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Jackfruit Seed Flour as a Functional Ingredient in Conventional Bread: Impact on Proximate Composition and Overall Acceptability

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Abstract

Despite their nutritional importance, jackfruit seeds are rarely used in food preparations due to their recalcitrant nature and limited availability after the seasonal glut. The study aimed to create nutritious bread enriched with the jackfruit seed flour in place of wheat flour. The nutritional, physical and sensorial properties of bread using various proportions (0, 5, 10 and 15%) of jackfruit seed flour were examined. The results of proximate analysis revealed that adding 15% jackfruit seed flour to breads significantly ($P<0.05$) increased the content of protein, moisture, ash and dietary fiber (12.90±0.05% to 13.83±0.12%, 26.90±0.12% to 28.63±0.16%, 0.68±0.20% to 1.07±0.8% and 1.77±0.10% to 2.07±0.15%, respectively), while decreasing fat (3.60±0.06% to 1.97±0.07%) content. It was observed that formulated breads were more nutritious than the control sample. In comparison to the control and other samples, bread made with a 10% jackfruit seed flour substitute was found more palatable, based on the physical appearance and sensory attributes. As a result, jackfruit seed may be considered as an unexplored source of dietary supplements and a possible source of natural, active chemicals for use in food applications.

Keywords: Bread, Jackfruit, Seed flour, Nutritional quality, Sensory attributes

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Introduction

The largest edible fruit in the Moraceae family is the jackfruit (*Artocarpus heterophyllus* Lam.), which is regarded as Bangladesh's national fruit (Goswami et al., 2010). The skin of jackfruit is thorny and tough. It comes out that the fruit is made up of several juicy flakes inside its skin. When ripe, it is luscious and tasty to eat, and it is also incredibly nutrient-dense. The phytochemicals (saponins) found in jackfruit, especially the phenolic compounds (lignans, isoflavones), may offer a variety of health benefits, including anticancer, antihypertensive, and antiulcer effects. All-trans-carotene, one of the many carotenoids that exist in jackfruit, is an important antioxidant for human health and may also help prevent a number of chronic degenerative diseases, such as cancer, inflammation, cardiovascular disease, cataracts, and age-related macular degeneration. All-trans lutein, all-trans-β-carotene, all-trans neoxanthin, 9-cis-neoxanthin, and 9-cis-violaxanthin have been recognized as the primary carotenoids in jackfruit (Ranasinghe et al., 2019). The jackfruit may be referred to as a functional food since it includes beneficial components in different parts of the fruit that have both medicinal and functional properties and qualities. Ripe flakes have 11–19 g of carbs, 30–73 mg of calcium, and 287–323 mg of potassium per 100g. This fruit is high in energy and has been proven to have antibacterial, antidiabetic, anti-inflammatory, antioxidant, and antilithic properties. It can also be used to treat physical or mental fatigue, stress, and muscle weakness (Jagtap et al., 2010). Jackfruit seeds are smooth, round, light brown seed (endocarp) encased in a thin white membrane (exocarp) is found inside each bulb. The seed is 1.5–2.5 cm thick and 2–4 cm long. A single fruit may contain 100–120 or even 500 seeds, making up 5–6% of the fruit overall (Bakewell-Stone 2023). The white, starchy flesh inside the seed has a subtle, nutty flavor. It can be used in a variety of culinary preparations, such as soups, curries, and desserts, or it can be cooked or roasted. Protein, fiber, and vital elements including potassium, vitamin A, and vitamin C are all abundant in jackfruit seeds (Sultana et al., 2017). Conversely, jackfruit seed flour offers a number of benefits. According to Tananuwong et al. (2002), the main constituents of jackfruit seed flour were crude fiber (1.67%), protein (11.17%), fat (0.99%), and carbs (82.25%). After analysis, the total starch and amylose contents were found to be 77.76 and 32.05 g/100g, respectively. Consequently, compared to whole wheat flour, white wheat granules have less fiber, vitamins, and minerals. Because of their high carbohydrate content, jackfruit seeds can be used to cook meals to add value without compromising the functional and sensorial attributes of finished product. The seeds are often thrown away as waste, though occasionally they are roasted or boiled for human consumption. Prompt spouting of seed keeping fresh seeds for an extended period of time is very difficult. In Bangladesh, a significant quantity of jackfruit seeds is wasted annually due to lack of processing and preservation methods. Consequently, a significant quantity of jackfruit seeds remains unused. Wheat flour is typically the main ingredient in bread and confectionery industries. The cost of wheat flour keeps rising. So, jackfruit seed flour can be utilized as a useful source in a lower cost in baking and making bread (Hossain et al., 2014). Considering the aforementioned, this research was designed to test the formulation of a certain type of baked food using powdered jackfruit seed in different addition ratios (0%, 5%, 10% and 15%) with wheat flour. It is anticipated that the new bread variant will have better nutritious qualities due to the mix of wheat and powdered jackfruit seed. The specific objectives of this study were to examine the nutritional, physical and sensorial qualities of bread incorporated with Jackfruit seed powder.

Materials and methods

Raw Materials

Jackfruit seed was collected from the local market, Bangladesh Agricultural University, Mymensingh, Bangladesh during the fruiting season. Superior commercial wheat flour (Brand: Fresh Maida) and all other necessary ingredients were purchased from the nearby market of Mymensingh, Bangladesh.

Preparation of jackfruit seed flour

About 3 kg of jackfruit seeds were hand cleaned. After cleaning, the jackfruit seeds were left to dry in the sun for consecutive 3 days. After that, it was oven-dried for a day at 65 °C in order to continue processing**.** Following the collection of jackfruit seeds, the defected and germinated seeds were separated. To remove any dirt particles or odd components, the seeds were washed with tap water. Seeds were sliced into 2 mm pieces and then blanched for 10 min at 70°C with 0.5% potassium metabisulfite (KMS) to maintain color and stop browning reaction from spreading. The hot air circulating tray dryer (CT-C-0, Jiangsu Shuntong Drying Tech., China) was applied to dry the pretreated slices for 48 h at 60 ± 1°C. After the dried seed was ground to a smooth texture using a grinder machine (Japan CM/L-7360065, Japan), the sifting procedure was completed using a stainless-steel sieve (MIC-212, 30 mesh standard sieve). Until it underwent further examination, the jackfruit seed powder was stored in airtight polyethylene (PE) bags that were dry, dark, and out of direct sunlight (Hossain et al., 2014).

Product development

The basic formula for jackfruit seed flour-incorporated breads and regular bread (multi-stage mixing) is presented in Table 1. Three categories referred to as 5%, 10% and 15% jackfruit seed flour-enriched breads, respectively, were prepared by partially replacing wheat flour with 5, 10 and 15 g of jackfruit seed flour. Pilot trial techniques and the information on the degree of substitution of wheat flour for comparable items were used to determine this quantity. Initially, the jackfruit seed flour, wheat flour, sugar, oil, dried yeast, egg, salt, and distilled water were all delicately weighed (Figure 1). To produce a soft and steady dough, all components were combined for 15 min in a dough mixer (SXBP-6, Guangdong Maxbaker Bakery Equipment Tech., China). These dough samples were put in 23 cm × 11 cm baking pans and let to ferment at room temperature (30 ± 2 °C) for 1 h. Following 45 min of baking at 230°C, the breads were removed from the oven (Figure 2), allowed to cool at room temperature (30 ± 2°C), for additional examination, placed in dry, airtight polyethylene (PE) bags for storage (Jahan et al., 2023).

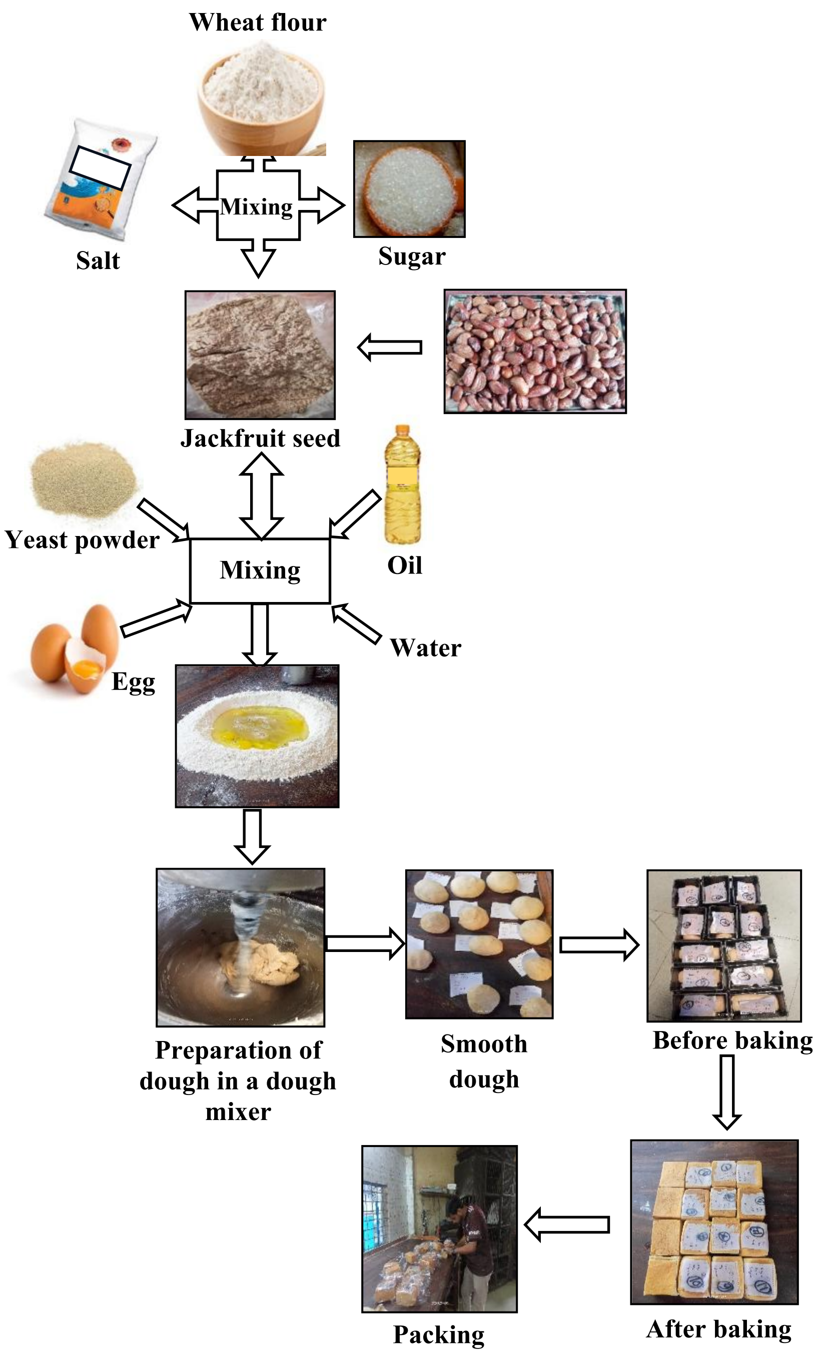

Fig. 1. Flowchart of formulated bread preparation.

Table 1. Basic formulation for preparation of supplemented breads (on g/100g flour basis)

Ingredients (g)	Samples			
	Jackfruit seed flour enriched bread formulations			
	C (Control)	S_1 (5%)	S_2 (10%)	S_3 (15%)
Wheat flour	100	95	90	85
Jackfruit seed powder	0	5	10	15
Sugar	6.0	6.0	6.0	6.0
Refined oil (ml)	6.0	6.0	6.0	6.0
Dry yeast	2.5	2.5	2.5	2.5
Salt	1.5	1.5	1.5	1.5
Egg (nos.)	1.0	1.0	1.0	1.0
Water (ml)	57.0	57.0	57.0	57.0

*C = Control; S_1 = 5% jackfruit seed flour + 95% Wheat flour; S_2 = 10% jackfruit seed flour + 90% Wheat flour; S_3 = 15% jackfruit seed flour + 85% Wheat flour.

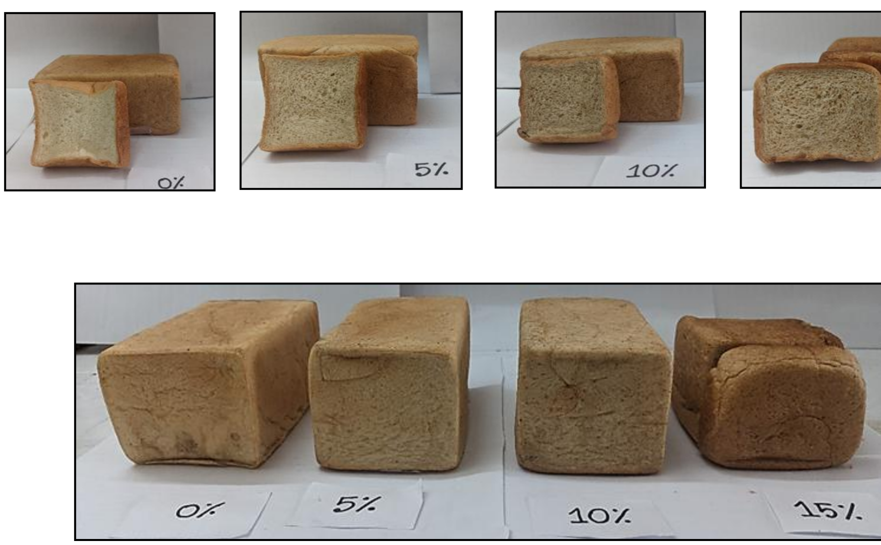

Fig. 2. Formulated Bread with different percentages of jackfruit seed powder (0%-15%)

Proximate composition analysis

Table 2 displayed the several quality parameters that had been evaluated for the prepared breads. The gross content of significant chemical components, such as moisture, dietary fiber, protein, fat and ash content was shown by approximate composition. It made it possible to examine several affirmative signs regarding the food's nutritional value. The analytical process for determining the proximate composition of the studied bread samples was described in this section. According to the guidelines set forth by the AOAC (*Association of Official Analytical Chemists*), the proximate characteristics of formulated bread were measured. The moisture content was determined using the methodology outlined in standard 930.15 (AOAC, 2023), by drying the sample at 105 °C for 8 h. The crude protein was determined by the Kjeldahl technique in standard 954.010 (AOAC, 2023), through completing the digestion, distillation and titration. The ashes were heated in a muffle furnace until light gray ash (or constant weight) was produced, in accordance with norm 942.05 (AOAC, 2023). Crude fat analysis was conducted according to standard 920.39 (AOAC, 2023), by ether extraction method.

Table 2. Experimental Design of Jackfruit Seed Flour Formulated Bread

Samples		Observed parameters
Jackfruit seed flour		Percentage (%) yield
Bread	C (Control) S_1 (5% JSF) S_2 (10% JSF) S_3 (15% JSF)	I. Proximate composition (Moisture, Protein, Fat, Ash, Carbohydrate, Fiber) II. Physical parameters (Crumb and Crust characteristics) III. Sensory attributes (crust color, crust shape, crumb color, taste, smell, sweetness, porosity, elasticity)

*C = Control; S_1 = 5% jackfruit seed flour + 95 % Wheat flour; S_2 = 10% jackfruit seed flour + 90 % Wheat flour; S_3 = 15% jackfruit seed flour + 85 % Wheat flour; JSF = Jackfruit seed flour

The total dietary fiber (TDF) content of the formulated bread was ascertained using the enzymatic-gravimetric method (AOAC, 2019). Protein and starch were extracted by enzymatic breakdown using protease and amyloglucosidase after the defatted and dried samples were separated into two parts and gelatinized and partially digested by α-amylase. An acetate buffer (5 mL, 0.1 M, pH 5.0) solution containing 100 µL thermostable α-amylase was combined with the prepared bread (300 g) and incubated at 96^{0}C for 60 min in a sealed tube. About 400 µL of amyloglucosidase and 400 µL of protease were added to the sample, which was then incubated for 4 h at 60°C. About 80% aqueous ethanol was used to precipitate the soluble fiber. The total fiber was obtained by centrifuging the samples for 20 min at 2000 rpm. After being cleaned with ethanol and acetone, the residue was dried and weighed. Protein and ash tests were performed on two different portions of the residue. The TDF was computed as a percentage of the initial sample weight by subtracting the residue's weight from the protein and ash weights (Mazumder et al., 2023).

The sum of the previously measured components was subtracted from one hundred percent in order to determine the amount of carbohydrates (Spanopoulos-Hernandez et al., 2010).

Carbohydrate = 100 – (% moisture + % protein + % ash + % fat + % fiber)

Sensory attributes of Formulated Bread

Four various types of the formulated breads were assessed by 50 untrained panelists (25 male and 25 female) from Mymensingh City Corporation, Mymensingh, Bangladesh, ranging in age from 18 to 55 for flavor, crust and crumb color, smell, sweetness, porosity, elasticity and shape. The panelists were selected from among those who frequently consume commercial bread. The samples were presented in a random order after being blindly coded. Samples were presented to panelists once at a time in order to reduce the impact of the sequence of samples delivery. In order to revitalize their palates, panelists were advised to consume water. The sensory session was conducted in individual cabins at 25±1°C with 54±1% relative humidity and white light (300 lx). Additionally, all panelists were informed beforehand that alternative food items were being produced to replace commercial breads in order to lessen the impact of shock (Almehizia et al., 2025). A five-point hedonic rating scale, with 1 denoting extremely dislikes, 2 denoting slightly dislike, 3 denoting neither like or dislike, 4 denoting slightly like and 5 denoting extremely like, was used for the statistical analysis of the degree of acceptability of the formulated breads (Berdos et al., 2020). The results were evaluated by one-way Analysis of variance (ANOVA) and Duncan’s multiple range test procedures of the statistical analysis system (SAS, 1985) by using the IMB SPSS 26.0 software.

Statistical Analysis

Every experiment was carried out three times and the average value was reported. Software called SPSS 26.0 (IBM SPSS Inc., Chicago, IL, USA) was used to conduct the statistical analysis (one-way analysis of variance, Duncan’s multiple range test). Excel software was used to draw each graph. At a 95 % level of confidence ($p<0.05$), the levels were deemed substantially different using test.

Results and discussions

Percentage (%) yield of jackfruit seed flour

The percentage (%) yield of jackfruit seed flour was statistically significant ($p<0.05$) was shown in Figure 3. The final jackfruit seed flour percentage was 48.50±0.12% and approximately 6.5±0.11% of the jackfruit seed flour was lost during the sifting process as the coarse particles being rejected. The milling process lost around

20.36±0.15% and the drying process lost about 24.64±0.16%. A sizable amount of jackfruit seed flour was extracted from jackfruit seed; however, it was only a rough estimate. This aligns with the findings of Chowdhury et al. (2012) and Hossain et al. (2014) who observed 46% and 48.25% recovery respectively.

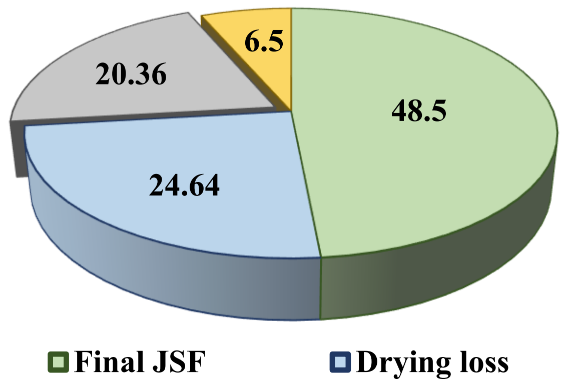

Fig. 3. Percentage (%) yield of Jackfruit Seed Flour

Proximate composition of formulated bread

All bread samples formulated with different amounts of jackfruit seed flour were outlined in Table 3 along with their moisture, ash, protein, fiber, carbohydrate, and fat contents. Duncan's multiple range test revealed that all of the samples were statistically ($p<0.05$) significant. The control sample contained highest fat (3.60±0.06%) and lowest moisture (26.90±0.12%) than the other bread samples. It was observed that the moisture content gradually rose while the fat content dropped from the control to S_3 sample as the amount of jackfruit seed flour in the dough increased. This pattern was similar to that of Butool and Butool (2015) and Hossain et al., (2014), who reported that the moisture content gradually rose and the fat content decreased from wheat flour bread samples to composite bread samples as the percentage of seed flour substituted in the dough increased. The reason for this is because there is an inverse relationship between the fat and moisture contents (Rasul et al., 2021). Out of all the samples, the control sample contained the lowest percentages of dietary fiber (1.77±0.10%), ash (0.68±0.20%), and protein (12.90±0.05%), respectively. It was shown that adding more jackfruit seed flour to the composite dough raised the amounts of ash, protein and dietary fiber in the bread samples. The S_3 sample had the highest levels of protein, dietary fiber, and ash (13.83±0.12%, 2.07±0.15%, and 1.07±0.8%, respectively). Due to the fact that jackfruit seed flour had adequate amounts of protein, ash, and dietary fiber (12.45 ± 0.54% protein, 2.46 ± 0.28% ash, and 3.53 ± 0.71% crude fiber), the protein, ash, and dietary fiber content of formulated bread was high (Eke-Ejiofor et al., 2014). The S_3 sample's high ash percentage indicated that there was a sizable amount of mineral in the powder. High mineral content has been found to raise ash content (Dada et al., 2012).

Table 3. Proximate Composition of Formulated Bread

Samples	Moisture content	Protein content	Fat content	Ash content	Carbohydrate content	Fiber content
C	26.90 ± 0.12^{d}	12.90 ± 0.05^{d}	3.60 ± 0.06^{a}	0.68 ± 0.20^{a}	55.86 ± 0.4^{a}	1.77 ± 0.10^{b}
S_1	27.24 ± 0.02^{c}	13.35 ± 0.01^{c}	2.97 ± 0.04^{b}	0.77 ± 0.09^{a}	55.67 ± 0.12^{a}	1.8 ± 0.05^{b}
S_2	27.51 ± 0.05^{b}	13.59 ± 0.10^{b}	2.32 ± 0.13^{c}	0.94 ± 0.11^{a}	55.64 ± 0.09^{a}	1.91 ± 0.02^{ab}
S_3	28.63 ± 0.16^{a}	13.83 ± 0.12^{a}	1.97 ± 0.07^{d}	1.07 ± 0.8^{a}	54.50 ± 0.6^{b}	2.07 ± 0.15^{a}

[1]C = Control; S_1 = 5% jackfruit seed flour + 95 % Wheat flour; S_2 = 10% jackfruit seed flour + 90 % Wheat flour; S_3 = 15% jackfruit seed flour + 85 % Wheat flour, [2]Different superscript (a,b,c,d) letters in columns indicate statistical differences ($p<0.05$) of the samples according to Duncan's multiple range test, [3]Data are the means ± standard deviations (n=3)

Physical characteristics of bread samples

Table 4 displayed the physical attributes of composite breads. Both the control sample and the S_1 sample had the same level of bright brown color intensity and crust consistency. More seed flour replacement resulted in composite breads with a significantly softer texture and a more brownish hue. Bread with 15% substitution (sample S_3) had a moderately firm and brown crust. In contrast, the bread's crumb and crust colors were identical, which was caused by a higher proportion of jackfruit seed flour.

Table 4. Physical Characteristics of Formulated Bread

Samples	Crust characteristics		Crumb characteristics				
	Color	Consistency	Color	Odor	Air cell	Lumps and Hardness	Surface
C	Bright brown	Tender	Bright brown	Present slightly	Smooth	Present slightly	Smooth
S_1	Bright brown	Tender	Bright brown	Appetizing	Large	Present slightly	Smooth
S_2	Brownish	Slightly tender	Brownish	Appetizing	Large	Present slightly	Smooth
S_3	Brown	Medium tough	Brown	Slight sweet	Medium	Present	Light rough

[1]C = Control; S_1 = 5% jackfruit seed flour + 95 % Wheat flour; S_2 = 10% jackfruit seed flour + 90 % Wheat flour; S_3 = 15% jackfruit seed flour + 85 % Wheat flour.

The control bread in Table 4 is light brown, has a wide air cell, a smooth surface, and is somewhat hard. Similar to the control, Sample S_1 has a smooth surface, a large air cell, a deep brown hue, and a moderate degree of hardness. Sample S_2 features a medium air cell, a smooth surface, a slight taste, a mild hardness, and a brownish tint. Sample S_3 has a medium air cell, a moderate hardness, a lot of sweetness, a little rough surface and brown in color. Samples S_1 and S_2 were discovered to have a smooth surface and the ideal texture, no lumps or hardness. Previous studies also reported that samples exhibited hardness and poor texture as the quantity of jackfruit seed flour increased (Hossain et al., 2014).

Sensory properties of bread samples

The sensory qualities of bread baked with jackfruit seed flour were assessed using a Duncan's multiple range test to see whether there were any significant differences ($p<0.05$), as seen in Figure 4 that displayed the findings of a sensory evaluation of bread samples with varying amounts of jackfruit seed flour in comparison to the control. Crust and crumb color scores showed that the S_2 sample (10% jackfruit seed flour substitution) had better crust color (4.88±0.11) and crumb color (4.69±0.14) than the other samples. As the amount of seed flour increased, the light-brown hue of the formulated breads turned darker. The results demonstrated that the sweetness and smell of the various samples were not all equally acceptable. The smell and sweetness of the various samples varied significantly ($p<0.05$). The control sample received the lowest score (3.38±0.12 for smell and 2.94±0.11 for sweetness), while the S_2 sample was the most desired. The bread and crust shapes of the formed breads and the control bread differed significantly ($p<0.05$). With a score of 4.75±0.12 for bread shape and 4.31±0.25 for crust shape, the S_2 sample (10% substitution) was the most popular among the formed breads. The control sample received the lowest scores, 3.88±0.33 for bread shape and 3.75±0.21 for crust shape. The taste of the S_2 and S_3 samples did not differ significantly ($p>0.05$), with the control sample and S_1 sample recording 3.38±0.25 and 3.94±0.34 respectively. The porosity and elasticity of the samples were found to differ significantly ($p<0.05$) in the results, with the S_3 sample receiving a high score of 4.06±0.22 and the S_1 sample receiving a high score of 4.44±0.14 correspondingly. According to the sensory evaluation, the S_2 sample was superior than the other samples. The results of the study by Hossain et al., (2014), who found that bread made with jackfruit seed flour (25%, 35%, 45%, and 55% replacement of wheat flour) and 25% supplemented bread performed the best in terms of sensory qualities when compared to other breads, were nearly in line with this finding because S_3 sample seems a little sweeter than S_2 sample.

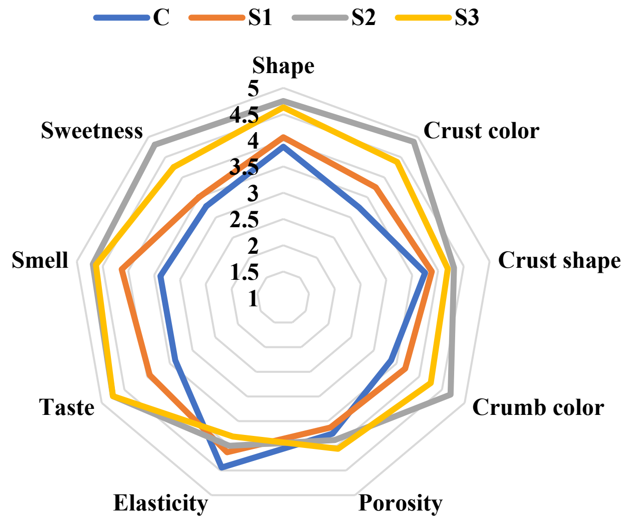

Fig. 4. Sensory Properties of Formulated Bread; C = Control; S_1 = 5% jackfruit seed flour + 95 % Wheat flour; S_2 = 10% jackfruit seed flour + 90 % Wheat flour; S_3 = 15% jackfruit seed flour + 85 % Wheat flour; Values are statistically significant ($p<0.05$) of the samples according to Duncan's multiple range test.

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Conclusion

Despite compromising sensory attributes, this study shows that adding jackfruit seed flour to wheat flour has a lot of promise for creating baked goods. When 10% jackfruit seed flour was added, the bread had a higher protein, ash, and crude fiber content than whole wheat bread, and it was more palatable overall. In this sense, it can give the existing bread formulation more economic value. Therefore, this study will contribute to the development of a new fortification scheme in the food industry that will guarantee the appropriate use of the underutilized jackfruit seeds. It is possible to make bread with additional nutritional value using jackfruit seed flour in place of wheat, according to nutritional data and general appeal. Further research should focus on *in vivo* metabolism and anti-oxidant activity of the breads containing jackfruit seed flour.

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