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Utilization of jackfruit seed flour in value addition of bakery products to enhance nutritional composition

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Abstract
Background: Jackfruit seeds offer significant nutritional benefits and could be used as a functional food ingredient; regardless of its nutrient composition and bioactive components, they remain underutilised and less popular among people. However more information regarding the production of jackfruit seeds for commercial purpose and their use in food products has to be investigated.
Objective: The aim of the study was to investigate the effect of heat treatment on nutritional and anti-nutritional composition of jackfruit seed flour (JSF) and utilize JSF in developing various products.
Materials and Methods: Jackfruit seeds were procured from agricultural by-products and converted into flour with heat processing. JSF without heat process was prepared. Both the flours were analysed for nutritional and anti-nutritional factors to investigate the effect of heat. Cookies and cake were developed by incorporating JSF at different levels (25, 50 and 75%) and best accepted product of each was analysed for nutritional composition.
Results: Heat processing showed no significant effect on the nutrient composition of JSF. However, reduction in tannin content was observed in the heat processed JSF compared to control. Sensory evaluation revealed that cookies and cake incorporated with 50% of JSF was best accepted among different variations and control. Jackfruit seed flour incorporated cookies showed higher nutrient composition especially protein (20%) and potassium (605 mg) when compared with control and same result was found with the JSF incorporated cake (23% & 706 mg respectively for protein and potassium) compared to the control.
Conclusion: The study found that JSF incorporated products were best acceptable in terms of sensory characteristics and can be used as a source of low-cost ingredient to develop protein rich foods. JSF can be a potential source of locally available and nutrient rich for value addition.

Keywords: Jackfruit seed flour, antinutrients, cookies, acceptability, protein

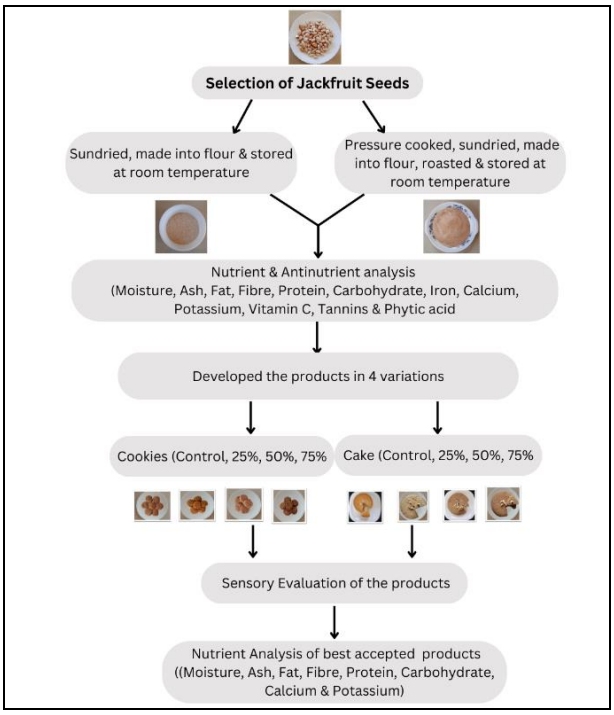
Introduction
Jackfruit is scientifically known as *Artocarpus heterophyllus*, belongs to a family of *Moraceae*, world's largest fruit bearing tree. It is widely distributed in tropical and subtropical countries including Bangladesh, Indonesia, Malaysia, Sri Lanka and Thailand [1]. Jackfruit tree is an ideal fruit crop for dry land horticulture since it can grow in both humid, warm climate of hill slopes and the parched plains of south India. It is mostly grown from seeds, and because of cross-pollination and heterozygous nature, varies greatly in yield, fruit size, and quality. Each fruit is divided into three sections: the rind (48%), seeds (18%), and bulbs (34%). The seeds are oval-shaped and range in size from 1.5 to 2.5 cm to 2-4 cm [2].
Jackfruit seeds, comprising 8-15% of the fruit's total weight, nestled within the jackfruit bulbs, are packed with beneficial components. Seeds contain essential nutrients like carbohydrates (60-80% based on dry matter), proteins, vitamins, and minerals, alongside dietary fiber, which boast impressive biological functions [3, 4]. They are also rich in phytochemicals including lignans, isoflavones and saponins, offering spectrum of health advantages, such as antiviral, antibacterial, cardio-protective, and anti-mutagenic properties [5, 6].
Jackfruit is seasonal and seeds have shorter shelf life. Seeds are usually eaten or used in other food preparations either in boiled or roasted form. Traditionally, in South India, they are harvested from ripe fruit, sun-dried, and kept for rainy season. However, because of difficulties in preparation and storage, a large number of seeds are lost every year [7]. Also, nutritional advantages of jackfruit seeds are sometimes disregarded and remains underutilised. Hence, seed flour can be an alternative way for storage and utilization, both for value addition

and blend with other grains to improve the functional and sensory properties of the final product [8]. Further heat treatment might help in reducing anti-nutritional components thus increasing the availability of nutrients.

With this background, heat treatment of jackfruit seed was carried to see its effect on anti-nutritional and nutritional composition. Then jackfruit seed flour was utilized in the value addition of bakery products to evaluate for its acceptability and nutritive value.

Materials and Methods

Procurement of raw materials: The main raw material for the study, Jackfruit seeds, were collected from the rural areas of Pallikunnu, Wayanad district, Kerala.



Preparation of jackfruit seed flour: Collected jackfruit seeds were sorted and washed with water. Washed whole seeds were pressure cooked for two pressure releases on medium flame. Cooked seeds were drained, followed by removal of loosened seed coat, cutting into thin slices and sundried for 16 hours. Further, dried seeds were powdered, sieved and dry roasted for 5 min at 45 °C to remove moisture, if present and packed in air tight containers. Another batch of seeds without heat treatment were sundried, powdered, sieved and packed for further studies.

Nutritional evaluation of jackfruit seed flour

Moisture, carbohydrate, protein, fat, fiber and ash were analysed by standard AOAC methods (9) for both heat processed and raw jackfruit flour. Micronutrients analysed included calcium, phosphorous, iron and vitamin C.

Analysis of antinutrient components of jackfruit seed flour: Heat processed and raw jackfruit seed flour were analysed for the presence of antinutrients such as tannins and phytic acid.

Ingredients and product development

Jackfruit seed is a good source of carbohydrates, proteins and minerals, can be effectively utilized in the development of nutrient rich products. Hence, prepared JSF was used in value addition of different products. Heat processed JSF was used at different levels (25, 50 and 75%) to standardize cookies and cakes by incorporating prepared jackfruit seed flour in different proportions to all-purpose flour and wheat flour. Other ingredients required for product development were sourced from local market.

Table 1: List of ingredients used for the development of jackfruit seed flour incorporated cookies

Ingredients	Control (gm)	JSF (25%) (gm)	JSF (50%) (gm)	JSF (75%) (gm)
Wheat flour	100	75	50	25
Jaggery	60	60	60	60
Ghee	30	30	30	30
Baking powder	4	4	4	4
Baking soda	2	2	2	2
Jackfruit seed flour	-	25	50	75

Table 2: List of ingredients used for the development of jackfruit seed flour incorporated cake

Ingredients	Control (gm)	JSF (25%) (gm)	JSF (50%) (gm)	JSF (75%) (gm)
All-purpose flour	100	75	50	25
Egg	150	150	150	150
Milk (ml)	50	50	50	50
Sunflower oil (ml)	10	10	10	10
Sugar	125	125	125	125
Baking powder	4	4	4	4
Baking soda	2	2	2	2
Cashew nuts	6	6	6	6
Jackfruit seed flour	-	25	50	75

Sensory evaluation

The developed products were subjected to acceptability test using 9-point hedonic scale by semi trained panellists (n=50). The sensory score sheet was comprised of 5 sensory attributes namely colour, texture, taste, flavour, appearance and overall acceptability. Nine-point hedonic scale ranged from 1 = dislike extremely to 9 = like extremely. Products developed with wheat and all-purpose flour alone were used as control.

Nutrient analysis of developed products

The highly accepted variation of cookies and cake, along with control were subjected to macro and micro nutrient analysis. The analysis was done to quantify the presence of macronutrients (moisture, carbohydrate, protein, fat, fiber and ash) and micronutrients (calcium and potassium) in the samples.

Results & Discussion

Nutrient and antinutrient composition of JSF

Table 3: Proximate and micronutrient composition of heat processed and raw JSF

JSF	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Crude fibre (%)	CHO (%)	Ca (mg)	Fe (mg)	K (mg)	Vitamin c (mg)
Heat processed JSF	6.36	1.62	12.6	0.32	2.59	56	60	12	199	10
Raw JSF	8.07	1.60	13.5	1.14	3.3	68.3	80	15	218	11

Nutrient composition of the JSF developed with and without heat processing is presented in Table 3. The table shows that the moisture content of the heat processed JSF (6.36%) was found to be less when compared to JSF (8.07%) prepared without heat processing. Carbohydrate content was found to be more in heat treated JSF (68.3%) than raw JSF (56%), whereas, not much difference was found in the content of fiber, protein, fat and ash.

The difference in the moisture content can be attributed to the processing method used. Heat processing of jackfruit seeds further reduced the moisture content of JSF, which may contribute to increased storage stability of the flour, as moisture plays a critical role in the shelf life of foods. A study conducted by Palamthodi *et al.*, 2021 [10], reported that the processed JSF contained 13.9% and 1.44% of protein and fat respectively. Decrease in the carbohydrate content in the roasted JSF can be attributed to non-enzymatic browning reactions that occur during the roasting process [11].

Micronutrient content of raw JSF was found be more for calcium, iron, and potassium (80 mg, 15 mg and 218 mg respectively) than heat treated JSF (60 mg, 12 mg and 199 mg respectively). However, vitamin C content was found be almost equal. Eyoh, 2020 [12] reported that roasting and blanching of jackfruit seeds caused reduction in the mineral content.

Table 4: Antinutrient composition of heat processed and raw JSF

Flour	Tannin (mg/100 g)	Phytic acid (mg/100g)
Heat processed JFS	1.92	46
Raw JFS	6.59	49

Table 4 represents antinutrient composition of heat processed and raw JSF. The main antinutrients present in jackfruit seeds include phytic acid and tannins and their levels were reduced after heat processing. Similarly, Bakri *et al.*, 2021 [13] found that the roasted jackfruit seeds showed reduced tannin and phytic content when compared to fresh samples. In general, roasting helps in reducing anti-nutritional factors present in foods. The results of the study confirmed that heat treatment had a positive effect on reduction of tannins and phytic acid and thus contributes to increased nutrient absorption.

Sensory evaluation of developed products

Mean sensory scores for the cookies and cake are presented in fig 1 and 2. Cookies and cake developed with incorporation of 50% of heat processed JSF scored highest in terms of colour, texture, taste, flavour, appearance and overall acceptability compared to other variations, whereas control scored highest acceptability rate. Further increased incorporation of JSF contributed to darker colour, increased bitterness, and grittiness. The similar result was found by Hasan *et al* 2010 [14], where 50% of JSF incorporation was highly accepted in terms of sensory characteristics and higher proportion of JSF increases the brownish colour and bitter taste of cookies.

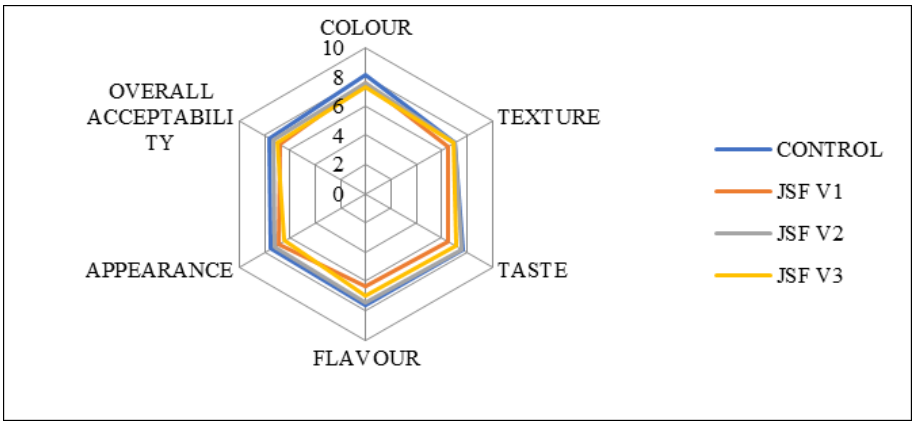


Fig 2: Mean sensory scores of cookies developed with incorporation of JSF

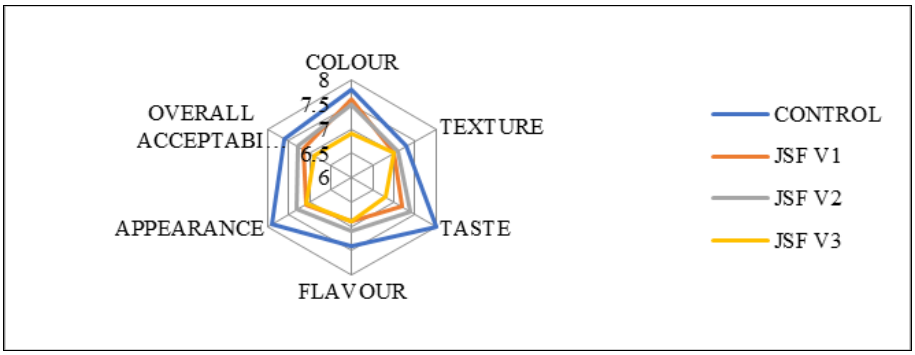


Fig 3: Mean sensory scores of cakes developed with incorporation o JSF

Study shows that JSF can be effectively incorporated into different products without compromising on the sensory attributes, Thus JSF can be cost effectively utilized in value addition to improve the nutritional composition and also contributes to environmental sustainability.

Nutrient analysis of products

Nutritional composition of cookies and cake incorporated with JSF are presented in Table 5. The results of the study revealed that JSF incorporated products showed an increased nutritional composition, especially protein, ash, calcium and potassium. Jackfruit seeds are good source of protein, fiber

and minerals. JSF was shown to replace cereal based flour in various proportions and has been utilized in the production of bakery products, extruded products and traditional products in Asian countries [15].

Table 5: Marco and micro-nutrient composition of cookies and cake incorporated with JSF

Samples	Cookies		Cake	
	Control	50% JSF	Control	50% JSF
Moisture (%)	4	4	18	17
Protein (%)	8	20	6.5	23
Fat (%)	20	24	19	10
Ash (%)	1	1.5	0.9	2.8
Crude Fibre (%)	2.5	3	0.9	3.5
CHO (%)	64.5	47.5	54.7	43.7
Calcium (mg)	45	49	45	97
Potassium (mg)	206	605	150	706

Brahma and Ray, 2023 [16], reported that high protein concentrations and amylose makes jackfruit seed flour as a potential ingredient to be used in the formulation of functional foods when compared to commercially available modified starches. Studies have indicated a significant increase in the nutritional content of jackfruit seed fortified products in terms of the ash, protein, dietary fiber and phytochemical contents. The incorporation of jackfruit seed flour at the optimum concentration aided in improving the physicochemical, textural, color and sensory properties of various products [17]. Bakery products are considered as convenient, ready to eat, less expensive and are available in diverse taste and texture. And they offer an advantage of fortification with functional foods and deliver their health benefits to the consumers. Hence, the present study indicated that various bakery products can be prepared by adding jackfruit seed flour without compromising on the sensorial characteristics to improve the nutritional profile.

Conclusion

Jackfruit seed, obtained as agricultural by-product, generally utilized at household level to some extent, but majority of seeds are discarded as waste and add to environmental pollution. Moreover, jackfruit seeds are rich in protein, fiber, carbohydrate and minerals. Apart from nutrients, they also contain anti-nutritional components, which affect the absorption of important nutrients. The present study carried out to analyse the effect of heat processing of jackfruit seeds on nutritional and anti-nutritional composition and utilization of jackfruit seed flour in fortification of various products has shown a positive result in terms of lessening the anti-nutritional factors in heat processed flour, sensorial acceptance and improved nutritional composition in the developed products. Hence, the study concluded that jackfruit seed flour can be a potential source to be utilized in value addition of various products and thus reducing negative effects on the environment.

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