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Review Article

Utilization of Jackfruit (*Artocarpus heterophyllus*) Seed's Flour in Food Processing: A Review

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Abstract

Although jackfruit (*Artocarpus heterophyllus*) seeds have significant food value, these are underutilized by both human and animals due to lack of information about nutrient contents and its effective use in food formulations. This review article aimed to highlight the information regarding physicochemical properties, nutrient contents and prospective use of jackfruit seeds flour in food formulations. Various research results on preparation of food products like bread, cake and noodles by supplementing jackfruit seeds flour are reported herein. Seeds flour contains high amount of starch, protein, fiber, ash and essential minerals such as calcium, phosphorus and iron. Functional properties – water/oil absorption capacity, solubility, swelling power, bulk density, gelatinization, foaming capacity, emulsification- of seeds flour are summarized. Facts from nutritional, functional and sensory assessments suggest that jackfruit seeds flour can be used in various processed products. It can also be used as an alternate source for starch.

Keywords: Jackfruit seed flour, nutritional potential, functional properties, processed products.

1. Introduction

Jackfruit (*Artocarpus heterophyllus*) is one of the important fruits belonging to the family *Moraceae* and to the genus *Artocarpus*. This genus comprises about 100 species that are distributed in the Indo-Malayan region and China. The fruit is widely cultivated in tropical region like in Bangladesh, India, Sri Lanka, Vietnam, Thailand, Malaysia, and Indonesia. Jackfruit is also found in East Africa, as well as Brazil and Caribbean nation like Jamaica. Jackfruit is the national fruit of Bangladesh, and is known as "kathal". It grows all over in Bangladesh, mainly on the hilly area of

Chittagong, Sylhet and on the highland of Gazipur, Mymensingh, Tangail, Comilla and Jessore. The jackfruit ranks third in area of cultivation and second in production among the fruits of Bangladesh. Nearly, 935965 tons of jackfruits grow annually from an area of 9977 hectares at the rate of 93.81 tons per hectare (BBS, 2011). It accounts about 22% of total fruit production in the country.

Jackfruit grows on evergreen and deciduous trees producing more yield than any other fruit tree species. Various cultivars grow in Bangladesh such as khaja, gala, and durasha (Haque, 1993). Jack fruit is cheaply available in large quantities

during the season in this country. Energy available to humans from jackfruit has been calculated as approximately 2 MJ/Kg wet weight of ripe perianth (Ahmed *et al.*, 1986). For easy availability and low purchasing cost, it is commonly referred as “poor man’s fruit” in Bangladesh (Rahman *et al.*, 1995). The juicy pulp of the ripe fruit is eaten fresh or preserved in syrup and has wide potential for preparing food items like jam and jelly and value added products due to the presence of pectin (Elevitch and Manner, 2006).

Jackfruit seeds are important by-products which consist more than 15% of total weight of a fruit (Prathima, 2008). The preliminary studies reported that this part of jackfruit is a good source of valuable nutrient components such as starch, protein and minerals (Ocloo *et al.*, 2010). Currently, jack fruit seeds are underutilized in both human and animal diets. Common reason for not consuming seeds is that it is not a traditional practice. Most peoples are not aware about the usage of seeds flour. Lack of awareness on nutrient contents and decent technologies for utilization of jackfruit seeds in food formulations are greatly responsible for such wastes of this fruit seeds (Gunaseena *et al.*, 1996). A pictorial view of jackfruit plant and it’s edible portions is presented in Fig. 1.

Jackfruit is highly seasonal. Therefore, seeds have shorter shelf life, hence, go wasted during

the season. The seeds can be processed to intermediate products like flour, which can be stored for long time. This flour can further be utilized individually or blended with other grain flours to manufacture new food items such as cake, bread and biscuit without affecting the functional and sensory profiles of the final product. Many benefits from consuming of jackfruit seeds are suggested in the literature. The most common benefits are preventing skin wrinkles, anti-cancer property and promoting digestion. Being a good source of vitamin A, vitamin B, vitamin C and pectin, jackfruit seeds also help in alleviating the pancreatic ailments and aid in blood purification. Vitamin C is vital to the production of collagen; a protein that provides skin with structure and gives firmness and strength (Babitha *et al.*, 2004). Jacalin, the major protein from the jackfruit seeds has proved as useful tool for the improvement of immune status of patients infected with HIV (Morton, 1987). Soong and Barlow (2004) suggested the use of jackfruit seeds as a source of natural food additives and ingredients. Bhushan *et al.*, (2008) and Z- zaman (2012) found its antioxidant properties. For these medicinal values and efficient ingredients seeds flour has prospectus to be utilized in food manufacturing and marketing. Such as an initiation can create employment among the rural dwellers including women, which would contribute in economic empowerment.

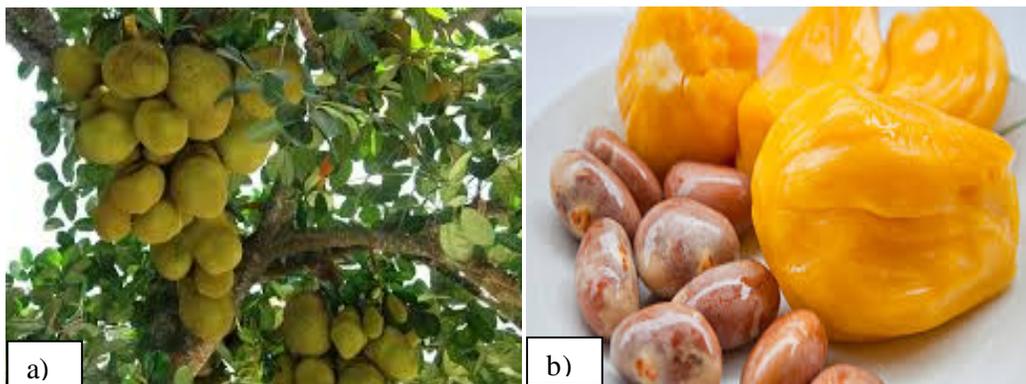


Fig. 1. a) A jackfruit tree with fruits, and b) Juicy cells of jackfruit and seeds

Considering the above background and benefits of jackfruit seeds, their utilization in an industrial level is important. For successful/profitable use in food formulations concentrated information regarding nutrient contents, functional properties and previous data on usability of flour in food preparation is necessary. Hence, the objectives of this review article were:

1. Summarizing the nutritional and functional information of jackfruit seeds flour
2. Presenting the findings of the studies regarding utilization of jackfruit seed flour in food processing.

2. Chemical composition of jackfruit seeds

Protein and carbohydrate contents of jackfruit seeds are reported as 13.50%, and 79.34%, respectively (dry basis) (Ocloo *et al.*, 2010). The seeds flour contains 2.70 % and 1.27 % ash and fat, respectively. (Ocloo *et al.*, 2010) reported that the Jackfruit seeds contain high amount of calcium that is 3087 mg/kg, iron 130.74 mg/kg, potassium 1478 mg/ kg, sodium 60.66 mg/kg, copper 10.45 mg/kg and manganese 1.12 mg/kg. However, the nutrient contents may vary based on variety and locality of growing. Various triterpenes and flavonoids can be isolated from this fruit seeds. It contains alkaloids, phenols, tannins, saponins, steroids etc. (Swami *et al.*, 2012). Jackfruit seed is very good source of vitamin B2 (Arpit and John, 2015).

3. Health benefits of jackfruit seeds

Jackfruit seeds are effective against diarrhea and dysentery and also helpful in digestion. It is known that excess number of free radicals disrupts the biomolecules, hence, their prevention is vital for cytoprotective effects. Previous studies proved that the antioxidants such as polyphenols, carotenoids and anthocyanin work as excellent scavengers of the free radicals, thus the human body is protected from cellular damage (Baliga *et al.*, 2011). Omale and Friday (2010) reported that jackfruit

seeds contains lignans, isoflavones, saponins, and many phytonutrients. The health benefits of these phytochemicals are wide-ranging from anti-cancer to anti-hypertensive. These antioxidants are also useful as anti-ulcer and anti-aging tonic. The seeds contain starch which is considered as useful in relieving biliousness, besides the roasted seeds are considered as an aphrodisiac. For good hair growth jackfruit seeds are very beneficial, besides, assist in healthy blood circulations (Swami *et al.*, 2012). Jackfruit seeds contain 2 lectins namely jacalin and artocarpin which show anti-bacterial, anti-fungal and anti-carcinogenic properties (Chowdhury *et al.*, 2012; Haq, 2006). Presence of high amount of dietary fiber makes it an excellent bulk laxative. Siddappa (1957) showed that the presence of high fiber content in jackfruit seeds flour prevents constipation and produces smooth bowel movements. Fiber have ability to protect the colon mucous membrane by reducing exposure time and also binding to cancer-causing chemicals in the colon (Mondal *et al.*, 2013). This seed is also helpful in bone health because rich in magnesium which is an essential mineral for absorption of calcium and works for strengthening the bones and prevents disease like Osteoporosis (Maurya, 2016).

4. Preparation of jack fruit seed flour

Different methods for preparation of jackfruit seeds flour are suggested in literatures. The most common methods are listed below.

- Lye peeling
- Heat processing
- Mechanical peeling

4.1 Lye peeling method

Tulyathan *et al.* (2002) used lye peeling method for preparation of jack fruit seeds flour. In this method Jack fruit seeds were collected and were treated with 3 % NaOH for 3 minutes to remove the thin brown spermoderm. Fleshy white cotyledons were obtained and were sliced into thin chips and dried at 50° cover night. Chips were ground in a pin mill to get flour. Then the

flour was packed in plastic pouches and stored in refrigerator (<5 °C).

4.2 Heat processing method

Munishammana *et al.* (2007) used heat processing method for preparation of jack fruit seeds flour. In this method, jack fruit seeds were boiled for 10-15 minutes. Water was decanted and seeds were cooled. Outer skin and seed coat were removed. Then they were cut into 3-4 pieces and were dried in sunlight or hot air oven (40-50 °C) for 48 hours. Finally, dried seeds were ground into flour, sieved and packed into plastic pouches.

4.3 Mechanical processing method

Praveenasri *et al.* (2006) used mechanical processing method for preparation of jackfruit seeds flour. In this method, jackfruit seeds were soaked in water for 10 minutes. Then individual seed was scraped by knife to remove thin brown spermoderm. Fleshy white cotyledon was then sliced into thin chips and dried over night at 50 °C. Chips were ground in a pin mill and packed in plastic pouches, labeled and stored in refrigerator (<5 °C).

5. Percent recovery of flour from jackfruit seeds by different methods

Airani (2007) carried out a comparative study to observe the percent recovery of jackfruit seeds flour from jackfruit seeds. Yield of flour from jackfruit seeds employing different methods are presented in (Table 1). Recoveries of the jack fruit seeds flour were estimated as 50%, 46%, and 43% from lye peeling, boiling, and mechanical peeling methods, respectively.

6. Proximate composition of jackfruit seed flour and starch (g/100 g)

Prathima (2008) compared jackfruit seeds flour and starch for proximate compositions such as moisture content, crude protein, and crude fiber and the results are presented as in Fig. 2. As seen in figure, each of the component except moisture

is higher in flour than in starch. It is also seen that jackfruit seeds flour contains almost 15% protein which must claim attention of the researchers for valorization of this important nutrient component.

Airani (2007) studied the seeds flour for some important characteristics parameters such as amylose and amylopectin content etc. It was found that the starch recovered from the jackfruit seeds flour contained 80% amylopectin and 20% amylose. Titratable acidity and lactic acid were also estimated and found as 5.78 and 1.12 % respectively. Neutral detergent fiber was found as 5.19%.

7. Functional properties of jackfruit seeds flour

Seeds are generally processed to boost up functional, nutritional or organoleptic characteristics in the resultant flour. The functional properties are important in food processing for the creation of new products. Results of the experiments to assess the water and oil absorption capacities, dispersibility, swelling power and percent solubility of jackfruit seeds flour is depicted in (Table 2). The flour possess adequate water and oil absorption capacities recorded as 112.00 ml/100g and 126 ml/100g, respectively. High water absorption capacity is a characteristic of the jackfruit seeds flour which is employed for bread making (Kent, 1975). Oil absorption capacity is an important property in food formulations because fats improve the flavor and mouth feel of foods (Kinsella, 1976). The dispersibility of the seed flour was found as 30%. The property of dispersibility determines the tendency of flour to move apart from the water molecules and reveals its hydrophobic action. The jackfruit seeds flour shows good foaming properties, which are very important determinants for the physical quality such as swelling and softness of bakery products. The bulk density (BD) of the flour is amenable. The lower the BD value the easier is to transport and packaging.

Table 1. Percent recovery of flour prepared from jack fruit seeds by employing different methods

Treatment	Whole seed weight (g)	Kernel weight (g)	Weight of husk (g)	Dry weight (g)	Weight of flour (g)	Percent recovery
Lye peeling	1000	884	116	552	522	50
Heat processing	1000	866	134	509	460	46
Mechanical peeling	1000	862	138	504	430	43

(Source: Airani, 2007)

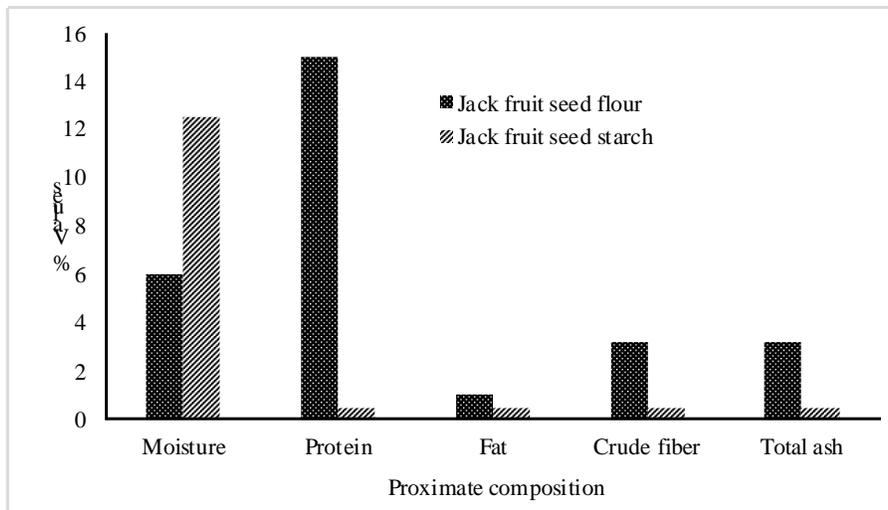


Fig. 2. Proximate compositions of jack fruit seeds flour and jackfruit seeds starch (adapted from Prathima, 2008).

Table 2. Functional properties of jackfruit seeds flour

Properties	Values
Water absorption capacity (ml/100 g)	112.00
Oil absorption capacity (ml/100 g)	126.90
Dispersibility (%)	30.00
Swelling power (g/g)	3.62
Per cent solubility (%)	1.80
Foaming Capacity (%)	25.34
Foam Stability (%)	33.00
Bulk density (g/cm ³)	0.80

(Source: Airani, 2007)

8. Isolation of starch and protein from jackfruit seeds flour

8.1 Isolation of Starch

Starch is the most common digestible form of carbohydrate, therefore, a major source of energy in human diet. Starch was prepared by using jack fruit seed flour by employing different methods suggested by Prothima (2008). The study assessed the performance of several methods for percent recovery of the starch. Starch extraction was done by three different proportions of flour and water as 1: 5 (Flour: water), 1: 10 (flour: water) and treatment with KMS 1:10 (flour: water). Maximum recovery was found when the flour was mixed with 10 (ten) folds of water. Percent starch yield from 1:5 (flour: water) ratio was 41% followed by 1: 10 (flour:water) ratio (47%) and by treatment with KMS 1:10 (flour: water) ratio (40%). Bobbio *et al.* (1978) reported that jackfruit seed starch can be useful in food industry where stable paste and rigid gel property are desirable.

8.2 Isolation of Protein

Unlike starch isolation of protein from jackfruit seeds has got less attention by the researchers. However, recently Akter (2018) has successfully isolated protein and determined the important functional properties. This study able to isolate the crude protein with 76.9% purity. The isolated protein was subjected to characterization for functional properties and found acceptable foaming, emulsion and gelling properties. These properties are very important determinants in food processing when the protein is used as an ingredient. The author also analyzed the protein for secondary structural elements by Fourier Transform Infrared (FTIR) spectrophotometer and found the β -sheet is the prominent structural element which consisted 50.28%. The other elements are found as 21.71%, 8.86% and 19.15% α -helix, β -turn and unordered structure, respectively.

9. Nutritional quality of jackfruit seed flour

Nutritional quality of food material can be determined by in-vitro study. Airani, (2007)

quantified the in-vitro digestibility of protein and starch from jackfruit seeds flour. In result, the protein in-vitro digestibility was documented as 78.17% and the starch digestibility was estimated as high as 69.30%. They observed that the digestibility slightly increased from 57.28% to 69.30% when the time was increased from 30 min to 60 min.

10. Shelf-life of jackfruit seeds flour

Some research findings based on storage stability of jackfruit seeds flour are found in the literatures. Polyethylene and foil coated aluminium pouches are easily available, comfortable, economic and commonly used for storage. Airani (2007) compared the shelf life of the flour packed in polyethylene pouches at ambient and refrigerated temperature. The flour stored in refrigerator was found in good condition for the period of six months with no unwanted changes in sensory and apparent visible properties. However, there was a gradual increase in moisture level over the period of extended life. Higher increase of moisture was observed in the samples stored at ambient temperature. The moisture content increased significantly from 7.3 to 8.9 %. No significant reduction was observed in the nutrients during storage except crude fiber.

11. Processed products made from jackfruit seed flour

Munishamanna *et al.* (2007) explored the possibility of the use of jack fruit seeds as a food ingredient. Hema (2015) reported that jack fruit seeds flour could be an alternative use of wheat flour that can be used in some food products like vada, chapatti, bread, cake, buttered biscuit, pancake and noodles. The standard protocols for processing of these products were used. The organoleptic characters like color, texture, appearance, flavor, taste and overall acceptability of the developed products were found to be highly acceptable. Praveenasri *et al.* (2006) studied for incorporation of jack fruit seeds flour in the extruded products like snacks, noodles and vermicelli. Jack fruit seed flour was substituted

from 30-50 % levels. They found that incorporation of 40 % level of jackfruit seeds flour gave the best results. Moreover, the incorporation of seed flour to deep fat fried products has found to reduce the fat absorption to a remarkable extent (Rajarajeshwari and Jamuna, 1999).

11.1 Bread

Utilization of jackfruit seeds flour in preparation of bread and some other confectionary products were studied by Ayodele and Oginni (2003). Jackfruit seeds were processed into flour and used to make the products like bread, cake, buttered biscuit and pancake. Hasidah and Noor (2003) reported that jackfruit seeds flour can be an alternative ingredient to be used in bakery and bread preparation in particular. With increasing level of replacement, the water absorption capacity increased which resulted in the reduced bread dough peak time and dough stability time.

The specific baking volume of the bread was reduced by 51% at 5% replacement with jackfruit seeds flour. The bread prepared mixed with jackfruit seeds flour had the color of the wheat flour 'brown bread'. The sensory panel assessed the products with acceptable rating. Tulyathan *et al.* (2002) reported that the substitution of wheat flour with 5, 10 and 20% levels of jackfruit seeds flour markedly reduced the gluten strength of the mixed dough. Butool and Butool (2013) studied for replacement of wheat flour with various proportions (10%, 20%) of jackfruit seeds flour. The dry ingredients along with salt and baking powder were mixed properly and sieved through 1 mm sieve. Supplementation of jack fruit seeds flour was found to increase the crude fiber content in bread (Fig. 3). The organoleptic characters like colour, texture, appearance, flavor, taste and overall acceptability of the developed products were found to be highly acceptable.

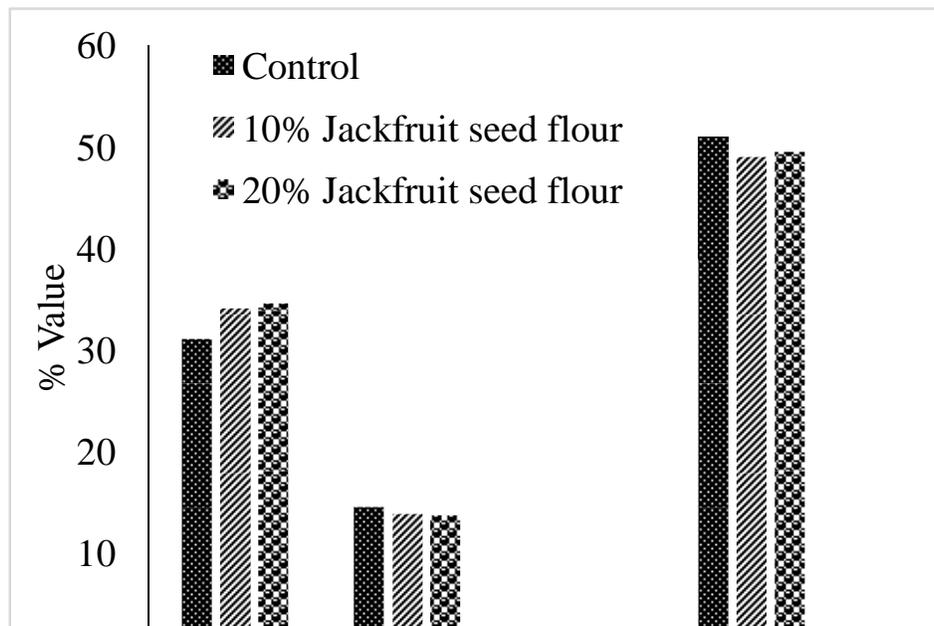


Fig. 3. Nutritional comparison of bread using 10% & 20% jackfruit seeds flour (adapted from Butool, and Butool, 2013).

11.2 Biscuit

The jackfruit seeds flour was utilized in the preparation of biscuits at different proportions to ascertain the acceptable level of incorporation (Airani, 2007). In another study, the experimental biscuit samples were prepared by Butool and Butool (2013) incorporating jack fruit seeds flour in various proportions (10%, 20%). Biscuits made from jackfruit seeds flour had dark brown color (Fig. 4). The biscuit samples were prepared according to the standard protocol of biscuit preparation. The ingredients were mixed properly and kneaded with the shortened hydrogenated fat and required amount of milk. The biscuits were baked at 150 °C temperature in an oven. The chemical analyses revealed that incorporation of jack fruit seeds flour slightly increased the ash and crude fiber in the formulated biscuits. The authors argued that increment of ash and fiber content could be attributed to the more mineral and fiber content of the seeds flour. The prepared mixed flours biscuits secured appreciable scores in the organoleptic taste. In a rigorous sensory assessment of biscuit supplemented with jackfruit seeds flour Hasan *et al.* (2010) suggested that the intensity of brown color and consistency of the biscuit increased with increasing the jackfruit seed flour in the formulation.

11.3 Cake

Cake is very important product in the baking industry. The consumers in all over the world like this product. Cake is high in calorific content, hence, overconsumption leads to obesity. Therefore, the consumers demand for reduced or low calorie and high fiber cake which would ensure the essential nutrients. Various researches are on the tract to prepare bakery products fortified with high fiber ingredients. In this connection, few researches aimed with fortification of jackfruit seeds flour in cake preparation have also been found in the literature. Arpit and John (2015) incorporated jackfruit seeds flour 5 to 15 % in cake preparation and abled to prepare cake with positive panel response in sensory evaluation. Mixing of jackfruit seeds flour increased protein and decreased fat content in the cake samples.

11.4 Cookie

Cookie is a sweet baked food that is usually small, flat, and round or square shaped. Airani (2007) incorporated 10% to 50% jackfruit seeds flour blended with wheat flour (maida and full wheat flour) for the preparation of cookies. The product at 20% and 30% incorporation were acceptable with good sensory profile, while 50 per cent incorporation resulted hard texture.



Fig. 4. Prepared biscuits using 10% & 20% jackfruit seeds flour (adapted from Butool and Butool, 2013).

Table 3. Replacement of wheat flour by jackfruit seeds flour

Types of food	% Replacement	References
Noodles	20%	Nandkule <i>et al.</i> (2015)
Wheat bread	5, 10, 20%	Tulyathan <i>et. al.</i> (2002)
Chapatti	25 %	Sultana <i>et. al.</i> (2014).
Cake	5, 15 %	Arpit and John (2015)

11.5 Noodles

Extruded product also prepared by using jackfruit seed flour like noodles. Nandkule *et al.* (2015) extruded up to 20% seeds flour in noodle and its protein and dietary fibers were increased. Amin (2009) used jackfruit seeds flour in noodles and observed more protein content and improvement of overall nutritional value of the noodles. The samples substituted with jackfruit seeds flour were high in fat and moisture content compared to control noodles. Substitution of 30% jackfruit seeds flour had higher ash and crude fiber contents than that of control sample.

11.6 Chapatti

Sultana *et al.* (2014) carried out research on preparation of chapatti fortified with jackfruit seeds flour. They suggested that up to 25% wheat flour can be replaced by jackfruit seeds flour within sensory acceptance. Addition of preservatives such as alcohol, vinegar, benzoates, and sorbates in such chapatti could extend the shelf life up to 3 to 4 days at ambient temperature and up to 30 days at refrigeration temperature (Sultana *et al.*, 2014). Due to low viscosity and lack of gluten protein, previously many researchers have used jackfruit seed starch or flour as an alternative substitute of wheat flour to prepare gluten free bakery products. Some of the studies are summarized in Table 3.

11.7 Use of jackfruit seeds flour as substrate

Jackfruit seeds powder were tasted as a substrate for the production of pigments by *Monascus purpureus* grown using solid-state fermentation (SSF) (Sumathy *et al.*, 2007). The fungus was grown at 30°C on powders containing 50% initial moisture and using an inoculation density of

9×10^4 spores per gm dry mass substrate. The yield of pigment after 7 days of inoculation was 25 optical density units per gm of dry matter fermented substrate. Use of this pigments in foods has a great potential.

12. Conclusions

The information piled in this review suggest that jackfruit seeds flour supplementation with wheat flour has great potential in developing bakery products without affecting sensory qualities. Addition of jackfruit seeds flour resulted in nutritionally superior products, particularly enriched with mineral and fiber content. The literature also suggests that the functional properties of seeds flour are favorable for manufacturing processed food. Based on the nutritional facts, functional properties and overall acceptability it can be concluded that these seeds can be processed and utilized for various purposes. The recommended scopes for utilization of jackfruit seeds flour are common bakery products (bread, cookies, and cake), extruded products (snacks, noodles, and breakfast cereals), baby foods etc. These seeds can also be utilized for starch and protein extraction. Majority of the reviewed studies indicated that processing of jackfruit seeds flour into value added products certainly serves towards sustaining farm income of jackfruit growers through enhancing their return.

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