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Analysis of Functional Properties of Jackfruit Seed Flour and Formulation of a Jackfruit Seed Flour-Based Snack

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Abstract

Most deep-fried snacks, which are currently in high demand, contain high calories and fat. Contrarily, Jackfruit seeds are rich in carbohydrates, and proteins but low in fat. Therefore, it is observed that jackfruit seed flour can be used as an alternative ingredient to make deep-fried snacks. This study explored the functional properties of jackfruit seed flour and its potential in snack production. The flour was prepared by roasting, oven drying, and boiling. Boiled jackfruit seed flour exhibited the highest moisture content (7.04%), water-holding capacity (2.08 g/g), bulk density (0.81 g/cm³), oil-holding capacity (2.04 cm³/g), swelling power (6.91%), and the lowest solubility (7.69%). Accordingly, the lowest oil-holding capacity (1.84 cm3/g) was found in roasted jackfruit seed flour. Snacks were prepared using the extrusion technique with a composite flour mixture of 4:1:1 (jackfruit seed flour: rice flour: wheat flour). The frying times for snacks made with roasted, boiled, and oven-dried flours were 15, 17, and 10 sec, respectively. A proximate analysis showed that the boiled jackfruit seed flour-based snack contained, 83.61% carbohydrate, 4.74% moisture, 6.46% fat, 2.90% ash, 1.70% fibre, and 0.59% protein. It was found that snacks made from boiled jackfruit seed flour received the highest consumer acceptance. This study demonstrated that jackfruit seed flour is a promising ingredient for creating nutritious and low-fat snacks.

Keywords: Capsicum annuum; Organic fertilizer; Bittern; Gliricidia sepium; Vegetative growth parameters

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) belongs to the family Moraceae (mulberry family). Jackfruit tree is a large tropical fruit crop and is native to Southwestern India and it is widely cultivated in tropical regions around the world including India, Sri Lanka, Malaysia, Indonesia, Thailand, Philippines, etc. Also, it can be seen in Africa, Brazil, Suriname Florida, etc. (Doijode, 2020). **J**ackfruit seeds account for 12% of the total fruit. Raw jackfruit seeds contain 4.27% ash, 6.73% protein, 73.34 % starch, 1.6% fibre, and 0.8% fat (Noor, 2014). Thus, jackfruit seed flour can be used as an alternative to wheat flour, which may reduce the post-harvest loss of jackfruit seeds and assist the development of nutritious food products (Noor, 2014).

Snack is a light meal, eaten in between main meals (Pikuda & Ilelaboye, 2009) and a deep-fried snack is a food that is immersed in hot oil resulting in a crispy golden surface, and a flavourful interior (Gupta, 2019). These deep-fried snacks contain high levels of fat and calories and have low nutrient content (Pikud & Ilelaboye, 2009), which may lead to negative health effects. To mitigate these negative effects, snacks made from jackfruit seed flour can be used as an alternative, as this flour is high in protein, fibre, and B-complex vitamins, and exhibits low oil absorption (Waghmare et al., 2019). While there are numerous studies on jackfruit seed flour, research on products made from jackfruit seed flour is limited. In particular, the development of deep-fried snacks using jackfruit seed flour is a novel area within jackfruit-based research. Therefore, this study aims to develop a marketable deep-fried snack using jackfruit seed flour that possesses acceptable sensory properties and nutritional content.

Materials and Methods

Seed treatment

Jackfruit seeds of the “Wala” variety had been collected and processed by carefully removing the white aril and washing thoroughly. Seeds were sorted to remove damaged or germinated ones.

Flour preparation

Jackfruit seed flour was prepared using three methods namely, boiling, oven drying, and roasting based on the preliminary trials and the previous literatures. The method described by Ejiofor et al. (2014) with slight modifications was used in the boiling method. Cleaned jackfruit seeds were boiled at 100 °C for 30 min and cut into 4 mm slices and dried at 60 °C for 8 h. In the oven drying method, aril removed, cleaned seeds were cut into 4 mm slices and dried at 60°C for 8 h. Sliced jackfruit seeds were roasted at 160°C for 15 min using an air fryer for the roasting method. The dried slices from all three methods were ground into flour separately, packed in low-density polyethylene bags, and stored in airtight containers.

Determination of flour properties

The flour yield was determined according to the method mentioned by Dey et al. (2015). The bulk density was determined using modified technique described by Falade and Okafor (2015). The moisture content was measured using the standard oven-dry method. A centrifugal approach described by Islam et al. (2015) was used to assess the water-holding capacity (WHC) and oil-holding capacity (OHC) of the samples. A modified methodology of Islam et al. (2015) was applied to determine the water solubility and swelling power of the jackfruit seed flour.

Preparation of the jackfruit seed flour-based snack

After conducting a series of preliminary trials, a flour mixture with a ratio of 4:1:1 jackfruit seed flour, wheat flour, and rice flour was selected based on its dough-forming ability, elasticity, stickiness, and deformation. Water (20.0 ml) was added to 100.0 g of the flour mixture and mixed thoroughly. The flour mixture was then added to the extruder (DOLLY 11F080) to produce the extruded snack. The snack was air-fried for 4 min at 160 °C and subsequently deep-fried at the same temperature.

Determination of colour

A colorimeter (CS10 CHN – Spec, China) was used to determine the colour of the jackfruit seed flour and snack. The L*, a*, and b* parameters were measured using the colorimeter.

Sensory evaluation

A seven-point hedonic test was conducted with thirty untrained panellists from the Faculty of Agriculture at the University of Peradeniya to select the best snack type from the three variations. The panellists evaluated the snacks based on texture, taste, colour, aroma, and overall acceptability.

Proximate composition analysis of the final product

Proximate analysis was conducted on the product selected from the sensory evaluation (the snack developed from boiled jackfruit seed flour), following the AOAC Official Method 920.39, 2019. The analysis included the measurement of moisture, ash, crude protein, crude fat, crude fibre, and carbohydrate content of the product.

Statistical analysis

The functional property parameters were presented as mean ± SD and one-way analysis of variance (ANOVA) was conducted for all tested parameters using CRD design. The mean comparison was carried out using Turkey test at $p<0.05$. The nonparametric data in sensory evaluation was analysed using the Friedman test. All the statistical data were analysed using the Minitab® 19 software.

Results and Discussion

Flour yield

The weight percentage of the jackfruit seed coat was 4-6%, rendering it unusable. The flour yield obtained by roasting, boiling, and oven drying was 35.26, 41.72, and 35.67%, respectively. These yields were lower than the yield (46%) reported by Roy Chowdhury et al. (2012) and it could be due to the variations in the flour preparation methods.

Functional properties of jackfruit seed flour

There was no significant difference ($p>0.05$) in the moisture content of all flour samples, but the moisture levels ranged from 5.73 to 7.40%, as shown in Table 1. These values were higher than the values (3.20 to 6.60%) reported by Ejiofor et al. (2014). Boiled jackfruit seed flour had the highest moisture content (7.40%) due to higher water absorption during the boiling. As a result of the rapid removal of moisture, the roasted flour sample had the lowest moisture content. There were significant differences ($p<0.05$) between the oven-dried flour and the other samples with respect to bulk density. Accordingly, boiled flour had the highest bulk density (0.81 g/cm^3) due to its higher moisture content, while oven-dried flour had the lowest (0.62 g/cm^3). During the roasting process, a rapid heating and drying occurs within a shorter period which leads to the shrinking and packing of the flour particles tightly, resulting in a higher bulk density compared to that of the boiled flour sample. Some significant differences ($p<0.05$) were noted in the water holding capacity, with boiled flour having the highest (2.08 g/g) and oven-dried flour the lowest (1.21 g/g), and these values were reported lower than the values (4.0 g/ml to 6.0 g/ml) reported by Ejiofor et al. (2014) which could be due to the variations in the flour preparation methods. No significant differences ($p>0.05$) among the samples were observed with respect to its oil holding capacity, with values ranging from 1.84 to 2.04 cm^3/g, however, boiled flour had the highest oil-holding capacity. Boiled flour showed the highest swelling power (8.26 %), significantly different ($p<0.05$) from roasted and oven-dried samples. The swelling power values range were in accordance with the values (6.58 to 9.46%) reported by Ejiofor et al. (2014) There was a significant difference ($p<0.05$) among the solubility of the flour samples, ranging from 7.69 to 11.40%, with roasted flour having the highest solubility.

Table 1. Functional properties of Jackfruit seed flour

Treatment	**Moisture (%)**	**Bulk density (g/ cm³)**	**Water holding capacity (g/g)**	**Oil holding capacity (cm³/g)**	**Solubility (%)**	**Swelling power (%)**
A	5.73±1.17^{a}	0.76±0.04^{a}	1.79±0.21^{a}	1.92±0.31^{a}	0.14±0.07^{a}	8.93±1.67^{a}
B	7.40±0.38^{a}	0.81±0.04^{a}	2.08±0.12^{a}	2.04±0.12^{a}	0.11±0.05^{a}	6.91±0.53^{ab}
O	6.48±0.51^{a}	0.62±0.07^{b}	1.21±0.15^{b}	1.91±0.22^{a}	0.10±0.01^{a}	5.67±0.89^{b}

Values are in means ±SD (n=3). Mean (±SD) followed by the same subscript within a column is not significantly different ($p>0.05$) as measured by the

Turkey test. A-Roasted jackfruit seed flour, B- Boiled jackfruit seed flour, O- Oven-dried jackfruit seed flour.

Properties of the snack

Frying time

After extrusion, the snacks were air-fried to enhance crispiness and flavour while reducing excessive oil absorption. The frying time varied according to the type of flour used in the snack preparation and was determined based on the flavour, colour, and texture of the final product, as shown in Table 2.

Table 2. Frying time for different types of jackfruit seed flour-based snacks

Flour type used for the snack preparation	Frying time (sec)
Roasting method	15
Boiling method	17
Oven- drying method	10

Colour determination of flour and snacks

Colour measurements of the jackfruit seed flour are presented in Table 3. The colour of the flour varied depending on the type of flour due to differences in processing methods. In the preparation of roasted seed flour, seeds were heated at 160 °C, resulting in a Maillard browning reaction, which imparts a characteristic colour and flavour. Similarly, in the boiled seed flour preparation method, the seeds were subjected to high temperatures, leading to a change in flour colour. Therefore, there was a noticeable colour variation among the different types of flour.

Table 3. Colour variation of jackfruit seed flour

Treatment	L*	a*	b*
A	78.67 ± 0.48^{a}	7.10 ± 0.22^{a}	12.36 ± 0.77^{a}
B	76.26 ± 0.76^{b}	6.59 ± 0.11^{ab}	10.43 ± 0.53^{b}
O	83.19 ± 1.03^{c}	6.23 ± 0.37^{b}	6.55 ± 0.45^{c}

Values are in means ±SD (n=3). Mean (±SD) followed by the same subscript within a column is not significantly different (p>0.05) as measured by the Turkey test. A-Roasted jackfruit seed flour, B- Boiled jackfruit seed flour, O- Oven-dried jackfruit seed flour.

Colour variations of jackfruit seed flour-based snacks are presented in Table 4. There were no significant colour differences (p>0.05) among this snack samples as deep-frying process was monitored to achieve the desired snack colour.

Table 4. Colour variation of jackfruit seed flour-based snack

Treatment	L*	a*	b*
A	32.23± 0.12^{a}	-0.77 ± 0.38^{a}	1.97 ± 0.42^{a}
B	31.86 ± 1.73^{a}	0.61 ± 0.59^{a}	3.06 ± 0.32 ^{a}
O	33.11 ± 2.34^{a}	1.15 ± 1.49^{a}	3.08 ± 2.21^{a}

Values are in means ±SD (n=3). Mean (±SD) followed by the same subscript within a column is not significantly different (p>0.05) as measured by the Turkey test. A-Roasted jackfruit seed flour, B- Boiled jackfruit seed flour, O- Oven-dried jackfruit seed flour

Sensory analysis

The sensory analysis results indicated that snacks made from boiled jackfruit seed flour received the highest scores across all tested attributes (Figure 1). Consequently, boiled jackfruit seed flour-based snack was selected as the most acceptable option among consumers.

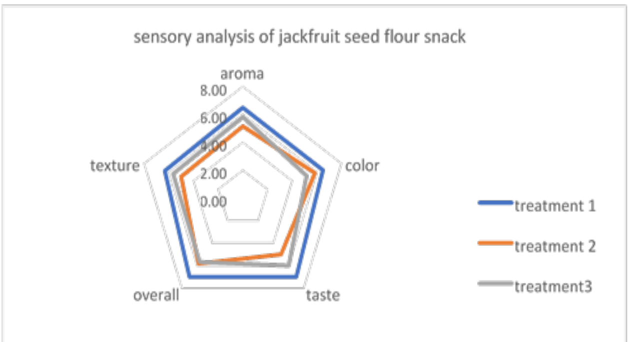

Figure 1. Radar chart of sensory evaluation. Treatment 1- Boiled jackfruit seed flour-based snack, Treatment 2- roasted jackfruit seed flour-based snack, Treatment 3- Oven-dried jackfruit seed flour-based snack

Proximate analysis

A proximate analysis of the selected boiled jackfruit seed flour-based snack is shown in Table 5.

Table 5. Proximate analysis of boiled jackfruit seed flour snack

Component	Amount (%)
Moisture	4.74
Ash	2.90
Fat	6.46
Fiber	1.70
Protein	0.59
Carbohydrate	83.61

Carbohydrates were the predominant component in the boiled jackfruit seed flour-based snack, comprising 83.61% of the content, while protein was the lowest. The fat content of the final product was 6.46%, which is lower compared to other deep-fried snacks (13.5%) (Pikuda & Ilelaboye, 2009). The protein content in the final product was also lower than the protein content reported for jackfruit seed flour (Dey et al., 2015). This reduction could be attributed to factors such as increased thermal activity, dilution of protein content from mixing with other ingredients, and protein leaching during boiling.

Conclusions

The study results indicate that deep-fried snacks can be successfully made using boiled, oven-dried, and roasted jackfruit seed flour. In addition to jackfruit seed flour, rice and wheat flours were also used in the mixture. This composite blend contributed to creating a softer dough, reduced its stickiness, and improved the crispiness of the snack. The sensory evaluation revealed that snacks made from boiled jackfruit seed flour had the highest consumer acceptability. The proximate analysis showed that carbohydrates were the major component in the boiled jackfruit seed flour-based snack, which also had a comparatively lower fat percentage. The low protein content of the snack may be a limitation, but this can be improved by incorporating protein-rich ingredients during the preparation process.

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