

Germinated Jackfruit Seed Flour as a Functional Food Ingredient: Nutritional, Functional and Bioactive Properties with Special Reference to Pasta

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Abstract

Jackfruit (*Artocarpus heterophyllus* Lam.) is an important tropical fruit widely cultivated in India and other Asian countries. Although the pulp is extensively consumed, the seeds are often underutilized or discarded. Jackfruit seeds contain appreciable amounts of starch, protein, dietary fibre, minerals and bioactive compounds, making them a promising raw material for food product development. Processing treatments such as soaking, drying and germination can modify the nutritional, functional and bioactive characteristics of the seed. Germination is particularly important because it can improve the availability of certain nutrients and enhance antioxidant-related compounds. Jackfruit seed flour possesses useful techno-functional properties such as water absorption, oil absorption, swelling and solubility, which influence its performance in food formulations. Its incorporation into

cereal-based products can improve nutritional value while contributing to food-waste valorization. Pasta is an attractive product for incorporation of jackfruit seed flour because partial replacement of semolina can increase the nutritional and functional value of the final product. However, increasing seed flour concentration may influence cooking quality, colour, texture and sensory acceptability because of gluten dilution. Therefore, optimization of the incorporation level is essential. This review summarizes the nutritional composition, processing, germination, functional properties, bioactive potential and food applications of jackfruit seed flour, with particular emphasis on its utilization in pasta.

Keywords: Jackfruit seed; germination; seed flour; functional food; bioactive compounds; antioxidant activity; pasta; food waste valorization

1. Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) belongs to the family Moraceae and is an important tropical fruit cultivated in India and other parts of South and Southeast Asia. The fruit consists of edible bulbs, rind and numerous seeds. Jackfruit seeds are commonly discarded despite being edible and nutritionally valuable. Their conversion into flour provides an opportunity for extending shelf life and incorporating the material into various value-added foods. The increasing demand for nutritious and functional foods has encouraged researchers to investigate unconventional plant materials as functional ingredients. Jackfruit seed flour has attracted attention because it can be incorporated into different food products while simultaneously contributing to the utilization of an underused agricultural by-product.

2. Jackfruit Seeds as an Underutilized Food Resource

Jackfruit seeds are traditionally consumed after boiling, roasting or frying in several regions. Their large-scale industrial utilization remains limited. Conversion of seeds into flour provides an opportunity for extending shelf life and incorporating the material into different food formulations. Jackfruit seed contains high levels of starch and appreciable protein, together with dietary fibre, minerals and bioactive constituents. Its utilization can support nutritional enhancement and food-waste valorization.

3. Nutritional Composition of Jackfruit Seed Flour

Jackfruit seed flour contains carbohydrates as its major component, predominantly in the form of starch. It also contains protein, dietary fibre, ash and a relatively low amount of fat. The composition reported in the literature varies depending on cultivar, maturity, growing conditions, processing and analytical procedures.

4. Processing of Jackfruit Seeds

Processing is necessary to convert fresh jackfruit seeds into a stable flour suitable for food applications. A typical sequence is: Fresh seeds □ Sorting □ Cleaning □ Washing □ Soaking □ Germination □ Drying □ Removal of seed coat □ Grinding □ Sieving □ Germinated jackfruit seed flour □ Packaging and storage. Processing can influence nutritional, functional and bioactive characteristics.

5. Germination of Jackfruit Seeds

Germination is a biological process during which metabolic activity increases within the seed. During germination, stored nutrients are mobilized to support seed growth. Consequently, changes may occur in proteins, carbohydrates, phenolic compounds, flavonoids and other biochemical constituents. Literature summarized in the thesis indicates enhancement of antioxidant, phenolic and flavonoid characteristics during germination compared with non-germinated seeds.

6. Functional Properties of Jackfruit Seed Flour

Functional properties determine how an ingredient behaves during processing and influence final product quality. Water absorption capacity indicates the ability of flour to absorb and retain water. Oil absorption capacity represents the ability to retain oil. Swelling power describes the increase in volume of starch granules after water absorption, while water solubility reflects the amount of flour components dissolving in water. Bulk density is important for packaging, transportation and formulation.

7. Bioactive Compounds in Jackfruit Seed Flour

Jackfruit seeds contain phytochemicals, particularly phenolic compounds and flavonoids. Reported compounds include catechin, ferulic acid, epicatechin, rutin and gallic acid. These compounds are associated with antioxidant activity. Total phenolic content is commonly estimated by the Folin–Ciocalteu method, while antioxidant potential may be assessed by DPPH radical-scavenging activity.

8. Antinutritional Factors and Their Reduction

Jackfruit seeds may contain antinutritional factors such as tannins, oxalates, phytic acid and trypsin inhibitors. Processing methods including soaking, germination and heating can influence their concentration and activity. Appropriate pretreatment can therefore improve nutritional quality and ingredient functionality.

9. Health and Functional Food Potential

The starch, protein, dietary fibre and phytochemical characteristics of jackfruit seeds provide a basis for their investigation as functional food ingredients. Resistant starch has also attracted interest because of its potential relevance to glycaemic response and gut health. Health claims, however, should be supported by appropriate human or clinical evidence.

10. Utilization of Jackfruit Seed Flour in Food Products

Jackfruit seed flour has been investigated as a partial substitute for conventional cereal flours in pasta, bread, cookies, cakes, noodles, vermicelli, snacks, extruded products, yoghurt and beverages. Such applications demonstrate its versatility as a food ingredient and its potential for value addition.

11. Jackfruit Seed Flour in Pasta

Pasta is a widely consumed cereal-based product and provides an effective vehicle for incorporation of alternative functional ingredients. Partial replacement of semolina with jackfruit seed flour can improve nutritional value while utilizing an underexploited resource. In the thesis study, germinated jackfruit seed flour was incorporated by partially replacing semolina at 6, 12, 18 and 24% levels and evaluated for proximate composition, cooking quality, functional properties, sensory attributes and storage stability.

12. Effect on Pasta Quality

Nutritional quality may improve through greater contribution of protein, dietary fibre and ash. Cooking parameters include optimum cooking time, water absorption, cooking loss, cooked weight and volume expansion. Increasing seed flour can alter colour and texture. Because jackfruit seed flour does not provide gluten in the same way as wheat/semolina, excessive substitution can dilute the gluten matrix and affect structural quality. Sensory optimization is therefore essential.

13. Storage Stability

Storage stability is important for functional pasta. Moisture, water activity, free fatty acids and other quality parameters may change during storage. Appropriate packaging and storage conditions are necessary to maintain quality and safety.

14. Research Gaps

Important research gaps include standardization of germination conditions, cultivar-specific composition, characterization of individual phenolic compounds, nutrient bioavailability, optimization of GJSF incorporation in pasta, long-term storage studies, industrial-scale processing and economic feasibility, and human studies to substantiate health-related claims.

15. Future Prospects

Future research can focus on optimization of germination, standardized GJSF processing, improvement of pasta texture and cooking quality, resistant starch characterization, individual phytochemical profiling, protein digestibility and mineral bioavailability, ready-to-cook products, industrial scale-up and sustainable utilization of jackfruit-processing by-products.

16. Conclusion

Jackfruit seeds represent an underutilized but nutritionally valuable plant resource. Their conversion into flour provides an effective approach for food-waste valorization and development of value-added foods. Germination offers an additional processing strategy that can modify biochemical and functional characteristics and may enhance antioxidant-related properties. Pasta is a promising vehicle for incorporating germinated jackfruit seed flour, but the substitution level must be optimized to balance nutritional improvement with cooking, colour, texture and sensory quality. Further research on bioavailability, storage, industrial processing and clinical validation can strengthen the potential of GJSF as a functional food ingredient.

Table 1. Major nutritional components of jackfruit seeds

Component	General characteristics
Carbohydrates	Major component, predominantly starch
Protein	Important plant protein contribution
Dietary fibre	Contributes to nutritional and functional value
Fat	Generally low compared with carbohydrates
Minerals	Calcium, magnesium, phosphorus, iron and zinc are reported
Bioactive compounds	Phenolics, flavonoids and other phytochemicals

Table 2. Reported applications of jackfruit seed flour

Food product	Major purpose
Pasta	Nutritional and functional enhancement
Bread	Fibre and nutritional improvement
Cookies/Biscuits	Flour diversification and nutritional enhancement
Cake	Increased fibre and bioactive potential
Noodles/Vermicelli	Alternative flour utilization
Snacks/Extruded products	Value addition and waste utilization
Yoghurt/Beverages	Alternative functional formulations

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