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RESEARCH PAPER

Development of Tender Jackfruit Flour and Study of its Physico-chemical and Functional Properties

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ABSTRACT

In the present study effect of different drying temperatures (40°C, 50°C, and 60°C) for times (14, 12, and 10 hours, respectively) on the quality of tender (unripe) and jackfruit flour. Higher temperatures adversely affected the nutritional quality of the product. The Effect of physicochemical properties Moisture, Protein, Fat, Ash, Fiber, Carbohydrate, Energy, Water absorption capacity, Oil absorption capacity, Bulk density, Total Sugar, Reducing Sugar, Titrable Acidity, Colour. The optimal drying condition was identified as 50°C for 12 hours, which yielded the best retention of physico-chemical and functional properties. The optimized flour contained 5.72% moisture, 2.75% ash, 9.1% protein, 0.98% fat, 13.02 % fiber, 68.71 % carbohydrates, and an energy value of 320.2 Kcal. Functional and chemical analyses revealed a bulk density of 0.64 g/ml, water absorption capacity of 3.48 g/ml, oil absorption capacity of 3.08 g/ml, pH of 5.74, TSS of 6.7 °Brix, titratable acidity of 0.16%, total sugars of 38.01%, reducing sugars of 5.9%, and a browning index of 0.042 was observed at the optimal drying condition.

Keywords: Tender Jackfruit, Physicochemical properties, Functional properties, Glycemic index

Jackfruit (*Artocarpus heterophyllus Lam*.), a member of the *Moraceae* family, is a 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).

Tender Jackfruit that stage are between the second and third week of maturation after anthesis are harvested from the tree during the Jackfruit growing season (Gonzalez Regalado *et al.* 2024). Jackfruit in its young stage, having a maturity of 60–70 days, is known as tender jackfruit and has been widely used as a vegetable (Rana *et al.* 2018). When the inner core of jackfruit is under development, i.e., the seed, testa and fruits are not fully matured the jackfruit is called tender jackfruit.

Tender jackfruit at its immature stage has gained considerable popularity for its culinary applications

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(Babu *et al.* 2022, Babu & Sudheer, 2020; Rana, 2019). Its meat-like texture has contributed to its use as a vegetarian substitute for meat. Additionally, tender jackfruit is increasingly processed into fruit flour or powder, with potential applications in staple foods such as bread (roti) and various bakery products (Rao *et al*. 2021; Varughese *et al*. 2020). Tender Jackfruit is a rich source of dietary fiber, and having low glycemic index suitable for diabetic friendly food application**.** Average weight of Tender Jackfruit is 430 g to 2 kg. Its Inch in (cm) 15- 20 cm.

Tender jackfruit is highly perishable due to its elevated moisture content and ongoing enzymatic activity. Transforming tender jackfruit into flour has been widely documented as an effective utilization strategy to extend shelf-life and augment value. Processed tender jackfruit in a dried and milled form is commonly termed tender jackfruit powder or jackfruit flour (Rao *et al*. 2021; Varughese *et al*. 2020).

Jackfruit in its young stage, having a maturity of 60–70 days, is known as tender jackfruit and has been widely used as a vegetable (Rana *et al.* 2018). When the inner core of jackfruit is under development, i.e., the seed, testa and fruits are not fully matured the jackfruit is called tender jackfruit.

Consumption of Raw Jackfruit and powder result in slowing down of blood glucose level and digestion and absorption of body. Intake of 30 g of Raw Green Jackfruit powder will lower HbA1c level and reduce the level of fasting and postprandial sugar level. Consumption of high intake of fibers with low calories significantly reduce HbA1c levels (Bashetti *et al.* 2022)**.**

Tender Jackfruit dried at various drying method like- Sun drying, Solar drying, Tray drying, among this drying method tray drying at 60° found superior for maximum retention of physical- chemical parameters. (Hyndavi *et al.* 2022).

Drying is one of the oldest methods of food preservation, and it represents a very important aspect of food processing. The advantage of dried foods is that they have decreased moisture content, which reduces thermodynamic water activity, thus preventing the growth of microorganisms that cause the spoilage reaction (Vega-Galvez *et al.* 2009). Functional quality of flour is important to determine its usefulness in food applications. Processing conditions have been shown to influence functional properties of flour; for example, heat processing have been found to affect the functional properties of taro flour, while drying temperature, milling procedure and particle size influenced gelatinization profiles of cassava flour (Olatunde *et al.* 2016). (Kamble *et al.* 2022) says that green banana dried at 50° retain quality and nutritional and functional quality.

The Tender Jackfruit is initially, were washed in tap water to remove the extraneous matter and the prickly non-edible outer skin/rind was removed (peeling). Then, the peeled samples were sliced into circular discs of about 8 cm diameter and 1 cm thickness. Each disc was further cut into eight pieces of almost uniform size and shape with respect to its center. Then, the slices were dipped in 0.1% potassium metabisulphite solution for 15 min to prevent browning reactions (Molla *et al.* 2008). To avoid browning blanching is done 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 physico-chemical properties. Babu *et al.* (2012). Preethi *et al.* (2021) reported that Drying of Tender Jackfruit is done in tray dryer at 60°C for 24 hours. Tasnim *et al.* (2025) reported that proximate analysis of green jackfruit flour - Moisture% 6.04 ± 0.37, Crude Protein % 12.27 ± 1.39, Ash % 3.28 ± 0.35, Crude fiber % 12.21, crude fat (1.59%) pH - 5.02, Total Soluble Solids (˚brix) 19 ± 0.01, Colour - L^* -(61.53 ± 0.04b), a^* **-** 61.53 ± 0.04b, b^* - 13.54 ± 0.03b, a^*/b^* - 0.12 ± 0.02a, Carbohydrate % 37.57 ± 3.67 , Titratable acidity (0.18 g/100g), Energy (Kcal) (HV2) variety is 371 kcal (Divya *et al.* 2025). Functional properties of tender jackfruit flour as Water Absorption Capacity (g/ml) - 3.2 ± 0.02, Oil Absorption Capacity(g/ml) - 2.1 ± 0.03, Bulk density (g/ml) - 0.56 ± 0.03 (Preethi *et al.* 2021).

MATERIALS AND METHODS

Selection of sample

Tender Jackfruit required for experimentation was collected from Local Market of Kolad Tal. Roha, District, Raigad. Fig. 1 shows the Ttender jackfruit.

Fig. 1: Tender Jackfruit

Processing of the Tender Jackfruit into flour

Fresh Tender Jackfruit were procured form the Local Market from Roha. The Fruits were washed and cleaned from dirt, dust. The clean tender jackfruit was used removal of outer peel. The peeled Tender Jackfruit was cut into small pieces of uniform thickness. The pieces were put into the tap water to reduce enzymatic browning. The pieces were exposed to the blanching Treatment. Blanching of tender jackfruit pieces were is done at 75 °C for 3 min with potassium metabisulphite solution (0.1 %) so that the colour and the texture remain maintain (Babu *et al.* (2012)). Then Jackfruit pieces were exposed for the drying in convective hot air dryer at various temperature 40°, 50°C, 60° for 14 hours, 12 hours, 10 hours respectively. After drying of tender jackfruit pieces, it was put in pulverizer for making its flour Fig. 2 illustrate the stepwise process involved in the preparation of tender jackfruit flour. Fig. 3 shows the tender jackfruit flour.

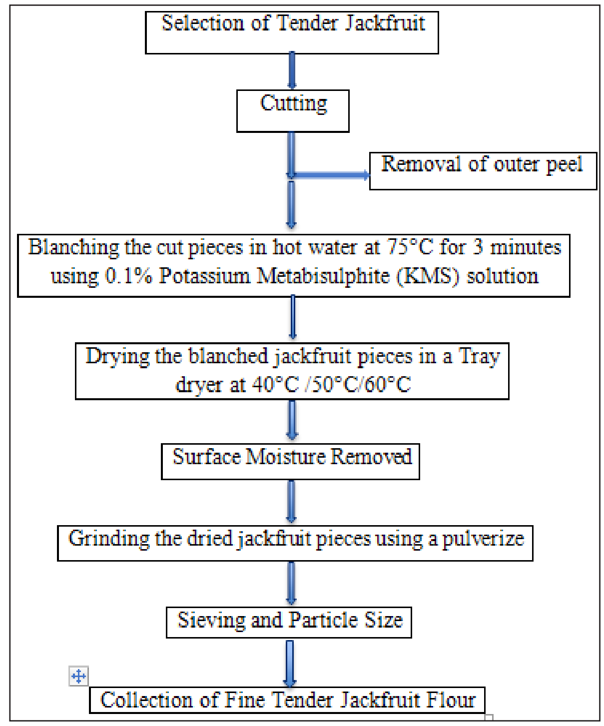

Fig. 2: Shows the process flow chart of Development of Tender Jackfruit Flour

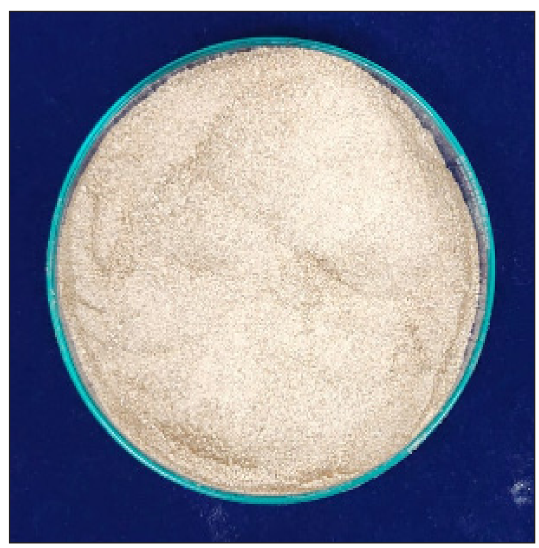

Fig. 3: Tender Jackfruit Flour

Physico-chemical Parameter for determination of Tender Jackfruit Flour

1. Moisture content, (% db.)

The moisture content of fresh tender jackfruit and thermally processed tender jackfruit flour at 40°, 50°, 60° was determined as per method according to AOAC (2005), Moisture content was determined by drying the sample at 105°C in hot air oven for 24 hours. After a full day, the dried flour sample's final weight was noted. Each observation was recorded three times to get the replication and the average reading was reported. The moisture content of the dried flour was calculated as per equation (1).

$$\text{Moisture Content (\% db.)} = \frac{W_2 - W_1}{W_3 - W_1} \times 100 \qquad \ldots(1)$$

Where,

W_1 = Weight of moisture box, g

W_2 = weight of moisture box + Sample, g

W_3 = Weight of moisture box + Oven dried sample, g

2. Protein, (%)

The protein content of fresh tender jackfruit and thermally processed tender jackfruit flour at 40°, 50°, and 60° was determined as per method according to AOAC (2005), Protein content was estimated using the Micro-Kjeldahl method with the nitrogen content multiplied by a factor of 6.25 (AOAC, 2005). The protein content of the sample was calculated as per the equation Eq. (2) and (3) the protein content of dried flour was calculated. Each observation was recorded three times to get the replication and the average reading was reported.

$$\%\,\text{N} = \frac{(1.4 \times \text{(ml Hcl-ml blank)} \times \text{Conc.of HCL}}{\text{Weight of Sample (g)}} \qquad \ldots(2)$$

$$\%\,\text{Protein} = \%\,\text{N} \times \text{Factor (6.25)} \qquad \ldots(3)$$

3. Ash content, (%)

The ash content of fresh tender jackfruit and thermally processed tender jackfruit flour at 40°, 50°, and 60° was determined as per method according to AOAC (2005), Take 5 g sample of tender jackfruit flour were weighted in a crucible and then incinerated in a muffle furnace at 600°C for four hours. Ash content was determined by heating the sample at 600°C in a muffle furnace (AOAC, 2005). The ash content was recorded three times to get the replication and the average reading was reported. The ash content of the samples were determined as per the equation (4).

$$\text{Ash (\%)} = \frac{\text{Weight of crucible with ash} - \text{Weight of crucible}}{\text{Weight of sample}} \times 100 \qquad \ldots(4)$$

4. Fat, (%)

The Fat content of fresh tender jackfruit and thermally processed tender jackfruit flour at 40°, 50°, and 60° can be determined as per method according to AOAC (2005), Fat content was measured by extracting ether from moisture-free sample. 1 g of each sample was placed in a cellulose thimble and extracted with 80 ml of petroleum ether (boiling range: 40-60 °C). The extraction consisted of two stages: an initial phase at 60 °C for one hour, followed by a second phase at 120 °C for 30 minutes. The remaining residue was dried in a hot air oven (International Commercial Traders) at 105 °C for 30 minutes. Fat content was determined based on the difference between the initial and final weights of the extraction flask. The fat content was expressed as g/100g

Using the following formula Eq (5) the fat content can be determined. The fat content was recorded three times to get the replication and the average reading was reported.

$$\text{Crude fat content (g/100g)} = \frac{\text{Weight of ether extracted}}{\text{Weight of samplr taken}} \times 100 \qquad \ldots(5)$$

5. Fiber, (%)

The fiber content of fresh tender jackfruit and thermally processed tender jackfruit flour at 40°, 50°, 60° was determined as per method according to AOAC (2005). Fiber was quantified by removing moisture and fat from the sample by acid alkali method, Take About 2 g of sample was digested with 1.25% sulfuric acid followed by 1.25% sodium hydroxide, each for 30 minutes. The residue was filtered, washed, dried at 105°C, and weighed. The ash obtained was weighed and the loss in weight (dried residue weight minus ash weight) was taken as the loss in weight and used to calculate the fiber content for the samples using equation (6).

$$\text{Crude fiber} = \frac{\text{Loss in wt.}}{\text{wt. of sample taken}} \times 100 \times 100 \quad \ldots(6)$$

6. Carbohydrates

The carbohydrate content of fresh jackfruit and thermally processed raw jackfruit flour at 40°, 50 60° was determined as per method according to AOAC (2005). Carbohydrates were calculated by subtracting the values of protein, fat, fiber, ash and moisture from 100.

The carbohydrate was calculated by using following equation:

$$\% \text{ Carbohydrate} = 100 - \% \text{ protein} + \% \text{ fat} + \% \text{ fiber} + \% \text{ ash} + \% \text{ moisture content} \quad \ldots (7)$$

7. Total Sugar, (%)

The total sugar content of fresh jackfruit and thermally processed raw jackfruit flour at 40°, 50°, 60° was determined as per method according to Rangana (1986). Take 50 ml millilitres of the filtrate obtained during reducing sugar estimation was taken in a 250 ml conical flask. To this, 10 ml of 50% HCl was added and kept for 24 h for inversion of non-reducing sugars. The sample was neutralized with 40% NaOH and adjusted to neutrality with 0.1 N HCl. The volume was then made up to 250 ml with distilled water. The inverted sugar solution was titrated against Fehling's solution (5 ml Fehling A + 5 ml Fehling B + 40 ml distilled water) using methylene blue as indicator. The end point was indicated by the appearance of a brick-red colour. The sugar content was expressed as percentage.

The sugar content was all shown as a percentage.

Using the following formula Eq (8) the Total Sugar content can be determined:

Total Sugar (%) =

$$\text{Total sugar \%} = \frac{\text{Factor (0.5)} \times \text{dilution} \times 5}{\text{Wt. of sample} \times \text{titre reading}} \times 100 \quad \ldots(8)$$

8. Reducing Sugar, (%)

The reducing sugar content of fresh tender jackfruit and thermally processed raw jackfruit flour at 40°, 50°, and 60° was determined as per method according to Lane and Eynon Method with modifications suggested by Rangana (1986). Take 5 g sample to it add 100 ml water. Add few drops of Phenolphthalein indicator and neutralize it by using 1 N NaOH. Then add 2ml of 22% Potassium oxalate. 250 ml volume of sample was made by adding water then the sample was filtered. The filtrate was taken for the titration. The filtrate was titrates against Fehling solution (5 ml Fehling A+ 5ml Fehling B+ 40 ml distilled water). Methylene blue indicator was added in to it. End point was Brick red Colour. The reducing sugar content was then recorded three times to get the replication and the average reading was reported. The reducing sugar was determined as per the equation (9).

Reducing sugar % =

$$\frac{\text{Factor (0.5)} \times \text{dilution}}{\text{Wt. of sample} \times \text{titre reading}} \times 100 \quad \ldots(9)$$

9. pH

The pH content of fresh jackfruit and thermally processed fresh tender jackfruit flour at 40°, 50° 60° can be determined as per method according to (Tawo *et al.* 2009). To measure pH, 10g of dehydrated tender jackfruit flour was added to 250 ml beaker with 100 ml of distilled water. The mixture was stirred for 5 minutes using a glass rod and allowed to settle for 15 minutes. The supernatant was then transferred to 100 ml beaker and the pH was measured using a digital pH meter. The pH content was recorded three times to get the replication and average reading was reported.

10. Titratable acidity

The Titrable acidity content of fresh jackfruit and thermally processed raw jackfruit flour at 40°, 50°, 60° can be determined as per method according to (Ranganna, 1986). For titratable acidity, the sample was titrated with 0.1 N sodium hydroxide solution, using phenolphthalein as an indicator, The end point was indicated by a light pink appearance. The results were expressed as percentage of citric acid.

% Total Acid =

$$\frac{\text{Vol. of sample taken for estimation} \times \text{wt. or .vol. of sample taken} \times 1000}{\text{Titre} \times \text{Normality of alkali} \times \text{vol. made} \times \text{equivalent wt. of acid} \times 100} \quad \ldots (10)$$

11. Colour

The Colour content of fresh jackfruit and thermally processed raw jackfruit flour at 40°, 50°, 60° can be determined as per method (Palou *et al.* 1999). According to Color measurements ($L^*a^*b^*$) values were taken with a Hunter Lab Colorimeter.). The values were expressed in term of L^* (black to white), a^* (red to green) and b^* (yellow to blue). The browning index was then calculated using the following formula.

$$\text{Browning Index (BI)} = [100\,(x - 0.31)] / 0.17 \quad \ldots(11)$$

where, $x = (a^* + 1.75\,L^*) / (5.645\,L^* + a^* - 0.3012b^*)$

12. TSS Brix (°)

The TSS Brix (°) content of fresh jackfruit and thermally processed raw jackfruit flour at 40°, 50°, 60° was determined as per method according to (AOAC, 1980). To measure TSS, for flour samples, 5 g of flour was mixed with 50 mL distilled water and homogenized thoroughly. The mixture was filtered through Whatman No. 1 filter paper and the filtrate obtained was used for TSS determination. Approximately 0.3 mL of the filtrate was placed on the prism surface of hand refractometer and the reading was recorded as °Brix at room temperature.

13. Energy

The Energy content of fresh jackfruit and thermally processed raw jackfruit flour at 40°, 50°, 60° can be determined as per method according to AOAC (2005). The energy of tender jackfruit flour was estimated by considering the amounts of protein, carbohydrate and fat, with 4 kcal per gram for protein and carbohydrate and 9 kcal per gram for fat

$$\text{Energy (Kcal /g)} = (4 \times \text{Protein}) + (4 \times \text{Carbohydrate}) + (9 \times \text{Fat}) \quad \ldots(12)$$

Functional properties of Tender Jackfruit Flour

1. Bulk Density, (g/cc)

The Bulk density of fresh jackfruit and thermally processed raw jackfruit flour at 40°, 50°, 60° was determined as per method according to Narayana and Rao (1982). The bulk density of the tender jackfruit flour was determined by weighing a calibrated centrifuge tube, then filling it with flour up to 10 ml mark by tapping until the volume stopped changing. The content was weighed and the bulk density was calculated from the weight difference with the result expressed in g/ml. Each observation was recorded three times to get the replication. The average reading was reported as Bulk density.

$$\text{Bulk density} = \frac{\text{Mass (g)}}{\text{Volume (ml)}} \quad \ldots(13)$$

2. Water Absorption Capacity, (ml/g)

The water absorption capacity of fresh jackfruit and thermally processed raw jackfruit flour at 40°, 50°, 60° was determined as per method Mishra and Dubey (2020). For each sample, 1g of dried flour was dispersed in 10ml of distilled water and stirred. After a 30-minute resting period, the mixture was centrifuged at 3500 rpm for 30 minutes. Following the removal of the supernatant, the samples were dried at 50°C for 30 minutes to eliminate surface moisture, cooled, and weighed to determine the final mass. Each observation was recorded three times to get the replication. The average reading was reported as water absorption capacity.

$$\frac{W_2 - W_1}{W_0} \times 100 \qquad \ldots(14)$$

Where,

W_0 = Weight of sample, (g)

W_1 = Weight of centrifuge tube plus sample, (g)

W_2 = Weight of centrifuge tube plus sediments, (g)

3. Oil Absorption Capacity, (ml/g)

The oil absorption capacity content of fresh jackfruit and thermally processed raw flour at 40°, 50°, 60° can be determined as per method according to Mishra and Dubey (2020). The oil absorption capacity of jackfruit flour was determined using centrifugation method. In pre-weighed centrifuge tubes, 1g of the tray dried raw jackfruit flour was taken and mixed with 10 ml of oil each. Then it was stirred for 5 minutes and hold for 30 minutes. It was centrifuged for 30 mins with rpm of 3500. The separated oil is removed and the tubes are allowed to drain the excess oil. The oil absorption capacity was expressed as grams of oil bound per 100g of the sample on dry basis.

$$\frac{W_2 - W_1}{W_0} \times 100 \qquad \ldots(15)$$

Where,

W_0 = The weight of sample, (g)

W_1 = The weight of centrifuge tube plus sample, (g)

W_2 = The weight of centrifuge tube plus sediments, (g)

Statistical Analysis

Tender Jackfruit was dried at 40°, 50°, 60° for 14 hrs, 12 hrs, 10 hrs. in tray dryer for experiment. Factorial completely randomized design was used to statistically analyses the experiment data. All the analysis reported in this study was performed in triplicate and data obtained is reported as mean ± standard deviation. Experimental design used for statistical analysis was Factorial Completely Randomized Design (FCRD). One way ANOVA at $p \leq .0.001$ was used to determine the statistical significance of results. The research data was statistically analyzed by following method described by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Moisture (% db.)

Table 1(a) shows the moisture content of fresh tender jackfruit flour before and after drying Moisture content of fresh raw jackfruit was 81.1 ± 0.40 (% db.) and it decrease after drying from 8.03 ± 0.05 (% db.) 5.76 ± 0.05 (% db.), 6.16 ± 0.05 at 40°, 50°, 60° temperature respectively. The effect of temperature on moisture content of raw jackfruit flour was significant $p \leq 0.001$. According to (Saikia *et al.* 2026) the Moisture (%) of raw jackfruit is 84.50 ± 0.20. Tray drying method showed a significant effect of temperature on the a_w ($p \leq 0.05$). Increasing temperatures led to decreased moisture content and a_w, as higher temperatures resulted in higher heat transfer rates and drying rates (Phungjab., 2003).

Protein

Table 1(b) shows the protein content of fresh tender jackfruit flour before and after drying. Protein content of raw jackfruit was 0.19 ± 0.012 Protein content varied with tender flour was 8.73 ± 0.16 % 9.00 ± 0.09 % 8.08 ± 0.12% at 40°, 50°, 60° temperature respectively. While protein content decreases with increase with temperature. Highest protein was available at 50°. The decrease in protein content increase in temperature was significant at $p < 0.001$. The Protein content in raw jackfruit was 1.20 ± 0.10 % (Saikia *et al.* 2026). According to (Siddiqui *et al.* 2024), drying temperature significantly influences protein properties. Excessive heat exposure leads to protein denaturation, thereby reducing protein content, which supports the finding that 60°C was optimal for retaining maximum protein content in the present study.

Ash

Table 1(c) shows the ash content of fresh tender

Table 1: Physico-chemical and functional properties of Fresh Tender jackfruit and dried jackfruit flour

Sl. No.	Proximate constituent	Fresh Sample	40 °	50°	60 °	SE(M)	CD
1	(a) Moisture (%db)	81.1 ± 0.400	8.033 ± 0.050	5.767 ± 0.057	6.160 ± 0.050	0.131	0.530
2	(b) Protein, %	0.190 ± 0.0125	8.733 ± 0.165	9.00 ± 0.095	8.080 ± 0.125	0.021	0.084
3	(c) Fat, %	0.113 ± 0.030	0.920 ± 0.040	0.987 ± 0.105	1.067 ± 0.040	0.040	0.016
4	(d) Ash, %	0.700 ± 0.100	2.800 ± 0.050	2.717 ± 0.050	2.35 ± 0.050	0.015	0.061
5	(e) fibre, %	1.126 ± 0.074	11.673 ± 0.448	13.017 ± 0.11	11.053 ± 0.10	0.125	0.505
6	(f) Carbohydrates, %	16.769 ± 0.528	67.657 ± 0.956	68.367 ± 0.32	71.393 ± 0.73	0.205	0.828
7	(g) Energy	68.861 ± 1.908	314.680 ± 2.909	319.507 ± 0.66	326.433 ± 2.12	0.733	2.954
8	(h) Bulk density, g/cc	0.61 ± 0.03	0.647 ± 0.005	0.65 ± 0.010	0.642 ± 0.05	0.002	0.008
9	(i) Water absorption capacity, ml/g	2.300 ± 0.200	3.000 ± 0.080	3.467 ± 0.041	3.500 ± 0.091	0.016	0.065
10	(j) Oil absorption ml/g	2.800 ± 0.300	2.620 ± 0.0754	2.950 ± 0.117	3.100 ± 0.200	0.057	0.229
11	(k) pH	5.370 ± 0.050	5.673 ± 0.070	5.857 ± 0.055	5.483 ± 0.065	0.010	0.042
12	(l) Total Soluble Solid	6.100 ± 0.100	6.000 ± 0.200	6.467 ± 0.25	7.600 ± 0.200	0.019	0.078
13	(m) Titratable Acidity, %	0.217 ± 0.045	0.130 ± 0.0128	0.150 ± 0.012	0.173 ± 0.015	0.002	0.008
14	(n) Total Sugar, %	19.797 ± 11.917	39.637 ± 5.688	37.827 ± 1.19	34.762 ± 0.370	0.236	0.95
15	(o) Reducing Sugar, %	4.299 ± 0.2700	5.753 ± 0.399	5.370 ± 0.47	4.765 ± 0.263	0.182	0.734
16	(p) Colour Browning Index	147.54 ± 6.62	0,036 ± 19.982	0.044 ± 24.978	0.054 ± 29.972	0.001	0.003

jackfruit and flour before and after drying. Ash content of raw jackfruit was 0.70 ± 0.10. Ash content with tender jackfruit flour was 2.800 ± 0.050 % 2.717 ± 0.050% 2.35 ± 0.05% at 40°, 50°, 60° respectively. The ash content decreases with increases in temperature 40° to 60°. The change in ash w.r.t. temperature was significant at $p < 0.001$. Drying of raw jackfruit flour at 50 ° was found to be 3.28% ash. (Tasnim *et al.* 2025).

Fat

Table 1(d) show the fat content of raw jackfruit flour before and after drying. Fat content for fresh tender jackfruit was 0.11 ± 0.03 %. Fat content varied for tender jackfruit flour was 0.920 ± 0.040 (%) 0.987 ± 0.105 (%) 1.067 ± 0.040 (%) at 40°, 50°, 60° respectively. The increase in fat w.r.t. increasing in temperature was significant at $p < 0.001$. The fat content observed in tender jackfruit flour was 1.59% at 50 ° (Tasnim *et al.* 2025). Similar result was observed in dehydrated tender jackfruit flour HV2, TCV 1.16 ± 0.06, 1.01 ± 0.02 respectively (Divya *et al.* 2025).

Fiber

Table 1(e) shows the fiber content of tender fresh jackfruit flour before and after drying. Fiber content of fresh tender jackfruit flour was 1.126 ± 0.074 (%). Fiber content varied for tender flour was 11.67 ± 0.44(%), 13.01 ± 0.11 (%), 11.05 ± 0.10 (%). at 40°, 50°, 60° respectively the fiber content increases from 40°C to 50°C followed by decreasing trend at 60°C. The change in fiber content w.r.t. change in temperature is significant $p \leq 0.001$. The fiber content of fresh tender Raw Jackfruit was 1.13 ± 0.06 (%) reported by Saikia *et al.* (2026). Tasnim *et al.* (2025) reported that fiber content of dried tender jackfruit crude flour fiber was 12.21.

Carbohydrate

Table 1(f) shows the carbohydrate content of fresh tender jackfruit and flour before and after drying. Carbohydrate content of fresh jackfruit flour was 1.12 ± 0.07(%). Carbohydrate content varied for tender jackfruit flour was 67.65 ± 0.95 (%), 68.36 ± 0.32(%), 71.393 ± 0.735 (%) at drying air temperature was 40°, 50°, 60° respectively. The carbohydrate content increases with increase in temperature, the increase in carbohydrates with increase in temperature was significant $p < 0.001$. According to Saikia *et al.* (2026), the carbohydrate content of fresh tender Jackfruit flour was 12.40 ± 0.10 (%) while dried fresh tender jackfruit flour was 37.57 ± 3.67 (%) (Tasnim *et al.*2025).

Energy

Table 1(g) shows the energy of fresh tender jackfruit flour before and after drying. Energy of fresh tender jackfruit flour was 68.86 ± 1.90(Kcal). Energy content varied with respect varying temperature of drying of Tender Jackfruit flour. It was 314.68 ± 2.90 (Kcal), 319.50 ± 0.66(Kcal), 326.433 ± 2.120(Kcal) at 40°, 50°, 60° drying air temperature respectively. The Energy increases with increase in temperature and was significant $p < 0.001$. Paul *et al.* (2017) reported that, the energy in fresh tender jackfruit flour was 383 Kcal. Saikia *et al.* (2026) reported that Energy in fresh dried tender jackfruit was 55.42 ± 0.53 kCal.

Bulk Density

Table 1(h) shows the Bulk density of tender jackfruit flour before and after drying. Bulk density of tender fresh jackfruit was 0.61 ± 0.03(g/ml). The bulk density of the tender jackfruit flour were 0.647 ± 0.005 (g/ml), 0.65 ± 0.010 (g/ml), 0.642 ± 0.05 (g/ml) at 40°, 50°, 60° respectively. The Bulk density increases from 40 °C to 50°C followed by the decreasing trend at 60 °C. The change in bulk density w.r.t. increasing in temperature was significant $p \leq 0.002$. According to Odoemelam (2005) the bulk density of fresh tender jackfruit flour was 0.61 ± 0.03 while heat processed flour was 0.54 ± 0.04

Water absorption

Table 1(i) shows water absorption capacity of fresh tender jackfruit flour before and after drying. Water absorption capacity of fresh tender jackfruit was 2.300 ± 0.200 (g/ml). The water absorption convective hot air dried tender jackfruit flour was 3.000 ± 0.080 (g/ml), 3.467 ± 0.041 (g/ml), 3.500 ± 0.091(g/ml) at 40°, 50°, 60° respectively. The water absorption capacity of the convective hot air dried jackfruit flour increases with increase in temperature from 40° to 60° respectively. The increase in water absorption capacity of tender jackfruit flour was significant at $p < 0.001$. According to Odoemelam (2005) the water absorption capacity of fresh tender jackfruit flour was 2.3 ± 0.2 (g/ml) while heat processed tender jackfruit flour was 3.5 ± 0.1 (g/ml) (Giami & Bekebain, 1992) reported that water absorption capacity of tender jackfruit flour at 50° reduces microbial activity and increases shelf life and safety.

Oil absorption

Table 1(j) shows oil absorption capacity of fresh tender jackfruit flour before and after drying. Oil absorption capacity of fresh tender jackfruit flour was 2.80 ± 0.30 (g/ml). The oil absorption capacity varied for tender jackfruit flour 2.620 ± 0.0754 (g/ml), 2.95 ± 0.117 (g/ml) 3.100 ± 0.200 (g/ml) at 40°, 50°, 60° respectively. The oil absorption capacity increases with increase in temperature from 40° to 60° and it was significant at $p < 0.001$. According to Odoemelam (2005) the oil absorption capacity of fresh tender jackfruit flour was 2.8 ± 0.3 (g/ml) while heat processed fresh tender jackfruit flour was 3.1 ± 0.2. (g/ml).

pH

Table 1(k) shows pH of fresh tender jackfruit flour before and after drying. pH of fresh tender jackfruit flour was 5.37 ± 0.05. The pH for various tender jackfruit flour was 6.73 ± 0.07, 5.85 ± 0.05, 5.48 ± 0.06 at 40°, 50°, 60° drying temperature respectively. The pH decreases with increase in temperature. pH of tender jackfruit flour was significant $p < 0.001$. Sahu *et al.* (2025) reported that the pH of raw jackfruit was 5.37 ± 0.05 while pH of tender jackfruit dried at 60° 6.20 ± 0.28, 5.71 ± 0.21of (HV2 and TCV respectively) (Divya *et al.* 2025). Reports say that Microorganisms, mainly lactic acid bacteria, produce organic acids, which then increase in total acidity content and decrease in pH value. (Pujari *et al.* 2024).

12. Total Soluble Solid (TSS)

Table 1(l) shows TSS of fresh tender jackfruit flour before and after drying. TSS of fresh tender jackfruit flour was 6.10 ± 0.10 °Brix While TSS varied for various tender jackfruit flour at 6.0 ± 0.20°Brix 6.46 ± 0.2°Brix, 7.60 ± 0.2 °Brix at the drying air temperature 40°, 50°, 60° respectively. Total Soluble solid increases with increasing in temperature. TSS of tender jackfruit flour was significant at $p < 0.001$. Changes in TSS with changes in temperature were also reported in (Raj, *et al.* 2006) and in Abano, *et al.* (2011) on drying of onion and garlic at different temperature levels, respectively.

Titrable Acidity

Table 1(m) shows Titrable Acidity of fresh tender jackfruit flour before and after drying. Titrable Acidity of fresh tender jackfruit flour was 0.21 ± 0.04 (%), The Titrable Acidity varied for various tender jackfruit flour at 0.13 ± 0.01(%), 0.15 ± 0.01(%), 0.17 ± 0.01 (%) at drying air temperature of 40°, 50°, 60° respectively. Titerable Acidity of solid increases as temperature increases. Titrable acidity of tender jackfruit flour was significant at $p < 0.001$. Sahu *et al.* 2025 reported the titrable acidity of fresh tender jackfruit flour was 0.34 ± 0.07 (%), amount of titrable acidity is their raw jackfruit. Pujari *et al.* (2024) reported that during drying, increase in acidity was mainly attributed to the increased moisture loss from the sample with corresponding increase in temperature.

Total Sugar

Table 1(n) shows total sugar of fresh tender jackfruit flour before and after drying. Total Sugar capacity of fresh tender jackfruit flour was 19.79 ± 11.9 %, while total sugar varied for various tender jackfruit flour 39.637 ± 5.688 %, 37.827 ± 1.19 %, 34.762 ± 0.370 % dried at temperature of 40°, 50°, 60° respectively. The total sugar decreases with increases in temperature. Total Sugar of tender jackfruit flour was significant $p< 0.001$. Sahu *et al.* 2025 reported the total sugar of raw jackfruit was 5.41 ± 0.93 while total sugar of tender flour was 37.57 % (Tasnim *et al.*2025).

15. Reducing Sugar

Table 1(o) shows reducing sugar of fresh tender jackfruit flour before and after drying. Reducing sugar of raw jackfruit was 4.29 ± 0.27% while reducing sugar for tender jackfruit flour were prepared from drying of tender jackfruit was 5.75 ± 0.39 5.37 ± 0.47%, 4.76 ± 0.26 % dried at temperatures 40°, 50°, 60° respectively. Reducing sugar decreases with increase in temperature. pH of tender jackfruit flour was significant $p < 0.045$. Sahu *et al.* (2025) reported the reducing sugar (%) of raw jackfruit was 4.30 ± 0.27 %. Reports say that decrease in reducing sugar resulted in the forming of browning compounds due to the non- enzymatic browning reaction between reducing sugar and amino acid (Pujari *et al.* 2024).

16. Colour

Table 1(p) shows Browning index of fresh tender jackfruit flour before and after drying. Colour of raw jackfruit was 147.54 ± 6.62 for fresh tender jackfruit flour. While Browning Index varied for various tender jackfruit flour 0,03 ± 19.98, 0.04 ± 24.97, 0.05 ± 29.97 at 40°, 50°, 60° respectively. As temperature increases the browning Index increases Browning index of tender jackfruit flour was significant at $p < 0.001$. According to Rana *et al.* (2018) reports say that $L = 24.49 \pm 2.43$, $a = 2.33 \pm 0.35$, $b = 19.88 \pm 0.74$ for the fresh tender jackfruit flour. and browning index ranges from 0.035 to 0. 057. Babu and Sudheer (2020) reported that the browning index of sterilized tender jackfruit samples were 43.81 and 22.42 for pasteurized samples. This discrepancy suggests that the higher temperatures used during sterilization may promote increased enzymatic activity or browning, which negatively impacts the colour quality of the product.

CONCLUSION

Tender Jackfruit, the unripe form of jackfruit is a nutritious and versatile fruit. Drying of raw jackfruit at various temperature 40°, 50°, 60° dried at 14 hours, 12 hours, 10 hours respectively Study was conducted on various temperatures in which 50° is best temperature for drying of tender jackfruit flour which achieved the desirable quantities. As temperature increases if affect the nutritional quality. The study of various parameter like – Moisture, Protein, Fat, Ash, Fiber, Carbohydrate, Energy, Water absorption capacity, Oil absorption capacity, Bulk density, Total Sugar, Reducing Sugar, Titrable Acidity, Colour. Better retention was observed at 50° Moisture- 5.72%, Ash-2.75 %, Protein- 9.1 %, Fat- 0.98%, Fiber - 13.02 g, Carbohydrate - 68.71 g, Energy - 320.2 Kcal, Bulk density - 0.64 g/ml, Water absorption capacity - 3.48 g/ml, Oil absorption capacity - 3.08, g/ml pH - 5.74, TSS- 6.7 °Brix, Titrable Acidity- 0.16 %, Total Sugar - 38.01 %, Reducing sugar - 5.9 %, Colour (Browning Index) - 0.042.

GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy, integrity, and originality of the work presented, and no AI tool was listed as an author.

REFERENCES

A.O.A.C. 1980. Official methods of analysis, Association of official agricultural chemists, 13th edition, Washington, D. C, USA.

A.O.A.C. 2005. Official method of analysis, Association of official analytical chemists, 18th edition, Analytical Chemists, Washington DC.

Abano, E.E., Ma, H., Qu, W. and Teye, E. 2011. Modeling pre-treatments effect on drying kinetics of garlic slices in a convective hot air dryer. *African Journal of Food Science,* **5**: 425–435.

Babu, P.S. and Sudheer, K.P. 2020. Quality evaluation of thermal processed tender jackfruit during storage. *Journal Tropical Agriculture,* **58**(1).

Babu, P.S., Sudheer, K.P. and Bindu, J. 2012. Optimization of blanching process for tender jackfruit, *Indian Journal of Dairy and Bioscience,* **8**(3): 5-9.

Babu, S.P., Kundukulangara, P.S., Chitradurga, J.B and Obaiah, M. 2022. Effect of thermal processing on quality of tender jackfruit in tin-free steel cans. *Journal Food Science Technology,* **59**(5): 2035–2046.

Bashetti, S. 2022, Beneficial effects of Jackfruit to control Type-2 Diabetes: A practice of medical nutritional therapy (MNT) along with Anti-diabetic Drug: An update Acta Scientific Nutritional Health, **6**(11): 2582- 1423.

Boning, C.R. 2006. Florida's best fruiting plants: Native and exotic trees, shrubs, and vines Rowman and Littlefield. 232

De Jesús González-Regalado, J., Montalvo-González, E., Miramontes-Escobar, H.A., Jiménez-Fernández, M., de Lourdes García-Magaña, M., Chacón-López, M.A., AlShammari, J. and Ortiz-Basurto, R.I. 2024. Texture profile analysis of heat-processed tender jackfruit and its potential use as a meat analog. *Emirates Journal of Food and Agriculture,* **36**: 1-11.

FAO, 2012. Food and Agricultural Commodities production. http://faostat.fao. Orged

Giami, S.Y. and Bekebain, D.A. 1992. Proximate composition and functional properties of raw and processed full-fat fluted pumpkin seed flour. *Journal Science Food Agriclture,* **59**: 321-325.

Hyndavi, A.V.S., Swami, D.V., Ashok, P., Salomi Suneetha, D.R. and Uma Krishna, K. 2022. Effect of drying techniques and packaging material on shelf life of tender jackfruit powder. *The Pharma Innovation Journal,* **11**(8): 1770-1775.

Kamble, M., Singh, A., Singh, S.V., Chinchkar, A. and Pareek, S. 2022. Optimization of Convective Tray-Drying Process Parameters for Green Banana Slices Using Response Surface Methodology and Its Characterization. *Journal of Food Quality,* 2022(1): 8208572.

Mishra, S. and Dubey, P. 2020. Assessment of physio-chemical & functional properties of jack fruit seed powder assessment of physio-chemical & functional properties of jack fruit) seed powder.

Ml, R. and Kv, J. 2025. Processing and Quality Evaluation of Tender Flour. *Mysore Journal of Agricultural Sciences,* **59**(3).

Molla, M.M., Nasrin, T.A.A., Islam, M.N. and Bhuyan, M.A.J. 2008. Preparation and packaging of jackfruit chips. *International Journal of sustainable crop production,* **3**(6): 41-47.

Narayana, K. and Narasinga Rao, M.S. 1982. Functional properties of raw and heat processed winged bean flour. *Journal of Food Science,* **47**(5): 1534-1538.

Odoemelam, S.A. 2005. Functional properties of raw and heat processed jackfruit flour. *Pakistan Journal of Nutrition,* **4**(6): 366-370.

Olatunde, G.O., Henshaw, F.O., Idowu, M.A. and Tomlins, K. 2016. Quality attributes of sweet potato flour as influenced by variety, pretreatment and drying method. *Food Science and Nutrition,* **4**(4): 623-635.

Palou, E., López-Malo, A., Barbosa-Canovas, G.V., Welti-Chanes, J. and Swanson, B.G. 1999. Polyphenol oxidase activity and color of blanched and high hydrostatic pressure treated banana puree. *Journal of Food Science,* **64**(1): 42-45.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical Methods for Agricultural Workers. 2nd ed. New Delhi: ICAR Publication.

Paul, C. and Isaac, B.R. 2017. Nutrient analysis of tender jackfruit (*Artocarpus heterophyllus*) flour and its incorporation in breakfast recipes for diabetics. *Food Science: Indian Journal of Research in Food Science and Nutrition,* **4**(2): 42-46.

Pearson, D. 1976. Chemical Analysis of Foods Seventh Edition London, Church Hill Livingstone, 72–3, 138–43, 488–96.

Phungjab, C. 2003. Drying strategy of whole longan with stepwise drying temperature, Chiang Mai University: Thailand.

Preethi, N.S., Sangeeta, A. and Jaganmohan, R. 2021. Comparative study of physicochemical properties of freeze dried and tray dried raw jackfruit flour. *International Journal of Chemical Studies*, **9**(1): 3053-3057.

Pujari, S.D., JH, K., Shirke, G.D., Tule, S.S. and Shinde, P.U. 2024. Effect of pre-treatments and storage on quality of green chilli powder. *Plant Science Today*, **11**: 4844.

Raj, D., Subanna, V.C., Ahlawat, O.P., Gupta, P. and Huddar, A.G. 2006. Effect of pre-treatments on the quality characteristics of dehydrated onion rings during storage. *International Journal of Food, Agriculture & Environment*, **4**: 30–33.

Rana, S.S., Pradhan, R.C. and Mishra, S. 2018. Variation in properties of tender jackfruit during different stages of maturity. *Journal of Food Science and Technology*, **55**(6): 2122-2129.

Rana, S.S., Pradhan, R.C. and Mishra, S. 2018. Variation in properties of tender jackfruit during different stages of maturity. *Journal of Food Science Technology*, **55**(6): 2122–2129.

Rangana, S. 1986. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. TATA McGraw Hill Education Private Limited, New Delhi.

Rao, A.G., Naik, K.S., Unnikrishnan, A.G. and Joseph, J. 2021. Efficacy of green jackfruit flour as a medical nutrition therapy replacing rice or wheat in patients with type 2 diabetes mellitus: a randomized, double-blind, placebo-controlled study. *Nutrition & Diabetes*, **11**(1): 18.

Sahu, N.K., Kumar, E.B., Sahu, R., Singh, K.P. and Singh, D.P. 2025. *Physico-chemical parameter of raw jackfruit, SP-***9**(10): 348-350.

Saikia, D., Saikia, T., Gohain, D., Bordoloi, N., Phukon, R.M., Phukan, D., Kansal, D., Dutta, A., Saikia, D. and Kumari, K. Variation in nutritional composition in tender and ripe stages of maturity of local variety of *Artocarpus heterophyllus* Lam.

Siddiqui, S.A., Ucak, İ., Jain, S., Elsheikh, W., Ali Redha, A., Kurt, A. and Toker, O.S. 2024. Impact of drying on techno-functional and nutritional properties of food proteins and carbohydrates-A comprehensive review. *Drying Technology*, **42**(4): 592-611.

Swami, S.B. and Kalse, S.B. 2019. Jackfruit (*Artocarpus heterophyllus*): biodiversity, nutritional contents, and health. *In* Bioactive molecules in food Springer, Cham. pp. 2237-2259.

Tasnim, A., Karim, M.R., Mukta, F.A., Islam, S.R., Hasan, M.R., Bhowmik, B. and Khan, A.A. 2025. Green Jackfruit Transformation: Dry Flour Processing, Nutraceutical Analysis, and its Revolutionary Application in Maintaining Optimum Blood Glucose Level. *Journal of Agroforestry and Environment*, **18**(2): 56-64.

Tawo, E.N., Abara, A.E., Malu, S.P. and Alobi, N.O. 2009. Evaluation of pH levels in some common carbohydrate food items consumed by communities in the Central Senatorial District of Cross River State, South-South of Nigeria. *Pakistan Journal of Nutrition*, **8**(9): 1387-1390.

Vega-Galvez, A., Lemus-Mondaca, R., Tello-Ireland, C., Miranda, M. and Yagnam, F. 2009. Kinetic study of convective drying of blueberry variety. *Chilean Journal of Agricultural Research*, **69**(2): 171-178.