4TH EDITION

E-EXTENDED

ABSTRACT

INTERNATIONAL AGROTECHNOLOGY INNOVATION SYMPOSIUM (i-AIS)

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INTERNATIONAL AGROTECHNOLOGY INNOVATION SYMPOSIUM (i-AIS)

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ABOUT FACULTY OF PLANTATION AND AGROTECHNOLOGY

The Faculty of Plantation and Agrotechnology was established in 2010 at Universiti Teknologi MARA (UiTM). The mission of the faculty is to play the vital role of producing well-trained professionals in all areas of plantation and agriculture-related industries at national and international levels.

Bachelor of Science (Hons) Plantation Technology and Management is a three-year program that strongly emphasizes the various aspects of Production Technology, Management, and Information Technology highly sought after by the agricultural and plantation sectors. Students in this program will be fully trained to serve as professionals in the plantation sector and related industries. They will have ample opportunities to fulfill important positions in the plantation industry such as plantation executives. This program provides a strong balance of technology and management courses essential for the plantation industry such as management of plantation crops, soil fertility, plantation management operation, plantation crop mechanization, and agricultural precision. As an integral part of the program, students will be required to undergo industrial attachment to gain managerial skills in the plantation industry.

The faculty is highly committed to disseminating, imparting, and fostering intellectual development and research to meet the changing needs of the plantation and agriculture sectors. With this regard, numerous undergraduate and postgraduate programs have been offered by the government's intention to produce professionals and entrepreneurs who are knowledgeable and highly skilled in the plantation, agriculture, and agrotechnology sectors.

PREFACE

International Agrotechnology Innovation Symposium (i-AIS) is a platform to be formed for students/lecturers/ staff to share creativity in applying the knowledge that is related to the world of Agrotechnology in the form of posters. This virtual poster competition takes place on the 1st of December 2022 and ends on the 8th of January 2023. This competition is an assessment of students in determining the level of understanding, creativity, and group work for the subject related to agrotechnology and being able to apply it to the field of Agrotechnology. The i-AIS 2022 program takes place from December 1, 2022, to January 8, 2023. The program was officiated by the Dean of the Faculty of Plantation and Agrotechnology, namely Prof. Madya Ts. Dr. Azma Yusuf. The program involves students from faculties of the Faculty of Plantation and Agrotechnology (FPA)and HEP participating in i-AIS 2022, namely, the Faculty of Education and Pre-Higher Education. This program involves the UiTM student and some of the non-UiTM students which come from the international university and the local university. Two categories are contested, namely UiTM and non-UiTM. To date, students from these programs have shown remarkable achievements in academic performance and participation in national as well as international competitions.

This competition is an open door for the students and lecturers to exhibit creative minds stemming from curiosity. Several e-content projects have been evaluated by esteemed judges and that has led to the birth of this E-Poster Book. Ideas and novelties are celebrated, and participants are applauded for displaying ingenious minds in their ideas.

It is hoped that such an effort continues to breed so that there is always an outlet for these creative minds to grow.

Thank you.

Dean
On behalf of the Organizing Committee
Conference Chair
Universiti Teknologi MARA
Faculty of Plantation and Agrotechnology
http://fpa.uitm.edu.my

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THE UTILIZATION OF JACKFRUIT SEED FLOUR IN THE DEVELOPMENT OF MALAYSIAN FISH CRACKER

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ABSTRACT - The utilization of jackfruit seed flour in the development of Malaysian fish crackers on the nutritional composition, Texture Profile Analysis (TPA), colour evaluation and linear expansion were investigated. Nutritional properties such as moisture content, total ash content, crude protein, crude fat and carbohydrate were conducted. Three formulation of different amount of jackfruit seed flour added were develop. Formulation 1, 2 and 3 contain 3.77 %, 7.54 % and 11.31 % jackfruit seed flour that give different nutritional value of end product. Moisture content (1.26 – 1.35 %), total ash content (2.47 – 3.08 %), crude protein (14.28 – 17.12 %) and carbohydrate (44.15 – 49.66 %) shows the increasing significant ($p<0.05$) trend with the increasing percentage of jackfruit seed flour. Meanwhile crude fat (37.60 – 29.93 %) shows the decreasing significant ($p<0.05$) trend with the increasing percentage of jackfruit seed flour. The texture of end product of Malaysian fish crackers were determine.The result shows the hardness and fracturability of fried fish crackers where the hardness (432.51 – 2156.75g) and fracturability (199.78 – 645.00 N) were increasing along with the increasing percentage of jackfruit seed flour. The colour evaluation of fried and unfried fish crackers made from jackfruit seed flour were conducted. The lightness (L*) (55.14 – 57.20) was increase with the increasing amount of jackfruit seed flour. For unfried fish cracker, the lightness (L*) (41.48 – 44.22) shows the decreasing trend along the increasing percentage of jackfruit seed flour. The redness (a*) of fried fish cracker (5.57 – 7.07) and unfried fish cracker (3.08 – 3.56) shows the increasing trend along with the increasing percentage of jackfruit seed flour. Meanwhile, for yellowness (b*) of unfried fish cracker (9.57 – 8.86) shows the decreasing trend with the increasing amount of jackfruit seed flour. The yellowness (b*) of fried fish cracker (19.80 – 22.57) shows the increasing significant ($p<0.05$) trend along with the increasing percentage of jackfruit seed flour.

Keywords: Jackfruit, jackfruit seed flour, fish cracker, nutritional composition, colour, linear expansion

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lam) is the yellow fruit that most common grow in the tropical area such as Malaysia, Thailand, Philippine and other Southeast Asia countries. The yellow sweet bulb contain high amount of nutrition.Jackfruit tree can grow up to 3 meters long and 20 inch wide [1] and the matured tree can grow up between 15 - 20 meters. Jackfruit classified as the largest tree-borne fruit in the world because the fruit itself can reach up to 18 kilograms weighing. The fruit contain multiple yellow flesh bulb around a stringy core that contain seed [2]. Jackfruit is quite popular fruit for vegan as it can be canned or processed to become a variety of vegan food such as nugget, tacos and more. The yellow sweet bulb contain high amount of carbohydrate and protein [3]. The jackfruit seeds make it around 10 - 15 % of the total fruit weight [4].

The jackfruit seeds and their inner skins that are not used become foodwaste is often discarded by food industrial company agricultural. Therefore, the dumping of food waste is one of the causes in Malaysia due to lack of appropriate planning, purchase and prepare too much food and over-preparation of food in restaurant, hotel and food service industry. In Malaysia, almost 38,000 waste per day was produced [5]. Currently, the problem faced by some food producing countries is the issue of dumping of food waste in the foodsupply chain. The food chain connects between food producers and consumers. It was reported that 931 million tons of food waste was produced in 2019 which 61 % produced from household, 26 % gains from food services and 13 % from retail and shops [6]. The negative attitude that often considers food waste management not important worsens the situation [5].

Jackfruit seeds have a lot of nutrients which contain high amount of starch, protein,vitamins, minerals and antioxidant. The seed contain low of fat that is suitable to consume in a big amount [7]. About 76.1 % carbohydrate, 17.8 % protein and only 2.1 % lipid content in a jackfruit seed [4]. The seeds have lignin that usually found at particularly seeds, whole grains and vegetables [8]. Besides it offers anticancer, antihypertensive, antioxidative and antiulcer effect [4]. The best ways to consume the jackfruit seed is by boiling with a pinch of salt for about 1 to 2 hours to get a soft and mushy texture. Other way to make it edible is to process it into flour to develop a new food product. The process of making jackfruit flour can be carried out by a few methods such as dried, roasted, boiling or autoclaved[4].

A lot of food products can be made from jackfruit seed flour and one of them is Malaysian fish cracker. Fish cracker is one of the famous Malaysians snacks, especially in the East and North Coasts of Malaysia [9]. There are many factories producing fish cracker that are still operating in the east coast areassuch as Kelantan, Terengganu and Pahang. The main ingredients for making fish crackers are cassava flour, sago flour, raw fish and a little salt. Types of fish that are suitable for use in making fish cracker are wolf herring fish (ikan parang), sardines, tamban fish, round scad (ikan selayang), goatfish (ikan biji nangka), ox- eyed scad (ikan lolong bara), lizardfish (ikan conor), threadfin bream (ikan kerisi) and others.

Fish cracker entrepreneurs live on the coast or near the area to get fresh fish supplydirectly from fishermen at a cheap price. Fish cracker is easy to process and highlyin demand by the Malaysian and tourist. High quality fish crackers can be achievedby carefully mixing the sago flour, cassava flour and fresh fish. These essential ingredients are then pounded or ground to a pulp and boiled in an oval shape so thatit is easy to cut. When the fish cracker dough is cold, it is slice into very thin sizes to shorten the drying process [9]. These fish crackers are unique because when fried in hot oil, they will expand to 2 - 3 times their size. Fish crackers dipped with chili sauce are very tasty as hi-tea for the whole family.

In order to reduce the food waste obtained from jackfruit, the processing of jackfruitseeds into flour is a good idea as it similar to the properties of cassava flour to it have higher amount of starch and give a texture of fish cracker. Hence, jackfruit seed flourcan be used to replace cassava flour and at the same time can reduce waste products.

The objective of this study is to develop the Malaysian fish cracker made from jackfruit seed flour. Besides that, the aims is to determine the physicochemical analysis of fish cracker made from jackfruit seed flour I term of its nutritional value that include moisture content, total ash, crude protein, crude fat and carbohydrate as well as physical analysis that include Texture Profile Analysis (TPA), colour evaluation and linear expansion.

The jackfruit seed flour is introduced in Malaysian fish cracker as it possess high amount of starch almost similar to cassava flour. Thus, jackfruit seed flour can be used as a substitute to cassava flour in Malaysian fish cracker and at the same time can reduce the jackfruit waste.

MATERIAL AND METHOD

Raw material

Jackfruit seed was purchased from sellers in Kampung Parit Karjan, Sri Medan, Batu Pahat, Johor. Sardine, cassava flour (cap kapal ABC) rock salt (Halagel), coarse sugar (CSR), monosodium glutamate (MSG) (Ajinomoto), iced water and cooking oil (Saji) will be purchased from local hypermarket (Giant, Selangor).

Processing of jackfruit seed flour

Jackfruit seeds are cleaned first, then the first and second skin layers was peeled and removed using a knife. Then the jackfruit seeds was sliced using the knife and arranged on a tray. Sliced jackfruit seeds was dried in the drying cabinet at a temperature of 60°C for 8 hours or overnight. Next, dry jackfruit seeds was grounded using the dry blender for 3 minutes.

Production of Malaysian fish cracker

The flesh of sardine, cassava flour, jackfruit seed flour, salt, sugar,monosodium glutamate and ice water were mixed together in the bowl. A well-mixed dough can be identified when the dough does not stick to the bowl and can form a dough. The dough that has been mixed was formed in the shape of a cylinder. The dough was formed in the same size i.e. the length of the dough was between30 cm and the diameter of the dough is 6 cm. The formed dough weighs around 200 - 250 g. The dough was boiled in boiling water for 40 minutes. The dough that has been boiled was drained and cooled at room temperature. After that, the dough was sliced to a thickness of 1 - 2 mm using kitchen slicer. The dough slices was arranged in a tray and dried using a cabinet dryer at 60°C overnight or 8 hours. The dried fish crackers was stored in airtight containers (Bake with Yen) for future use. The dried fish cracker was deep fried using cooking oil at 200°C for 10 seconds or until the crackers expended (double in size).

Formulation of Malaysian fish cracker

Based on Table 4.1, the preparation of Formulation 1, 2 and 3 of Malaysian fish cracker made from jackfruit seed flour were using the same ingredients with the same brand but different in weight of flesh of sardine, cassava flour and jackfruit seed flour.

Physicochemical analysis

In nutritional composition analysis, the fish cracker was analysed based on their moisture content, total ash content, crude protein, crude fat and carbohydrate content.

Moisture content

Moisture content was determined by using oven drying method. This method based on the evaporation of water in sample. Firstly, aluminium dish with cover was dried for 4 hours in oven at 105°C. The dish was transferred into the desiccator to let it cool and weighed after it had attained room temperature. 5g of homogenized sample was weighed approximately into the aluminium dish. The sample was placed uncovered, in the oven overnight at 60°C or at 105°C for 5 hours. The lid was replaced while the dish was in the oven, the dish was removed from oven. The dish was cooled in desiccator and weighed soon after attained room temperature. The weight obtained was recorded. The drying process was repeated until constant weight was achieved. The percentage of moisture was calculated as described below.

Calculation percentage moisture (wt/wt):

$$\frac{(Weight\ of\ wet\ sample + pan) - (Weight\ of\ dried\ sample + pan)}{(Weight\ of\ wet\ sample + pan) - (Weight\ of\ pan)} \times 100$$

Total ash content

The total of ash content was determined by using dry ashing method. Firstly porcelain dish was dried in the oven at 105°C for 3 hours and cool it in the desiccator and weighted after it had attained room temperature. 5g of homogenized food sample was weighed accurately into a porcelain dish. The dried sample was char gently over a Bunsen burner until it had ceased smoking. The dish was placed in muffle furnace (Daihan Scientific Muffle Furnace, Australia) and heated at 550°C for 3 hours. The sample was ash until whitish or greyish ash was obtained. The dish was removed, cooled in desiccator and weighed soon after attained room temperature. The total ash content of the food sample was calculated using formula above.

$$Total\ ash\ content\ = \frac{weight\ of\ ash}{weight\ of\ the\ original\ sample}\ X100$$

Crude protein

Digestion operation

Protein content is determine by using Kjeldahl distillation apparatus in threeformulation of Malaysian fish cracker [10]. Firstly, the digestion tube was placed in the digestion tube holder on the rack. 0.6 g of sample was weighed into the digestion tube. 2 pills of catalyst mixture (5g potassium sulphate + 5mg selenium) and 150mL 96 % concentrated sulphuric acid were added. Then duplicate blank were prepared. Unused connected branched was sealed with glass cap. The suction mould was placed with the fitted gaskets in the digestion tube holder. The water supply was turned on to the condenser and scrubber unit was switched on. The digestion unit was switched on and the energy regulation was set in position 10. The samples were let digested until digestion was completed. The sample should be clear with no charred material remaining. The samples were taken off the digestion block and were allowed cooling.

Distillation operation

The power system of distillation until was switched on. The system was let warmed up at least 10 – 15 minutes before the first run. The appropriate procedure was followed to start up distillation system. 60 mL 2 % boric acid and 3 drops of screened methyl red as an indicator were filled into the receiving flask. The distillation apparatus was set up with the delivery tube dipping below the solution. The sample tube was put in place, make sure it is seated securely. 70 mL distilled water was added to the digestion tube. 50 mL 40 % NaOH was added to the digestion tube by pressing the NaOH button until desired volume. The STREAM switch was turned on to start distillation process. 200 mL of the distillate was collected.

Titration

The normality of the standardized solution was recorded. The contents of the receiver flask was titrated with 0.1M HCl. The volume of HCl used was recorded for the samples and blank.

Calculation

The percent protein was calculated for each replicate and then the average was determined. The conversion factor that used was 6.25 and the protein content was calculated using the formula below.

1 mL 0.1M HCl	= 1.4 mg N
Therefore, total nitrogen (g) per 100g food sample	$\frac{(titre-blank) \times 1.4 \times 100}{1000 \times sample\ weight\ (g)}$
Total protein (g) per 100g food sample	= total nitrogen × conversion factor for foodstuff analysed

Crude fat

Fat content is determined by using solvent extracted method. Soxhlet extractor (Behr Labor-Technik behrotest R 104 S, Germany) is often use in laboratory for solvent extracted method. Firstly, 2g of dried sample was weighed accurately into an extraction thimble or a piece of filter paper. The opening of the thimble was plug loosely with cotton or fold the filter and plug with cotton. The thimble or paper was placed and content into a Soxhlet extractor. The dried round bottom flask was weighed accurately and 150mL petroleum ether was added. The apparatus was connected to the condenser. The water was turned on and was extracted for minimum 8 hours on the electrothermal extraction unit. The flask containing the petroleum ether extract was removed after the extraction complete. The petroleum ether was evaporated off on the boiling water bath. The flask was transferred into the oven at 105°C for one hour to dry the extract. The flask was transferred immediately into a desiccator to cool and weighed. The fat was calculated using formula above.

$$\% \text{ Fat in sample} = \frac{Weight\ of\ fat\ in\ sample\ (g)}{Weighed\ of\ sample\ taken\ (g)} \text{ x } 100$$

Weight of fat in sample = (Weight of flask + fat) – Weight of flask

Carbohydrate

Total carbohydrate content of fish cracker was determined by using formula above. Total carbohydrate (%) = 100 – (moisture + ash + crude protein + crude fat) × 100

Texture Profile Analysis

Texture Profile Analysis (TPA) was conducted by using Texture Analyser (TA-XT2i, Stable Micro System, UK) for three formulation of fish crackers. Samples was tested for the hardness and fracturability. The spherical/Magness-Taylor Probe (SMS P/0.25S) was used for testing the sample. Fish cracker was fried using cooking oil at 200°C for 5-10 seconds as sample preparation step. Then, fried fish cracker of about 4 cm length was placed on the TPA platform which was the center of the fixture (the gap between the supports was 24mm). The spherical probe was moved with the speed of 1 mm/min until breakage of cracker occurred. The attributes of texture profile analysis which were hardness and fracturability were determined by selected the Force 1 (hardness) at maximum peak and Force 2 (fracturability) at first peak. The data were automatically obtained and were recorded.

Colour evaluation

The colour of fish cracker was measured on the surface of unfried and fried fish cracker by using chromameter (Konicha Minolta CR-400, Japan). Firstly, the instrument was calibrated with a white colour standard [11]. Fish cracker was placed in the petri dish and was measured the direct contact between the sensing head of colorimeter and samples. The lightness (L*), redness (a*) and yellowness (b*) of the fish cracker was recorded [11] at random position of fish cracker.

Linear expansion

The percentage linear expansion was calculated based on the expansion of fish cracker after and before fried. The initial diameter of unfried fish cracker was measured by using Vernier caliper (Mitutoyo, Japan). Then, fish cracker was fried using cooking oil at 200°C for 5-10 seconds. The diameter of fried fish cracker was measured using same tool. The percentage linear expansion was calculated using formula above.

$$\text{Linear expansion (\%)} = \frac{(Length\ after\ frying - Length\ before\ frying)}{Length\ before\ frying} \times 100$$

RESULTS AND DISCUSSION

Nutritional composition of Malaysian fish cracker

In nutritional composition, there were five analysis have been conducted which were moisture content, total ash content, crude protein, crude fat and carbohydrate content. These analysis was calculated in Table 4.1 above.

Moisture content

Moisture content of different formulation was given in Table 4.2 for fried fish crackers. Moisture content was the crucial element because it is the percentage of water contain in fish cracker. Moisture content was determined by using oven drying method. The moisture content of fried Malaysian fish crackers made by jackfruit seed flour were 1.26 %, 1.33 % and 1.35 % for Formulation 1, 2 and 3. Formulation 1 has the lowest moisture content compared to Formulation 2 and 3. This shows the significant increase in moisture content of fish cracker made from jackfruit seed flour when jackfruit seed flour was added. This was directly proportional relation with the increasing of concentration of jackfruit seed flour.

Based on Table 4.2, the value of moisture content was increase ($p<0.05$) as the percentage of jackfruit seed flour added increase in the formulation. The moisture contents of the commercial fish crackers under study ranged from 9.37 % to 13.83 % [9]. The finding on jackfruit seed flour has moisture content about 6.28 – 9.16 % [8]. Based on research Waghmare (2019), expanded snacks has increased in nutritional and phytochemical properties with 10 – 40 % amount of supplementation.

Total ash content

Total ash content was determined for fried fish crackers. From the results shown in Table 4.2, the mean of ash for fish crackers were 2.47 %, 2.71 % and 3.08 % for Formulation 1, 2 and 3. There were no significant different were found between three formulations of fried fish crackers. Total ash content was depend with the types of the flour used. Jackfruit seed flour has total ash content about 3.93 % with the removal of brown spermoderm [12]. Formulation 3 has higher total ash indicate that it has higher mineral content.

Ash content of jackfruit seed flour found in Noor *et al.*, (2014) was 1.53 – 2.66 % while Tulyathan *et al.*, (2002) reported that the jackfruit seed flour with the removal of brown spermoderm has total ash content about 3.93 %. Different varieties, seed maturation, and environmental factors were all contribute to these variation value of total ash content [12].

Crude protein

Crude protein were determined for three different formulation of fried fish crackers. From result at Table 4.2, Formulation 3 contain significantly ($P<0.05$) higher protein content which was 17.12 % compared to Formulation 1 and 2 which were 14.28 % and 14.54 % respectively for fish cracker. There was no significant different of protein content between Formulation 1 and 2. This result was consistent with Malaysian Food Regulation No. 168, which specifies 15 % as the minimum level of protein [9]. Fish crackers have a higher protein content when more jackfruit seed flour was used to make them [9]. Therefore, the low protein content points to a low level of jackfruit seed flour in the formulation. Fried fish crackers has lower protein content due to absorption of oil during frying process [13].

Based on study, the mean crude protein of commercial fried fish cracker was 10.86% [14]. Codex Alimentarius conclude that protein content of fish cracker which above 12 % can be classified as grade 1 [14]. Jackfruit seed contain high amount of protein which is 17.8 % on dry basis [4]. Tulyathan (2022) reported that the jackfruit seed flour has protein content about 11 %. The result was different due to the differences in seed maturity, growth condition and variety of fruits [12]. Therefore, fried fish cracker made from jackfruit seed flour can be considered as a goof source of protein.

Crude fat

Fish crackers contain minimum 15 % of fat. This derived from the fat that contain in fish flesh used and jackfruit seed flour used. Cooking oil from olein used for frying method was contributed to the increases of fat content in fried fish crackers. Based on Table 4.2, the fat content on Formulation 1 of fried fish cracker made from jackfruit seed flour has higher value which was 37.60 % compared to Formulation 2 and 3 which were 32.00 % and 29.93 %. Fat content was decrease along with the increasing of jackfruit seed flour in the formulation. These three different formulation of fried fish cracker made from jackfruit seed flour have found the significant different ($p<0.05$) of fat content.

Jackfruit seed flour contain about 1.18 – 1.40 % of fat content [8]. Raw jackfruit seed has higher in fat content which it can reached about 0.68 – 0.80 % while roasted jackfruit seeds contain lower in fat content which were 0.54 – 0.71 % [8]. Tulyathan *et al.,* (2002) stated that the fat content of jackfruit seed flour was 0.99 % in dry basis. The different value of fat found in jackfruit seed flour due to the nature of seed and its variation.

Carbohydrate

Total carbohydrate was determined in fried fish crackers made by jackfruit seed flour. Based on Table 4.2, fried fish crackers in Formulation 3 contain higher carbohydrates which was 49.66 % compared to Formulation 1 and 2 which were 44.15 % and 48.52 %. These total carbohydrate content were increase with the increasing of amount of jackfruit seed flour in development of fish crackers. There was found no significant different ($p<0.05$) between Formulation 2 and 3.

The starch in cassava flour and jackfruit seed flour that were used increases the amount of carbohydrates in fried fish crackers [15]. The commercial fish crackers contain total carbohydrate range between 66 - 68.3 % [9]. According to Tulyathan *et al.,* (2002), total carbohydrate content was found higher value which was 82.25 % if the brown spermoderm was removed while non-removable brown spermoderm jackfruit seed flour contain total carbohydrate about 81.64 %.

Texture Profile Analysis

Texture Profile Analysis was measured by using Texture analyser with spherical/Magness-Taylor Probe (SMS P/0.25S). The texture analysis was performed for fried fish crackers in room temperature. Plotter recording speed was set to 3 mm s^{-1} and 10 mm s^{-1} for recording force-distance deformation curves [17].

Using the Micro Stable programme in texture analyzer, hardness and fracturability were calculated and reported in Table 4.3. Fried fish cracker in Formulation 1 has the highest hardness value which was 11947 g compared to Formulation 2 and 3 while Formulation 3 has the highest hardness value for fried fish crackers which was 2156.75 g. High hardness levels indicated high product resilience and high breaking forces [11].

Fracturability level in Formulation 1 for fried fish cracker has the higher value which was 645 N compared to Formulation 2 and 3. There were found the significant different ($p<0.05$) between these three different formulation of fried fish cracker made form jackfruit seed flour for hardness while in fracturability, there were no significant different found in all these three formulation. Hardness and fracturability value in Formulation 1, 2 and 3 were continued to increase with the increasing the amount of jackfruit seed flour.

The hardness value of commercial fried fish cracker that can be found was 1462.10 g. Food that was brittle, such as fish crackers, chips, and cereal has a characteristic called fracturability. The load force of the first notable peak determines the material's fractureability [16]. High hardness levels indicated high food product resilience and high breaking forces [11].

Colour evaluation

The quality of fish crackers was determined by their colour of final product. This was crucial in industry due to the customer evaluate the product before purchase it through product's colour. Colorimeter used in colour evaluation gives the differentiation between L*, a* and b* value. The colour appearance reflects both the non-homogeneous oil distribution and the heterogeneous surface that was created as a result of frying.

Based on Table 4.4, fried fish cracker with Formulation 3 has the highest lightness (L*) compared to Formulation 1 and 2. This can be conclude that the lightness of fish cracker was increase with the increase of amount of jackfruit seed flour. But, for unfried fish cracker, it can determine based on Table 4.3 that Formulation 1 has the highest lightness (L*) than other formulation. There were no significant different ($p<0.05$) found in three different formulation of fried and unfried fish cracker in term of lightness (L*). Formulation 3 have the highest value of redness (a*) for fried and unfried fish crackers compared to Formulation 1 and 2. In terms of redness, there were no significant differences ($p>0.05$) among the three formulations of fried and unfried fish crackers. The redness value tend to increase with the increasing of jackfruit seed flour in the formulation.

The yellowness of unfried fish crackers decrease by the increasing of amount of jackfruit seed flour. But for fried fish cracker, the yellowness was increase by the increases of jackfruit seed flour. This color analysis was also influenced by the method of frying fish crackers where the color of the product will be darker if the frying time in hot oil increases. Figure 4.1 shows the fried fish cracker made from jackfruit seed flour for three different formulation. There were no significant different ($p<0.05$) found in the yellowness of unfried fish cracker made from jackfruit seed flour based on Figure 4.2 meanwhile there were the significant different ($p<0.05$) found in yellowness of fried fish cracker among Formulation 1 and 2 or Formulation 2 and 3.

The colour of jackfruit seed flour in Figure 4.3 also affects the final result of the product where the level of fish cracker colour will be higher if more jackfruit seed flour was added. This is because jackfruit seed flour has a brownish yellow colour which was different from cassava flour in Figure 4.4.

Due to structural changes in starch granules and proteins, thermal processing (frying) may also have an impact on the colour of fish crackers [17]. One or more elements that affect the colour of a cracker include slight browning, such as the Maillard process and heat-induced caramelization, as well as variations in pigment concentration brought on by drying and expansion [17]. Outer brownish layer of jackfruit seed in Figure 4.5 may become one of the reason that affect the colour varying in the final product of fish cracker

Linear expansion

Linear expansion was determined by measured the diameter of fried and unfried fish cracker by using Vernier Caliper. Based on Table 4.5, Formulation 1 has good linear expansion which was 92.91 % while Formulation 2 and 3 have linear expansion 74.53 % and 54.88 %. There were found the significant different ($p<0.05$) between these three formulation. Based on the observation through these three formulation, the linear expansion of fish crackers were decrease by the increasing of jackfruit seed flour. The degree of linear expansion in the product fish crackers was reduced by increasing the ratio of fish to starch [11]. This is due to the starch content in in jackfruit seed flour that influence the expansion of fish crackers during frying.

The most crucial quality characteristic of fish cracker was the degree of linear expansion, which is connected to the sensory crispiness parameter [11]. The linear expansion of fish crackers can be used to measure their crispiness [14]. When fish cracker was deep-fried in hot oil at 200°C for about 5 – 10 seconds, the extrudes with less than 12 % moisture content expanded into a low density porous product [11].

When fish crackers were exposed to high temperatures about 200°C, rapid water evaporation and subsequent expansion of starch granules and vacuoles would cause linear expansion occurred [14]. This process improves the sensory qualities of fish crackers, but it also raises the fat and calorie contents, which was detrimental to the cracker's nutritional value [14]. By combining temperature, time spent exposed to the temperature, and final moisture, it can optimize linear expansion of fish crackers.

Table 4.1: Formulation of Malaysian Fish Cracker

INGREDIENTS	FORMULATION 1		FORMULATION 2		FORMULATION 3	
	g	%	g	%	g	%
Flesh of sardine	88.78	37.7	88.78	37.7	88.78	37.7
Cassava flour	79.90	33.93	71.02	30.16	62.14	26.39
Jackfruit seed flour	8.88	3.77	17.76	7.54	26.64	11.31
Salt	2.66	1.13	2.66	1.13	2.66	1.13
Sugar	1.78	0.76	1.78	0.76	1.78	0.76
Monosodium glutamate	0.26	0.11	0.26	0.11	0.26	0.11
Iced water	53.22	22.6	53.22	22.6	53.22	22.6

Table 4.2: Nutritional Composition of Fried Malaysian Fish Crackers

Analysis	Formulation (%)		
	1	2	3
Moisture content	1.26 ± 0.121^{a}	1.33 ± 0.462^{a}	1.35 ± 0.120^{a}
Total ash content	2.47 ± 0.5^{a}	2.71 ± 0.197^{a}	3.08 ± 0.412^{a}
Crude protein	14.28 ± 0.212^{a}	14.54 ± 0.609^{a}	17.12 ± 0.250^{b}
Crude fat	37.60 ± 0.267^{c}	32.00 ± 0.189^{b}	29.93 ± 0.378^{a}
Carbohydrate	44.15 ± 0.530^{a}	48.52 ± 0.193^{b}	49.66 ± 0.792^{b}

Value are the means of triplicates ± SD
[ab]Mean in the same column followed by different superscript letter differ significantly ($p<0.05$)

Table 4.3: Texture Profile Analysis Of Fried Malaysian Fish Cracker

Analysis	Attributes	Formulation		
		1	2	3
Texture	**Hardness (g)**	432.51 ± 16.828^{a}	1243.26 ± 294.396^{b}	2156.75 ± 95.266^{c}
	Fracturability (N)	199.78 ± 120.273^{a}	542.40 ± 239.353^{a}	645.00 ± 321.618^{a}

Value are the means of triplicates ± SD
[ab]Mean in the same column followed by different superscript letter differ significantly ($p<0.05$)

Table 4.4: Colour Evaluation Of Fried And Unfried Malaysian Fish Cracker

Analysis			Formulation		
			1	2	3
Colour	L*	Unfried	44.22 ± 0.480[a]	42.48 ± 1.853[a]	41.84 ± 0.905[a]
		Fried	55.14 ± 2.537[a]	55.44 ± 1.848[a]	57.20 ± 4.523[a]
	A*	Unfried	3.08 ± 0.164[a]	3.55 ± 0.390[a]	3.56 ± 0.121[a]
		Fried	5.57 ± 1.342[a]	6.94 ± 1.308[a]	7.07 ± 0.484[a]
	B*	Unfried	9.57 ± 0.544[a]	9.03 ± 0.928[a]	8.86 ± 1.412[a]
		Fried	19.80 ± 3.398[a]	21.76 ± 1.571[ab]	22.57 ± 0.776[a]

Value are the means of triplicates ± SD

[ab]Mean in the same column followed by different superscript letter differ significantly ($p<0.05$)

Table 4.5: Linear Expansion Analysis Of Malaysian Fish Crackers

Analysis	Formulation (%)		
	1	2	3
Linear expansion	92.91 ± 0.092[c]	74.53 ± 0.881[b]	54.88 ± 1.319[a]

Value are the means of triplicates ± SD

[ab]Mean in the same column followed by different superscript letter differ significantly ($p<0.05$)

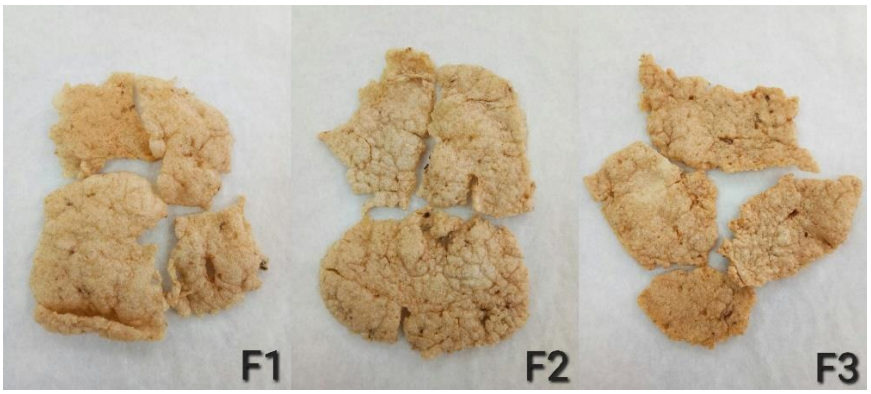

Figure 4.1: Fried Fish Crackers For Formulation 1, 2 And 3

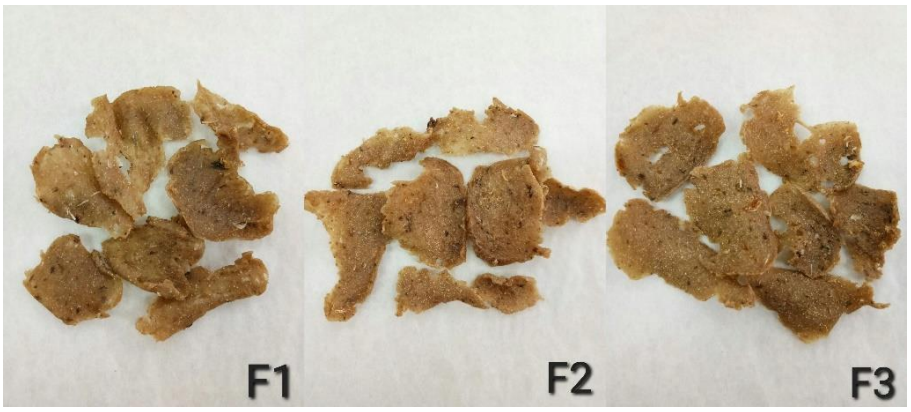

Figure 4.2: Unfried Fish Crackers For Formulation 1, 2 And 3

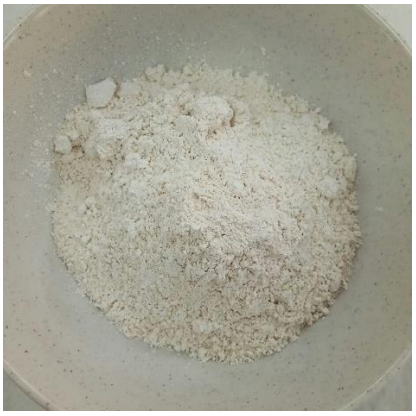

Figure 4.3: Jackfruit Seed Flour

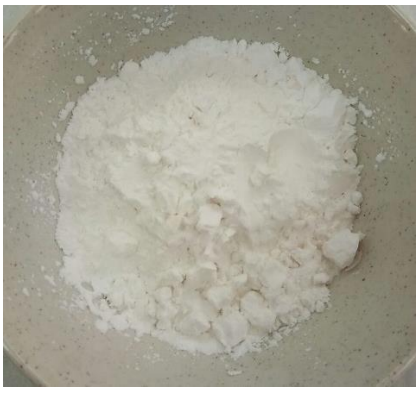

Figure 4.4: Cassava Flour (Cap Kapal ABC)

Figure 4.5: Raw Jackfruit Seed With The Outer Layer

CONCLUSION

Based on this study, the physicochemical properties of fish crackers made from different concentration jackfruit seed flour were analysed. The utilization of jackfruit seed flour in the development of Malaysian fish cracker improved and give value added to nutritional composition and their physical appearance. Different amount of jackfruit seed flour added give the different result in nutritional content and physical characteristics. Partial addition of jackfruit seed flour in Formulation 1 of Malaysian fish cracker produce high quality and good appearance of end product. The nutritional composition increases in moisture content, total ash content, crude protein, crude fibre and carbohydrate. The colour of fish cracker made from jackfruit seed flour in Formulation 1 was light brown that attracted consumer to choose that kind of formulation. Formulation 1 also give the best crispness texture when customer consumed it. Formulation 1 has good linear expansion compared to Formulation 2 and 3. This can contribute to the sensory crispness parameter of fish cracker made form jackfruit seed flour and make it very tempting to consume it.

The application of jackfruit seed flour in the development of fish cracker give many benefit to its nutritional value and physical properties such as texture, colour and linear expansion of end products. By applying basic technology to transform this jackfruit seed flour into value-added goods, not only would their economic value grow, but it would also encourage the use of these underutilised resources, reducing poverty and generate source of income [13]. By creating a low-fat, low-calorie fish cracker that is well-liked around the world, the development of fish crackers made from jackfruit seed flour that have high nutritional value can be a strategy to increase fish consumption and, at the same time, an adjuvant strategy to improve the quality of the diet of children and adolescents [14].

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