Research Article

Development Of Vegetarian Nugget Using Unripe Jackfruit

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ABSTRACT

Jackfruit (*Artocarpus heterophyllus*) is well known as a good source of carbohydrate and dietary fibre. Unripe jackfruit has fibrous texture that is very similar to meat, which makes it a suitable meat alternative. High consumption of less nutrient dense foods has increased the prevalence of non-communicable diseases. This research was carried out to investigate the effect of the addition of unripe jackfruit in vegetarian nugget on sensory properties and nutritional content. This was compared with the commercial vegetarian nugget as the control. A total of 4 formulations were produced followed by determination of the best formulation through sensory evaluation using the 9-point hedonic test. The F4 formulation with 25% unripe jackfruit and 75% of konjac-tofu was chosen as the best formulation as this formula achieved higher mean scores for all attributes (Appearance=7.28±1.578, Aroma=6.48±1.502, Taste=6.14±1.852, Texture=6.52±1.717, Overall acceptance=6.72±1.485) compared to other formulations. Proximate analysis showed that it contains carbohydrate (30.90%±0.32), crude protein (9.54%±0.22), crude fat (4.94%±0.23), crude fibre (2.60%±0.23), ash (2.21%±0.03), moisture content (49.81%±0.48), and energy content of 206.22 kcal. The unripe jackfruit nugget was developed as a new and healthy convenience food product which could be an alternative for the vegetarian consumer.

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1. Introduction

Jackfruit or its scientific name *Artocarpus heterophyllus* is known as one of the most popular tropical fruits in Asia. It is recognized for its unique size, shape, and intense fruity aroma emitted from its sweet arils. Jackfruit belongs to the family of *Moraceae*, which is a congener of the tree of fig, mulberry, and breadfruit (Boning, 2006). Jackfruit is widely consumed as a fresh fruit and it is often used as an ingredient in Asian culinary preparations since all parts of it are edible including the seeds (Ranasinghe *et al.,* 2019). Ripe jackfruit has a very chewy, stringy texture and unique tropical flavour. Meanwhile, the flesh of unripe or young green jackfruit is off-white in colour and almost neutral in flavour. Jackfruit has a variety of nutritional and health benefits. For instance, young jackfruit is well known as a good source of carbohydrate and fibre. It also has high phenolic content which could prevent the onset of cardiovascular disease (Parihar *et al.,* 2021).

Nuggets are popular fried foods that are very common and are generally acceptable worldwide, especially in Malaysia where nuggets are predominantly served at almost all fast-food restaurant chains. Nuggets are a restructured meat product with batter and coating to retain the quality. The main composition of nuggets is trimmed and deboned meat, usually from chicken, fish or a combination of vegetable protein and gum (Lukman *et al.,* 2009; Marikkar *et al.,* 2011). It is usually seasoned with different kinds of functional ingredients like salt and mixed spices. Nuggets are a ready to cook and ready to eat product with simple

preparation which makes it a popular choice with consumers for a quick meal (Brunner *et al.,* 2010). Moreover, it is tasty, has a long shelf life, and can easily be made into different kinds of dishes. However, the biggest issue with nuggets is their high saturated-fat and trans-fat content (Cascio *et al.,* 2012).

In recent years, consumers have been reducing the amount of meat in their diets and opting for vegetarian food. Interest in veganism has increased seven-fold between 2014 and 2019. The report published in 2019, Vegan Food Market by Product Type and Distribution Channel: Global Opportunity Analysis and Industry Forecast (2019-2026), shows that veganism has become one of the rising trends in the food and beverages industry. The global vegan food market was valued at $14.2 billion in 2018. According to Grand View Research (2019), the world's vegan market is also expected to grow to $24 billion in 2025, showing an average growth rate of 9.6 percent annually. Between 2012 and 2016, new vegetarians and vegan product launch increased by 140% and 440%, respectively, in Southeast Asia alone (FAIRR, 2018). The recent rapid growth of the plant-based sector has been driven primarily by the emergence of flexitarians, those who occasionally consume meat and dairy products but are seeking to reduce their consumption levels, as well as increased numbers of vegetarians and vegans as a response to a combination of ethical, health, and environmental concerns (Dagevos, 2021).

There are several factors contributing to the switch towards vegan products. These include extensive media coverage of the impact of meat on global warming and resource consumption (Sanchez and Sabaté, 2019). Moreover, there have been numerous reports on the possible links between the high consumption of processed or red meat and forms of cancer and cardiovascular disease (Bronzato and Durante, 2017). Currently, many plant-based-alternative manufacturers seek to overcome the barriers that prevent traditional meat-eating consumers from choosing plant-based alternatives, which include the unsatisfying flavour characteristics, as well as dissimilarities to the taste and texture of meat (Corrin and Papadopoulos, 2017; Lea *et al.,* 2006; Pohjolainen *et al.,* 2015). Thus, plant-based products need to be made more attractive in order to continue growing the market and appeal to meat-eating consumers.

Jackfruit is grown in many countries including Malaysia. It is of significant economic value as Malaysia alone has an annual production of jackfruit amounting to 19,515.6 metric tons with a production area covering 2015.1 hectares (MoA, 2012). However, the commercial potential of the fruit is yet to be fully exploited and it is still commonly sold in the form of individual fresh bulbs by local vendors. Several factors could be responsible for the low commercial utilization of jackfruit and for the product's lack of popularity, including its large size, low shelf life, and high flavour intensity which may be undesirable to some consumers (Saxena *et al.,* 2011). Therefore, some modifications are needed to make it commercially available. The aim of this study is to investigate and develop the best formulation of vegetarian nugget by utilising unripe jackfruit that potentially has lower fat content.

2. Materials and Methods

2.1 Materials

The materials/ingredients used to make the vegetarian nuggets are as follows: vegan konkayku nugget, konjac powder, medium firmflour, breadcrums, coconut milk, cooking oil and salt. These were obtained from either supermarkets or local markets around the city of Kota Kinabalu, Sabah, Malaysia. Unbranded materials were obtained from raw materials (fresh produce) such as unripe jackfruit or from natural sources such as water.

2.2 Formulation of Vegetarian Nugget Using Maturity Index 1 of Unripe Jackfruit

Table 1 shown the ingredients of the nugget formulation are young jackfruit, konjac powder, medium-firm tofu, seaweed powder, flour, breadcrumbs, coconut milk, water, cooking oil, and salt. Ingredients for the nuggets are identical with the exception of the konjac and jackfruit ratio. This study used four ratios of jackfruit/konjac tofu mixture which respectively: 1/0, 1/3, 1/1, 3/1. These ratios were chosen after

considering another study (Nisa, 2013). F0 is the control formulation, the OKK Konnyaku Fish Nugget. This product was chosen because it is one of the most popular vegetarian nuggets made from konjac, which is known for being high in fibre, low in calories, aids in reducing cholesterol level as well as in controlling sugar levels of diabetics.

Table 1. Formulations of unripe jackfruit nugget

Formula	Konjac-tofu ratio (% w/w)	Jackfruit ratio (% w/w)	Other Ingredients
F0	100	0	seaweed powder, flour, breadcrumbs, coconut milk, water, cooking oil, and salt
F1	0	100	
F2	25	75	
F3	50	50	
F4	75	25	

2.3 Process of Making Vegetarian Nugget Using Unripe Jackfruit

The unripe jackfruits were purchased from the Kota Kinabalu Market and the maturity index of 1 for jackfruit was chosen (Anon, 2011). The unripe jackfruits were peeled, cut, and washed thoroughly using running tap water. Then, the jackfruits were drained and manually torn apart by hand to resemble shredded fish. The torn jackfruits were put into a pot containing water and seaweed powder was added for seasoning purposes. The pot was covered and brought to a boil over high heat, then turned down to a simmer and cooked for approximately 30 minutes to tenderise and flavour the jackfruit. This was done to remove the fruity taste of jackfruit and to give it a fishy flavour. After that, the jackfruit was drained well.

The medium-firm tofu was mixed with konjac powder in a food processor and pureed. The jackfruits were combined with the konjac-tofu mixture according to the formulation. The mixtures were made into 5cm round shape and flattened to form the nugget shape. Next, the pieces were put into a steamer and steamed for 30 minutes until firm. The steamed nuggets were kept in the freezer at -7°C for 3 to 4 days. Before being cooked, the nuggets were taken out of the freezer and thawed. The cooking oil was preheated up to 180°C. Nuggets were dipped into flour seasoned with salt and coconut milk and then coated with breadcrumbs. Then, the coated nuggets were fried in the preheated cooking oil until golden brown.

2.4 Sensory evaluation

This test was applied to determine the best formulation of the unripe jackfruit vegetarian nugget in the sensory aspect. The hedonic test was conducted to evaluate specific attributes of the 4 formulations. Attributes tested included appearance, aroma, taste, texture, and overall acceptance. The 9-point hedonic scale was used for this test. A total of 50 semi-trained panelists were recruited and were asked to rate the given products by characteristics: colour, taste, appearance, texture and overall acceptability using a 9-point hedonic test with scores corresponding to degree of liking (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely).

2.5 Proximate composition analysis

The aim of this analysis is to determine the nutritional content of the developed product in terms of moisture, ash, crude fat, crude protein, crude fibre, and carbohydrate content. All tests were performed in triplicates. The best formulation and the control samples were analysed.

2.5.1 Determination of Moisture Content

By following AOAC method (2000), moisture content was determined by drying as the main method whereby a 3.0g ± 0.1g sample was subjected to high temperature. Firstly, a crucible was cleaned and then dried in a drying oven at temperature of 100°C for about 3 hours until it became completely dry. Next, the crucible was placed in a glass desiccator for cooling process. Then, the crucible along with its lid was weighed on an electronic weighing scale and its weight labelled as (a).

A sample of 3.0g ± 0.1g was placed in the crucible and covered with lid. The mass (b) was obtained from the weight of the crucible, its lid, and the sample. Then, the sample was dried in an oven for 24 hours at a temperature of 100°C. After the drying process, the sample was taken out and cooled in the desiccator before weighing to obtain the mass labelled as (c). Finally, the moisture content was calculated by applying equation (1):

$$\text{Moisture content percentage (\%)} = \frac{b-c}{b-a} \times 100 \quad (1)$$

where,
a = Mass of crucible + its lid (g)
b = Mass of crucible + lid + wet sample (before drying) (g)
c = Mass of crucible + lid + dry sample (after drying) (g)

2.5.2 Determination of Crude Fibre Content

The crude fibre content was determined through utilization of Fibretherm system (Gerhardt, Germany). The first step involved weighing the fibre bag and labelled as (a). A total of 1.0g ± 0.1g sample was then weighed, labelled as (b) and proceed by inserting it into the fibre bag. The bag was placed into the Fibretherm machine for condensation process to commence for approximately 1 hour and 45 minutes. Sodium hydroxide (NaOH) and sulfuric acid (H_2SO_4) were used for crude fibre content determination.

Next, a crucible was weighed and labelled as (c). The previous fibre bag was placed inside the crucible and put inside an oven for heating process at temperature of 100°C for 24 hours. After that, the fibre bag was put in the desiccator for cooling process before weighing and recording it as (d). An empty fibre bag that has been burnt was weighed along with the crucible and labelled as (e). Then, the crude fibre content was calculated using the equation (2):

$$\text{Crude fibre content percentage (\%)} = \frac{[(f-a)-(g-e)]}{b} \times 100\% \quad (2)$$

where,
e = d – c
a = Mass of fibre bag (g)
b = Mass of sample (g)
c = Mass of crucible (g)
d = Mass of crucible + empty ash-turned fibre bag (g)
e = Reference value for empty fibre bag (g)
f = Mass of crucible + dry fibre bag (g)
g = Mass of crucible + ash-turned fibre bag (g)

2.6 Determination of Carbohydrate Content

The carbohydrate content was determined by deduction from residue weight after determination of all the other nutritional content. Total available carbohydrate was calculated by using equation (3):

Carbohydrate content percentage (%) = 100% - (a + b + c + d + e) (3)

where,
a = Moisture content
b = Ash content
c = Fat content
d = Protein content
e = Fibre content

2.7 Statistical analysis

Statistical analysis was performed using the statistical software of the Social Science Statistical Package (SPSS) version 29. Statistical significance between the values of variables was evaluated by one-way ANOVA with a confidence level of 0.05. The mean values were compared by Tukey's post hoc test (p <0.05).

3. Results and Discussion

3.1 Hedonic Test

Figure 1 shown the four formulations of raw unripe jackfruit nugget. From Table 2, it is evident that there were significant differences in the appearance, taste, texture, and overall acceptance level between formulations. However, the aroma attributes were not significantly different. From the overall acceptance mean score, it showed that F4 scored the highest mean value with 6.72, followed by F3 (6.60), F2 (5.94), and F1 (5.06) indicating that formulation 4 was the most preferred over other formulations.

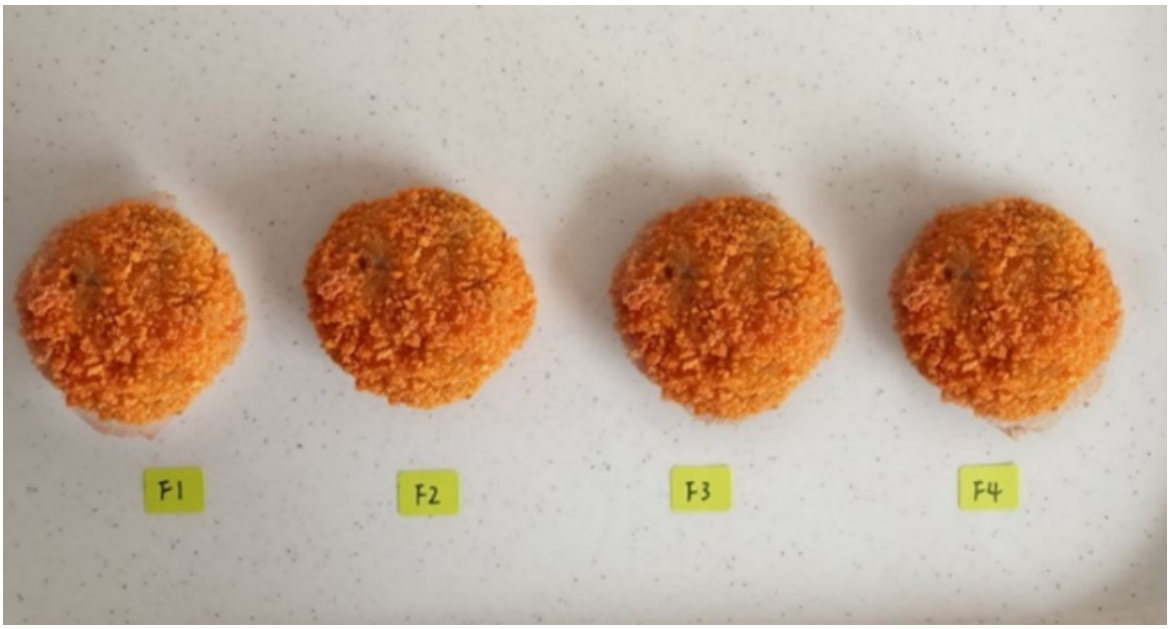

Figure 1. Appearance of four formulations of fried nugget F1, F2, F3 and F4

Table 2. Sensory evaluation results of jackfruit nugget

Attributes	F1	F2	F3	F4
Appearance	5.45±1.832^{b}	5.68 ± 1.845^{b}	6.72 ± 1.443^{a}	7.28 ± 1.578^{a}
Aroma	6.04 ± 1.590^{a}	6.20 ± 1.552 ^{a}	6.14 ± 1.525^{a}	6.48 ± 1.502^{a}
Taste	4.54 ± 1.821^{b}	5.90 ± 1.799^{a}	6.36 ± 1.367^{a}	6.14 ± 1.852^{a}
Texture	5.00 ± 1.829^{b}	5.86 ± 2.030^{ab}	6.62 ± 1.563^{a}	6.52 ± 1.717^{a}
Overall	5.06 ± 1.544^{b}	5.94 ± 1.834 ^{a}	6.60 ± 1.355^{a}	6.72 ± 1.485^{a}

F1 and F2 significantly differed ($p<0.05$) in appearance from F3 and F4. There was no significant difference ($p>0.05$) between F1 and F2, F3 and F4. From Figure 2, F4 showed the highest mean score while F1 exhibited the lowest mean score. Visually, the appearance between these formulations were almost similar in terms of coating colour. However, F1 and F2 had darker colour filling than F3 and F4 due to the higher percentage of jackfruit content, thus lowering panellists' acceptance towards it. As for aroma, there was no significant difference ($p>0.05$) between the four formulations in the mean score of aroma acceptance. The aroma between these formulations were almost similar. F4 showed the highest mean score at 6.48 while F1 exhibited the lowest mean score at 6.04. The scores for aroma ranged between 6.04 to 6.48, indicating that the panellists "like slightly" the aroma of the nuggets. This may be due to the use of the same batter, seasoning ingredients and same frying methods in preparation of the vegetarian nugget.

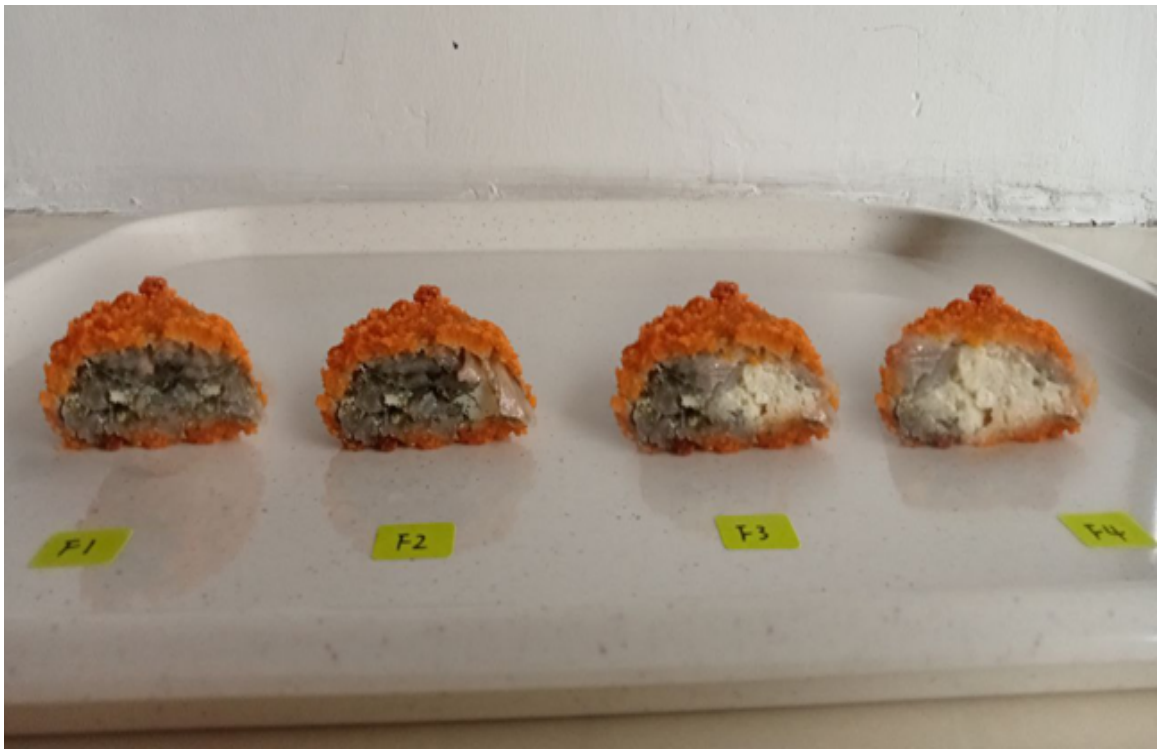

Figure 3. Texture of fried nuggets formulation F1, F2, F3 dan F4

There is a significant difference ($p<0.05$) of all attributes (appearance, aroma, taste, texture and overall) between F1 with the other formulations which are F2 until F4. Whereby F3 exhibited the highest mean of all the attributes while F1 scored the lowest mean. Notably, there was no significant difference ($p>0.05$) between F2 until F4. The low mean score of F1 was probably due to the jackfruit taste and

exhibited appearance (Figure 2), which influenced overall judgement of the panelists. On the contrary, F3 showed the highest mean score for texture (Figure 3) but this was not significantly different ($p>0.05$) from F2 and F4. The mean score for texture of F1 significantly differed ($p<0.05$) from other formulations. There was a decrease in the liking of nugget texture with increasing percentage of unripe jackfruit ($p<0.05$). F3 seemed to have smoother surface and was easier to chew due to the addition of konjac tofu. It was also noted that F1 was less firm and less chewy in texture compared to F3 and F4. Firmness and chewiness were related to the batter and water content of the nuggets. Hence, it could be assumed that the incorporation of jackfruit in large amounts would affect texture as it would have high moisture content (Abdullah, 2017). In terms of overall acceptance, F4 exhibited the highest value while F1 had the lowest value for the mean score, both of which differed significantly ($p<0.05$) from each other. Only F1 was significantly different ($p<0.05$) from other formulations while F2, F3 and F4 were not significantly different ($p>0.05$) from each other. Since there was no significant difference ($p>0.05$) between F2, F3 and F4, consumers are likely to accept any of these three formulations.

3.2 Proximate analysis

The best formulation chosen from the Hedonic test, F4, underwent proximate analysis for determination of macronutrient content which are required for nutrition labelling such as energy content, carbohydrate, protein, and fat (Food Act 1983 and Regulation, 2010). Values for ash, moisture, and fibre content are required for determination of carbohydrate content. Table 3 showed the results of proximate analysis.

Table 3. Nutrient composition for control and best formulation F4

Nutrient composition (%)	Control	Best Formulation (F4)
Moisture	44.60 ± 0.29^{a}	49.81 ± 0.48^{b}
Ash	1.27 ± 0.02^{a}	2.21 ± 0.03^{b}
Crude Fibre	1.59 ± 0.18^{a}	2.60 ± 0.23^{b}
Carbohydrate	25.74 ± 0.84^{a}	30.90 ± 0.32^{b}
Energy (kcal)	273.86	206.22

Values are shown as mean ± standard deviation (n=3)
The values for ash, crude protein, crude fat, crude fibre, and carbohydrate content are based on dry weight

3.3 Nutrient composition for control and best formulation

Based on the results, the moisture content of the F4 formulation was higher than the control sample. The higher moisture content in nuggets incorporated with unripe jackfruit may be attributed to the ability of jackfruit to hold water (Ranasinghe *et al.,* 2019). A previous study also reported that vegetarian nuggets added with jackfruit had higher moisture content than nuggets without the addition of jackfruit. In addition, the moisture content of the commercial nuggets in the market are high which is about 52.58% $\pm$ 0.74 (Babji and Yusof, 1995). Hence, it is reasonable for the F4 formulation to have high moisture content.

The results showed that F4 formulation contains 2.60% of crude fiber content which was higher than the control sample. This result agrees with Parihar *et al.* (2021) which stated that unripe jackfruit is a rich source of fibre whereby one serving size contains 2.5 g of fiber. The finding is similar to a study by Abdullah (2017) that was on the development of a meat patty using unripe jackfruit as a meat substitute which observed an increase in crude fibre content with an increase in unripe jackfruit content.

Based on the results, the carbohydrate content of F4 formulation was higher than the control sample. The carbohydrate content of the developed product is contributed by unripe jackfruit which is well-known as a good source of carbohydrate where 100 g edible portion of unripe jackfruit contains 9.4 to 11.5 g of

carbohydrate content. Meanwhile, the lower (9.94%) carbohydrate content was shown in the control sample as expected since its main ingredient is konjac. Konjac is not considered to contain carbohydrate as the net carbs for a serving is zero (Laignier *et al.,* 2021). The carbohydrate content in the control sample was mainly contributed by the starch.

Conclusion

In this study, formulation F4 was selected as the best formulation based on the results obtained from the hedonic test conducted on four formulations with varying unripe jackfruit content. The F4 formulation showed the highest mean score among the other formulations regarding appearance, aroma, and overall acceptance. This can be justified because the F4 formulation (25%) contained a lower percentage of unripe jackfruit as compared to F3 formulation (50%), which scored the highest mean score in taste and texture. The proximate analysis for the F4 formulation and the control sample showed that the F4 formulation possessed lower fat, protein, and energy content than the control sample, which agrees with previous studies. As for the moisture, ash, crude fibre, and carbohydrate content, the F4 formulation had higher values than the control sample, which confirms that unripe jackfruit contains a large amount of moisture, vitamins, minerals, fibre, and carbohydrates. Further study on the storage stability and microbiological quality of the developed jackfruit-based product is required to ensure its commercial viability.

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