Disorder (IDD), 48.2 percent of primary school children aged 8 to 10 years have deficiencies in iodine. In fact, a shortage of iodine is one of the causes of goitre problems in 2.1 percent of youngster. Furthermore, pregnant women and school pupils have lower than ideal iodine levels. Iodine biofortification of vegetables provides an excellent opportunity to boost human iodine intake. The study conducted at the Plant Factory, Horticulture Research Centre, MARDI aimed to investigate the effect of potassium iodide (KI) on the growth, development, and iodine uptake of butterhead lettuce grown in a nutrient film technique (NFT) hydroponic system. The study used different doses of KI (0, 1, 5, 7, 13 and 26 mg L^{-1}) for biofortification of lettuce with iodine. The results of the study showed that the application of 5 mg L^{-1} of KI significantly increased the biomass, leaf area, phenolic content, and antioxidant capacity of butterhead lettuce. Additionally, application of KI less than 7 mg L^{-1} increased iodine content without toxicity effects on plants. This indicates that biofortification of lettuce with iodine is easily applicable in a hydroponic growing system and can significantly improve the nutritional quality of the crop. One of the major implications of this study is that iodine biofortification of vegetables, such as lettuce, can provide an excellent opportunity to boost human iodine intake. The study found that one gram of iodine-biofortified lettuce would provide 60%, 46%, and 30% of the recommended daily allowance of iodine for children, pregnant women, and adolescents, respectively.

Keywords: Biofortified, Iodine, lettuce, hydroponic system

133-126

FIELD MECHANIZATION FOR SHALLOTS PRODUCTION IN MALAYSIA

ABSTRACT

Allium ascalonicum or shallots demand supplies in Malaysia rely on it imports for a long decades. Ministry Agricultural and Food Industri Malaysia has strategy to reduce imported shollot by local cultivation using mechanization. As the cost of labor increases and the availability of good labor decreases, farmers raising vegetables must mechanize or else turn to other crops that have already become mechanized and thus require a minimum of labor for their production. Mechanization has been a favourite item of discussion among all agricultural practises for many years .The necessity of mechanizing vegetable production as well as planting and harvesting operations has greatly increased in Malaysia during the past five years and the need will become more acute during the next five if the state is to stay competitive. Shallot cultivation using mechanization just begin new chapter in vegetables production to achieve field mechanization for best cultivation that suits local land condition and develop suitable machineries to reduce manpower in shallots production . The expected outputs are experimental on the usage a current system of machineries. The significances of output are improvement and promotion of shallots production, attracting new crop for farmer into supply chain of local shallots.

FORESTRY

035-026

POTENTIAL OF BORNEO TALLOW NUT BUTTER (TENGKAWANG) AS TOPPING ON FUNCTIONAL FOOD: CONSUMER' ACCEPTANCE PROSPECTIVES

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ABSTRACT

Terang Bulan is a functional food which is a favorite culinary delight has been sold in Samarinda, East Kalimantan. Terang Bulan is usually served with various kinds of toppings, and chocolate topping is the most popular. Chocolate is a sweet topping and probably can be caused obesity or diabetes among consumers. Tengkawang butter is extracted from the fruit of *Shorea* spp which is native in Borneo, Java, Malaya and Philippines. Tengkawang Butter has been tested can be equivalent with Cocoa Butter, and it is healthier than Cocoa Butter. Therefore, Tengkawang Butter can be used as a substitute of Cocoa Butter, and it has never been used as a topping for Terang Bulan. This study aimed to compare the consumer acceptance through organoleptic analysis of both Tengkawang Butter and Cocoa Butter as a topping for Terang Bulan. Organoleptic analysis was consisting on acceptance of aroma, taste, and level of preference for those toppings. Organoleptic tests were conducted to compare 1 g of both of topping on Terang Bulan for 40 trained respondents, both of male and female. The results showed that 55% of respondents likes Tengkawang Butter topping more than Cocoa Butter, while 65% among consumers prefer Tengkawang Butter topping due to its taste, and there was a relationship between Tengkawang Butter topping preference based on aroma and taste. However, this study provided Tengkawang Butter has the potential to be developed for healthy household-scale culinary businesses.

Keywords: Culinary, Cocoa Butter, Organoleptic, Terang Bulan, Tengkawang Butter.

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ORGANOLEPTIC ANALYSIS AS APPROACH STUDY FOR CONSUMER PREFERENCE OF CAJUPUT (*Melaleuca cajuputi*) SPONGE CAKE

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ABSTRACT

Sponge cake is a delightful food for gathering in the afternoon or evening. Sponge cake tastes sweet with various additions such as chocolate, chopped walnuts, cheese, pandan aroma, and others. The development of the culinary business requires some innovations to create a new variant of sponge cake. Cajuput is a familiar herb for bio-food and bio-medicine material. Thus, it can be used as a different taste for a unique sponge cake. An innovation was made with additional dried Cajuput leaves flour into sponge cake, adding aroma, taste, and health benefits. This study aimed to determine panelists' response to additional Cajuput leaves flour in sponge cake. The research was carried out by adding 10, 20, and 30 g of dried Cajuput leaves flour to a sponge cake. Organoleptic testing was conducted on 40 trained panelists to describe consumer acceptance of this bioproduct. The results showed that 35% of panelists preferred the aroma of sponge cake with 10 and 20 g of Cajuput leaves flour added. Meanwhile, 65% of panelists liked the taste of sponge cake with 10 g of Cajuput leaves flour. On the other hand, 45% of panelists liked the texture of sponge cake with 20 g of Cajuput leaves flour. 55% of panelists liked sponge cake with 10% cajuput leaf flour. However, these panelist responses described consumer acceptance of the Cajuput sponge cake innovation for market enthusiasts in the marketing chain.

Keywords: sponge cake, Cajuput leaves, organoleptic, culinary, bioproduct

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012-041

DESICCATION AND THE STORABILITY OF DESICCATION-SENSITIVE SEEDS OF A DIPTEROCARP SPECIES, HOPEA ODORATA

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ABSTRACT

Some species, particularly trees, may not be able to be preserved due to sensitive seeds to desiccation. This paper explored the influence of seed moisture content and storage conditions on the germination of Hopea odorata seeds, a tropical forest species. The first part of the study aimed to identify the effect of desiccation on the germination of these seeds. Seeds were dried down to several moisture content levels in silica gel: 40.1%, 39.8%, 34.9%, 32.0%, 21.7%, and 16.1%. The initial moisture content of fresh *H. odorata* seeds were 45.6% with 100% germination. Reduction of moisture content level to 40.1%, 39.8%, and 34.9% did not affect germination percentage, where germination percentages were maintained at 100%. However, the desiccation *of H. odorata* seeds from 32.0% to 21.7% moisture content reduced germination from 96 to 50%. No germination (0%) was detected once the seeds were further desiccated to 16.1%. From this observation, the estimated lowest safe moisture content (LSMC) for *H. odorata* was 32.0% and was desiccation sensitive as expected for recalcitrant seeds. In the second experiment, winged and de-winged seeds were stored under different temperatures and durations; with the presence of vermiculite. Results obtained revealed that the most effective way to store *H. odorata* seeds is at 20°C for 5 weeks with the wings removed; where 98% of the seeds germinated.

Keywords: Recalcitrant, desiccation-sensitive, storage, germination, dipterocarp

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PRODUCTION OF EURYCOMALACTONE AND SCOPOLETIN IN DIFFERENT PARTS OF 2 YEARS OLD *EURYCOMA LONGIFOLIA* (TONGKAT ALI) SEEDLINGS AND TISSUE CULTURE PLANTLETS

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ABSTRACT

Eurycoma longifolia (Tongkat Ali) is one of the most widely used herbs in Malaysia and other Asian country and its demand is increasing rapidly. As raw material supplies from natural resources begin to decreasing, it is necessary to cultivate them widely to meet the demands of the herbal and pharmaceutical industries. For this purpose, seedlings are the main requirement because the harvest of *E. longifolia* involves the whole tree. The production of seedlings through the tissue culture method is one of the commonly used methods to contribute in increasing the supply of planting material. Plantations for forest species and herbal plants are needed to address the problem of insufficient supply of raw materials to meet the demands of the timber, herbal and pharmaceutical industries. Quality of *E. longifolia* raw material for the herbal and pharmaceutical product muchly depends on the production of chemical compounds in the planting material. In this study, eurycomalactone and scopoletin is our main focus, since this compounds are also valuable compound and have substantial effect on human health. Stem and leaves also evaluated because normally for *E. longifolia* products the roots were harvested. If stem and leaves have comparable amount of bioactive compound so we can save *E. longifolia* from destructive method. In this study, different parts of 2 years old *E. longifolia* seedlings and tissue culture plantlets grown in the nursery were evaluated for the production of eurycomalactone and scopoletin using High Performance Liquid Chromatography (HPLC). The results of chemical analysis showed that eurycomalactone and scopoletin were found in root and stem samples except leaf samples from tissue culture plantlets and seedlings.

Keywords: *E. longifolia*, tissue culture plantlets, seedlings, chemical analysis

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071-061

AN APPROACH IN MEASURING THE SUSTAINABILITY TOWARDS ECOSYSTEM MANAGEMENT IN FIREFLY ECOTOURISM SITES: A REVIEW

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ABSTRACT

Ecotourism is one of the tourism developments that support conservation. The ecotourism industry is highly dependent on ecosystem stability to remain relevant in the long term. The stability of the ecosystem is related to the management of the ecosystem itself. However, there are difficulties in assessing ecosystem stability or existing management. The approach to the concept of sustainability is a key aspect to achieve this goal, especially in firefly ecotourism sites in Malaysia. Sustainability indicators should be easy to understand and technically feasible to measure. Good indicators can produce better results to reduce risk or cost, measure the performance of development, reduce the risk of planning errors, reduce public liability and could be regularly monitored. Therefore, it is crucial to measuring the sustainability of the management of fireflies ecotourism to ensure the survival of this industry in long term and further improve existing policies as well as conservation measures can continue to be implemented more efficiently and holistically. This paper presents a review on the common indicators used in measuring sustainability in natural ecosystem that could be applied in ecotourism sites in Malaysia. The result shows there are three main indicators involved which are economic, social and environment. In addition, there are also some indicators that has been used in measuring sustainability such as institutional and technology. Overall, the indicators can be used as guidelines in maintaining the current ecosystem and corrective measures can be taken at an early stage to ensure the survival of the ecosystem and the ecotourism industry itself.

Keywords: Ecotourism; firefly; sustainability; indicators.

Introduction

The Sustainable Development Goals (SDGs) are part of the most recent action plan to stimulate all countries towards a sustainable and resilient world (UN 2015). There are 17 goals outlined in the sustainable development goals and supported by 169 targets set to be achieved by 2030 (Dong & Hauschild 2017). The overall goal of sustainable development is long-term stability from an economic and environmental point of view, and its targets are social progress and equality, environmental protection, natural resource conservation and stable economic growth (Kurdi 2020). All countries around the world are responsible for improving the condition of the earth and people's lives to achieve a better and sustainable future.

Sustainable tourism development is part of a strategy that aims to meet the current needs without compromising the ability of future generation's needs (WCED 1987). Sustainable tourism is important to ensure that tourism areas are well managed (Jayaraman et al. 2010). Sustainable tourism covers environmental, social and economic perspectives. This means there is environmental control, ecological stability, social justice in addition to economic development to meet future needs. Following that, sustainable eco-tourism is important to ensure that the development of eco-tourism is in line with the quality of the environment (Tisca et al. 2016). In addition to that, the promotion of tourism development in the natural ecosystem could achieve other SDGs such as goal 8 (satisfying employment and economic growth), goal 13 (action against the effects of climate change), goal 14 (life below water) as well as goal 15 (life on land) (Tagulao et al. 2022).

Fireflies watching is the main attraction of eco-tourism in Malaysia (Foo & Dawood 2015). Most popular sites of fireflies eco-tourism are located in Selangor river (Shahara et al. 2017), Kinabatangan river (Mahadimenakbar et al. 2004), Paitan river (Chey 2006), Garama river (Mahadimenakbar et al. 2007), Johor River (Norela et al. 2015), Sepetang River (Izfa Riza & Sharifah Aliya 2017), Rembau River (Lailatul-Nadhirah et al. 2021), Panjang River (Shahara et al. 2017) and Chukai River (Adam et al. 2018). According to Norela (2020), there are six genera that have been found in Malaysia, namely *Colophotia*, *Pteroptyx*, *Luciola*, *Lamprogera*, *Pyrocelia* and *Diaphanes*. However, the main firefly species in Malaysia is *Pteroptyx tener* (Nada et al. 2012; Norela et al. 2015; Shahara et al. 2017). Fireflies are only about 6 mm long (Nada & Kirton 2004) and use flashing signals as a

signal between males and females before mating (Kevin & Mahadimenakbar 2015). The light is seen as a luminous beat in thousands of fireflies. The light flashes produced by male fireflies are brighter because they have two light organ segments compared to female fireflies which only have one light organ segment. The brightness of male fireflies will attract the attention of female fireflies (Nada & Kirton 2004). Thousands of these unique insects perform flashing rituals in groups by the river (Shahara et al. 2017). Thus, many visitors are willing to come from far away to see the uniqueness of fireflies up close.

Eco-tourism has a strong relation with sustainable tourism that includes economic, ecological and social. However, the unsustainable management of tourism will causes the destruction of habitats and landscapes, eliminating natural resources, which ultimately creates a serious environmental pollution problem. Therefore, a sustainable development approach is vital in order to attract tourists and at the same time to preserve the natural environment. Thus, the guiding factors or indicators of tourism sustainability should be identified (Hon et al. 2020). This article reviewed the benefits of applying indicators in measuring sustainability in Section 2. Further discussion in Section 3 focuses on various dimensions of indicator used in measuring sustainability.

Benefits of applying indicators in measuring sustainability

Sustainable tourism can reduce ecological and socio-cultural impacts while providing economic benefits to local communities. It includes development in terms of natural aspects, social and economic integrity (Zaimah et al. 2015). Exploitation of the destination will occur at a rapid rate if the focus is only on economic generation through uncontrolled growth of tourist flows. The tourism industry will be affected and no longer be attractive in a short period of time. Therefore, sustainability assessment must be carried out from time to time.

Indicators are defined as parameters or values obtained from certain observations or measurements that provide information about a situation (OECD 1993). Indicators are sets of information that are officially selected to measure changes in assets and issues that are important for the development and management of tourism in a destination (Yunis 2004). Indicators provide information about upward or downward trends and help in the decision-making process after consultation with stakeholders. Indicators are very important to assess, report and improve the environmental performance at the decision-making level. The development of sustainable tourism indicators has been pioneered since the early 1990s by the WTO, with the first significant attempt in 1996. The WTO has identified 11 core indicators for comparing tourism sustainability between destinations, along with various additional indicators for use in specific situations. In the beginning, some trial and error will probably occur in producing a usable set of indicators. But it can continue to be improved based on the errors identified. The most effective sustainability indicators can be created if flexible indicators can be created.

Indicators have been rapidly adopted and integrated as a basis for monitoring and evaluating environmental management (Ching et al. 2022). Good indicators can produce better results to reduce risk or cost, help prevention, measure the performance of development plan implementation, reduce the risk of planning errors, reduce public liability and monitor regularly. The UNWTO states that indicators are measures of the existence of current issues, signals of impending situations or problems, the need for action, and ways to identify and measure the results of an action (UNWTO 2004). Indicators also provide a comprehensive framework that supports comprehensive assessment that can be used as an important and practical planning and management tool at local and regional levels through short-term strategies and guidance to policy makers (Torres-Delgado & Saarinen 2013). Therefore, the indicator system can support practical evaluation and monitoring for the implementation of a policy (Park & Yoon 2011).

Sustainability indicators are potentially used by management to plan policy on priority issues and determine the necessary actions through communication with all stakeholders involved (De Kruijf & Van Vuuren 1998). Indicators not only indicate issues but also help determine corrective actions once a problem has been identified. It also shows how the system works, and provides a basis for continuous improvement.

Various dimensions on indicators

The use of indicator systems can be used in various types of industries to evaluate performance (UNWTO 2004). Indicators are simple statistical information with little or no data manipulation. While complex indicators are the result of multi-dimensional evaluation of more than one simple indicator based on a weighting system. Indicators can be differentiated according to quantitative and qualitative. Quantitative indicators can include ratios, percentages or raw data that are easy to measure and reliable (Miller & Twining-Ward 2005). Meanwhile, qualitative indicators tend to address more significant, and subjective issues (Tsaur et al. 2006).

The multiple dimensions need to be developed and evaluated by a set of relevant indicators. The data or information obtained provides details or specific measures to improve the accuracy of the assessment of an indicator. The specialization of sustainable indicators for the tourism industry needs to be developed as problem has

caused difficulties in measuring the level of sustainable development and the contribution of tourism in Malaysia (Mohammad Kazar & Hairul 2014). Therefore, consideration of the deep implications into all aspects of the destination must be included in the development of indicators that include the environment, society, culture and economy (UNWTO 2004). In addition, other dimensions such as governance also require serious attention.

Indicators can also be selected to estimate future changes. This is particularly relevant given that social-ecological systems tend to be characterized by temporal, spatial and nonlinear dynamics. Indicators that can offer insight into future threats and any measures to overcome or mitigate impacts can be suggested and initiated. Sustainability indicators are also increasingly used for impact assessment for development projects (Agol et al. 2014). This impact assessment can provide information to project implementers, funders, and target communities to monitor and evaluate the impact of their actions on sustainability. Sustainability indicators are also included in the assessment of the potential impact of a project before it is funded to assess the extent to which it contributes to the improvement of well-being between generations.

Table 1 shows various indicators used in three main dimensions in measuring sustainability in nature ecosystem. Most of the study used indicators in mangrove ecosystem. In environment dimension, the main indicators that has been used in measuring sustainability are utilization of resources, biodiversity and habitat, land use and pollution. Meanwhile, public awareness, educational workshops and community participations are main indicators in social dimension. In economic dimension, expansion of employment, increased original local government revenue and increasing the number and quality of facilities are main indicators used. These mentioned indicators could be used as well in measuring sustainability in fireflies ecosystem.

Table 1. Various indicators used in three main dimensions in measuring sustainability in nature ecosystem.

Dimension	Indicators	Ecosystem	References
Environment	Nature-based facilities; utilization of resources according to carrying capacity; changes in landscape	Mangrove	Harahab et al. 2021
	Water resources; pollution; biodiversity & habitat; forests; fisheries; climate change	Environmentally sensitive areas	Sakalasooriya 2021
	Water pollution; Tourism land use; mangrove conservation function; successful replanting	Mangrove	Afifa & Idajati 2020
	Availability of mangrove tree seeds; the diversity of mangrove trees; the pollution in mangrove areas; the diversity of flora & fauna	Mangrove	Pudji et al. 2018
Social	Natural & cultural value are explored; tourism activities are programmed to enjoy; satisfaction, safety and comfort standard are met	Mangrove	Harahab et al. 2021
	Public awareness to conserve mangrove through planting; community participation in managing ecosystem; community activities that damage forest ecosystem	Mangrove	Pudji et al. 2018
	No of trained local people in field of local skill; educational workshop; brochure about attraction areas & biodiversity; educated & trained local people; warning tableaus about waste management	Protected watershed	Azlizam et al. 2015
	Ratio of the number of tourists to local community	Amenity forest	Jabil et al. 2015
Economic	Increased original local government revenue; expansion of employment; improving tourism services; increasing the number & quality of facilities	Mangrove	Harahab et al. 2021
	Community income derived from ecosystem; job opportunities; the availability of ecosystem utilization zones; training & counselling in the utilization of ecosystem	Mangrove	Pudji et al. 2018
	The role of mangrove to regional development; mangrove forest rehabilitation; mangrove land use zonation; stakeholder participation;	Mangrove	Pattimahu et al. 2017

mangrove utilization inventory

Conclusion

Overall, there are three main indicators that should be focus on to meet the Sustainable Development Goal. These indicators can be used as guidelines in maintaining the current ecosystem and corrective measures can be taken at an early stage to ensure the survival of the ecosystem and the ecotourism industry itself.

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053-063

INCORPORATION OF PLANT PRESERVATIVE MIXTURE (PPM) TO IMPROVE SURFACE STERILIZATION OF *TINOSPORA CRISPA IN VITRO*

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ABSTRACT

Tinospora crispa (L) Hook. F. & Thomson is locally known as Patawali and belonging to the Menispermaceae family. It is mostly found in Asia and Africa. It is well known for the traditional medicinal properties. It is used for traditional medicine against jaundice, rheumatism, fever, malaria, diabetes, hypertension and reduce body temperature. Micropropagation techniques can be an alternative method for mass propagation of this species particularly from selected clones. In this regard, young nodal segments are more recommendable as they are more juvenile and easier to be micropropagated than older part of the plants. The purpose of this paper is to provide information regarding the preliminary study on the utilization of young nodal segments from Patawali field plot and incorporation of PPM for micropropagating *Tinospora crispa in vitro.*

Keywords: *Tinospora crispa*, Patawali, micropropagation

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080-074

AN INTRODUCTORY FOR REHABILITATION GROUNDWORK OF SELECTED TREE SPECIES IN A DEGRADED PEAT SWAMP FOREST AT RAJA MUSA FOREST RESERVE, KUALA SELANGOR

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ABSTRACT

Peat swamp forests (PSF) in Malaysia was once estimated around 1.54 million hectares. However, it depleted occasionally driven by anthropogenic activities namely deforestation, conversion to other land uses, indiscriminate fires and drainage. PSF is fragile with unique forest ecosystem and usually found in the lowland of tropical forest areas. Their environmental functions and economic roles are significant and recognized. Previous studies conducted in Peninsular Malaysia, found that logged-over PSFs and those burnt through forest fires, require restoration or rehabilitation. Repeated fires incidents at PSFs resulted in depletion of seed bank embedded in the peat, thus human intervention through rehabilitation is needed to assist faster recovery moreover enrich the areas with high quality PSF species. In this study, an approximately 1.65 ha of degraded PSF area at Raja Musa Forest Reserve (RMFR) was planted with a total of 900 trees comprised of five PSFs species namely Ramin melawis, Bintangor gambut, Bintangor jangkang, Durian paya and Tenggek Burung. Three different planting techniques were opted which is conventional, compressed soil and planting box. Apart from that, line planting method with spacing of 3m ×5m were selected. NPK fertilizer was applied to enhance the fertility of the peat soils. Growth performance and survival were monitored at periodically basis. Internet of things (IoT) were applied to remotely monitor the ground water level (GWL) and other environmental conditions at the plot at real time basis. After 4 months of planting, the survival rate recorded was very high which was 91% in average with Bintangor jangkang exhibiting the highest increment in height while Tenggek burung has highest increment in diameter, throughout planting measurements. Data from GWL sensor reflected that the plot has very high water table since planting took place until recently. Nevertheless, the trees survived well in an extremely wet conditions and exhibited a promising growth increment. We believed that pre-planting preparation, techniques opted and fertiliser application have boost the survival as well as increased the growth rates of the saplings planted in the study area.

Keywords: degraded peat swamp forest; rehabilitation; Raja Musa FR; peat swamp forest tree species; improvised planting technique

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QUICK STUDY AT THE MAK JINTAN PEAT SWAMP FOREST, KUALA NERUS, TERENGGANU – A STATELAND BLACK WATER JEWEL FOREST

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ABSTRACT

Mak Jintan Peat Swamp Forest (MJPSF) is a state land forest area under the jurisdiction of Kuala Nerus District and Land Office, Terengganu. This forest was discovered in year 2016 during an assessment of High Conservation Value (HCV) conducted by WWF-Malaysia and Daemeter Consulting Group. Total area of MJPSF is around 1300 ha and surrounded by mix horticulture land uses with rubber and oil palm plantations occur in the west and north part of the area. Adjacent to this forest is Belara Forest Reserve (FR) (south and east). The Belara FR includes some part of MJPSF in the south at about 600 ha. The adjacent forest is consisting of lowland dipterocarp forest, with undulating terrain. Ecological studies are needed for MJPSF to provide imperative information on the forest structure and environment for future management of this area. In the light of conservation, WWF-Malaysia and Forest Research Institute Malaysia (FRIM) have initiated a quick study at MJPSF in year 2020. Total study area is about 700 ha, which is only cover part of MJPSF, while the other half of MJPSF which within the Belara FR was not included. The key aspects of the study were included of tree inventories, soil carbon assessment and peat swamp forest classification. Eight line transects were established randomly at study area. Each transect consist of three circular plots with 10 m radius. As a result, a total of 473 trees of $\geq$ 10 cm diameter-at-breast-height (dbh) were enumerated in this study. Besides that, the study area is habitat for 63 tree species which belongs to 52 genera and 32 families. Among high quality value timber species of peat swamp forest recorded in this study were Meranti paya (*Shorea platycarpa*), Keranji (*Dialium* sp.), Bintangor (*Calophyllum ferrugineum*) and Nyatoh (*Palaquium* sp.). While, soil carbon at study area is averaged at 163.20-ton C/ha. Forest canopy density (FCD) in this study ranged from 0.6 (60%) to 0.8 (80%) which indicate that the condition of MJPSF is intact with high FCD. Findings from this study will provide valuable insights for peat swamp forest management in Malaysia as well as to encourage more conservation efforts and projects within MJPSF in the future.

Keywords: peat swamp forest, species composition, soil carbon, peatland

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084-079

PRELIMINARY ASSESSMENT ON EARLY GROWTH PERFORMANCE OF *Neobalanocarpus heimii, Hopea odorata* AND *Shorea roxburghii* PLANTED IN DEGRADED PLOT IN BESUL FOREST RESERVE, TERENGGANU

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ABSTRACT

Planting saplings of selected species is the conventional means of rehabilitating a degraded plot in a forest. In this study, three species namely *Neobalanocarpus heimii, Hopea odorata* and *Shorea roxburghii* were planted in one hectare degraded plot in Besul Forest Reserve, Terengganu using improved planting tchnique whereby it takes nto account the use of fit and quality saplings, big hole, combination fertilizers and ideal planting spacing. These species represented three different wood class; *N. heimii* (heavy hardwood), *H. odorata* (medium hardwood) and *S. roxburghii* (light hardwood). Different planting spacing were implemented as part of the treatment in this study. The main objective of this study is to monitor the early growth performance of *N. heimii, H. odorata* and *S. roxburghii* in relation to different planting spacing. Combinations of organic soil and slow-release fertilizer were applied as a part of the improved planting technique. Major elements of soil mineral content and physical properties were also determined. Preliminary assessment on the early growth performance conducted after six months of planting showed an average survival of 86% regardless of planting spacing. *H. odorata* recorded the highest survival rate of 100% within the first 6 months. Saplings planted using 5 m x 3 m spacing showed highest mean increment in height meanwhile saplings planted using 4 m x 4 m spacing showed highest mean increment in diameter. This study proved that saplings planted with different spacings gave a significant increment in growth performance of both height and diameter. Nevertheless, these species with different wood classes have successfully been planted in a degraded forest.

Keywords: rehabilitation, planting spacing, degraded forest, timber species, growth performance

076-086

GENIC MICROSATELLITE LOCI OF A CRITICALLY ENDANGERED DIPTEROCARP, *DIPTEROCARPUS CORNUTUS* (KERUING GOMBANG), DERIVED FROM TRANSCRIPTOME SEQUENCES

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ABSTRACT

Dipterocarpus cornutus is an important timber tree in Southeast Asia. Population decline of the species due to habitat loss and conversion has threatened its existence and it is listed as Critically Endangered in the IUCN Red List. To aid in the assessment of the species' genetic diversity, we developed microsatellite loci mined from

transcriptome sequence data. Specific microsatellite primer pairs obtained after agarose electrophoresis screening were further evaluated for polymorphism through fragment analysis using 24 wild individuals from Pasoh Forest Reserve, Negeri Sembilan. Nineteen loci were isolated for *D. cornutus*. These loci showed specific amplification and are polymorphic (*Dco*T01, *Dco*T02, *Dco*T03, *Dco*T04, *Dco*T06, *Dco*T14, *Dco*T22, *Dco*T25, *Dco*T26, *Dco*T27, *Dco*T28, *Dco*T31, *Dco*T32, *Dco*T35, *Dco*T36, *Dco*T44, *Dco*T45, *Dco*T59 and *Dco*T60). The number of alleles ranged from 2 to 19, and the observed and expected heterozygosity ranged from 0.208 to 1.000 and from 0.191 to 0.948, respectively. Null allele was detected at two loci, namely *Dco*T06 *and Dco*T26. Excluding these two loci, we have successfully developed 17 microsatellite loci in *D. cornutus*, readily available to be applied for its conservation genetics.

Keywords: Simple sequence repeat, tropical timber, next generation sequencing, conservation genetics, timber tracking.

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098-087

TEMPORAL CHANGES OF TREE CARBON WITHIN THE SECOND GROWTH FOREST OF TEKAM FOREST RESERVE, PAHANG, MALAYSIA

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ABSTRACT

Forest ecosystems have been recognized as carbon reservoirs for terrestrial land surfaces. Forests can be either a sink, or a source of atmospheric carbon as result from the natural or anthropogenic disturbances. The understanding on the status of forest carbon change within logged-over forest may be beneficial for future management. Hence, this paper assessed temporal changes of tree carbon within the second growth forest of Tekam Forest Reserve, Pahang, Malaysia. The long-term data (as early as 1979) was gathered from three, 1-hectare plots of Tekam Forest Reserve. The study area had been logged in 1979 using conventional tractors with a minimum cutting limit of 52 cm. Basically, any trees with $\geq$ 10 cm diameter-at-breast-height (dbh) were identified and recorded in all censuses. Tree carbon was then calculated using local allometric equations. As a result, this study found that the dipterocarp group showed a decreasing trend on tree carbon from 1979 to 2012. The non-dipterocarp group was spotted with higher tree carbon in 2012 as compared to 1979 with an increment of 15.7%. Tree carbon by diameter classes and tree species are the key aspects that were also discovered in this paper. Three diameter classes, i.e., 30-45 cm, 45-60 cm and 60-75 cm showed increment in 2012 over total tree carbon of similar classes in 1979. Large tree mortality may affect total tree carbon within this forest area. Moreover, Elateriospermum tapos, Intsia palembanica, Koompassia malaccensis, Santiria laevigata and Shorea pauciflora were among tree species that stored the highest carbon in 1979 and 2012. Proper planning for the subsequent logging cycles is needed as the stand structure and tree species play significant roles in carbon accumulation within this forest area. These findings may be useful baseline information for current prescription in order to combat global climate change.

Keywords: tree carbon, temporal change, second growth forest, long-term monitoring, Tekam Forest Reserve.

INTRODUCTION

Forest ecosystem is well known as a major terrestrial carbon reservoir with the potential to absorb and store carbon dioxide from the atmosphere. The source and sink carbon dynamics are dependent on tree growth, die and decay which are subjected to magnitude of disturbance (e.g., natural and anthropogenic) and forest management. Besides that, tree carbon storage is mostly affected by stand age, followed by climate, biodiversity and structural attributes (Li et al., 2019). Large and old trees are able to store large amounts of carbon within its stand. Generally, the increment of tree diameter is strongly influencing the total tree biomass (Loubota Panzou et al., 2018). Previous study by Ruiz-Benito et al. (2014) also showed that the functionally important species should be maintained to adequately preserve and promote key ecosystem functions such as carbon storage and tree productivity. Hence, further studies are needed to learn about appropriate species to be maintained. Long-term studies can reveal the site-specific effect of any disturbances or silvicultural interferences on stand structure, production and carbon sequestration within a period of time (Pretzsch et al., 2019). One of the long-term monitoring plots set up within

production forests is known as growth and yield plot. In this context, the growth and yield plots were established within the production forest of Tekam Forest Reserve Pahang in 1979. Since then, these growth and yield plots were used to study the dynamics of forest stockings after logging, tree growth and yields of Tekam Forest Reserve (e.g., Abd Rahman et al., 1991; Ismail et al., 2005). Considering that forest management of Peninsular Malaysia is currently practising bicyclic cutting of 25 to 30-year cycle, information such as long-term carbon change within this period is beneficial as a basis to draw up proper strategies in managing production forests in future. These strategies may highlight the services that can be committed by production forests as a part of effort in climate change mitigation. Current study discovered the trend of tree carbon change within 33 years after previous logging. Therefore, this paper assessed temporal changes of tree carbon within the second growth forest of Tekam Forest Reserve, Pahang, Malaysia.

MATERIALS AND METHODS

Study area

This study was conducted in Compartment 65, Tekam Forest Reserve, Jerantut, Pahang. The study area is located northeast of Kuala Lumpur (latitude 3˚ 59' 38.71" N, longitude 102˚ 34' 45.36" E) whose elevation ranges about 100 to 150 m above sea level. The annual precipitation recorded for this area is around 2,765 to 2,980 mm. This compartment had been logged in 1979 using conventional tractor methods with three types of cutting limits. The study area was demarcated in 1979 based on three different logging treatments prior to execution of logging activities. The growth and yield plots were set up inside all treatment areas after logging activities were ended. However, this paper was focussing on three growth and yield plots with cutting limit 52 centimetre (cm). The distribution of the plots was shown as in Figure 1.

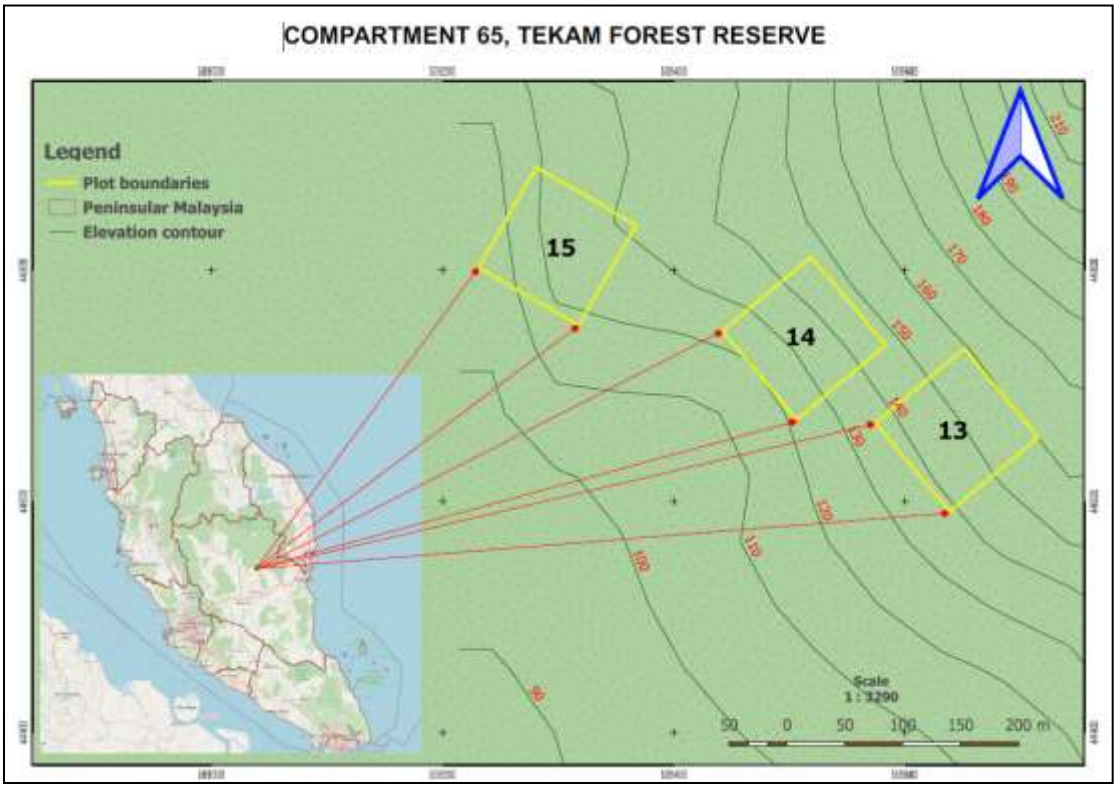


Figure 1: Location of study area

Sampling and data collection

Three, 100 × 100 m growth and yield plots were established within the treatment of cutting limit 52 cm with different topography conditions i.e., ridge, mid slope and valley bottom. The trees were measured and tagged since 1979 and these include trees with diameter-at-breast-height (dbh) $\geq$ 10 cm within the plots. The measurements were taken periodically between 1979 to 2012. All tree identification was made on the groundworks till species level.

Any unidentified trees were tagged and specimens were brought back to FRIM's Herbarium Laboratory. For identification purposes, Tree Flora of Malaya was used as a reference.

Data analysis

Tree carbon in this study was estimated based on existing allometric equations for Peninsular Malaysian. In this case, tree carbon was later derived from tree biomass using carbon conversion coefficient. Basically, the tree biomass including aboveground biomass and belowground biomass was estimated using Kato et al. (1978) and Niiyama et al. (2010), respectively. From the values of measured dbh, the dry mass of stems, branches, leaves and root of the tree were estimated for each tree within study plots. The allometric equations used to estimate these components are shown as in Table 1.

Table 1: Allometric equations used to estimate tree biomass

Biomass	Allometric equation		Reference
Aboveground	$\frac{1}{H} = \frac{1}{2 \times dbh} + \frac{1}{61}$	(1)	Kato et al. (1978)
	$M_S = 0.0313(dbh^2 H)^{0.9733}$	(2)	
	$M_B = 0136(M_S)^{1.070}$	(3)	
	$\frac{1}{M_L} = \frac{1}{0.124(M_S)^{0.794}} + \frac{1}{125}$	(4)	
	Aboveground = $M_S + M_B + M_L$	(5)	
Belowground	$M_R = 0.023 \times dbh^{2.59}$	(6)	Niiyama et al. (2010)
Total tree biomass	**Aboveground + Belowground**		

Notes: Aboveground and belowground biomass in kg/tree, H is tree height in metre (Eq. (1)), MS, MB and ML represent tree height, dry mass of stem, branches and leaves in kg, respectively (Eqs. (2)-(5)), MR is dry mass of root (belowground) in kg (Eq. (6)), and dbh is diameter-at-breast-height in centimetre (cm).

According to the United Nations Framework Convention on Climate Change (UNFCCC), the value of tree carbon is usually 47% from the total tree biomass. Hence, the total tree biomass will be multiplied with conversion coefficient which equal to 0.47 to estimate tree carbon resides within study plots.

The tree carbon was calculated for all measurement years from 1979 to 2012. The mean tree carbon for each year was then obtained by species group (i.e., dipterocarp and non-dipterocarp). This study calculated the means of tree carbon by six diameters classes (i.e., 10-15 cm, 15-30 cm, 30-45 cm, 45-60 cm, 60-75 cm and 75+ cm) for 1979 and 2012. Besides that, the ten species with highest tree carbon was also shown in this paper.

All analysis was carried out using recent versions of open-source freeware, i.e., R-statistical software and R-Studio.

RESULTS AND DISCUSSION

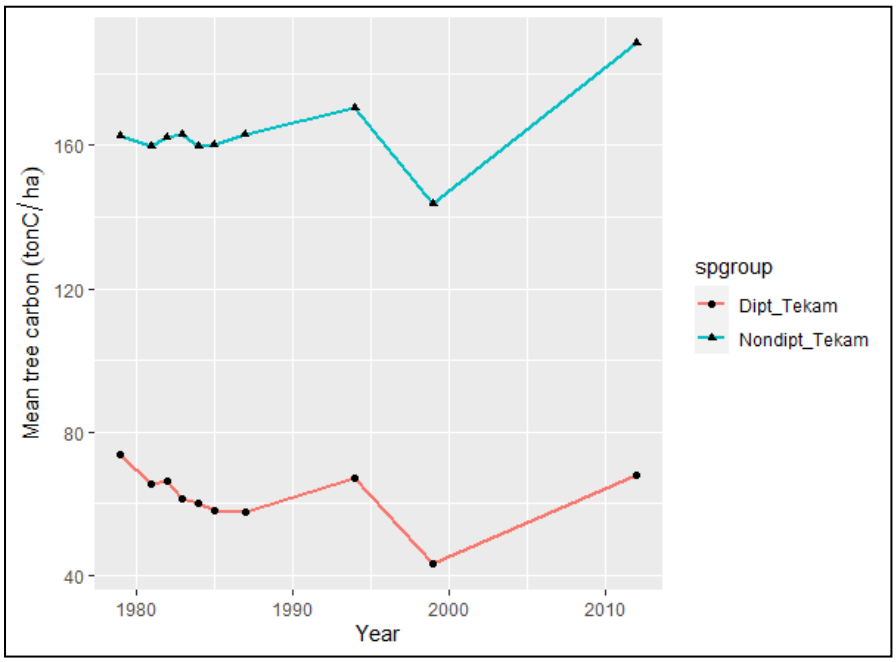
Stand structure

In 2012, a total of 1,481 individuals from 400 species and 55 families were recorded in this study. The dominant tree species by number of trees per hectare occurred in this area was *Elateriospermum tapos*. Other species that co-dominated this study area were *Santiria laevigata* and *Knema latericia*. The descriptive statistics for stand structure of all study plots in 2012 were tabulated in Table 2.

Table 2: Descriptive statistics for stand structure of all study plots in 2012

Plot	Area (m^2)	Number of tree	Number of species	Mean dbh (cm)	Minimum dbh (cm)	Maximum dbh (cm)
13	100 × 100	498	215	25.06	10.2	122.0
14	100 × 100	427	169	25.44	10.3	101.0
15	100 × 100	556	221	24.23	10.0	130.0

The temporal changes of mean tree carbon by species group were displayed as in Figure 2. The amount of tree carbon for the non-dipterocarp group was relatively higher in all measurement years as compared to dipterocarp group in this second growth forest. From 1979 to 2012, the mean tree carbon for dipterocarp and non-dipterocarp groups were ranging from 43.14-73.80 tonC/ha and 143.67-188.33 tonC/ha, respectively. Besides that, the mean tree carbon for dipterocarp group showed a decreasing trend in 33 years after logging. The non-dipterocarp group displayed an increasing trend of tree carbon storage from 1979 to 2012 (15.7% increment). Subsequent logging activities without proper planning in this second growth forest may accelerate the loss of tree carbon storage from the dipterocarp group.



Notes: Dipt and Nondipt denote dipterocarp and non-dipterocarp groups, respectively, spgroup is species group.

Figure 2: Temporal change of mean tree carbon by species group

The percentage changes of mean tree carbon of 1979 and 2012 by diameter classes were pooled in Table 3. Within 33 years after logging, the diameter class with the highest percentage change recorded in this second growth forest was 45-60 cm (77.78%). The trees with dbh 30-75 cm showed increment in mean tree carbon from 1979 to 2012. While, the negative percentage changes in this study were recorded in diameter classes of 10-15 cm and followed by 75+ cm and 15-30 cm. Negative changes indicate that these diameter classes have lost carbon in 2012 as compared to initial values recorded in 1979. There are many factors that may affect this condition such as slow growing species, mortality rate, ingrowth rate, natural disturbance, soil condition, etc within this second growth forest.

Table 3: Percentage changes of mean tree carbon between 1979 and 2012 by diameter classes

Diameter class (cm)	Mean tree carbon (tonC/ha)		Percentage change (%)
	1979	2012	
10-15	9.52	8.10	-14.92
15-30	41.38	38.59	-6.74
30-45	48.05	57.95	20.60
45-60	29.52	52.48	77.78
60-75	27.93	28.80	3.11
75+	80.16	70.18	-12.45

Species wise distribution

Ten species with highest tree carbon in 1979 and 2012 as illustrated in Figure 3 and 4, respectively. Among similar tree species recorded highest tree carbon between both years were *Elateriospermum tapos*, *Intsia palembanica*, *Koompassia malaccensis*, *Santiria laevigata* and *Shorea pauciflora*. The mean tree carbon for *E. tapos* was found to

increase from 11.01 tonC/ha in 1979 to 14.90 tonC/ha in 2012. The canopy opening through harvesting activities in 1979 may have influenced the growth of *E. tapos* within the study area. Moreover, there are three species from the dipterocarp group; i.e, *Hopea sp.*, *S. lepidota* and *S. curtisii* were found absent as highest tree carbon in 2012 whereby these species previously appeared in 1979 of this second growth forest.

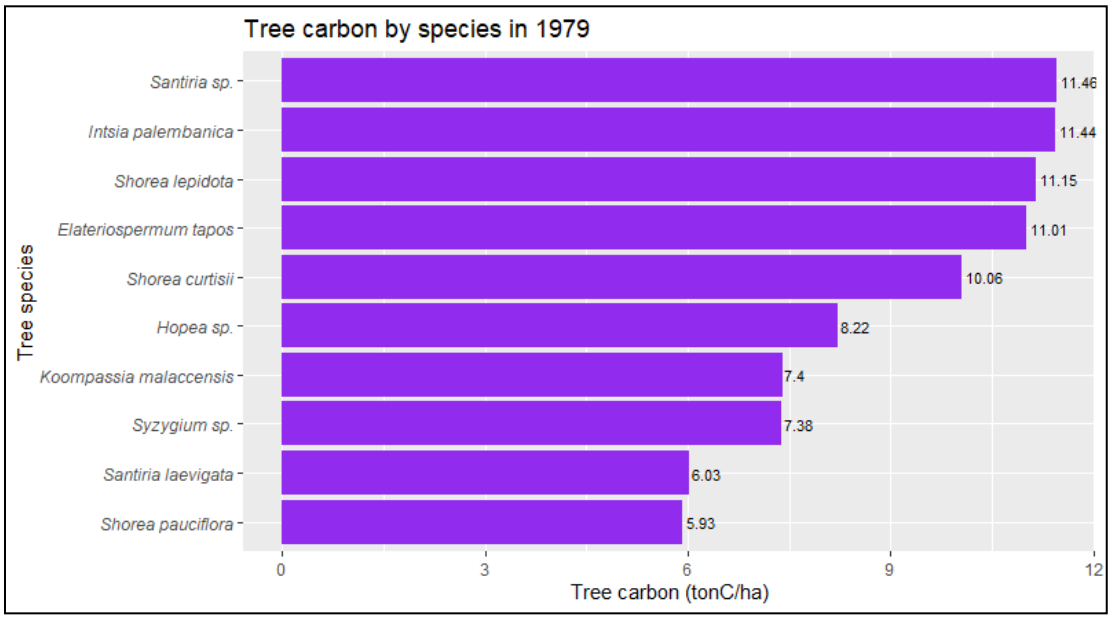


Figure 3: Species wise distribution for tree carbon in 1979

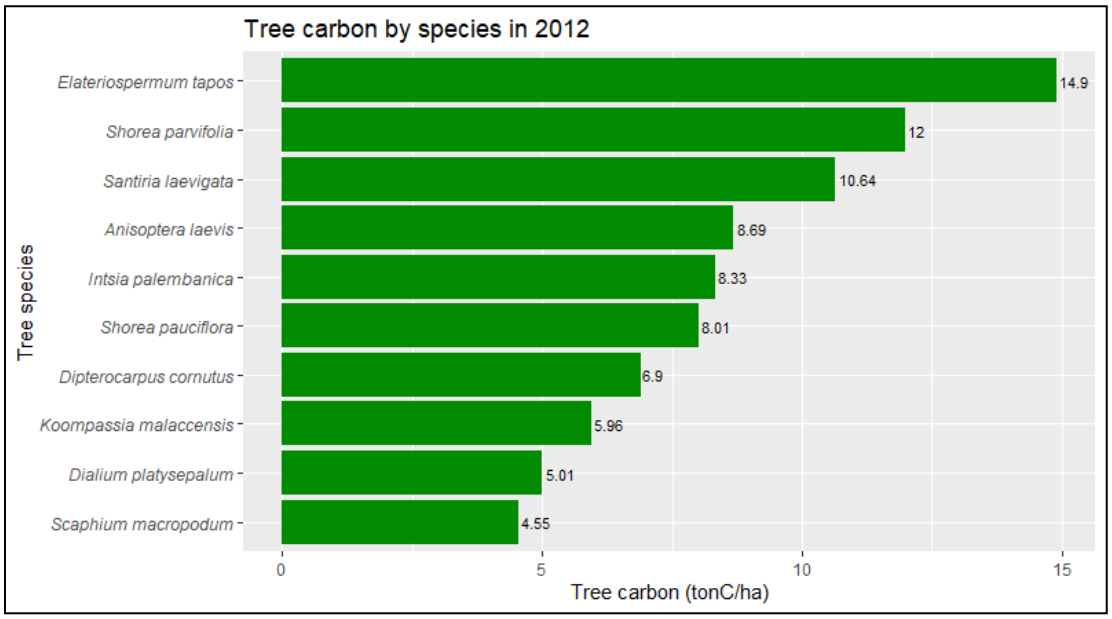


Figure 4: Species wise distribution for tree carbon in 2012

CONCLUSION

The temporal changes of tree carbon within the second growth forest of Tekam Forest Reserve, Pahang were assessed in this paper. This study found that the amount of tree carbon for the non-dipterocarp group was relatively higher in all measurement years as compared to the dipterocarp group. Besides that, the highest percentage change recorded in diameter classes were 45-60 cm. While trees below than 30 cm found greater in tree carbon loss within 33 years after logging. In terms of species wise distribution, *E. tapos, I. palembanica, K. malaccensis, S. laevigata and S. pauciflora* were among tree species that stored the highest carbon within this second growth forest. Therefore, the conventional tractor with cutting limit 52 cm logging treatment generally affected the long-term tree

carbon storage of the dipterocarp group; tree with diameter class below than 30 cm; as well as particular species in this second growth forest. These findings may be used as a basis to draw up proper strategies in managing carbon storage within production forests. Further studies are needed to discover suitable strategies or plan of harvesting to highlight the role of production forests as part of climate change mitigation in Peninsular Malaysia.

ACKNOWLEDGEMENT

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108-122

DRY CONDITIONS OF SOIL MOISTURE AND EVAPOTRANSPIRATION IN THE LOWLAND TROPICAL FOREST BASED ON GROUND AND REMOTE SENSING ASSESSMENT

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ABSTRACT

During the dry season, tropical forests have high evapotranspiration (ET) demand. The amount of rainfall and variables such as vapour pressure deficit (VPD) are used to measure how dry a place is. This study focused on how evapotranspiration and soil water content change in response to drought. Pasoh Forest Reserve (FR) near Jelebu, which has the lowest annual rainfall in the region, was chosen as the test site. The possible impacts of climate change on the forest environment can therefore be tested in this area. The main objectives of this study are to quantify soil water content and evapotranspiration, compare it with rainfall and vapour pressure deficit throughout the study period, and determine how the forest environment responds to exceptionally dry conditions. Despite a consistent VSWC pattern throughout the observation period, the observation in 2019 and 2020 demonstrates that the forest in Pasoh FR responded favourably to the amount of rainfall. Several dry spells with very low monthly rainfall (less than 50 mm per month) were recorded in 2019. February 2019 was one of the driest months on record, with only 3.56 mm of rain falling. January 2022 was also classified as dry, with less than 50 mm of monthly rainfall. The mechanisms of the forest ET rely on the fluctuations in VPD. There was no prolonged dry period during the observation, so soil moisture and precipitation were also related. In summary, the results of this study should shed light on the resilience of the forest to the potential impacts of climate change.

Keywords: Tropical forest, climate change, water use, Vapour pressure deficit

PLANTATION

018-010

EFFICACY OF SEAWEED EXTRACT FOR OIL PALM BASAL STEM ROT (BSR) DISEASE MANAGEMENT

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ABSTRACT

Sustainable oil palm basal stem rot (BSR) disease management is vital in obtaining The Malaysian Sustainable Palm Oil (MSPO) certification. At present, the most common disease management method is via synthetic fungicide application that contributes to harmful effects to the ecosystem and the palm oil products itself. Therefore, this current study explored a sustainable disease control method using *Sargassum* sp. seaweed extract. An array of treatments was designed to evaluate the potential of *Sargassum* sp. extract application in an in vivo greenhouse trial for six months. The effects of the designed treatments on disease severity (DS) and plant growth promotion of oil palm seedlings pre and post applied with seaweed extract prior to artificial inoculation with pathogenic *Ganoderma* that causes BSR infection were determined. In the greenhouse trial, the application of seaweed extract on oil palm seedlings contributed in increased vegetative growth parameters such as plant height, stem diameter, number of leaves, bole diameter, bole weight, top and root weight. Disease reduction (DR) analysis showed reduced disease incidences of BSR disease by 67.6%. Application of seaweed extract managed to enhance the vegetative growth of oil palm seedlings. Nevertheless, reduced disease incidences and severity of infected oil palm seedlings were also noted.

Keywords: *Sargassum* sp.; seaweed; oil palm; basal stem rot disease; *Ganoderma* spp.

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046-037

DIVERSITY OF NON-VOLANT RODENT PEST AND DAMAGE ON FRESH FRUIT BUNCHES IN AN OIL PALM PLANTATION IN SUNGKAI, PERAK

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ABSTRACT

The abundance of non-volant rodent pest species in an oil palm plantation located in Sungkai, Perak was evaluated using live-trap sampling method. For the study, 100 traps were set for 3 consecutive nights at 30 trapping sites in a 1688 ha oil palm plantation for over 6 months. After determining the major rodent species, physical measurements and body conditions of male and female rodents were recorded and compared. The relationship between the population of the major rodent species, using trap success, and the availability of fresh fruit bunches (FFB), amount of damage to oil palm FFB and the preference of the rodents towards ripe and unripe oil palm fruit bunches were also evaluated in this study. A total of 132 individual non-volant rodents were captured from 9000 trap-nights. From the total of rodents captured, 82.58% were the Malaysian house rat, Rattus rattus diardii, 13.64% were the Malayan wood rat, Rattus tiomanicus, 2.27% were the Plantain squirrel, Callosciurus notatus and 1.52% were the common treeshrew, Tupaia glis. Thus, R. rattus diardii was the most dominant rodent species in the study area. There were no statistically significant differences ($P>0.05$) between the weight, head-to-body length, tail length, ear length, hindfoot length, and breadth of upper incisor teeth for both sexes of captured R. rattus diardii. The result shows that there was a positive correlation between the indices of the percentage of trap success and the percentage of fresh rat damage on oil palm fruit bunches. Ripe oil palm FFB showed higher mean fresh rat FFB damage at $7.72 \pm 0.66\%$, compared to unripe oil palm FFB damage of $6.01 \pm 0.38\%$; indicating that the rats preferred ripe oil palm FFB compared to unripe oil palm FFB. However, statistically, there was no significant difference ($P>0.05$) between the fresh rat damage on ripe and unripe oil palm FFB. The information in this study is essential to understand the rodent pest distribution and its relationship with damage in a Malaysian oil palm plantation.

Keywords: Rodent, diversity, oil palm, fresh rat damage

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026-049

POPULATION STRUCTURE OF TAGNANAN COCONUT (*Cocos nucifera* L.) AND CORRELATION AMONG FRUIT YIELD AND QUALITY TRAITS

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ABSTRACT

MATAG is one of Malaysia's widely cultivated coconut hybrids for its high fruit yield and quality traits, utilized in various food and nutraceutical products. It is obtained from the cross between Tagnanan, a tall-type coconut, with Malayan dwarf coconut varieties. The low success rate and inconsistencies in MATAG hybrid production were possibly due to the condition of Tagnanan as the pollen source, as tall-type coconuts are generally allogamous, making them heterogeneous. The study was conducted to obtain the phenotypic data on yield and fruit quality to describe the population structure and relationship among traits of the Tagnanan population at DOA, Teluk Bharu, Perak. One hundred palm of 12 years old were selected as representative of the whole Tagnanan population, where phenotypic and fruit quality data were collected. Generally, the Tagnanan population was divided into six clusters. Cluster 4, with 67% of the sample population, performed best in terms of meat weight and fruit yield. Cluster 3 grouped individuals with high shell weight and shell and copra thickness. Correlation analysis shows a strong positive relationship between fruit weight, nut weight, split nut weight and most fruit quality traits. However, a negative correlation existed between copra thickness and shell thickness. Clustering of individuals in the sample population of Tagnanan based on their phenotypic performance is an essential step in identifying and selecting groups with high fruit yield and quality. Understanding the relationship among fruit quality components enables the estimation of correlated responses in selecting these traits. Selection of these individuals based on their cluster allows the improvement of the Tagnanan population by only harvesting nuts from these clusters to form the new population as a pollen source for Matag hybrid production.

Keywords: Cluster analysis, Coconut, Correlation, Tagnanan.

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064-056

THE EFFECT OF DIFFERENT PRE-TREATMENTS TO IMPROVE THE SEED GERMINATION OF URBAN LANDSCAPE TREE SPECIES

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ABSTRACT

An urban landscape tree species is a multifunctional tree with many environmental and biological implications. However, due to seed dormancy and a poor germination rate, it is unsuited for agroforestry activities. The majority of these urban tree species are from the legume family, which has hard coated seeds that hinder seed germination, thus there is a need to find the best approach to break its dormancy. Investigations were conducted on two selected species which are *Adenanthera pavonina and Delonix regia*. For improving the seed germination three different treatments were tested, physical scarification, scalding in actively boiling water for 10 minutes followed by physical scarification, overnight soaking in boiling water, and a control treatment. Results showed that physical scarification and scalding in actively boiling water for 10 minutes followed by physical scarification were the most effective methods to break seed dormancy in both species, while overnight soaking in boiling water and control treatment gave low 8% and 0% seed germination, respectively.

Keywords: *Seeds, germination, pre-treatment, dormancy*

INTRODUCTION

Trees play an important role in biodiversity conservation and facilitate in providing clean air by maintaining the levels of carbon dioxide in atmosphere and increase the ration of rainfall and improve the air quality. Ornamental and native landscape trees are significant part of cities infrastructure and ornamentation of urban landscape. The majorly used landscape trees are from the family Leguminosae. Legumes are fast-growing plant species that are capable of nitrogen fixation and thrives on infertile, acid, alkaline, salty, and waterlogged soils (Hossain et al., 1997). These species have the potential to be used to manage erosion, save water, and provide biomass for fuel production (Hossain et al.,2009). Leguminous and versatile tree can grow in a variety of tropical climates in Southeast Asia, Africa, and Latin America (Das and Alam, 2001; Simons and Leakey, 2004).

Generally, many trees exhibit seed dormancy in order to survive against unfavourable conditions (Carvalho & Nakagawa, 2000). For these leguminous trees, they possess hard coated seeds. This condition can result into delay germination; thus, the use of pre-treatment is necessary to increase the rate of seed germination (Doran et al., 1983; Aref et al., 2011).

Proper seed conditioning is important for optimal germination and seedling vigour. The use of pre-treatment to break seed dormancy has been applied in many species, including legumes (Doran et al., 1983; Tietema et al., 1992; Sahoo, 2007). For example, pre-treatments such as hot water, physical scarification, acid treatment, and cutting were performed to initiate germination. In order to promote seed germination and seedling development in trees, inorganic substrates such as sand, filter paper, and vermiculture have been used (Rawat, 2009).

As part of the legume family, these species have also shown seed dormancy. Little information is available on techniques to break dormancy particularly for *Adenanthera pavonina* and *Delonix regia* seeds. Therefore, this study was conducted to determine the best pre-sowing treatment for *A. pavonina* and *D. regia* seeds. Information obtain from this study will be useful to improve seed germination of these species and enhance seedling germination and growth in a short period of time under nursery condition.

MATERIAL AND METHOD

PLANT MATERIAL

The research was carried out at the Seed Technology Laboratory, Forestry Biotechnology Division, Forest Research Institute Malaysia (FRIM). Mature seeds of multifunctional tropical legume species were gathered directly from naturally grown standing trees.
Seeds of *A. pavonina* and *D. regia* were harvested from their pods. Healthy and mature seeds were air dried and kept at ambient temperature (28°C). Contaminated and unhealthy seeds were carefully screened and discarded.

SEED TREATMENTS

These two species were subjected to three major pretreatments to break seed dormancy.

Hot water treatment with physical scarification (HwPs). Seeds were soaked in hot water at 95°C and left for 5 minutes respectively in 100 ml beakers at room temperature (28 °C) which then ultimately scarified manually by cutting 1mm of the seed coat at the opposite site of the helium.

Physical scarification (PS). Seeds were cut carefully from the side with the help of manual cutter while protecting the embryos.

Hot water treatment (HWo). Soaking seeds in boiling water overnight is a standard technique used to break seed dormancy in tree species. Therefore, seeds were soaked overnight in boiling water.

As a comparison, the control experiment (C) was also done on these two species without the pre-treatments mentioned above.

The treated and non-treated (C) seeds were sown on moistened tissue paper in glass petri dishes (9 cm diameter). Throughout the study, the experiment was arranged in a complete randomized design (CRD) with four replicates for each treatment and each treatment had ten seeds. A total of 320 seeds (2 species x 4 treatments x 4 replicates x 10 seeds) were used for the whole experiments.

Seeds were germinated between the layers of tissue papers and maintained moist by adding distilled water as required and incubated at a constant temperature of 30°C. The petri dishes were incubated in a growth room at a constant temperature of 30±2°C with 16/8-hour light and darkness cycles. Number of germinated seeds in each petri dishes was recorded every alternate day. The observation lasted over a period of five (5) weeks after sowing. When a healthy white radicle came through the outer layer, the seed was termed germinated (ISTA, 1976). The early growth characteristics of the seed were estimated using ISTA (1999) standards as the seed broke dormant and seedlings appeared.

The following formula was used to determine the germination percentage (GP):

$$(\%)\ \text{Germination} = \frac{\text{Seed germination}}{\text{Total number of seeds}} \times 100$$

RESULTS AND DISCUSSION

SEED GERMINATION

Pre-treatments have a significant impact on seed germination. Among these pre-treatments, hot water treatment with physical scarification (HwPs) gave maximum seed germination (*A. pavonina* = 100%; *D. regia* 90%). Germination compeleted after 8 and 11 days for *A. pavonina* and *D. regia*, respectively. For physical scarification (PS) pre-treatment, the seeds obtained 65% (10 days) and 62.5% (14 days) germination, respectively. However, the proportion of seeds that germinated in overnight soaking boiling water (HWo) treatment was 0% for both species. The control treatment recorded 8% (8 days) for *D. regia* and 0% for *A. pavonina*. (Figure 1 and 2)

Figure 1: **The effect of pre-sowing treatments on the germination percentage of *Adenanthera pavonina* and *Delonix regia.***

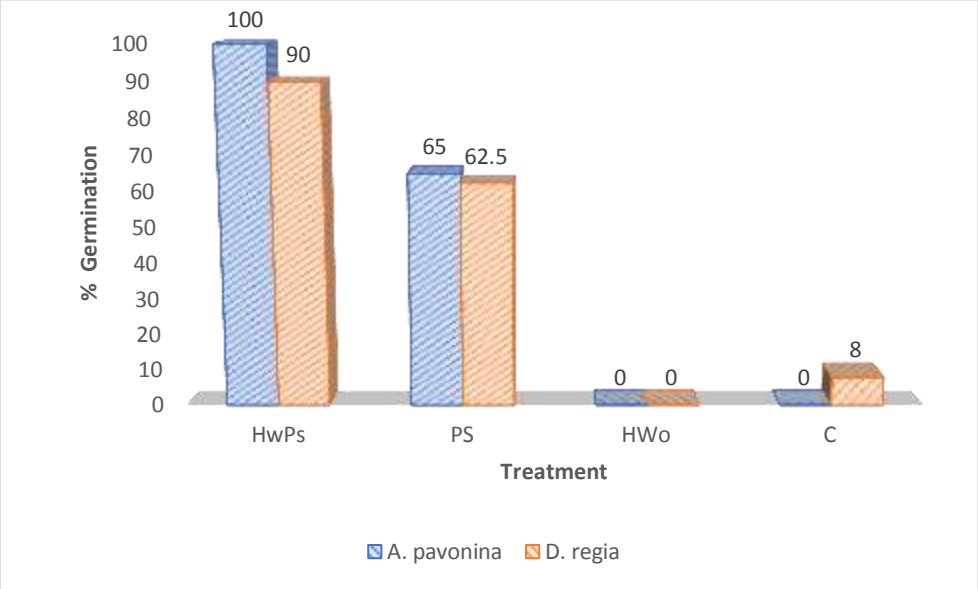
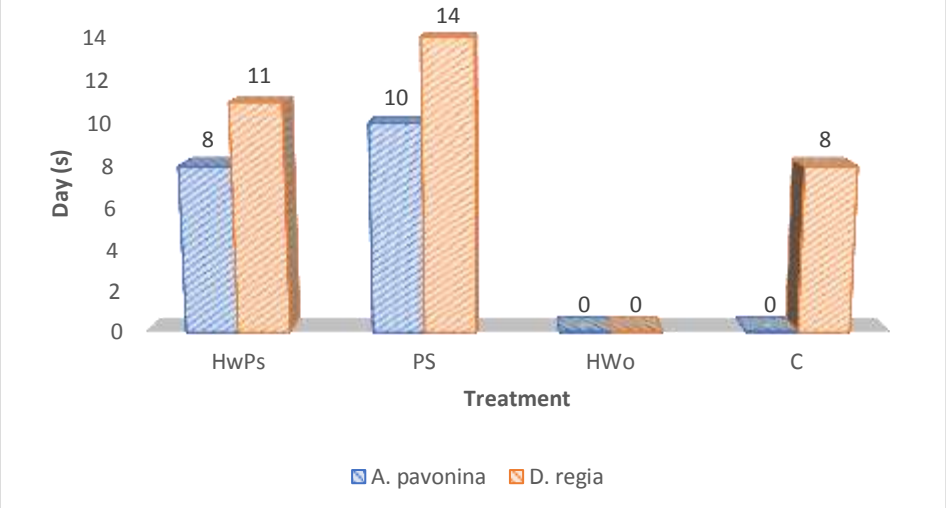


Figure 2**: The effect of different pre-treatment test on the germination of *Adenanthera pavonina* and *Delonix regia* over a period of fourteen (14) days after sowing.**



This study demonstrated the effectiveness of pre-treatments in breaking dormancy in *A. pavonina* and *D. regia*. According to Hossain et al. (2005), seeds that have a firm, solid, impermeable seed coat are more prone to germinate after pre-sowing treatment. In order to enhance germination rate and increase seedling vigour, different approaches can be applied to break seed dormancy (Yadav, 1992; Alamgir and Hossain, 2005a, b; Airi et al., 2009; Azad et al.,

2010a; b). The effect of these pre-treatments also varied depending on the plant species (Aydin and Uzun, 2001; Uzun and Aydin, 2004). In this study, seeds treated with hot water failed to break the seed dormancy. However, physical scarification is capable of initiating seed germination. It is reported that physical treatments can break down the integrity of the seed coat, thus facilitates water absorption and embryo expansion (Huang et al., 2017). By combining physical treatment and hot water, the efficiency of the method significantly improved as compared to separate treatment. Further studies on the pre-treatments are suggested to improve the seed germination in *D. regia.*

CONCLUSION

Pre-treatment of physical scarification with a germination percentage of 100% which is an increase of 12.5% from the control treatment proved to be the most optimum method that capable of breaking seed dormancy and enhance the seed germination in *A. pavonina* and *D. regia*. Pre-treatment with soaking hot water with physical scarification provides less efficacy yet still able to enhance a higher seed germination rate of 65%. These pre-treatment methods certainly save costs, time and guarantees that these species will be consistently selected to be one of the sustainable landscape trees planted by the stakeholders.

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Dormancy in seeds may be advantageous or problematic during seed handling. The advantage is that it prevents seeds from germinating during storage and other handling procedures, and induction of dormancy, for example by

drying and dark storage generally promotes storability. Indeed, seeds with no dormancy like recalcitrant seeds of rain forest species are very difficult to handle, e.g. because germination may begin already during transport and temporary storage. On the other hand, where dormancy is complex and seeds need very specific pre-treatment, failure to overcome these problems may result in very poor germination. A low germination rate of seeds which have proven to be sound and viable, in e.g.. cutting or TTZ test, can often be ascribed to some type of dormancy. Seeds which have not been given an appropriate pre-treatment to overcome dormancy may fail to germinate altogether, germination may be slow or germination of individual seeds in a seed lot may take place over a lengthy period.

The purpose of pre-treatment is to ensure both that seeds will germinate, and that germination is fast and uniform. Pre-treatment methods have been developed and described for many species. Yet, dormancy still causes problems of low germination rates for several tropical species, partly because of lack of general knowledge of their seed physiology, partly because of variation in dormancy rate. Pre-treatment methods often have to be adjusted to individual species and seed lots based on experience and experiments. Knowledge of the biology and physiology of various types of dormancy and the occurrence in relation to regeneration biology may often suggest the nature of particular seeds problems and possible pre-treatment methods. Further, taxonomically related species often share similar types of dormancy, for example physical dormancy in legumes and thermos-dormancy in pines. Here the main variable is strength of dormancy, and elaboration of pre-treatment methods can often be limited to increasing or shortening the duration of already known methods, rather than adopting new ones.

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CHEMICAL PROPERTIES OF OIL PALM TRUNKS FROM AGEING OIL PALM TREES FOR DOWNSTREAM APPLICATIONS

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ABSTRACT

Oil palm trees become economically unproductive and undergo replanting after reaching 25-30 years. Increasing tree maintenance costs, critical labour shortages and mechanisation issues in harvesting old and tall oil palm trees have necessitated research on the viability of early replanting. In this study, oil palm trunks (OPT) from ageing oil palm trees at 19 and 23 years were analysed for chemical properties, i.e., alcohol-toluene extractives, holocellulose, α-cellulose and lignin contents to identify suitable downstream applications. Results showed that holocellulose and lignin contents were significantly higher in the 23 years OPT at 66.50% and 23.98%, respectively, compared to 60.44% holocellulose and 21.61% lignin in the OPT at 19 years. Conversely, the ethanol-toluene solubles content was significantly higher in the OPT at 19 years at 25.80% compared to 13.03% obtained in the 23 years OPT. There was no significant difference in the α-cellulose contents between the OPT in the two age groups, with cellulose contents averaging from 42.89% - 44.13%. Results from this study suggest that ageing OPT biomass can potentially be converted into value-added products and serve as promising feedstocks in the biocomposites, biochemicals, pulp and paper and biofuels industries. Furthermore, these findings imply that early replanting of oil palm trees below 25 years may be deemed feasible and could provide a viable solution to the ongoing issues related to harvesting old and tall palm trees currently faced by the oil palm industry.

Keywords: oil palm trunk, lignocellulosic biomass, chemical properties, early replanting, value addition

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A REVIEW OF BACTERIAL DISEASES OF PINEAPPLE AND ITS MANAGEMENT

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ABSTRACT

A native crop from South America, scientifically known as Ananas comosus is widely grown due to its valuable attributes such as its potential in assisting body metabolism, inflammatory prevention, as well as prohibiting or decelerating the process of blood forming a clot. It is typical in cultivation industry; every crop growth will attract the presence of pests or diseases. The common bacterial disease for pineapple industry is bacterial heart rot, marbling disease and pink disease. This paper aimed to deliver the bacterial diseases related to pineapple industry and the effective management method to overcome this diseases development. Recently, chemical pesticides showed widely used in pineapple industry; however, it is not good measure for prolong due to the residue that could be harmful to environment. It includes the used of malathion, metalaxyl, fosetyl Al, benomyl, difenoconazole and mancozeb. Current studies focus on the application of biological method, even though it slow reacts to prevent the disease, it delivers a good long-term usage. For instance, Bacillus cereus and leaf extract of Vernonia amygdalina are the two-biocontrol agents used to inhibit the dissemination of Erwinia/Dickeya pathogen. Sanitation and selection of non-contaminated planting sources are also review as cultural control. Thus, this review will provide information for phytopathologist or plant breeders in managing bacteria disease of pineapple.

Keywords: Bacterial Heart Rot, Pineapple, Erwinia, Dickeya, Management Method

INTRODUCTION

Native fruit from South America (Yong *et al*., 2022) and scientifically known as Ananas comosus, pineapple comes from Bromeliaceae family, and a significant crop grown in vary tropical regions of Africa, Asia, and Latin America (Cano-Reinoso *et al*., 2021). Flourish with nutritional elements such as vitamin C, potassium, and Bromelain enzyme, which are mostly for healthcare recovery and development (MPIB, 2022), for instance, for digestion assistance, anti-inflammatory, and anti-clotting (Rohrbach, 1983). Thus, it influences the increase of pineapple production between the year 2020 (323,421 mt) to 2021 (375,423 mt) (MPIB, 2020; MPIB, 2021). Historically, Malaysia used to have excellent performance by being key industry player in 1970s era (Sidik and Sapak, 2021). Aside from their substantial worth, pineapples have been distinguished as an epic crop with notable tourism and advertising value (Yong *et al*., 2022).

Within Malaysian overview, there are 4 class of cultivars which are Spanish, Smooth Cayenne, Queen & Hybrid (MPIB, 2022), distributed into 14 different varieties, registered, and planted in this country land consist of Gandul, Sarawak, Yankee, Moris Gajah, Moris, Maspine, Josapine, N36, MD2, View of Sunset, Crystal Honey, Cobek and Keningau Diamond (Husin and Sapak, 2022). The Malaysian Pineapple Industry Board (MPIB) and government insist to expand the land cultivation as well as the productivity of MD2 variety as its only devoted 16% of mass production (Thalip *et al*., 2015). However, the nature in agriculture, every cultivated crop has problem pest and disease. As for pineapple, the most fatal disease is known as Bacterial heart Rot (BHR) disease caused by Erwinia sp. or Dickeya sp. (Husin and Sapak, 2022; Cano-Reinoso *et al*., 2021; Aeny e*t al*., 2020)

In general, this paper aimed to review bacterial diseases of pineapple and the effective management method to overcome this diseases development. The idea of management approach includes the chemical techniques, biological, cultural as well as development of resistance offspring. This review will aid not simply experimental intentions but also for organizational performance of poor pineapple cultivars, which are currently the remarkably prevalent demanded fruits.

REVIEWED TOPICS

Origin, Distribution and Production of Pineapple

The crop's origins can be traced back to Paraguay and Brazil in the Amazon jungle, from where it was initially farmed (Collins, 1949). The ideal temperature for growth is around 20 to 30°C, specifically at 23-24°C as suggested by Neild and Boshell, (1976). Heat damage may take place because of increased respiration rate and metabolism, as well as reduced food assimilation, if exposed to temperatures considerably above 30°C (Bartholomew and Kadzimin, 1977). Initially, Smooth Cayenne (Cayena lisa) are the famous variety planted (Medina and Garcia, 2005). Figure 1 shows the regular Cayena lisa variety. However, MD2 variety win over the position after contributed for 80% of the total global pineapple production after it was introduced in the market (Ndungu, 2014). In Southeast Asia perspective, Philippines, Thailand, Malaysia, Laos, and Indonesia, are the top pineapple distributor countries (Mohammad *et al*., 2022). MD2 variety is the highest demand variety, recently, due to the low-fat and cholesterol-free attributes (Mahmud *et al*., 2018). Mohammad *et al*., (2022) interpreted that MD2 should be plucked between 145-150 days after inflorescence to attain the desired level of maturity. Hence, they were also highlighted that the product should be in cylindrical shape, green skin, golden-yellow pulp with an aromatic scent on this phase.

Figure 1: Regular cultivar of Cayena lisa fruit (Medina and Garcia, 2005)

Management of Field of Pineapple

Widely known as pineapple (Ananas comosus), a crop which belongs to Bromeliaceae family is widely grown in tropical and subtropical regions. The plant is made up of spiny fruit and extending foliage that are spirally organized around a solitary butt (Pandit *et al*., 2020). The physical of Ananas comosus is quite lengthy, average leaf margin, sharp leaf and with juicy inside, along with a spike of leaves solely on a single side (Mansuri and Wahab, 2019). Yet, pineapple preferences sites, according to Hossain, (2016) are warm and humid environments, when the days are bright, and the nights are cool. Nowadays the current pineapple variety that planted in Malaysia, significantly MD2, N36, Josapine, Moris, Moris Gajah, Sarawak, Yankee, Maspine and Gandul (Mansuri and Wahab, 2019). On the other hand, pineapple crops also have their own natural pests and diseases. Previous studies have shown several diseases related to pineapple crops and the most severe cause by bacteria. As an example, pink disease, marbling disease and bacteria heart rot (BHR) disease.

Bacterial Diseases related to Pineapple Crop

Pink Disease

Pink disease has been reported in various countries to be the global potential threat towards pineapple industry as mentioned by (Rohrbach, 1983; Cha *et al*., 1997; Marín-Cevada *et al*., 2010). Bartholomew and Kadzimin, (1977) and Marín-Cevada *et al*., (2010) enlightened that the confirmed causal agents of this disease are the enterobacteria of Tatumella morbirosei and Tatumella ptyseos. The elements of rainfall and temperature are reported by Hine (1976) and Pujol and Kado, (2000), are influenced to the increased occurrence of pink disease through florescence under wet conditions followed by dry times. Kado, (2003) reported that symptoms presence for this disease are hard to recognize in real field since the external symptoms are absent. According to Pujol and Kado, (2000), the

appearance of a unique dark orange-brown colour in the fruit tissue following the heat treatment of preserving is distinguished from pink disease. Heating causes the normally golden yellow tissue to turn red to rusty brown in colour (Kado, 2003) (Figure 2). Hence, pink disease is very rare to be found in the world production of pineapple (Rohrbach, 1983)

Figure 2: Pineapple fruit slices react to develop pink disease symptoms after heat treatment of preserving. Normal reaction (top), disease presence – pink-brown coloration (bottom). (Kado, 2003)

The application of disulphoton with concentration of 0.83 kg/ha applied at intervals of five days at the red bud stage, are the management that successfully done in Philippines (Rohrbach and Schmitt, 2003; Rohrbach and Johnson, 2003). Moreover, the use of antagonistic bacteria such as *Bacillus gordonae* 2061R has been found and tested with positive feedback in preventing pink disease (Kado, 2003). Besides that, the implementation of antagonistic bacteria of *Burkholderia gladioli* (*B. gladioli*) from the isolates (UAPS070707), successfully restrained the expansion of *T. ptyseos* (Marín-Cevada *et al*., 2012). Furthermore, Kado (2003) suggested the option of genetically engineered pineapple that minimize the substrate that leads to 2,5-diketogluconate structure and genes that prevent the proliferation of P. citrea in fruit tissue. However, Marín-Cevada *et al*., (2012) enlightened that there are still no cost-efficient management solutions for successful disease control.

Marbling Disease

Rohrbach, (1983) highlighted that the world pineapple industry classified marbling disease as the most destructive bacterial disease. The causal agents of this disease include *Acetobacter peroxydans* (acetic acid bacteria), *Pantoea ananas* reclassified to *Pantoea ananatis*, and *Acetobacter* sp. (Rohrbach and Schmitt, 2003; Rohrbach and Johnson, 2003; Joy amd Sidhu, 2012). The symptoms presence of yellow-to-red brown-stain on the flesh which also influenced that infested area to solid, grainy, and crumbly (Rohrbach and Schmitt, 2003) (Figure 3) and mainly take part on inner side of pineapple. The disease favors within the temperature between 21-27°C and occurs in the subtropics (Rohrbach and Schmitt, 2003). According to Rohrbach and Apt, (1986), the preserving processes in Thailand has been halted due to disease affected to 20% of production. Around Hawaii, the degree of occurrence is highest in April, and the sickness can strike at any moment without notice. The low acidity concentrations in fruit are also contributing to the high illness levels (Mansuri and Wahab, 2019). The expanded planting of Smooth Cayenne cultivar should alleviate this issue as the variety itself fairly invulnerable (Rohrbach and Schmitt, 2003; Joy and Sindhu, 2012). In different perspective by [36], they recommended that when conducting disease census and their symptoms of this disease emerged, the infected fruit should be eradicate. In short, no effective control assessment has been established to overcome this marbling disease until today.

Figure 3: Inner part of infested flesh show the discoloration of red brown stain from yellow. Joy and Sindhu, 2012)

Bacterial Heart Rot (BHR) Disease

Bacterial heart rot disease that frequently caused by *Dickeya zeae* or *Erwinia chrysanthemi* was first identified in Malaysia in 1957, reoccurred back in 2006. (Kaneshiro *et al*., 2008; Peckham *et al*., 2010; Prasetyo and Aeny

(2014); Yasuhara-Bell *et al*., 2014; Aziz *at al*., 2018; Sidik and Sapak, 2021). The early stage of disease development presents the soggy laceration and rotting signified though brownish leaves, which eventually will cause detachable stem as well as bad essence (Kaneshiro *et al*., 2008; Aziz *at al*., 2018); Negron *et al*., 2022). Kaneshiro *et al*., (2008) highlighted that the blister- like blemishes on foliage, which occasionally packed with gas, are typical of the condition (shown as Figure 4). Moreover, the BHR disease caused by *Erwinia chrysanthemi* (*Dickeya zeae*) can be characterized by signs of water on the white bottom part of the foliage in the center area (Shen at al., 2013; Pires de Matos, 2017). Figure 5 shows a darkish border is formed when such contamination of the green area of the foliage is trapped (Pires de Matos, 2017; Ratti *et al*., 2018). According to Sipes and Pires de Matos, (2018), the disease starts through the pores, and the pathogens are predominantly spread by insects such as big-headed ants (*Pheidole megacephala*) and Argentine ants (*Linepithema humile*), as well as wind and debris. According to Aziz *et al*., (2018), the most recommended chemical for the insect is Malathion. Furthermore, research conducted by Sidik and Sapak (2021) found that bacteria of *Dickeya zeae* and *Erwinia chrysanthemi* can be efficiently restraint through the usage of fungicide of difenoconazole, mancozeb and benomyl. Yet, according to Thalip *et al*., (2015), they suggested the spraying of Mancozeb 80% on the initial planting to control the disease. Moreover, metalaxyl (Ridomil) and fosetyl Al (Allette) are also found to be successfully restrained pineapple heart rot disease (Rohrbach and Schenck, 1985). On the opposite of biological perspective, *Vernonia amygdalina* chloroform leaves extract is the most efficient biopesticides (Aziz *at al*., 2018). This is because the presence of bioactive elements including alkaloids, saponin, tannin and flavanoids have been discovered to have antimicrobial activities. Recent studies by Husin and Sapak (2022) proven the use of *Bacillus cereus* as biological control agent (BCA) to restraint the disease development as it able to obtain 18.10 ± 0.36 mm of inhabitation diameter, which is the highest. Table 1 shows the attributes and inhibition area of bacteria and Table 2 shows the Disease Severity Index (DSI) of inoculation between three treatments (T1, T2 and T3) with *Dickeya zeae*. Within cultural perspectives, prevention through sanitation maintenance (Pandit *et al*., 2020) and the removal of contaminated planting materials from cultivated areas are the approach used to control Dickeya strains Husin and Sapak (2022). Moreover, any crown or slips should be avoid using as planting materials if it came from massive, infected area (Rohrbach and Johnson, 2003). Other than that, fruit that is contaminated is wised to be detached (Rohrbach and Schmitt, 2003). Moreover, Ismail, (2019) stated that the disease can be prevent through having proper drainage, raising the planting bed more than twenty centimeter, liming to maintain soil pH, and control the ants' populations.

Figure 4: Typical gas blister presence on symptomatic pineapple leaves. (Kaneshiro *et al*., 2008)

Figure 5: A – Top view of peduncle. B – Peduncle internal view after removal. (Cano-Reinoso *et al*., 2021)

Table 1: The Different Attributes and Result of Inhibition Zone (Husin and Sapak, 2022)

Code	Gram stain, cell shape, colony colour, form, elevation and margin edge of single colonies	Inhibition zone of bacteria (mean of 3 replicates ± SD mm)
BC1	Positive, cocci, white, circular, flat and entire	6.33 ± 0.58
BC2	Negative, cocci, white, irregular, flat and undulated	7.33 ± 0.58
BC3	Positive, rod, white, irregular, flat and undulated	18.10 ± 0.36
BC4	Positive, rod, cream, irregular, flat and undulated	4.83 ± 0.76
BC5	Positive, rod, cream, circular, flat and undulated	5.00 ± 0.20
BC6	Negative, cocci, white, circular, raised and entire	5.20 ± 0.20
BC7	Negative, cocci, white, circular, flat and entire	5.20 ± 0.26
BC8	Negative, cocci, white, circular, convex and entire	5.50 ± 0.50
BC9	Positive, cocci, white, circular, flat and entire	4.77 ± 0.25
BC10	Positive, cocci, cream, irregular, flat and undulated	5.17 ± 0.21
BC11	Positive, cocci, white, irregular, raised and undulated	5.77 ± 0.25
BC12	Negative, cocci, white, irregular, flat and entire	4.77 ± 0.25

Table 2: Disease Severity Index of Inoculation Between Three Treatments (T1, T2 & T3) (Husin and Sapak, 2022)

Observation weeks	Disease severity index		
	T1 *Mean ± SE	T2 *Mean ± SE	T3 *Mean ± SE
1	0.05 ± 0.01^{b}	0.04 ± 0.01^{b}	0.53 ± 0.04^{a}
2	0.09 ± 0.02^{b}	0.06 ± 0.02^{b}	0.64 ± 0.03^{a}
3	0.10 ± 0.03^{b}	0.10 ± 0.02^{b}	0.73 ± 0.04^{a}
4	0.12 ± 0.03^{b}	0.10 ± 0.02^{b}	0.76 ± 0.03^{a}
5	0.16 ± 0.03^{b}	0.13 ± 0.03^{b}	0.79 ± 0.03^{a}
6	0.21 ± 0.03^{b}	0.17 ± 0.03^{b}	1.00 ± 0.01^{a}

CONCLUSION

In conclusion, bacterial diseases such as pink disease, marbling disease and bacterial heart rot are very damageable and can be detrimental to the nation's production and income generation. The incidence of disease development mostly takes part during the natural opening of flower emergence of pineapple, thus, affected the fruit. On the other hand, mechanical damage like cutting of leaf or fruit also triggered the occurrence of disease development. Based on these studies, the latest and most catastrophic disease is Bacterial Heart Rot disease caused by *D. zeae* and *E. chrysanthemi*. This disease is related to pineapple yield, which influences output quality and production. Various control assessments have been used to control this disease, either through chemical, biological or cultural approach. Benomyl is the most famous chemical used in the industry. However, difenoconazole and mancozeb has been proved recently as the best fungicide treatment. Nevertheless, biological methods have also been enforced more in recent years. The application of chloroform leaves extract of *V. amygdalina* and *B. cereus* is the most successful biological approach. Thus, further study is needed to enforce biological methods as promising prevention approach rather than chemicals in real field. Moreover, cultural practices such as selection of non-contaminated planting substance, controlling ant's or insect's populations and sanitation act as the early step for preventing these bacterial diseases. Cultural control is the prominent and best method to be applied. This is because it takes part in the early stage of planting, whenever it is practiced. Understanding the stage development of disease along with the effective application will help to prevent these diseases effectively. Initial observation with instant removal of infested plant part is essential as prefix approach to prevent the diseases. Chemical usages are proven to be more effective but endangered to the environment in prolong implementation. Thus, more research and development towards biological based approach is needed as it safer to the environment and human health. In short, all the knowledge gathered from this paper might be a beneficial mechanism for the growers to identify the bacterial diseases in their pineapple field and also suggested the effective control approach to overcome the disease. From these studies, the combination of control approaches is personally suggested for the long-term. This can be done through the combination of cultural and biological control.

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APPROACHES ON CLONAL PROPAGATION OF DIFFICULT-TO-ROOT *GARCINIA ATROVIRIDIS* FOR MASS PRODUCTION *OF* HIGH-YIELDING PLANTING MATERIAL

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ABSTRACT

Garcinia atroviridis or commonly known as Asam Gelugor or asam keping is a large perennial fruit tree species that grows throughout the rainforest of Southeast Asia. The species can be found in a large part of the northern states of Peninsular Malaysia and is widely cultivated in India, Indonesia, and Thailand for its culinary and medicinal uses. The tree can grow up to 30 m high, has drooping branches, and produces a yellowish to orange fruit when it is ripe. The acidic nature of fruit with ascorbic acid, citric acid, and tartaric acid, has antioxidant, anti-fungal, and anti-microbial properties. However, the fruit is commonly used for weight reduction due to its high content of hydroxycitric acid (HCA) with fat-burning properties. Increasing awareness of the medicinal value of this fruit has led to an upsurge in market demand. However, the dioecious nature of the species makes it difficult to be propagated by seeds that produce a high percentage of male trees that can only be identified when the tree starts to reach its reproductive stage after 7 to 10 years of planting. Initiatives have been taken to develop an appropriate vegetative propagation method for the clonal propagation of high-yielding mother trees. Hence, this study aims to select the superior and productive female mother tree based on its HCA content, superior phenotype, and fruit characteristics. The selection was carried out at various sites from different parts of Peninsular Malaysia by selecting at least 30 potential mother trees from each population. A few preliminary trials were undertaken to study the rooting ability of Asam Gelugor cuttings and the ability of root cuttings to produce new shoots. Preliminary results found no root formation from the stem cuttings even after being treated with rooting hormone. Cuttings stayed green with the formation of tiny fresh multiple leaves on the tip of the cuttings in a cluster and start to decay slowly after 3 months in the propagation bed. Root cuttings produced new shoots directly from the wounded root section, and transplanted root cuttings were able to initiate new roots from the donor roots in the nursery. Production of clonal planting materials in the nursery is still at an early development stage and factors affecting the root formation from the cuttings need to be optimized for mass propagation of selected superior mother trees.

Keywords: Plant propagation, Asam Gelugor, Genotype evaluation, Hydroxycitric acid, Horticulture

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GENETIC IMPROVEMENT PROGRAMS OF *Tectona grandis* (TEAK) IN PENINSULAR MALAYSIA

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ABSTRACT

Tectona grandis, locally known as teak, is listed as one of the nine selected species in the forest plantation development program (PPLH) initiated by the Malaysian Timber Industry Board (MTIB) to ensure the sustainability of timber supply. However, even though teakwood is used worldwide for its alluring aesthetics and high economic value, not many industrial planters in Malaysia are willing to plant *T. grandis* due to the slow-growing nature of this species and the longer maturity period. Therefore, the selection process to ensure that only high-quality planting materials are planted in the forest plantations is very crucial. This long decade's study is conducted to provide high-quality planting sources of *T. grandis* that can grow optimally in Peninsular Malaysia. Progeny and clonal trials are vital to test the performance of different genotypes under local climates. During the early introduction in the 1950s, *T. grandis* has been planted in the northern states of Malaysia (Perlis and Langkawi Island) and Sabah. A resource stand was established with provenances from Thailand, Indonesia, India, Papua New Guinea, Trinidad, and Sabah at FRIM Research Station (SPF) Mata Ayer, Perlis. Selected mother trees were then identified for the establishment of a clonal bank. This clone bank was listed in the Malaysia Book of Records in 2012 as 'The Largest Collection of Teak Clones in Malaysia'. The planting materials for the clonal trial study were obtained from this clone bank and mass-propagated via a budding technique (macro-propagation). In addition, four clonal materials were selected based on the performance of a progeny trial of the 29 families planted at Papulut Forest Reserve, Gerik, Perak. The clonal trial plots were then established at SPF Jeli (Kelantan) and SPF Mata Ayer in 2014. Assessment of the growth performances of eight years old data showed that based on the sites' comparison, there was a statistically significant difference ($p < 0.05$) on all the growth parameters tested except for the Total Height (HT) at one-year and Diameter at Breast Height (DBH) and HT at three years. An overview of the growth performance showed *T. grandis* planted at SPF Mata Ayer has a better growth performance. However, based on clonal variations, the differences are not significant except for the parameters of DBH at three years and HT at eight years. Clones by sites interaction also showed no significant difference except for the parameters of HT at four and five years. Considering the good and stable growth performances at the ages of 3, 4, 5, 7 and 8 years across the two locations, there were five best clones selected namely; T28, T3, T1, T24, and T4. The mean annual increment (MAI) for DBH and HT of the clonal trial plot at the age of eight years is 1.9 cm/year and 1.6 m/year, respectively. Whereas the MAI for DBH and HT of the

progeny trial plot at the age of 20 years are 1.8 cm/year and 1.03 m/year, respectively. These selected clones have the potential to be planted as forest plantations, consequently supporting an effort by the government to maintain the sustainable supply of wood materials.

Keywords: selection, family, clones, variation, stability

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MONITORING WATER QUALITY FROM OIL PALM MILL DISCHARGE IN JASIN, MALACCA: A CASE STUDY

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ABSTRACT

Palm oil mill contributed a benefit to agriculture industry in Malaysia. As palm oil mill effluent (POME) considered as polluted wastewater and treated POME sludge was produced in open treatment ponds. Even though palm oil mills generate liquid and solid waste yet POME has been pointed out to be one of the most expensive and yet difficult to manage. Characterization of POME had been conducted in various way, where the parameters involve were: pH level, total solid (TS), total suspended solid (TSS), biological oxygen demand (BOD), total organic matter (TOM). These parameters are very important in determining the level of compliance set by the DOE and to validate the use of POME as fertilizer. This research was done to observe the level of compliance set by the Department of Environment (DOE) towards the oil palm mill. Besides to determine the characteristics of treated POME, also to validate the use of POME as a fertilizer in oil palm plantation in order to manage the environment pollution more efficiently. An overall characteristic of POME gained from this research indicate that pH level was 7.77875; total solid was 5220 mg/L; total suspended solid was 261.4 mg/L; biological oxygen demand was 223 mg/L; total organic matter 90.57%. The POME characteristic obtain shows that the POME treated by the mill in Jasin does not full comply with the DOE standard and also the content in POME does help the growth of oil palm tree. In conclusion, treated POME has the potential to be used as a fertilizer even it does not meet the standard to release it in water resources.

Keywords: Palm oil mill effluent, fertilizer, Department of Environment.

INTRODUCTION

As oil palm being the fastest growing and also becoming the most important vegetables oil in Malaysia, palm oil has caused the country to benefit in natural resources with great economic value. In extracting the palm oil from fresh fruit bunch (FFB), a palm oil mill processing goes through several procedures including sterilization, bunch stripping and others. Through the process of oil extraction process it generates the end products such as oil palm trunks (OPT), oil palm fronds, empty fruit bunches (EFB), palm pressed fibers, palm kernel shells and palm oil mill effluent. The development of this industry does contribute the economy but also the environmental pollution. Amidst the waste produced by oil palm, palm oil mill effluent (POME) were considered to be the most harmful towards the environment if it was released untreated. POME is a thick liquid that has solids of oil and grease, biological oxygen demand (BOD) values, different pH level, temperature, chemical oxygen demand and total suspended solid (Rupani et al., 2010). The discharge of this effluent into water resources untreated causing an environmental pollution (Akhbari et al., 2019).

Thus, an alternative need to be consider for current uses and disposal of mill residue in order to address the potential for recovery of energy in oil palm industry (Abdullah & Sulaiman, 2013). The Roundtable for Sustainable Palm Oil (RSPO) was recently established with the support from government and Malaysia Palm Oil Council (MSPO). RSPO which involves palm oil producers, processors, traders, consumer goods manufacturer, retailers as they will develop a principles and criteria of a sustainable palm oil industry. The proposed guidelines include commitment in transparency and compliance with all applicable local, national and ratified international regulations and in this research mainly focusing on the water quality level of compliance set by the Department of Environmental.

On the other side, crude palm oil (CPO) mills using a large quantity of water and energy during the production process and generate a large amount of solid waste, wastewater and even air pollution. The solid waste usually consists of empty fruit bunches (EFB), mesocarp fruit fibers (MF) and palm kernel shells (PKS). The liquid waste is

generated from an extraction of palm oil of a wet process in a decanter. This liquid waste combined with the wastes from cooling water and sterilizer is called palm oil mill effluent (POME). During POME digestion, odor released into the environment and reduces the air quality nearby. Besides, the POME emitted from the mill and went through several pond system before it being released in water resources or used as other purposes (Mohammad et al., 2021).

This paper discussing the POME physiochemical characteristics that allows it to be used as a fertilizer on oil palm tree and also to monitor the quality level if it meets the Department of Environment requirement.

a) To observe the mills level of compliance that has been set by the standards of the Department of Environment DOE.
b) To determine the characteristics of treated POME
c) To validate the use of POME as a fertilizer

MATERIAL AND PARAMETER OF RESEARCH

The materials used in this study for the biological oxygen demand BOD, required BOD bottle, pipette, burette, glass flask for the equipment. As for the reagent are sulfuric acid, manganese sulfate, alkali-iodide-azide reagent, starch solution and sodium thiosulfate. Secondly, for the total suspended solid equipment are HDPE 1 L container, filter holder, filter, pan, weighing scale, drying oven and desiccator. As for the reagent it only required distilled water. Next is for finding the total solid which requires analytical balance, conventional oven, desiccator and a crucible only. After that, in order to determine the total organic matter, require crucible, spatula, electronic balance, muffle furnace and a desiccator. Lastly, to measure the pH level of POME, pH meter, distilled water and lint free wipes needed. For the reagent list buffer at value of pH4, 7 and 10 needed mostly to calibrate the pH meter so the result that will be recorded is more precise and accurate. As for the parameter of research it involves experiment to determine the pH level, total solid, total suspended solid, biological oxygen demand and total organic matter as shown in Figure 1.

Figure 1: The pH level of Palm Oil Mill Effluent (POME) process

The data were collected from oil palm mill in Jasin as in Figure 2, for 2 months starting from 1st November 2022 until 3rd January of 2023. The amount of sample collected for every sampling is 4000mL in air tight plastic container to prevent oxidation. After the sample collected then brought it to run a test in lab to determine those several parameters.

Figure 2: Oil Palm Mill in Jasin

RESULTS AND DISCUSSION

The pH level is necessary especially in determining the acidity level. In order to have an accurate reading, the pH level for each sample were taken twice to minimize error. Based on the study, it shows that the shows a range of minimum reading from 7.38 until 8.12 which still in between neutral to alkaline. The pH reading was mainly affected due to high organic acid content in the POME (Kamaruddin et al., 2018). This also a reason why POME has faulty to sour smells. Therefore, the pH level on Sample 3 shows a high content of organic acid in the sample due to high alkalinity level in it.

Table 1: pH level of POME

Sample no.	**Date of sample Taken**	**pH level**		**Acidic/ Neutral/Alkaline**
		1st read	2nd read	
1.	1/11/2022	7.52	7.59	Slightly alkaline
2.	8/11/2022	7.38	7.48	Neutral
3.	29/11/2022	8.10	8.12	Alkaline
4.	6/12/2022	7.70	7.73	Slightly alkaline
5.	13/12/2022	8.01	8.01	Alkaline
6.	21/12/2022	7.72	7.73	Slightly alkaline
7.	27/12/2022	7.88	7.88	Slightly alkaline
8.	3/1/2023	7.67	7.69	Slightly alkaline

Meanwhile, the average weight of total solid were 5.220625 g as shown in Table 2. The highest weight of total solid was in Sample 1 which were 9.8936 g and lowest was in Sample 3 which were 3.4895 g. The weight of total solid was affected from oil palm extraction process (Kamaruddin et al., 2018). The amount of total solids will affected due to the discharge of solid residue that trapped in the drain before reaching the sludge pit. However, from 6th December until 3rd January the weight of total solid does not change much. Moreover, since weather does affect during this sample collection during December until early January the amount of rainfall distribution was higher during those month (Rainfall Data – the Official Web of Public Infobanjir, 2023).

Table 2: Total solid of POME

Sample no.	**Date sample taken**	**ofVolume of sample taken (mL)**	**Before drying in oven**		**After drying in oven**	**Total Solid (g)**
			Weight of empty crucible (g) W1	Weight of crucible with sample (g) W2	Weight of crucible with sample (g)	
1.	1/11/2022	5ml	23.9176	34.3770	24.4834	9.8936
2.	8/11/2022	5ml	25.5336	32.8763	26.1026	6.7737
3.	29/11/2022	5ml	27.0203	31.6095	28.1200	3.4895
4.	6/12/2022	5ml	27.8066	32.4070	28.4006	4.0064
5.	13/12/2022	5ml	22.9787	27.6480	23.2676	4.3804
6.	21/12/2022	5ml	24.6985	29.3931	24.9886	4.4045
7.	27/12/2022	5ml	27.5733	32.3431	27.9031	4.44
8.	3/1/2023	5ml	25.2165	29.8998	25.5229	4.3769

The suspended solid was a solid that trapped by filter and usually tested to determine the quality of sample wastewater especially after treatment. Based on the table 3, the average weight for total suspended solid is 0.2614g. There was no constant pattern available to determine the cause. In other hand, the average amount of biological oxygen demand, the average falls at 223mg/L since most of the data were around 205mg/L until 235mg/L.

Table 3: Total suspended solid in POME

Sample no.	Date of sample taken	Volume of sample taken (mL)	Before drying	After drying	Total Suspended Solid (g)
			Weight of empty filter paper (g)	Weight of filter paper with sample (g)	
1.	1/11/2022	25ml	0.8053	1.1790	0.3737
2.	8/11/2022	25ml	0.8093	1.2204	0.4111
3.	29/11/2022	25ml	0.8123	1.1893	0.377
4.	6/12/2022	25ml	0.8155	1.0282	0.2127
5.	13/12/2022	25ml	0.8255	1.1528	0.3273
6.	21/12/2022	25ml	0.8151	0.9478	0.1327
7.	27/12/2022	25ml	0.8163	0.9501	0.1338
8.	3/1/2023	25ml	0.8306	0.9535	0.1229

In other hand, the Biological Oxygen Deman (BOD) analysis based on oxidation reaction of organic matter with oxygen in water and process taken place due to the presence of aerobic bacteria. The data of COD is an indicator for water pollution by organic matter where it can naturally be oxidized through microbiological processes and results in decreasing oxygen dissolved level in water (Leela et al., 2018). Based on this study, it shows the highest BOD level was on 1st November and decrease to 205mg/L in 8th November. However, the data increase to 225mg/L and remain the same until 13th December and continuing to increase in following week at 229mg/L. Then it started to decrease to 221mg/L and 213mg/L in the following week and slightly increase in 3rd January by 224mg/L.

Generally, content in the POME has the nutrient elements required by plants to grow and as the percentage was higher the better it will be for plant as the POME has a high nutrient content (Khairuddin et al., 2016). Total organic matter sample found for this study are mostly contains more than 90% of organic matter level and also the average percentage was at 90.57% which consider high and good to be used as a fertilizer (Khairuddin et al., 2016) as shown in Table 4.

Table 4: Biological Oxygen Demand in POME

Sample no.	Date of sample taken	Dissolved oxygen content mg/L		B.O.D mg/L (5 days 20 ℃)
		Initial (D1)	Final (D2)	
		D.O Value	D.O Value	
1.	1/11/2022	7.95	3.20	235
2.	8/11/2022	7.95	3.85	205
3.	29/11/2022	7.90	3.40	225
4.	6/12/2022	7.85	3.35	225
5.	13/12/2022	8.00	3.42	229
6.	21/12/2022	7.95	3.53	221
7.	27/12/2022	7.70	3.44	213
8.	3/1/2023	7.90	3.43	224

The characteristics of treated POME

The pH level of POME was in range between 7.52 until 8.12. The pH level indicate that the POME was between neutral to slightly alkaline. The total solids and suspended solid, the average were around 5.22 grams for the total solid and 0.2146 for total suspended solid. As for the biological oxygen demand (BOD) shows an average of 223mg/L. Lastly the total organic matter shows 90.57% which shows a quite high organic matter content. Besides there several factors that effecting the result such as climatic condition. During sample collection in November until January the rainfall distribution is high (Rainfall Data – the Official Web of Public Infobanjir, 2023). Therefore, the pH level becomes less acidic due to increase of water in the treatment pond. Treatment efficiency also decrease in raining season due to limited sunlight that reduced the photosynthesis process in pond and also reduce the dissolved oxygen in pond treatment (Rupani et al., 2010).

The mills level of compliance set by the standards of the Department of Environment DOE.

During this research, the POME does not comply all of the required parameters set by DOE. The pH level does comply with DOE standard which still in the range of 5.0 until 9.0. As for total solid there were no standard set by the DOE but for total suspended solid the limit was 400mg/L and based on the result the collected POME still under the limit range (Ismail et al., 2019). Next is for biological oxygen demand (BOD), the sample result was around 205 to 235, however, the limit range was supposedly to be at 100mg/L. In terms of BOD it does not meet the limit range (Leela et al., 2018). Lastly, the organic matter content. The percentage of organic matter content was 90.57% which optimum to use as a fertilizer for the oil palm tree. Due several reason the palm oil mill does not release their POME to any water resources nearby.

The use of POME as fertilizer.

Based on the result from this research, the organic matter content was between 90% and 94% which is optimum to be used as a fertilizer. The potential of using POME as a cheap organic fertilizer may be an alternative for using a chemical fertilizer (Khairuddin et al., 2016).

CONCLUSION

As conclusion, the palm oil industry continues to expand, the generation of POME also expected to increase significantly. However, there are several challenges and issue related to POME, in term to ensure the final discharge effluent obeys the standard limits set up by Department of Environment Malaysia. Characteristics study of wastewater is essential in industry as it provides data on design parameters that could be extracted for the design or modification. Thus, there is a need of appropriate waste minimization or recycling technology which should be easy to operate and cost effective. As palm oil mill effluent is nontoxic and considered as a good source of organic nutrients and POME can be suitable waste management option. By using POME as fertilizer is an also efficient waste management option and it will help in recycling plant nutrient and helps soil from soil degradation. However, further study should be conducted to improve the waste management of wastewater either enhancing the existing method or introducing new method.

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