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REVIEW PAPER

Tender Jackfruit its Stages of Maturity, Functional Properties of its Flour and Value-added Products—A review

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ABSTRACT

Tender Jackfruit (*Artocarpus heterophyllus* Lam.) is gaining attention as a valuable plant-based food material because of its nutritional richness, functional properties, and potential use in healthy and sustainable food products. It focuses on dietary fiber, mineral content, bioactive compounds, and low glycemic nature, which support its suitability for health-oriented and diabetic-friendly diets. There is the increasing demand for healthy food consumption which encouraged the exploration for alternative plant based as nutritional and functional benefit. The partial or complete replacement of conventional flours such as wheat or refined flour with tender Jackfruit flour has shown potential to enhance nutritional quality while reducing glycemic load in food product. The Processing methods including blanching, drying, and thermal treatment play a significant role in determining the physicochemical and functional properties of the flour, influencing its performance in different food systems. Incorporation of tender Jackfruit flour into bakery products, pasta, snacks, and plant-based alternatives supports the development of nutrient-dense and sustainable foods. Overall, tender Jackfruit flour shows strong potential as a functional ingredient, encouraging further research and wider adoption in plant-based and nutraceutical food formulations.

Keywords: Tender jackfruit, stages of maturity, health benefits, functional properties, tender jackfruit processing

Jackfruit (*Artocarpus heterophyllus* Lam.), a member of the Moraceae family, is a significant tropical fruit crop native to Southeast Asia. India is regarded as one of its possible centers of origin, particularly the south-western rain forest regions (Boning, 2006). The crop is extensively cultivated across tropical and subtropical regions including India, Bangladesh, Sri Lanka, Thailand, Malaysia, Indonesia, the Philippines, and Brazil. Jackfruit is well known as the largest fruit borne on a tree and contributes significantly to food and nutritional security in several developing countries (FAO, 2012). In India, its cultivation is widespread in states such as Assam, West Bengal, Kerala, Karnataka, Tamil Nadu, Maharashtra, and Uttar Pradesh (Swami *et al.* 2019).

Due to its high availability, affordability and rich nutritional profile, Jackfruit is commonly described as the "Poor man's food" (Rahman *et al.* 1995). Jackfruit is National fruit of Bangladesh (Baliga *et al.* 2011). Based on morphological characteristics, Jackfruit is categorized into different types depending on fruit size, namely smaller (Barka) and larger (Kappa) varieties, as well as based on pulp texture, which includes soft and firm (Manjunath, 1948; Mukprasirt and Sajjaanantakul, 2004). The fruit passes through

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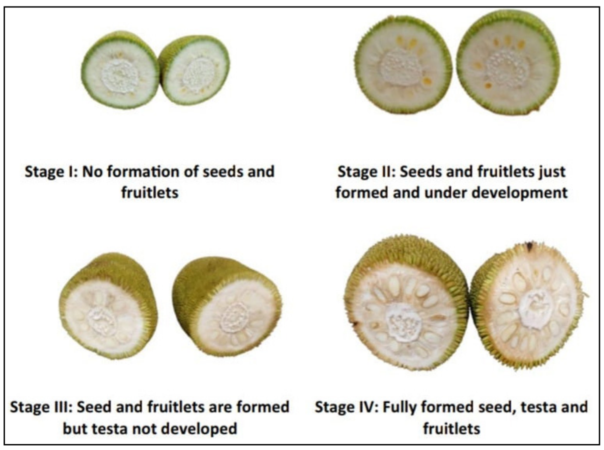
several maturity stages from immature to fully ripe, with each stage exhibiting distinct Physical, Chemical and Culinary properties.

Stages of Jackfruit on Maturity

Jackfruit undergoes several developmental stages from fruit set to ripening, and each stage exhibits distinct physical characteristics that determine its suitability for consumption and processing. Classification of Jackfruit based on maturity is essential for identifying its appropriate culinary and industrial applications. Fig. 1 shows various maturity stages of Jackfruit Swami *et al.* (2019).



Swami et al. (2019)

Fig. 1: Maturity stages of Jackfruit

Stage I (0–15 days after fruit set)

During the earliest stage of development, seeds and fruitlets are absent. The tissue at this stage is highly fibrous and possesses a texture similar to that of chicken meat. Owing to these characteristics, Jackfruit harvested at this stage is primarily used for cooking purposes and pickle preparation (Sidhu, 2012). This stage generally occurs within 0 to 15 days after fruit set (Ullah *et al.* 2008).

Stage II (15–60 days after fruiting)

At this stage, initial development of seeds and fruitlets begins, and very small or immature seeds can be observed upon cutting the fruit. Jackfruit at this maturity level is considered ideal for use as a vegetable due to its favorable texture and cooking quality (Sidhu, 2012). Ullah *et al.* (2008) reported that this stage extends from 15 to 60 days after fruiting.

Stage III (60–90 days after fruiting)

In this stage, the seeds and fruitlets are completely formed but remain immature, and the seed coat (testa) has not yet developed. The seeds are soft and edible and can be consumed as a vegetable without peeling (Sidhu, 2012). According to Ullah *et al.* (2008), this stage occurs between 60 and 90 days after fruiting.

Stage IV (Above 90 days after fruiting)

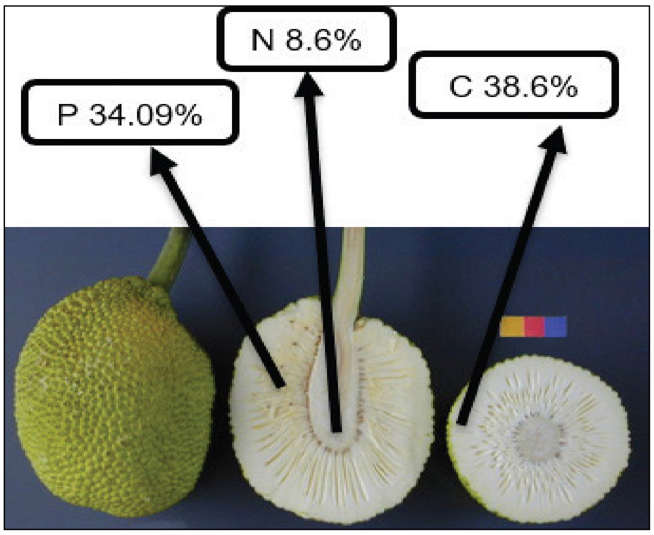
This stage is characterized by fully developed fruitlets and seeds with a hardened testa. Jackfruit at this stage is suitable for the preparation of chips and various curry-based dishes (Sidhu, 2012). Progressive changes in pulp and seed texture are observed during fruit development. The pulp transitions from soft to semi-hard between 15 and 30 days, becomes hard after 45 days and maintains this texture until about 105 days. Upon ripening (115–120 days), the pulp softens again. Similarly, seeds remain soft up to 45 days, become semi-hard between 45 and 75 days, and subsequently harden until full ripening.

Based on these developmental changes, Ullah *et al.* (2008) identified 45 to 75 days after fruiting as the optimum maturity period for using Jackfruit as a vegetable, as both pulp and seeds exhibit desirable textural qualities during this stage.

Botany of Jackfruit

Jackfruit belongs to the family Moraceae which comprises of 40 genera and more than 1200 species (Anon, 2013). According to cytogenetics, Jackfruit is a tetraploid species with a basic chromosome number of 14 and a somatic chromosomal number of 56 ($2n = 4x = 56$).

The medium sized Jackfruit tree has enormous fruits on its trunk and old branches that can weigh up to 50 kg. Perianth of the individual flowers becomes the fleshy pericarp and surrounds the seeds each pericarp and seed being an individual fruit. The outer surface of the syncarp is covered with a stiff rind and spines which are formed from the hardening of the middle and upper parts of the tubular perianth (Kishore, 2018). Fig. 2 shows the Sections of unripe Jackfruit. *P* = perianth, *N* = core, *C* = cortex.



González Regalado et al. 2024.

Fig. 2: Sections of unripe Jackfruit.
P = perianth, *N* = core, *C* = cortex

Tender Jackfruit that are between the second and third week of maturation after anthesis are harvested from the tree during the Jackfruit growing season. The goal of the removal is to lessen the tree's fruit production. As a result, different fruits are chosen for export since their development is superior (González Regalado *et al.* 2024)

Production Status of Jackfruit

Jackfruit (*Artocarpus heterophyllus*) is a versatile and economically important tree crop cultivated across more than 60 countries worldwide, with major production concentrated in South and Southeast Asia, including Bangladesh, India, Nepal, Sri Lanka, Indonesia, China, Myanmar, Malaysia, the Philippines, Thailand, and Vietnam, as well as parts of Latin and East America. Several countries such as Australia, Canada, China, Indonesia, Japan, New Zealand, the United States, and Vietnam are recognized as leading exporters of Jackfruit.

According to the first advance estimation of World 2024- 2025 the Area and production of Jackfruit is 186 ha and 3284 M.T. production respectively and of Maharashtra 43 ha. Area and 7.84 M.T. production (Ministry of Agriculture and Farmers Welfare 2024-25)

Nutritional Profile and Health Benefits of Tender Jackfruit

Jackfruit is referred to as tender Jackfruit when the internal components, including seeds, testa and fruitlets, are not fully developed. Tender Jackfruit is nutritionally rich and contains significant levels of antioxidants (Rana *et al.* 2018). It is typically available in markets from spring through summer and is widely consumed as a vegetable. During this period, when the availability of common vegetables is limited and prices are high, tender Jackfruit experiences increased consumer demand and commands a premium price (Samaddar, 1985).

Fresh tender Jackfruit is a good source of vitamin A, which exhibits strong antioxidant activity and contributes to protection against diseases such as lung and oral cavity cancers. In addition, it contains antioxidant flavonoids including carotene and lutein, which have been associated with various health benefits (Kandasamy and Shanmugapriya, 2015). Tender Jackfruit is primarily consumed as a vegetable and is distinguished by its mild flavor, appealing colour and meat-like texture (Jagtap *et al.* 2010). In its unripe form, its texture closely resembles that of chicken meat, making it a widely accepted vegetarian alternative to meat. Consequently, numerous food products such as salads, curries and pickles have been developed using tender Jackfruit.

Moreover, the rising consumer preference for ready-to-eat and minimally processed foods has encouraged the use of mild processing techniques for fruits and vegetables. However, such processing conditions may also create favorable environments for microbial growth, emphasizing the need for appropriate processing and preservation strategies for tender Jackfruit products (Lakshmana *et al.* 2013)

Enzymatic Browning in Tender Jackfruit

Tender Jackfruit is prone to enzymatic browning due to polyphenol oxidase enzyme (PP0) result in discoloration, deterioration of quality, sensory and consumer acceptance. Browning, tissue result in softening and weight loss are major problems in storage of minimally processed products (Koukounaras *et al.* 2008).

So, pre-treating of fruits for storage is an important step in preserving the produce, so that it retains the natural color of the fruit and inactivates enzymes that can cause food spoilage. Blanching prior to drying of fruits and vegetables effected the prevention of discoloration. The pre-treatment media giving the best product with respect to appearance and color was identified (Liji *et al*. 2015).

Numerous studies have studied that Blanching is considered as effective method for inactivating polyphenol oxidase enzyme (PP0) while chemical reagent like potassium metabisulphite, citric acid has been used.

Bhatia *et al.* (1995) reported that pre-treatment of green Jackfruit slices by steeping in a 0.1% potassium metabisulphite solution for 30 minutes resulted in a dried product of superior quality, exhibiting improved rehydration capacity and better cooking characteristics. Similarly,

Molla *et al.* (2008) observed that dipping fresh tender Jackfruit slices in a 0.1% potassium metabisulphite solution for 15 minutes was effective in preventing enzymatic browning during processing.

Thermal pre-treatments, particularly blanching, have also been identified as an effective approach for improving the quality of tender Jackfruit. Babu *et al.* (2012) optimized blanching time and preservative treatment for tender Jackfruit and reported that blanching at 100 °C for 1 minute in the presence of 0.3% citric acid was the most effective combination in terms of sensory attributes and physicochemical properties.

The combined influence of blanching and chemical pre-treatments has been explored in the development of ready-to-cook Jackfruit products. Liji *et al.* (2015) developed a Jackfruit -based ready-to-cook instant mix and standardized preliminary processing parameters such as slice size, blanching duration and pre-treatment media. Their results indicated that blanching for 3 minutes yielded the highest sensory score (8.45), followed by 5 and 7 minutes. Among chemical treatments, the combination of salt (0.5%) and potassium metabisulphite (0.2%) recorded the highest acceptability score for avail mix, whereas treatments involving salt with ascorbic acid (0.1%) and combinations of ascorbic acid and citric acid showed comparatively lower sensory scores.

Further investigations by Babu and Sudheer (2020) evaluated the effect of different thermal processing methods, namely sterilization at 121 °C and pasteurization at 90 °C, along with preservatives such as brine (2%), potassium metabisulphite (0.1%), citric acid (0.3%) and their combinations on the quality attributes of tender Jackfruit. Based on sensory evaluation, pasteurization combined with brine, citric acid, and citric acid–potassium metabisulphite treatments were recommended as the most suitable processing method for tender Jackfruit.

Table 1: Physical and Chemical Characteristics of Fresh Tender Jackfruit

Sl. No.	Parameters	Average ± SD
1	Fruit Length (cm)	30.26±1.15
2	Fruit Width (cm	16.16±1.47
3	Fruit Weight (kg)	2.194±0.30
4	Moisture Content (%)	81.10±0.40
5	Fruit Shape	Ellipsoid
6	TSS (°Brix)	6.10±0.1
7	pH	5.37±0.05
8	Titratable acidity (%)	0.34±0.07
9	Ascorbic acid (mg/100 g)	8.33±1.44
10	Total sugar (%)	5.41±0.93
11	Reducing sugar (%)	4.30±0.27
12	Non-reducing sugar (%)	1.11±0.67

Sahu et al. (2025).

The physical and chemical properties of fresh tender jackfruit clearly show its high nutritional and functional importance. Its high moisture content, moderate fruit size, and soft texture make it easy to cook and process. From a chemical perspective, tender jackfruit contains low total soluble solids and low sugar levels, mild acidity, and a moderate amount of vitamin C, all of which contribute to easy digestion and better health. The presence of ascorbic acid (vitamin C) is especially beneficial, as it acts as a natural antioxidant, boosts immunity, supports collagen synthesis for healthy skin and tissues, aids wound healing, and improves the absorption of iron in the body. Table 1 shows the Physical and Chemical Characteristics of Fresh Tender Jackfruit Sahu *et al.* (2025).

In comparison with ripe jackfruit, tender jackfruit has a low glycemic index, which ensures a slower and more controlled release of glucose into the bloodstream. Its low total sugar content, along with reduced reducing and non-reducing sugars, helps prevent sudden rises in blood sugar levels. Lower reducing sugars limit rapid energy release, while balanced non-reducing sugars provide steady energy without excessive sweetness. Because of this favorable sugar profile, tender jackfruit is more suitable for diabetic individuals and those focused on maintaining metabolic and weight balance.

Overall, the combined physical and chemical characteristics confirm that tender jackfruit is a nutritious, low-sugar, and low-glycemic food. Together with the health-promoting role of ascorbic acid and its balanced sugar composition, tender jackfruit has strong potential for regular dietary use and for the development of healthier, functional, and value-added food products.

The Mineral content in Young (tender) jackfruit exhibits a higher mineral density compared to ripe jackfruit due to its lower sugar content and greater proportion of structural tissues at the immature stage. The total mineral content of young jackfruit is about 0.9 g/100 g, with potassium as the predominant mineral (287–323 mg/100 g), followed by calcium (30.0–73.2 mg/100 g), phosphorus (20.0–57.2 mg/100 g), sodium (3.0–35.0 mg/100 g), and iron (0.4–1.9 mg/100 g), highlighting its nutritional relevance for electrolyte balance, bone health, and hematological functions. In contrast, ripe jackfruit generally shows a relative decline in mineral concentration per unit weight as ripening progresses, mainly due to dilution effects caused by increased moisture and sugar accumulation and the breakdown of cell wall components. Although ripe jackfruit continues to supply essential minerals, particularly potassium, its mineral density is lower than that of young jackfruit, indicating a nutritional shift from mineral-rich composition in the tender stage to an energy-dense, carbohydrate-rich profile at full ripeness. (Ranasinghe *et al.* 2019).

Dietary Fiber

Tender Jackfruit is nutritionally rich and is considered a good source of dietary fiber, carbohydrates, vitamins, and essential minerals. From a nutritional perspective, tender Jackfruit contains appreciable amounts of protein, potassium, calcium, and iron, along with vitamins A, B-complex and vitamin C (Jagtap *et al.* 2010; Longvah *et al.* 2017). Owing to its high fiber content and low-fat levels, tender Jackfruit is considered suitable for diabetic and health-oriented diets.

Studies have reported that the nutritive value of tender Jackfruit per 100 g edible portion includes approximately 26 kcal of energy, 2.0–2.6 g of protein, 3.48 g of carbohydrates and 4.4 g of dietary fiber. It is also a good source of minerals such as calcium (≈50 mg), phosphorus (≈97 mg), iron (≈1.5 mg) and potassium (206–327 mg), along with vitamins including vitamin C (≈11–17 mg) and vitamin A (≈17.6 IU) (Jagtap *et al.* 2010; Longvah *et al.* 2017). Variations in reported values across studies may be attributed to differences in maturity stage, cultivar, and analytical methods.

Tender Jackfruit as a Meat Analog

The development of a meat analogue as alternatives for meat has become a trend. Reducing the consumption red meat consumption can play an important role in addressing the sustainability challenges possessed by the livestock sector (Gerber *et al*. 2013).

It has considered as alternative due to its unique fibrous texture and nutritional profile and dietary fibre (Nova *et al.* 2023) Meat analogue is a food product which is made from non-animal protein and its appearance and smell are very much similar to meat (Kumar *et al*. 2017).

Meat alternatives about 30% protein and low-fat content effectively replaces traditional meats (Kyriakopoulou *et al.* 2019). It has high fiber, low in calories, and rich in various vitamins and minerals (Sadhana *et al.* 2019). Studies show that the plant-based meat alternatives can reduce metabolic risks linked to obesity and cardiovascular disease (Craig *et al.* 2010; Wanezaki *et al.* 2016) and exhibit anticancer, anti-inflammatory, and immune-enhancing properties (Nakata *et al.* 2017).

Tender Jackfruit: Glycemic index

Jackfruit has low to medium glycemic index (GI) of 50 to 60, which leads to the synergistic impact of dietary fiber and slowly digestible glucose. Hence, the fruit has beneficial effects in preventing and managing certain diseases like heart diseases, chronic inflammations, diabetes and many more (Bashetti, 2022). Table 2 shows the Glycemic levels of study participants before and after eating bread (*roti*) made by Jackfruit flour and whole meal wheat flour.

Studies say that Jackfruit flour bread (+1.1 mmol/l, $p<0.001$) and wheat flour bread (+0.84 mmol/l, $p<0.001$) were found to significantly raise mean blood glucose levels between 0 and 30 minutes after consumption. Jackfruit bread showed an increase of +0.11 mmol/l ($p=0.687$) while wheat bread showed an increase of +0.18 mmol/l ($p=0.346$) between 30 and 1 hour after consumption. However, both wheat flour bread (-1.1 mmol/l, $p<0.001$) and Jackfruit flour bread (-1.2 mmol/l, $p<0.001$) showed a significant drop in blood glucose levels between one and two hours after consumption (Tasnim *et al.* 2025).

Table 2: Glycemic levels of study participants before and after eating bread (*roti*) made by Jackfruit flour and whole meal wheat flour

Blood sample	Jackfruit flour	Wheat flour
Before meal (0 minutes)	9.5 (4.1)	8.8 (3.3)
30 minutes after eating bread	10.5 (3.9)	9.6 (3.4)
1 hour after eating bread	10.6 (3.7)	9.8 (3.3)
2 hours after eating bread	9.4 (3.5)	8.7 (3.4)

Tasnim et al. 2025.

Studies say that the type 2 diabetes mellitus double-blind, placebo-controlled clinical trial evaluated the efficacy of green Jackfruit flour as a component of medical nutrition therapy in patients with type 2 diabetes mellitus. Adult participants with established diabetes were assigned to replace an equivalent portion of rice or wheat flour with Jackfruit flour (30 g/day) or a control flour for 12 weeks. Glycemic indicators, including fasting plasma glucose, post-prandial glucose, and HbA1c, were assessed along with body weight. The intervention group exhibited a significantly greater reduction in HbA1c and blood glucose levels compared to the control group, with improvements observed within the early phase of dietary intervention. These findings indicate that incorporating Jackfruit flour as a staple carbohydrate substitute can effectively enhance glycemic control and may serve as a promising dietary strategy for diabetes management (Rao *et al.* 2021).

Tender Jackfruit flour: Processing, Functional Properties and Application

Tender Jackfruit is highly perishable in nature due to high moisture and enzymatic activities. Converting tender Jackfruit into flour has been widely reported as an effective utilization strategy to improve shelf life and enhance value addition. Processed tender Jackfruit in dried and milled form is commonly referred to as tender Jackfruit powder or Jackfruit flour (Rao *et al.* 2021; Varughese *et al.* 2020).

Existing studies indicate that flour production involves sequential operations including peeling, cutting, shredding, drying, and grinding. However, variability in processing conditions across studies highlights the need for standardized protocols, as processing parameters significantly influence the quality and functional properties of tender Jackfruit flour. (Pawar *et al.* 2024) It has excellent low-fat protein source it is gluten free. Table 3 shows the Physicochemical and functional properties of Tender Jackfruit flour (Paul *et al.* 2017).

Physicochemical and Functional Properties of Tender Jackfruit Flour

Table 3: The proximate composition of tender Jackfruit flour is given below

Sl. No.	Nutrients	Amount /100g
1	Carbohydrate	84.6g
2	Crude Fibre	10 g
3	Total Protein	4.99g
4	Total fat	2.72g
5	Energy	383 Kcal
6	Moisture	5.23 g
7	Total ash	2.43 g
8	Sodium	30 mg
9	Calcium	100 mg
10	Potassium	860 mg

Paul et al. 2017.

Tender jackfruit flour is a nutritionally rich, plant-based ingredient that offers multiple health benefits. It is predominantly composed of carbohydrates, providing sustained energy, while its appreciable crude fiber content supports digestive health, improves bowel function, and helps in glycemic control. The presence of moderate protein and low fat makes it suitable for calorie-conscious and diabetic-friendly diets. Its mineral profile, particularly high potassium and calcium, contributes to electrolyte balance, bone health, and proper muscle and nerve function. Low moisture and ash content indicate good shelf stability and mineral availability. Being naturally gluten-free, tender jackfruit flour serves as a valuable alternative for individuals with gluten intolerance and supports the development of functional and health-oriented food products. Table 4 shows the functional Properties of Freeze dried and Tray dried raw jackfruit flour (Preethi *et al.* 2021).

The functional characteristics of raw jackfruit flour are significantly influenced by the drying method employed. Freeze-dried flour exhibited lower bulk density and reduced water activity, reflecting a more porous structure and improved storage stability, along with higher water absorption capacity that enhances its suitability for structured food systems such as meat analogues and bakery formulations. In contrast, tray-dried flour showed relatively higher bulk density, oil absorption capacity, and water activity, indicating a denser matrix with better lipid-binding properties. Both flours maintained a mildly acidic pH with only minor variation between treatments. Compared to ripe jackfruit flour, raw jackfruit flour generally possesses lower sugar content, lower water activity, and superior water absorption capacity, making it more appropriate for low-glycemic and savory product development, whereas ripe jackfruit flour is more hygroscopic and is primarily suited for sweet and bakery-based applications

Tender Jackfruit source of Amino Acid

Tender jackfruit flour serves as a valuable source of both essential and non-essential amino acids, contributing

Table 4: Functional Properties of Freeze dried and Tray dried raw jackfruit flour

	Flour properties				
Raw jackfruit flour	**Bulk density (g /ml)**	**pH**	**Water Absorption Capacity (g / ml)**	**Oil Absorption Capacity (g / ml)**	**Water activity**
Tray dried (TD)	0.56 ± 0.03^b	5.3 ± 0.01^a	3.2 ± 0.02^a	2.1 ± 0.03^b	0.52 ± 0.07^a
Freeze dried (FD)	0.52 ± 0.02^a	5.38 ± 0.04^b	4.1 ± 0.03^b	1.8 ± 0.02^a	0.462 ± 0.09^b

a and b represent the significance difference among 2 samples variance; p<0.05; Preethi et al. 2021.

to its nutritional and functional powder. It contains aspartic acid (20.6%), glutamic acid (11.4%), and alanine (10.0%), contributing to its nutritional value. The presence of essential amino acids such as lysine (6.0%) and leucine (6.7%) underscores its potential as a protein source (Tasnim *et al.* 2025). The presence of essential amino acids such as lysine and leucine supports protein synthesis, muscle maintenance, tissue repair, and immune function, while non-essential amino acids like glutamic acid, aspartic acid, and alanine play key roles in energy metabolism and neurotransmission. Compared to matured jackfruit flour, tender jackfruit flour generally exhibits a more balanced amino acid profile with lower sugar and higher fiber content, making it more suitable for metabolic health and diabetic-friendly applications. Its amino acid composition enhances its potential as a plant-based functional ingredient, supporting overall growth, cellular repair, and long-term human health.

Evaluation of Phenolic Compound in Tender Jackfruit Flour

According to the (Maradesha *et al.* 2022). The methanol extract of green jackfruit flour (MJ) exhibits a robust phenolic profile characterized by Ascorbic acid (6.828 µg/mg), Gallic acid (6.176 µg/mg), Methyl gallate (5.667 µg/mg), Kaempferol (5.167 µg/mg), Syringic acid (2.206 µg/mg), Caffeic acid (2.104 µg/mg), Ferulic acid (1.062 µg/mg), and Quercetin (0.631 µg/mg); when compared to ripe jackfruit flour, the green version possesses significantly higher concentrations of these specific phenolic acids and resistant starches which are essential for inhibiting carbohydrate-digesting enzymes, whereas the ripening process typically results in a sharp decline of these bioactive compounds as they are metabolized into simple sugars and volatile aromatics, shifting the flour's profile from a medicinal, low-glycemic functional food to a high-calorie, sugar-dominant ingredient that lacks the potent alpha-glucosidase inhibitory effects found in the unripe stage.

Compared to ripe or mature jackfruit flour, tender jackfruit flour generally shows higher antioxidant efficiency and phenolic content with lower sugar levels, whereas ripe jackfruit flour is richer in sugars but exhibits comparatively reduced antioxidant activity. Therefore, tender jackfruit flour offers superior functional and protective health benefits, making it a promising ingredient for health-oriented and preventive nutrition.

Value-added products developed from tender Jackfruit flour

Tender Jackfruit is increasingly processed into flour or powder due to its versatility and potential application in a wide range of staple and convenience foods, including traditional flatbreads and baked products (Rao *et al.* 2021; Varughese *et al.* 2020). The development of value-added products from tender Jackfruit flour, along with minimal processing approaches and utilization of processing by-products, has been recognized as an effective strategy for reducing postharvest losses while enhancing economic value (Pawar *et al.* 2024). Several studies have explored the incorporation of tender Jackfruit flour into cereal-based products to improve nutritional quality without adversely affecting sensory acceptability.

Fig. 3: Pasta product from the Tender Jackfruit

Pasta is a widely consumed and versatile food product that can be effectively incorporated into balanced diets. Mohan *et al.* (2023) investigated pasta prepared using composite flour blends comprising tender Jackfruit flour, wheat flour, rice flour, and ragi flour. Fig. 3 shows the Pasta product from the Tender Jackfruit. Their findings indicated that an optimum dough consistency was achieved at a water content of approximately 38%. Among the formulations evaluated, a blend containing 90% wheat flour and 10% tender Jackfruit flour resulted in the most acceptable pasta in terms of cooking quality and sensory attributes. Other composite formulations, including blends with wheat flour (70%), tender Jackfruit flour (10%), and ragi flour (20%), were also reported to perform well across water content levels ranging from 30% to 38%. Overall, these studies demonstrate that partial substitution of wheat flour with tender Jackfruit flour enhances the nutritional profile of pasta while maintaining desirable textural and sensory characteristics.

Fig. 4: Vermicelli product from the Tender Jackfruit flour

Vermicelli has also been successfully developed using Jackfruit -based flour formulations. Ajisha *et al.* (2022) reported that acceptable vermicelli dough could be prepared by combining raw Jackfruit flour with Jackfruit seed flour using approximately 30% water and proofing for 30 minutes at room temperature. Fig. 4 shows the Vermicelli product from the Tender Jackfruit flour. The study further highlighted the application of roasted Jackfruit flour and roasted Jackfruit seed flour in vermicelli payasam, where a 70:30 blend ratio achieved high sensory acceptability scores of 8.55 and 8.57. These findings underline the potential of tender Jackfruit flour not only in conventional cereal-based products but also in traditional snack and dessert preparations, thereby expanding its scope for value addition.

Fig. 5: Fries product from the Tender Jackfruit flour

Jackfruit flour has also been incorporated into fried snack products. (Mahesh, 2023) optimized fries using ten different treatment combinations of starch and tender Jackfruit flour, ranging from 95:5 to 50:50, with 100% tender Jackfruit flour as the control. Sensory evaluation revealed that the 90:10 starch-to-tender Jackfruit flour formulation received the highest acceptability score of 8 for both hot-air puffed and deep-fat fried fries. Fig. 5 shows the Fries from the Tender Jackfruit flour. These results indicate that a moderate addition of tender Jackfruit flour can improve the nutritional quality of fried products without compromising sensory attributes.

Fig. 6: Meat analogue curry from Tender Jackfruit

Meat analogue curry prepared using tender jackfruit has shown good potential as a plant-based alternative to conventional meat dishes. (Nova *et al.* 2023) says that among the formulations studied, the best treatment consisted of 40% cooked wheat protein, 25% tender jackfruit, 25% wheat gluten, 5% dietary soy fiber, and 5% oyster mushroom flour, which exhibited the highest sensory acceptability. Fig. 6 shows the Meat analogue curry from Tender Jackfruit. Tender jackfruit improved fibrous texture and juiciness, while wheat gluten enhanced binding and chewiness, making the product suitable for curry preparation without loss of structure or flavour.

Tender jackfruit–based meat analogue curry can serve as a nutritionally enriched, sensory-acceptable plant-based alternative to meat, with strong potential for application in traditional culinary preparations and functional food development.

According to the (Ismail *et al.* 2023) Tender (unripe) jackfruit has been effectively utilized for the development of plant-based meat analogue patties owing to its fibrous texture and favorable nutritional characteristics. In the reported study, patties were formulated using varying proportions of tender jackfruit and vital wheat gluten. Three formulations were evaluated: F1 (55% jackfruit + 25% vital wheat gluten), F2 (45% jackfruit + 35% vital wheat gluten), and F3 (35% jackfruit + 45% vital wheat gluten). Among these, F3 was identified as the best treatment, exhibiting significantly improved textural properties, reduced cooking loss, and minimum shrinkage after cooking. The higher inclusion of vital wheat gluten enhanced protein content and structural integrity, while tender jackfruit contributed to desirable meat-like texture and sensory acceptability. Overall, the optimized formulation demonstrated strong potential for developing nutritionally enriched and consumer-acceptable tender jackfruit-based meat analogue patties suitable for plant-based food applications.

As per report (Kumari *et al.* 2016) say that Raw (unripe) jackfruit has been explored as a functional ingredient for the development of nutrient-dense noodles due to its dietary fiber and mineral content. Fig. 7 shows the Noodles prepared from Tender Jackfruit flour. In the reported study, noodles were prepared by incorporating raw jackfruit bulb flour and seed flour with refined flour in different proportions, including 40:30:30, 50:25:25, 50:30:20, 50:40:10, 50:10:40 (T5), and 50:20:30 (T6). The results indicated that noodles enriched with jackfruit bulb and seed flour exhibited higher protein, fiber, and mineral content compared to the control. Based on sensory evaluation, T5 (50:10:40) and T6 (50:20:30) were identified as the best treatments, showing superior acceptability in terms of texture, taste, and overall quality.

Fig. 7: Noodles from the Tender Jackfruit flour

Overall, partial replacement of refined flour with raw jackfruit bulb and seed flour was found to be effective in enhancing the nutritional profile of noodles while maintaining desirable sensory characteristics, highlighting their potential as functional cereal-based products.

Fig. 8: Jackfruit-based meat analogue

According to (Gopi *et al.* 2023) a jackfruit-based meat analogue was formulated using cold extrusion technology by optimizing critical processing variables, including the proportion of refined wheat flour as the texturizing agent, extruder rotational speed, and the concentration of carboxymethyl cellulose as a binding agent. The optimal treatment involved 58.556 g of refined wheat flour, operation at a higher rotational speed, and 7.434 g of carboxymethyl cellulose, which collectively produced a product with a distinct meat-like texture and improved sensory quality. The findings indicate that extrusion technology is a viable and effective method for developing jackfruit-based meat analogues, highlighting the potential of jackfruit as a valuable raw material for plant-based meat alternatives. Fig. 8 shows the Jackfruit based meat analogue.

Prospects and Challenges

Tender Jackfruit and its flour possess significant nutritional importance due to their high dietary fiber content, low fat levels, and presence of essential minerals and bioactive compounds. They provide a nutrient-dense yet calorie-efficient food source that supports digestive health and contributes to improved satiety. The functional components of tender Jackfruit flour, including water- and oil-holding capacity, further enhance its suitability for incorporation into a wide range of food products such as meat analogs, bakery items, and extruded foods, thereby improving both nutritional quality and product functionality.

From a health perspective, tender Jackfruit is associated with a low to moderate glycemic index, primarily attributed to its high fiber content and complex carbohydrate structure, which slows glucose release and absorption. This characteristic makes tender Jackfruit and its flour particularly suitable for diabetic-friendly and weight-management diets. Regular inclusion of tender Jackfruit –based foods may aid in better glycemic control while supporting overall metabolic health, highlighting its potential role in the development of functional and therapeutic food products.

CONCLUSION

Tender Jackfruit and its flour represent a promising and underutilized plant resource with significant potential in the development of nutritious and functional foods. Their rich dietary fiber content, favorable physicochemical and functional properties, neutral flavor, and fibrous structure make them suitable for a wide range of applications, including meat analogs and other value-added products. Converting tender Jackfruit into flour enhances shelf life, allows year-round utilization, and helps reduce post-harvest losses associated with this seasonally abundant crop.

Moreover, the low to moderate glycemic response of tender Jackfruit supports its inclusion in diabetic-friendly and health-oriented diets, while its compatibility with clean-label and minimally processed formulations aligns well with current consumer trends. With further standardization of processing methods and interdisciplinary research focusing on nutrition, functionality, and sensory acceptance, tender Jackfruit and its flour can contribute meaningful to sustainable food systems and future functional food innovations.

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