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The Effect of Processing Methods on Quality Parameters of Jackfruit Seed Flour (JSF) from Different Cultivars

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

India has a large jackfruit farming industry; however, after the edible part is eaten, the nutrient-rich seeds are thrown away as waste. The study was aimed at investigating the functional properties and sensorial attributes of jackfruit seed flour from various treatments. The results revealed a significant difference between the functional characteristics and sensory attributes of jackfruit seed flour samples processed by soaking the seeds in various soaking media. Based on the results, two seed flour samples (VS_1 - *Varikka* soaked in water and KS_1 – *Koozha* soaked in water) were selected as the best and evaluated for their proximate composition. The cultivar *Varikka* had more crude fiber (2.96%), ash (2.61%), protein (13.17 g/100g) and carbohydrate content (76.82 g/100g). Both the seed flour samples had negligible amount of fat (VS_1 – 1.72 and KS_2 – 1.68%), less fat

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allows for the prevention of rancidity issues and longer shelf life of the product. This procedure makes it feasible to preserve jackfruit seeds by converting them into flour, extending their shelf life. Facts from nutritional, functional and sensory assessments suggest that jackfruit seed flour can be employed in various processed products. It can also be used as substitute for starch.

Keywords: Functional properties; jackfruit seed flour; soaking media; tray drying.

1. INTRODUCTION

"The focus of research in recent years has been on the search for lesser-known and under utilised crops, many of which have the potential to be useful as human nourishment. The jackfruit, *Artocarpus heterophyllus*, is an Indian native and member of the mulberry family. It is widely distributed over the Indian states of Assam, West Bengal, Uttar Pradesh, Maharashtra, Kerala, Tamil Nadu, and Karnataka" [1]. "Jackfruit seeds contain important minerals such as magnesium, potassium, phosphorus, calcium, sodium, iron, copper, zinc, and manganese" [2]. "These minerals serve as the building blocks of our bones, influence muscle and nerve activity, and balance the body's water levels" [3]. "Jackfruit seeds are rich in dietary fibre and B-complex vitamins, and their high fibre content helps to lower the risk of heart disease, avoid constipation, and limit adipogenesis [4]. "Lignans, flavones, and saponins found in jackfruit seeds exhibit antioxidant, anticancer, antiulcer, antihypertensive, and antiaging properties" [5]. Every year, a large number of seeds are wasted owing to processing and storage issues. Jackfruit is considered an underutilized fruit due to a lack of understanding about effective usage, a lack of post-harvest equipment, and supply chain network deficiencies [6]. Hence, the jackfruit seed is a rich source of carbohydrates and other nutrients; the seed flour can be added to baked goods to increase their nutritive value without altering the functional or sensory aspects of the finished product [7]. The purpose of this study is to investigate the effect of various soaking processes on the functional qualities, sensory attributes, and proximate composition of jackfruit seed flour.

2. MATERIALS AND METHODS

2.1 Raw Materials

The jackfruit cultivars *Koozha* (k) and *Varikka* (v), which are widely available in Kerala, were selected for the study. Whole jackfruits were procured from Instructional farm, College of Agriculture, Vellayani, Trivandrum.

2.1.1 Processing of jackfruit seed flour

In the present investigation to obtain good-quality jackfruit seed flour, the jackfruit seeds of cultivars *Koozha* and *Varikka* were subjected to various soaking treatments. The white arils (seed coat) were peeled off and the seeds were soaked for 30 minutes in various soaking media, *viz.*, S_1 - water, S_2 - 4% sodium metabisulphite, and S_3 - 3% sodium hydroxide. After soaking, the brown spermoderm were removed from the seeds using a stain-less steel knife. The seeds underwent cleaning and washing under running water. The seeds were gelatinized at 65°C for 10 minutes. Following gelatinization, the seeds were sliced and tray-dried at 110 °C for 12 hours. After tray drying, seeds from both cultivars were ground into powder, sieved through a fine wire mesh (150 micron), stored in polyethylene pouches, and used for further investigation.

2.2 Analytical Methods

2.2.1 Functional quality analysis of jackfruit seed flour samples

"Food's functional properties are determined by its organoleptic, physical, and/or chemical characteristics. The functional qualities of foods and flours are impacted by the food's components, particularly carbohydrates, proteins, lipids and oils, moisture, fiber, ash, and other substances or food additives added to the food (flour), as well as the structures of these components" [8]. "Water absorption capacity and oil absorption capacity of the jackfruit seed flour was determined by the method" of Niba et al. [9] and Beuchat [10]. "Solubility index and swelling power were determined according to the method of Oladele and Aina" [11]. Bulk density and flour dispersibility were determined by the method suggested by Okaka and Potter [12] and Islam et al. [13].

2.3 Evaluation of Sensory Quality Attributes of Jackfruit Seed Flour Samples

The organoleptic evaluation the samples was performed by 25 semi trained panelists. To develop the sensory sample, 10 g of jackfruit seed flour from various treatments were mixed in 200 ml of cold milk. The sensory attributes of the jack fruit seed flour, such as their colour and appearance, taste, texture, flavour, and overall acceptability, are evaluated using a 9-point hedonic scale (1= dislike extremely and 9= like extremely). The difference in the scores was analyzed using Kruskal – Wallis test.

2.3.1 Selection of the Best Jackfruit Seed Flour Samples

Based on the results of organoleptic evaluation, the best jackfruit seed flour samples were chosen for quality analysis.

2.4 Determination of Proximate Composition of Jackfruit Seed Flour Samples

Moisture, ash, crude protein, crude fiber and crude fat content of the samples were determined by the AOAC [14] method. The carbohydrate content was calculated by difference, (100- sum of the values for moisture, crude protein, crude fiber, crude fat and crude ash).

2.5 Statistical Analysis

All data obtained from various analysis were pooled and subjected to Completely Randomized Design (One-way ANOVA) using KAU-GRAPES software. The sensory scores were analysed using Kruskal – Wallis test.

3. RESULTS AND DISCUSSION

3.1 Functional Properties of the Jackfruit Seed Flour Samples

Functional properties of jackfruit seed flour samples from various treatments are depicted in Table 1.

Water absorption capacity (WAC), also known as water absorption, is the amount of water (moisture) absorbed by food or flour in order to attain the desired consistency and produce a quality food product [8]. In the present investigation the WAC of Jackfruit seed flour ranged between 194.8 – 202.1 ml/100g. Water absorption capacity was found to be higher for the cultivar *Varikka* (VS_1 – 202.1ml/100g, VS_2 – 198.7 ml/100g and VS_3 – 197.7 ml/100g). It may be ascribed to the greater concentration of carbohydrates (namely starch) and fiber in the *Varikka* cultivar compared to the *Koozha* cultivar. The increase in water absorption capacity of flour could also be attributed to an increase in amylose solubility and leaching, as well as the degradation of crystalline structure of starch [15]. The results are comparable with the values reported by Reddy et al. [16] and Chowdary et al. [17] who reported the water absorption capacity of jackfruit seed flour as 184.27 ml/100g and 203.4%, respectively.

“Oil absorption capacity is the binding of fat by the non-polar side chain of proteins. The rate of oil absorption is very high in foods with high protein content. The oil binding capacity of protein in food depend on the intrinsic factors such as protein conformation, amino acid composition, and surface polarity or hydrophobicity” [18]. Oil absorption capacity was significantly higher for the cultivar *Varikka* (VS_1 – 87.80 ml/100g, VS_2 – 85.80 ml/100g and VS_3 – 86.50 ml/100g). Suresh and Samsher [18] reported that foods high in protein have a high rate of oil absorption. The findings abide by the study done by Borgis and Bharati [19] and Reddy et al. [16] who reported oil absorption capacity of jackfruit seed flour as 89.93 ml/100g and 87.65 ml/100g, respectively.

“The swelling capacity is the measure of the starch ability to absorb water and swell. The extent of swelling is determined by water absorption, temperature and availability of water. It is considered a quality requirement in high quality food compositions, such as bakery products” [20]. “The swelling power of the jackfruit seed flour samples ranged between 3.99 – 4.82 g/g. The highest swelling power was observed for the cultivar *Varikka* (VS_1 – 4.82 g/g, VS_2 – 4.28 g/g and VS_3 – 4.18 g/g) than the cultivar *Koozha*. It could be attributed to the high starch content of the cultivar *Varikka.* The swelling capacity (index) of flours are also influenced by the particle size, species variety and method of processing” [18]. The swelling power of jackfruit seed flour is reported as 3.62 g/g by [21] and 4.77 g/g by Ocloo et al. [22], respectively; the obtained values are consistent with the reported values.

Table 1. Functional properties of jackfruit seed flour samples

Treatments	WAC (ml/100g)	OAC (ml/100g)	SP (g/g)	SI (%)	BD (g/cm^3)	Dispersibility (%)
VS_1	202.1^a	87.80^a	4.82^a	2.05^a	0.73^a	33.66^a
VS_2	198.7^b	85.80^c	4.28^b	1.97^b	0.71^b	31.64^b
VS_3	197.7^c	86.50^b	4.18^c	1.92^c	0.70^b	30.66^c
KS_1	196.7^d	84.62^f	4.09^d	1.84^e	0.66^e	28.33^d
KS_2	195.0^e	85.11^d	4.01^e	1.87^d	0.67^d	30.33^c
KS_3	194.8^e	84.90^e	3.99^e	1.85^e	0.69^c	28.66^d
±SE(m)	0.133	0.008	0.008	0.004	0.004	0.333
CV%	0.117	0.016	0.315	0.388	1.069	1.89

Values are means of triplicates. Values with different superscripts (a,b,c,d) within the same column are significantly different (P≤0.05). VS_1- Varikka soaked in water, VS_2- Varikka soaked in *3% Sodium hydroxide, VS_3- Varikka soaked in 4% Sodium metabisulphite, KS_1- Koozha soaked in water, KS_2- Koozha soaked* in *3% Sodium hydroxide, KS_3- Koozha soaked in 4% Sodium metabisulphite. WAC= Water absorption capacity, OAC= Oil absorption capacity, SI= Solubility index, SP= Swelling power, BD = Bulk density*

In the food system, solubility is the ability of solid, liquid, or gaseous food (chemical) compounds known as solutes to dissolve in a liquid, gaseous, or solid solvent. It is measured and determined in terms of the maximum quantity of solute dissolved in a given solvent at equilibrium [8]. In the present investigation solubility index of jackfruit seed flour ranged from 1.84 – 2.05%. Solubility index was found to be significantly higher for the cultivar *Varikka* (VS_1 – 2.05%, VS_2 – 1.97% and VS_3 – 1.92%). The solubility index of jackfruit seed flour has been reported as 1.80% by Akter and Haque [7] and 1.46% by [16], respectively. The obtained values are comparable with the reported values.

Bulk density may change depending on how the food material is handled; it is not an intrinsic property of a food material. Bulk density depends on the size of the particles in the samples and measures the heaviness of the flour. In the food processing industry, bulk density is important in determining to package and handling materials and used in the application of wet processes in the food industry [8]. The bulk density of the jackfruit seed flour samples ranged from 0.66 – 0.73 g/cm^3. It was observed that the cultivar *Varikka* exhibited highest bulk density (VS_1 – 0.73 g/cm^3, VS_2 – 0.71 g/cm^{3}and VS_3 – 0.70 g/cm^3) than the cultivar *Koozha.* The variation in bulk density could be attributed to the cultivar *Varikka's* higher starch content. The higher the starch content the more likely the increase in bulk density [15]. The findings are consistent with studies conducted by Nabubuya et al. [23] and [24], who reported the bulk density of jackfruit seed flour as 0.70 g/cm^3 and 0.64 g/cm^3, respectively.

Dispersibility describes flour's tendency to separate from water molecules and displays its hydrophobic effect. The higher dispersibility, the better is the reconstitution property [25]. According to Eke-Ejiofor et al. [26] the dispersibility percentage is a measure of flours strong water absorption capacity as well as the good quality of gel. In the present investigation the dispersibility of seed flour samples ranged between 28.33% - 33.66%. The highest flour dispersibility was observed for the treatment VS_1 – 33.66%, while the treatments VS_3 (30.66%), KS_2 (30.33%) and KS_1 (28.33), KS_3 (28.66) were statistically found to be on par. The obtained values are in agreement with the findings of Sultana et al. [27] and [28], who reported the dispersibility of jackfruit seed flour as 28% and 32.67%, respectively.

3.2 Evaluation of Sensory Quality Attributes of Jackfruit Seed Flour Samples

The sensory quality attributes of jackfruit seed flour are depicted in the following Table 2.

3.2.1 Colour and Appearance

"Colour and appearance aspects of products should not be overlooked because these features may render the product acceptable or unacceptable. The appearance is an attribute which a decision is taken to purchase or consume" [29]. The mean value for colour and appearance ranged from 6.2 – 8.4. highest score was observed for the samples VS_1 (8.4) and KS_1 (8.1), they were found to be on par.

Table 2. Sensory attributes of jackfruit seed flour samples

Treatments	Colour and Appearance	Taste	Texture	Flavour	Overall Acceptability
VS_1	8.4^a	8.1^a	7.8^a	7.9^a	8.0^a
VS_2	6.6^b	5.4^b	6.2^b	5.6^b	5.9^{bc}
VS_3	6.9^b	6.5^c	6.4^b	6.1^b	6.4^c
KS_1	8.1^a	7.9^a	7.5^a	7.5^a	7.7^a
KS_2	6.2^b	5.5^b	5.8^b	5.5^b	5.7^b
KS_3	6.6^b	6.1^{bc}	5.9^b	6.0^b	6.1^{bc}
χ^2	44.331	48.768	42.223	40.8	46.342
p_value	0	0	0	0	0

Values with different superscripts (a,b,c,d) within the same column are significantly different ($P \le 0.05$). VS_1- Varikka soaked in water, VS_2- Varikka soaked in 3% Sodium hydroxide, VS_3- Varikka soaked in 4% Sodium metabisulphite, KS_1- Koozha soaked in water, KS_2- Koozha soaked in 3% Sodium hydroxide, KS_3- Koozha soaked in 4% Sodium metabisulphite

3.2.2 Taste

"Taste is a key aspect in determining whether a consumer would accept a certain food product. When food is ingested, its taste provides the consumer with crucial information about its quality and thus its acceptability. There is a strong correlation between the quality of taste and product's palatability" [30]. The mean value for taste ranged from 5.4 – 8.1. There was a significant difference between the scores. The treatments VS_1 (8.1) and KS_1 (7.9) were statistically found to be on par.

3.2.3 Texture

Texture is a multimodal, multisensory food attribute. It is defined as the sensory, functional manifestation of the surface, mechanical, and structural qualities of foods that are perceived by touch, vision, hearing, and kinesthetic senses [31]. The mean value for the attribute texture ranged between 5.8 – 7.8. There was a significant difference between the jackfruit seed flour samples for the attribute texture.

3.2.4 Flavour

Flavor is defined as the sum of perceptions resulting from stimulation of the sense ends that are grouped together at the entrance of the alimentary and respiratory tracts. The mean value for flavour ranged from 5.5 – 7.9. For the attribute flavour highest score was obtained for the treatments VS_1 (7.9) and KS_1 (7.5), and they were statistically found to be on par.

3.2.5 Overall acceptability

Finding the treatment that performs the best across all of these criteria, including colour, appearance, taste, texture, and flavour, makes up overall acceptability. Food's sensory qualities, including taste, texture, flavour, and appearance, have distinct and significant effects on the overall acceptability of food [32]. The sensory assessment revealed that the treatments VS_1 (8.0) and KS_1 (7.7) had maximum score for overall acceptability and they were statistically found to be on par.

3.2.6 Selection of the best jackfruit seed flour samples

The best jackfruit seed flour samples were selected based on the results of sensory assessment. The sensory evaluation results demonstrated a substantial difference between the six jackfruit seed flour samples in terms of colour and appearance, taste, texture, flavour, and overall acceptability. The treatments VS_1 and KS_1 had the highest score for all the sensory attributes; hence, these two samples were selected for further quality analysis.

3.3 Proximate Composition of Jackfruit Seed Flour Samples

The proximate composition of jackfruit seed flour samples is depicted in Table 3.

Moisture content is one of the most important parameters which determine the shelf-life quality of food product. In the present investigation moisture content of the jackfruit seed flour samples ranged from 7.79 – 7.81%. There was no significant difference observed between the jackfruit seed flour samples for moisture content. The results obtained were in agreement with the values reported by Juárez-Barrientos et al. [23] and [27], who reported 7.8% and 8.1% of moisture content in jackfruit seed flour.

Table 3. Proximate composition of jackfruit seed flour samples

Treatments	Moisture (%)	Ash (%)	Protein (g/100g)	Fat (%)	Crude fiber (%)	Carbohydrate (g/100g)
VS_1	7.81	2.61^a	13.17^a	1.72^a	2.96^a	76.82^a
KS_1	7.79	2.55^b	12.58^b	1.68^b	2.87^b	74.30^b
±SE(m)	0.005	0.003	0.011	0.005	0.005	0.05
CV%	0.105	0.223	0.142	0.478	0.28	0.114

Values are means of triplicates. Values with different superscripts (a,b,c,d) within the same column are significantly different (P≤0.05). VS_1- Varikka soaked in water, KS_1- Koozha soaked in water

In the current investigation, the ash content of jackfruit seed flour samples ranged between 2.55 and 2.61%. It was found that the ash content was substantially higher for the cultivar *Varikka*. The ash content of jackfruit seed flour was reported as 2.57% and 2.60% by Arefin et al. [32] and Nabubuya et al. [23]. The obtained values correspond to the reported values.

Protein is a necessary ingredient for the body's vital processes. The protein content of the jackfruit seed flour samples ranged between 12.58 g/100g to 13.17 g/100g. The protein content was found to be significantly higher in the cultivar *Varikka*. The results are comparable with the values reported by [33] and [12], who reported the protein content of jackfruit seed flour as 13.86 g/100 g and 12.45 g/100 g, respectively.

In the present investigation the fat content of jackfruit seed flour samples ranged between 1.68 – 1.72%. The fat content was found to be higher in the cultivar *Varikka*. Jackfruit seed flour has low lipid content, preventing rancidity and extending its shelf life. The results are consistent with the findings of Islam et al. [13] and [34], who reported the fat content of jackfruit seed flour as 1.77% and 1.44%, respectively.

The crude fiber content of the jackfruit seed flour samples ranged between 2.87% - 2.96%. The crude fiber content of the jackfruit seed flour samples was found to be substantially higher in the cultivar *Varikka*. The findings abide by the study done by Sultana et al. [27] and [22], who reported the crude fiber content of jackfruit seed flour as 2.8% and 3.19%, respectively.

Carbohydrates are one of the most abundant and widespread organic substance in nature. The carbohydrate content of the jackfruit seed flour samples ranged from 74.30 g/100g to 76.82 g/100g. It was found that the *Varikka* jackfruit seed flour samples had more carbohydrates than the *Koozha* jackfruit seed flour samples. The findings are comparable with the values reported by Eke-ejiofor et al. [26] and Ocloo et al. [22], who reported 72.16 g/100 g and 79.34 g/100 g of carbohydrate content in jackfruit seed flour.

4. CONCLUSION

The purpose of the study was to assess the functional properties, sensory qualities, and proximate composition of jackfruit seed flour from various soaking treatments. The primary processing processes employed in this study to produce jackfruit seed flour were gelatinization and tray drying. The functional properties of Koozha and Varikka jackfruit seed flour, including WAC, OAC, SP, SI, BD, and dispersibility, were recorded. The functional properties of jackfruit seed flour from two distinct cultivars differed significantly. The cultivar *Varikka* exhibited higher WAC, OAC, SI, SP, BD, and dispersibility than cultivar *Koozha*. The sensory evaluation revealed that the treatments VS_1 and KS_1 had the highest scores for all the attributes; hence, these two samples were chosen for proximate analysis. The quality analysis revealed that the jackfruit seed flour is a high-quality source of carbs, protein, and fiber. Jackfruit seed flour had minimal fat content. Reduced fat prevents rancidity and increases flour shelf life. The tray drying process can alter the color, aroma, and textural properties of the seed samples. This procedure makes it feasible to preserve jackfruit seeds by converting them into flour, extending their shelf life. The findings revealed that jackfruit seed flour can be employed as a key ingredient in a variety of nutrient-dense foods.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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