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Development of Vegetarian Burger Patties from Jackfruits' (*Artocarpus heteropyllus*) Inner Skin

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ABSTRACT

Jackfruit is a native kind of Malaysian fruit. During its fruiting season, the peels are usually discarded as waste and become a source of pollution. From the research that has been done, the inner skin, which is about 60% of the fruit, has a high nutritional value which can be utilized for human consumption, mainly as a source of dietary fiber. Hence, this paper reports the chemical compositions, comprising the percentage of the moisture content, ash, crude fiber, fat, protein, and carbohydrate, as well as the physical properties; texture analysis, color, and sensory evaluation of the jackfruit inner skin (JIS) vegetarian patty. Overall, JIS vegetarian patties consist of 62.75% moisture, 2.67% ash, 23.93% protein, 1.80% fat, and 18.50% crude fiber. These values have contributed to the calculation of carbohydrate and calorific value, 8.88% and 143kcal/100g respectively, lower than the control. In terms of physical properties, the texture analysis shows higher hardness and chewiness which is indirectly associated with the overall acceptance of the panelists on sensory evaluation. Within the hedonic values 1 to 9 which 9 being the highest, on average the panelist rated JIS vegetarian burger patties as 7.61. This value is in overall acceptance for the color, texture, odor, and taste of the JIS patties.

Keywords: Jackfruit (*Artocarpus heterophyllus*), Vegetarian Patty, Proximate Composition, Colour, Texture

1. INTRODUCTION

The idea of vegetarianism started as early as in the 5th century among ancient Indian and Greece citizens to overcome the shortage of food by practicing a non-meat diet. As time goes by, some groups of people turn to vegans either as the ideology of their religion, concern for their health, or animal rights and also due to food shortages. Generally, vegetarianism has brought the necessity to improve and introduce new food items which have all the nutrients same as meat. Therefore, advancement in food engineering has come up with various food items which have the same texture, taste, color, and even odor similar to meat products.

Jackfruit (*Artocarpus heterophyllus*) is the largest edible fruit in the world belongs to the family Moraceae. Jackfruit can be eaten fresh or processed into chips, juice, jam, pickles and canned. There are about 5,097 hectares of jackfruit grown in Malaysia with an annual production of 28,042 metric tons per year (Department of Agriculture Malaysia, 2017). Fresh jackfruit has the potential to penetrate the China and USA market. There are approximately 33,979 MT of jackfruit peel and inner skin as byproducts (Foo & Hameed, 2012), and almost 60% of the fruit has been discarded without any use (Aziah, 2009).

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The utilization of the jackfruit inner skin as the main ingredient in the production of vegetarian burger patties has the potential to create a new market for farmers. The flesh of the jackfruits was found to be rich in vitamin A and K, low in total lipids and saturated fatty acids and contain fair amounts of vitamin C, carbohydrates, and fiber. It also contains all the essential minerals, folate, thiamine, riboflavin, niacin, and vitamin B-6. Recently, it has been found that the jackfruits is a good source of provitamin A carotenoids, eventhough not as high as in papaya (Chandrika *et al.,* 2006). The seeds of jackfruits were also found to have higher protein content compared to animal proteins such as in marine fishes and beef (Ajayi, 2008). Thus, this study aimed to determine the formulation to use jackfruits' (*Artocarpus heteropyllus*) inner skin as the raw material for vegetarian burger patties with simpler and fewer processes involved.

2. MATERIAL AND METHODS

2.1 Materials

Jackfruits' inner skin (JIS) was collected in a local market near Beseri, Perlis, Malaysia. The spices and other ingredients such as potatoes, onions, garlic, fennel, cumin, salt, pepper, and cooking oil were purchased from the local supermarket in Perlis, Malaysia.

2.2 Preparation of JIS Vegetarian Patties Materials

The samples consist of jackfruits' inner skin which is the by-product of the fruit. Only the matured ripe fruit was used. First, the jackfruit's inner skin was peeled and washed using hot water to remove any foreign particles and kept in a dry place. The onions and other spices are sautéed till the onion is soft and cooked well. Then, the jackfruits' inner skins were added and sautéd for about 5 minutes and left to cool. Then, boiled and mashed potatoes were added into the mixture. The sautéed ingredients and mashed potatoes were mixed and added with some salt and pepper for flavor. The mixture was stirred until the ingredients were well-mixed, shaped into patties and refrigerated under 4 ± 1ºC for 45 minutes. Then, the patties were cooked under medium-low heat using microwave for 5 minutes. After that, the patties were baked using an oven at 180ºC for 10 to 15 minutes. JIS patty was compared with the ones without JIS as the control.

2.3 Proximate Composition Analyses

Proximate analysis of moisture (Method 925.40), ash (Method 923.03), fat (Method 920.39), protein using the Lowry Method (Lowry *et al.,*1951), and crude fiber (Method 7.504) was determined according to a standard AOAC 1990 method (Helrich, 1990). Carbohydrates and calories were calculated according to Equation 1 and 2 below:

$$\text{Carbohydrate} = [\,100 - (\text{moisture} + \text{protein} + \text{crude fat} + \text{ash} + \text{crude fiber}) \qquad (1)$$

$$\text{Calories}\left(\frac{\text{kcal}}{100\text{g}}\right) = (\%\ \text{protein x 4}) + (\%\ \text{fat x 9}) + (\%\ \text{carbohydrate x 4}) \qquad (2)$$

2.4 Color

The random samples were taken in triplicate for both JIS and commercial vegetarian patties. The color was determined where the sample was cut into 1cm x 1cm x 1cm size and the outer and

inner parts of the patties were used to determine the color using a Chroma meter (Konica Minolta CR-400, Japan) from L* = lightness, a* = redness, and b*= yellowness (Rosli & Fakurudin, 2011).

2.5 Textural Analysis

Textural analysis was done on random samples after cooking, where the patty samples were cut into uniform cubic size (2×2×0.5 cm) and subjected to a texture profile analysis. Samples were analysed in terms of hardness (g), adhesiveness, resilience, cohesiveness, springiness (mm), gumminess (g), and chewiness (mJ) (Akwetey & Knipe, 2012) which was recommended earlier by Bourne (1978).

The objective of the texture analysis is expressed as breaking strength (kg force) was measured using CT3 texture analyzer. This test was developed by a group of food scientists from the General Food Cooperation and is compiled as a force during compression and time. A needle or rod probe of TA39 is a black dextrin with 2mmØ and was used to break the vegetarian patties with a crosshead speed of 2mm/s and trigger load of 7g. The force required to break the patties individually was noted and the average was calculated. The texture analyzer connected to the Texture Expert Computer to analyze the data and all the setting data were based on the texture profile of AACC 74 - 09 (2000).

Data analyses correlated numerous sensory parameters including hardness, adhesiveness, springiness, gumminess, and chewiness with texture terms determined from the TPA test curve. The sample was put on a plate grain gage and broken by the probe with two times bites. The force used was recorded by computer with the plot of graph versus time. All the data were calculated by using the Texture Expert Computer program. The data were taken three times and average data were calculated.

2.6 Fourier -Transform Infrared Spectroscopy (FTIR)

Sensory evaluation was carried out by choosing 30 panelists who are chosen randomly among Biosystem Engineering students in UniMAP. The samples were evaluated using a scale from 1 to 9, with 9 being the highest (extremely like). All panelists assessed both JIS and commercial vegetarian patties and the criteria used were the color, odor, texture, taste, and overall acceptance (Ramadhan *et al.,* 2011). The samples were coded blindly, and the panelists were briefed with the instructions before running the test. Water was provided to rinse the mouth right before and after tasting the samples.

2.7 Statistical Analysis

Data obtained from the evaluation forms were analyzed for variance using the one-way analysis of variance (ANOVA) in Microsoft Excel 2020.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

Table 1 clearly shows that the mean value of moisture contents among the sample is to be significant with a value of $p<0.05$. The moisture content of the JIS is higher due to its botanical properties (Rengsutthi & Charoenrein, 2011). The moisture content in the JIS vegetarian patties were also high compared to control because of the jackfruit's nature to absorb water as reported by Tulyathan *et al.* (2002).

Table 1. Proximate Composition of Jackfruit Inner Skin (JIS), Texture Vegetable Protein (TVP), JIS Vegetarian Patties and Control.

Types	Jackfruit Inner Skin (JIS)	Texture Vegetarian Protein (TVP)	JIS Vegetarian Patties	Control Vegetarian Patties
Moisture (%)	64.81 ± 0.49^{a}	10.32 ± 0.41^{b}	62.75 ± 0.16^{c}	45.94 ± 0.86^{d}
Ash (%)	5.00 ± 0.00^{a}	2.38 ± 0.29^{b}	2.67 ± 0.76^{c}	1.67 ± 0.29^{d}
Protein (%)	20.62 ± 0.02^{a}	77.79 ± 0.04^{b}	23.93 ± 0.02^{c}	36.87 ± 0.01^{d}
Fat (%)	0.00 ± 0.00^{a}	0.01 ± 0.02^{b}	1.80 ± 0.79^{c}	4.51 ± 0.49^{d}
Crude Fiber (%)	29.47 ± 0.37^{a}	9.79 ± 1.09^{b}	18.50 ± 0.21^{c}	6.65 ± 0.65^{d}
Carbohydrate (%)	9.59	10.28	8.88	11.02
Calorie (kcal/100g)	120	321	143	232

Values are means of triplicates; ^{abcd} means in same row with different superscripts are significantly different ($p<0.05$).

The ash content among the samples were significant with the value of $p<0.05$, in which JIS showed the highest, 5.00% compared to other samples. Also, the JIS vegetarian patties have slightly higher ash content compared to commercial vegetarian patties which are 2.67%. This proves the theory of food that high dietary fiber has more ash content compared to foods with low dietary fiber, thus the fiber content is associated with the ash content of the food (Anyakora & Anglais, 2013).

Protein content in textured vegetables protein (TVP) showed the highest compared to JIS which is 77.79%. This is because the raw ingredient used in making the TVP mostly are from protein-rich sources such as soybeans or legumes (Boone, 2012). Most manufacturers used soy protein as non-meat protein ingredients to partially replace meat (Ramadhan *et al*., 2011). In this analysis, TVP has been used as a raw ingredient for vegetarian patties to improve the flavor and texture of burgers by increasing the fat and moisture binding ability (Gujral *et al.,* 2002). The mean value of protein among the sample was significant with a value of $p<0.05$.

Next, the fat content in JIS and TVP were almost 0% since it is made from the natural resources of least fat content such as jackfruit and soybeans (Shrinath *et al.,* 2011). Yet, the commercial vegetarian patties showed the highest fat content compared to JIS patties which was 4.51% which usually are vegetable fat to increase the shelf life and frying capacity of the patties (Rosli & Fakurudin, 2011).

Carbohydrate and calorific values were obtained from the formula by calculating the percentage of the crude fiber, protein, moisture, ash, and fat in the sample. Thus, it can be seen that JIS and JIS patties have a lower carbohydrate percentage compared to TVP and control vegetarian patties which are 9.59% and 8.88%, respectively. The values from the raw ingredient to JIS patty showed a decrease in value which showed the loss of some nutrients in the process of making. This may be due to the sauté technique of cooking used in the recipe which causes a loss of nutrients (Schaschke, 2011).

3.2 Color Analysis

Table 2 shows that JIS vegetarian patties are darker compared to control vegetarian patties where the lightness (L*) is 67.23 compared to 85.64. This might be due to the commercial vegetarian patties' ingredients being boiled prior to preparation at industrial scale involving the steaming process. Also, the raw ingredients of commercial vegetarian patties are from TVP which are mainly soybeans which is naturally brighter in color (Nikolić *et al.,*2009). This is proven by analysis where there was a slight difference in the value of the inner part of both vegetarian patties which is 90.07 for the commercial vegetarian patties and 74.41 for JIS patties. The mean value for lightness (L*) among the sample was significant with a value of $p<0.05$.

Table 2. Color Analysis of JIS Vegetarian Patties and Commercial Vegetarian Patties.

Types	JIS Vegetarian Patties	Control Vegetarian Patties	Inner JIS Vegetarian Patties	Inner Control Vegetarian
Lightness(L*)	67.23±0.52^{a}	85.64±0.59^{b}	74.41±0.43^{c}	90.07±0.94^{d}
Redness (a*)	3.54±1.34^{a}	3.57±1.83^{a}	2.45±0.91^{a}	1.92±0.36^{a}
Yellowness (b*)	28.69±0.62^{a}	28.36±0.54^{a}	26.34±0.91^{b}	26.53±0.59^{b}

Values are means of triplicates; ^{abcd}means in same row with different superscripts are significantly different ($p<0.05$).

However, the mean value for redness (a*) among the samples were not significant with the value of $p>0.05$ where the redness of both commercial and JIS patties were almost the same, 3.54 and 3.57, respectively indicating that JIS patties were at par with the redness of commercial patties (Rodríguez-carpena *et al.,* 2012). There was no significant difference between JIS and commercial patties on the outer part.

In terms of yellowness, all the samples have more or less the same value. In JIS patties the yellowness maybe present as a natural coloring of the JIS which is yellow (Jagadeesh *et al*., 2007). At the same time, the yellowness in the commercial patties might be due to artificial coloring added to the soybeans which allow the physical attributes of the patties to make it comparable with the quality of fake meat, especially chicken (Barakat *et al.,* 2015). This eventually will make the patties quite attractive to the customer as it displays the quality of vegetarianism as discussed by Stockburger *et al.,*2009 which has also been accepted by the customer for fake meat products.

3.3 Color Analysis

Overall, textural analysis (Table 3) showed no significant difference among the samples. Yet, there are some attributes that are slightly different among the samples, which might be due to the different cooking types used in both samples.

Table 3. Texture Profile Analysis for JIS and Control Vegetarian Patties.

Types	JIS Vegetarian Patties	Control Vegetarian Patties
Hardness (g)	42.67 ± 3.78[a]	38.00 ±1.00[a]
Adhesiveness (g)	8.33 ±2.89[a]	15.67 ±5.13[a]
Resilience	0.01 ±0.01[a]	0.04 ±0.04[a]
Cohesiveness	0.31 ±0.26[a]	0.55 ±0.17[a]
Springiness (mm)	4.92 ±3.17[a]	7.20 ±0.61[a]
Gumminess (g)	30.33 ±6.66[a]	31.33 ±3.51[a]
Chewiness (mJ)	4.97 ±1.74[a]	3.97 ±1.66[a]

Values are means of triplicates; [a]means in same row with same superscripts are not significantly different ($p>0.05$).

3.4 Sensory Analysis

Based on Table 4, in term of colors, the panelists also proved that there was no significant difference among the samples that have been tested ($p>0.05$) which is likely to be associated with TPA analysis. Odor and taste show a significant difference with the value of $p<0.05$ between JIS and commercial vegetarian patties. The role of spices in the vegetarian patties showed positive results among the panelists since it has the highest value based on average points given. Odor on average has a value of 7.64 for JIS and 6.39 for commercial vegetarian patties based on the evaluation done on a scale of 1-9. Lastly, the textural value of the JIS vegetarian patties compared to commercial has also shown a significant difference ($p<0.05$) where panelists were more likely attracted to hard patties compared to a smooth one.

Table 4. Summary of Sensory Evaluation

	JIS Vegetarian Patties	Commercial Vegetarian Patties
Color	7.11±1.82[a]	6.93±1.56[a]
Odor	7.64±1.25[a]	6.39±3.24[b]
Texture	7.21±2.04[a]	6.36±6.76[b]
Taste	7.50±1.89[a]	6.54±5.43[b]
Overall Acceptance	7.61±0.83[a]	6.82±2.22[b]

Values are means of triplicates; [ab] means in same row with different superscripts are significantly different ($p<0.05$). Sensory attributes were scored for “like extremely” = 9 to “dislike extremely” = 1.

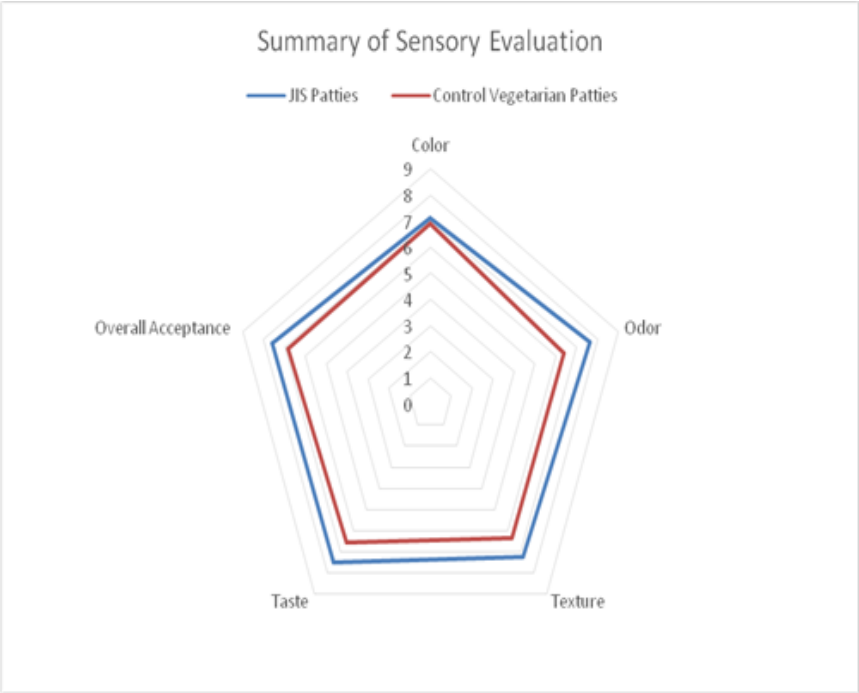

Figure 1. Spider Web Chart on Summary of Sensory Evaluation

4. CONCLUSION

In conclusion, JIS has shown potential as an alternative to textured vegetarian protein made from soybean in terms of chemical and physical attributes. The chemical analysis emphasizes the nutritional value of JIS which has a higher crude fiber,18.5% compared to commercial vegetarian patties which were only 6.65%. Dietary fiber in JIS patties is essential for the digestion tract and system for healthy intake. Fat content in JIS vegetarian patties is lower compared to the commercial ones with the percentage values of 1.8% and 4.51%, respectively. This value of low fat is an added value for the commercialization of the JIS vegetarian patties. Physical analysis comprises of color, texture profile analysis (TPA), and sensory evaluation also gave a positive result which were equal and better than the commercial vegetarian patties as the control. TPA has shown that the JIS vegetarian patties are higher in chewiness compared to commercial patties with the value of 4.97mJ and 3.97mJ, respectively. Even lower in springiness, other aspects such as hardness, resilience, cohesiveness, and gumminess show almost similar values among the samples. The aspect of chewiness is to be associated with the sensory analysis done by untrained 30 panelists which showed a significant difference between JIS and commercial vegetarian patties in terms of texture. A significant difference was also achieved in terms of odor and taste of the JIS vegetarian patties compared to the control where the panelists were more likely to choose JIS compared to the commercial vegetarian patties.

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