Effect of Pre-treatment on jackfruit seed powder and its utilization in crackers development

[1]Mr. Mukesh P. Kale, [2]Dr. Sujata V. Ghodke, [3]Dr. Prerana D. Shere, [4]Dr. Rinku S. Agrawal

[1]Post graduate research scholar, [2,3]Associate professor & HoD, [4]Assistant professor
[1,2,4]Department of Patronage of Traditional and Specialty Food, [3]Department of Food Product and Process Technology,
[1,2,3,4] MIT School of Food Technology, MITADT University, Pune, INDIA
[1]Mukeshkale0507@gmail.com, [2] sujata.ghodke@mituniversity.edu.in,
[3]Prerana.shere@mituniversity.edu.in, [4]rinku.agrawal@mituniversity.edu.in,

***Abstract*— The jackfruit seeds, being rich in dietary fiber and B-complex vitamins, lower the risk of heart disease, prevent constipation and promote weight loss. Jackfruit seeds also contain resistant starch, which controls blood sugar and keeps the gut healthy. In the present investigation, jackfruit seed powder was prepared by application of pre-treatments (Germination and roasting) and evaluated for proximate composition, mineral composition, functional properties, anti-nutritional factors, total phenol content, flavonoid content and antioxidant activity. Germinated seed jackfruit seed powder found to have superior nutritional and functional profile against roasting. Hence, germinated jackfruit seed powder is incorporated to develop crackers at different proportions (20, 25 and 30%). Crackers developed by 20% germinated jackfruit seed powder incorporation exhibited the highest sensorial scores for overall acceptability.**

***Keywords* — Pre-treatments, Germination, Roasting, Antioxidant Activity, Phenol Content, Flavonoid Content, Anti-nutritional Factors, Crackers**

1. INTRODUCTION

In current scenario and situations like covid-19, consumers are more cautious regarding their eating habits. Developing countries looking for healthy food product option which can provide them more than energy. Consumer demand for a protein, vitamin and mineral rich food product. Additionally, health food products are becoming popular among consumer as protect them from various diseases like cancer, heart diseases. Jackfruit seed has potential to fulfil health demands as it is rich in protein, minerals, vitamin, antioxidants and phenolic compounds.

Jackfruit (Artocarpus heterophyllus Lam.) is an indigenous fruit widely consumed in the world. Jackfruit grows worldwide in tropical and subtropical area. The unique flavors of ripe jackfruit have been exploited in several Asian cuisines and food industries. Jackfruit consist of main three parts outer rind, inner edible yellow fleshy bulbs, and the seeds. Ripen fruits are consumed or used for processing or canning. Seeds make up around the 10 to 15% of the total fruit weight [1].

Jackfruit seed contains lots of nutrients which provides lots of health benefits to the consumer. The ripened jackfruit is fibrous and composed of sugars like glucose, fructose, xylose, rhamnose, arabinose, and galactose. Seeds of ripened fruit are also rich source of carbohydrates, proteins, fiber and B-complex vitamins. Jackfruit seed contains phytonutrients such as lignans, saponins, and isoflavones helps in improving human health [2].

In india kerala, Tamil nadu, Karnataka, Andra Pradesh, Asam, Bihar, Orisa, Maharashtra are the states that cultivate jackfruit in more than 32,600 ha, alone Karnataka produces around 2.5 lakh tones per year [3]. Jackfruit is made up of four main parts pulpy bulbs (29%) attached to central core, protective rind (54%) and seeds (12%). Jackfruit is made up of four main parts pulpy bulbs (29%) attached to central core, protective rind (54%) and seeds (12%) [4]. Eke- Ejofer reported raw jackfruit seeds, moisture (5.07%), protein (12.45%), Ash (2.46%), carbohydrate (70.76%) and negligible amount of fat (0.77%). Ash of jackfruit seed is rich in many vital minerals (N, P, K, Ca, Mg, S, Zn, Cu, etc) which can prevent from many diseases [5]. Protein of jackfruit seeds are composed of hisdine, threonine, valine, lysine, isoleucine, leucine and phenylalanine which makes protein of jackfruit seed a better and suitable option as a ingredient to develop products [6]. Countries like india which is fighting with malnutrition need a better solution which can be jackfruit seeds. Jackfruit seeds has very low shelf life to increase shelf life with better nutritional profile seeds can be treated with treatments like germination, roasting boiling, autoclaving, drying [4].

Germination is natural process occurs slowly but causes many metabolic activities which are result of heightened reactions of amino acids which has many benefitable effects. Digestibility of carbohydrates specially starches, improves protein and antioxidant activity with better shelf life [7]. Roasting can improve protein content both quality and quantity wise. Roasting Heat causes denaturation of protein bonds and eventually can be utilized to synthesize new form of proteins [6]. Roasting also affect on bonds of other nutrients which led in improving digestibility. Roasting can improve functional properties more effectively and germination shows more enhancement on antioxidant activity protein content and shelf life as it contains less moisture content.

Pre-treated jackfruit seeds can be used to improve nutritional profile of bakery products, extruded products and other products like cereal bars, chapatis[5]. Flour of jackfruit seed can be a ingredient that can be used to fortify the products that has better organoleptic, nutritional and phytochemical properties when used in in between 5-40%.

In present time, consumer demands for healthy snack substitute to the currently available products in market. Convenience, low price, ready to eat nature, health aspects and nutraceutical properties are the key attraction for the innovative bakery products. Bakery products being a popular food sector in all age group people such as crackers. Taking consideration of need and demand of nutritionally enriched ready to eat snack products efforts have been carried out to formulate jackfruit seed powder incorporated crackers to fulfil the requirement of nutrition

2. MATERIAL AND METHODOLOGY

2.1. MATERIAL

Jackfruit seeds were procured from Kairali fresh organic shop from Thiruvananthapuram, Kerala. The raw materials required during research work such as whole wheat flour, sugar, butter, salt, cinnamon, cumin were procured from the local market of Pune.

Jackfruit seed pre-treatment

Seeds of ripened fruit were cleaned with water and further treated with Germination and roasting.

I. Germination:

Germination process carried out in two steps; first one is soaking for 12 hrs in tap water followed by 7-9 days tying in jute cloth with intermittent sprinkling of water on the tied bags. Sprouted seeds were dried in a cabinet dryer (60°C for 5-6 hrs) after sliced into small chips. Further dried chips were converted into powder by using grinder.

II. Roasting:

Washed seeds were roasted at 160°C as suggested by Mandve *et al.*, (2018) [1], If roasting is done at the proper temperature, then nutrients like protein and minerals are retained well [1].

Chemicals Glassware and Equipments

Analytical grade Chemicals, glassware and Equipments were available in the laboratory of FPPT/FSQN, School of Food Technology.

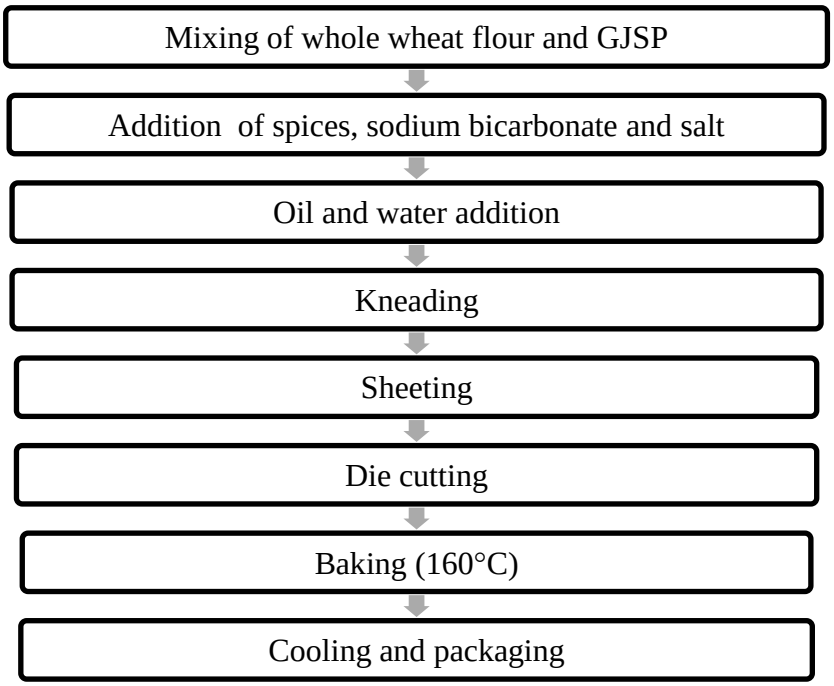


Fig.1 jackfruit seed powder incorporated cracker processing technology

2.2. Incorporation of jackfruit seed powder into crackers:

Crackers were developed by replacing whole wheat flour with germinated jackfruit seed powder in different proportion (20, 25, 30%) 100% whole wheat flour for control sample.

2.3. Proximate Analysis:

2.3.1. Moisture Content

The moisture of the sample is expressed as a percentage and determined by weight difference method **[8]**

$$\textbf{Moisture content}(\%) = \frac{\textbf{weight of fresh sample} - \textbf{weight of dried sample}}{\textbf{weight of fresh sample}} \textbf{X100}$$

2.3.2. Determination of protein

Protein content was determined using Kjeldahl method (Aoac, 2005) with some modifications **[8].**

$$\% \textbf{ Nitrogen} = \frac{\textbf{14 X Normality of acid X Actual titrate value X 100}}{\textbf{Sample weight X 1000}}$$

$$\% \textbf{ of Protein} = \% \textbf{ of Nitrogen X Power Factor}$$

2.3.3. Fat analysis

Fat content was estimated using SoxTRON apparatus standard method of (Aoac 2005) [8] with some modifications was employed.

$$\textbf{Fat content } (\%) = \frac{\textbf{weight of sample in beaker} - \textbf{weight of empty beaker}}{\textbf{weight of sample}} \textbf{x100}$$

2.3.4. Ash Content

Ash content of the sample is expressed as a percentage and determined by weight difference method [8]**.**

2.3.5. Total carbohydrate

Total carbohydrates were calculated by difference method, i.e., subtracting sum of moisture, protein, fat and ash content from 100 [8].

2.3.6. Mineral content

2.3.6.1. Iron:

Iron The amount of iron in food is determined by oxidising the iron with oxidising agents such as potassium persulfate or hydrogen peroxide, then treating the ferric iron with potassium thiocyanate to create red ferric thiocyanate, which is calorimetrically detected at 480 nm [8].

2.3.6.2. Calcium:

Calcium is precipitated as calcium oxalate. The precipitate is dissolved in hot dilute H_2SO_4 and titrated with standard potassium permanganate [8].

2.4. Functional properties:

Water absorption capacity, oil absorption capacity and swelling index were calculated by method suggested by [9].

2.5. Antioxidant activity:

Antioxidant activity is measured by preparing assay of methanol and DPPH solution and free radical scavenging activity was measured at 517 nm [10].

2.6. Total phenol content:

Phenol content was determined by Phenolic folin-ciocaltau colorimetric method described by [11].

2.7. Flavonoid content:

To calculate flavonoid content procedure described by Adom *et al.,* (2003) [12] was employed.

2.8. Antinutritional Factors:

Antinutritional determination carried out for tannin and phytic acid content.

2.8.1. Tannin

75 ml of water was added in 250 ml conical flask then add 0.5 g jackfruit seed powder, heat 30 min at 50°c. Centrifuge 20 min for 2000 rpm and supernatant was collected in 100 ml volumetric flask and make up volume of 100 ml. 1ml of sample, 5 ml of folin Denis reagent and 10 ml sodium bicarbonate and 100 ml volume made up. absorbance was measured at 700nm. (Thimmaiah S. k. (2016) [13]**.**

2.8.2. Phytic acid

Take finely ground 2 gm of jackfruit seed powder in 100 ml conical flask. Then added 50 ml 3 % TcA and Shaked for 2 hrs and centrifuged at 4000 rpm for 8 min to get supernatant. Then by adding 4 ml $Fecl_3$ heated for 30 min. centrifuge for 15 min to separate supernatant and washed with 3% TCA in water bath at 50°c for 5-10 min. add 3 ml of 1.5N NaOH and mixed water to bring volume to 30 ml boil from another 30 min and filtered with Whatman filter paper No. 2. Wash precipitate with 60-70 ml of hot water and filtrate was discarded. precipitate was filtered from paper with 40 ml of 3.2N HNO_3 into 100 ml volumetric flask. Extract 5 ml of aliquot and diluted with 70 ml water and mixed with 1.5M KSCN and evaluate within 1 min at 480 nm. Phytate p was calculated by formula. (Thimmaiah S. k. (2016) [13].

$$\text{Phytate P (mg/100g)} = \frac{\mu g \text{ fe} \times 15}{\text{Wt.of sample}}$$

2.9. Sensory Analysis

Sensory analysis of jackfruit seed crackers carried out on various sensory parameters like smell, texture, color, taste, appearance by using 9-point hedonic scale by the semi trained panel. The data was collected from total 10 panelist from MIT School of food technology.

3. Results and discussion

3.1. Nutrient profile of jackfruit seed powders

Table. 1 Nutritional profile of jackfruit seed powders

Parameter (%)	Raw jackfruit seed powder	Germinated seed powder	Roasted jackfruit seed powder
Moisture	4.1±0.10	3.7±0.05	3.9±0.10
Protein	11.4±0.02	16.3±0.19	13.1±0.15
Fat	0.77±0.01	0.13±0.01	0.27±0.01
Carbohydrate	81.27±0.15	77.11±1.00	80.24±0.37
Ash	2.46±0.08	2.76±0.005	2.94±0.06

*Each value represents the average and standard deviation of three determinations

Moisture content of jackfruit seed powders was found in the range of 3.9 to 4.1%. Germinated seed powder had lowest moisture content while raw jackfruit seed powder had highest moisture. Similar results reported by Eke-ejofer et al., (2014)[4] found out moisture in range of 30.2 to 6.6%. Protein content of powders obtained from jackfruit seeds was observed in the range of 11.4 to 16.3%. Germinated jackfruit seed exhibited highest content (16.3%) whereas raw jackfruit seeds exhibited lowest protein content (11.4%). This may be due to germination process which boosts reformation of amino acid and breakdown of carbohydrates into simpler form that allows absorption of atmospheric nitrogen and reformation of amino acids Joshi *et al*., (2016) [14]. Increase in protein content might be also due to increase in mobilization of nitrogen storage to produce protein required for embryo formation. Similar values of protein are also reported by Ocloo *et al.,* (2010) [15] and Eke-ejofer *et al*., (2014) [4]. The highest fat content was observed in raw jackfruit seed powder (0.64%) followed by roasted (0.27%) and germinated (0.16%). This reduced fat content in germinated seed powder might be due to increased lipolytic enzymes activity which resulted in complex fat hydrolysis into simpler forms which was used as energy during formation of embryo. Similar decreasing significance was observed by Kumar (1998)[16] and Eke-ejofer *et al*., (2014) [4].

Germinated jackfruit seed powder found to contain lowest carbohydrate (76.88%) and raw highest (81.36%). Carbohydrate reduction in germinated pre-treatment may be caused by increase in activity of amylolytic enzymes like α-amylase which break down starch into simple sugars thereby improves digestibility. Roasting treatment also led to reduction in carbohydrate from 81.27% to 80.24% because of polysaccharide degradation to simpler monosaccharides. The similar results are also reported by Ocloo *et al*., 2010 [15] and Siti and Noor 2003 [17].

Ash content of jackfruit seeds powder were analyzed and values ranged from 2.50 to 2.91%. Germinated jackfruit seed powder showed highest ash content (2.91%) followed by roasted (2.94%) and raw (2.76%). The results recorded are in good agreement with the findings of Eke-ejofer *et al.,* (2014) [4].

3.2. Selective mineral composition of jackfruit seed powder

Table 2. Calcium and iron content of jackfruit seed powders

Mineral	Jackfruit seed powders (mg/100g)		
	Raw jackfruit seed powder	Germinated jackfruit seed powder	Roasted jackfruit seed powder
Calcium	296.2±1.90	298.3±1.10	297.5±1.66
Iron	10.8±0.10	10.94±0.35	10.87±0.02

*Each value represents the average and standard deviation of three determinations

Calcium content of seed powders ranged between 296.2 and 298.1 mg/100g. Germinated seed powder exhibited highest calcium content (298.1mg/100g) than roasted (297.5 mg/100g) and raw (296.2 mg/100g). Iron is an essential mineral for hemoglobin, protein synthesis and act as oxygen carrier to various parts. Iron content was observed in the range of 10.8 to 10.87 mg/ 100g in raw and

pre-treated jackfruit seed powders. The calcium and iron of jackfruit seed powders were found similar to the results reported by Ocloo *et al*., (2010) [15].

3.3. Antinutritional factors in jackfruit seed powders

Table 3. antinutritional content of jackfruit seed powders

Antinutritional factors	Jackfruit seed powders		
	Raw jackfruit seed powder	Germinated seed powder	Roasted seed powder
Tannin(g/100g)	0.61 ±0.01	0.07 ±0.01	0.05 ±0.01
Phytic acid (mg/100g)	50.3 ±0.19	22.8 ±0.14	24.6 ±0.23

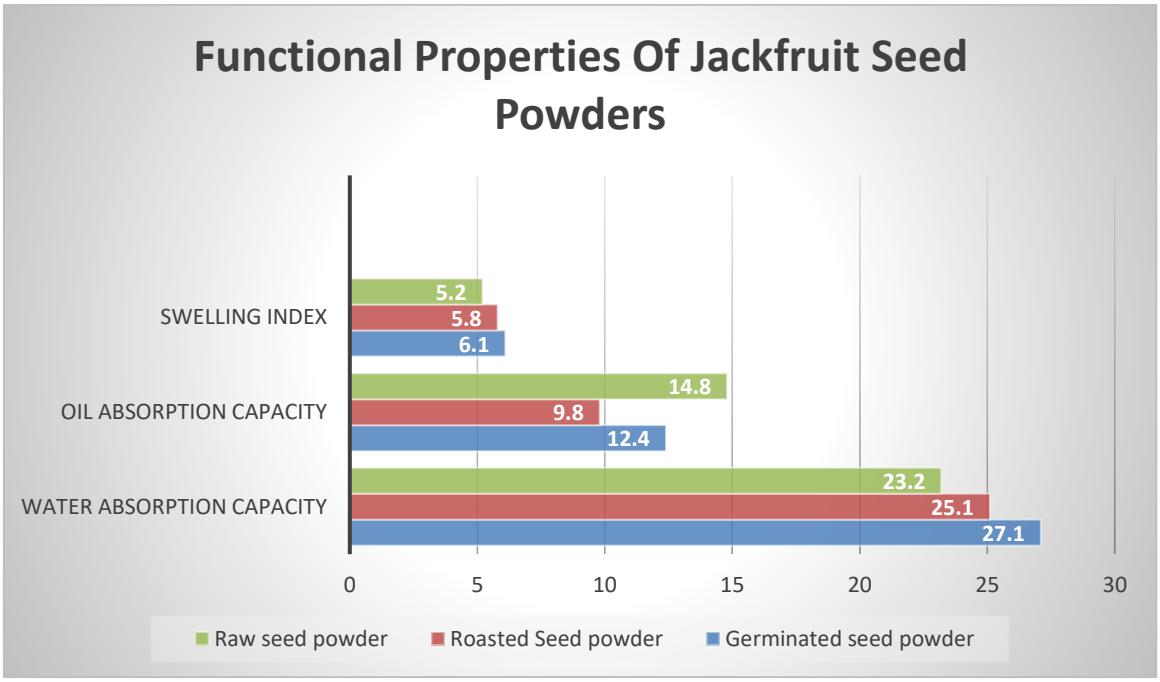
*Each value represents the average and standard deviation of three determinations

Tannin content in jackfruit seed powders were found to be in the range of 0.05 to 0.61g/100g. The tannin content was observed to be reduced by 88% and 91 % with germination and roasting pre-treatments respectively. The pre-treatments may be resulted in hydrolysis of galo tannins to gallic acid and glucose Kartik Sharma *et al*., (2019) [18].

Phytic acid content of raw seed powder was reduced from 50.3mg/100g to 22.8mg/100g (54%) and 24.6mg/100g (51%) in case of germination and roasting treatments respectively. This reduction may be attributed to hydrolysis of phytic acid into phytate and removal of phosphate group in roasting and germination process of jackfruit seed (Vikas *et al*., 2020) [19]. The similar trend of reduction of antinutritional factors in jackfruit seed powder was also reported by N mb *et al*., (2021) [6].

3.4. Functional properties of jackfruit seed powder

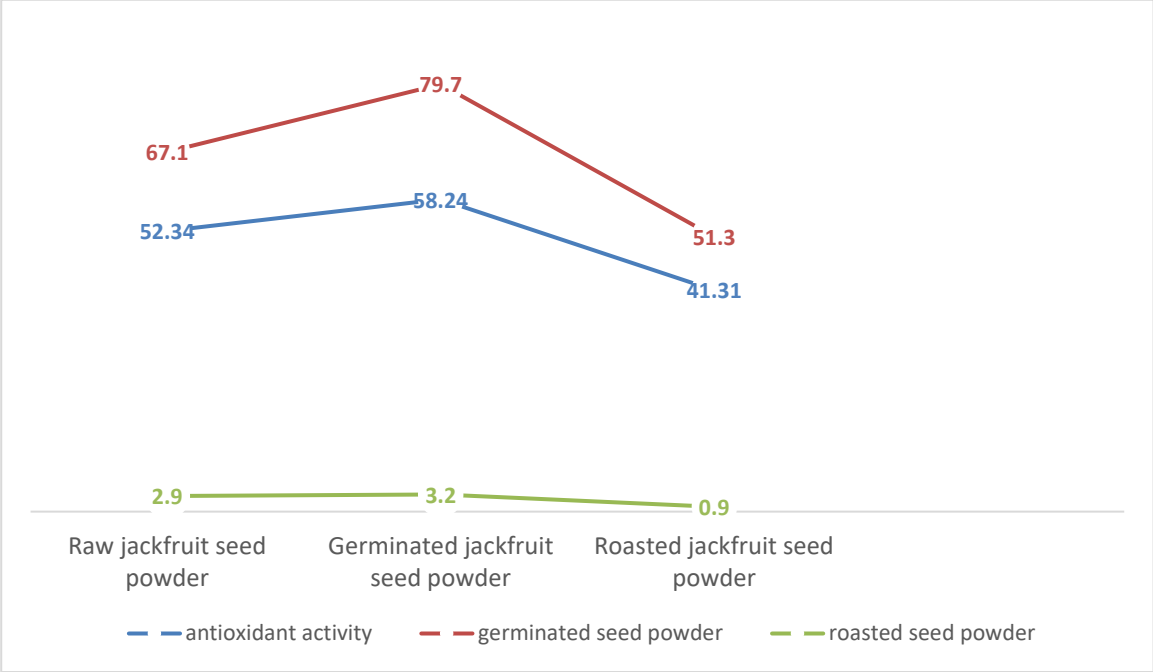
Table 4. Functional properties of jackfruit seed powders



Water absorption capacity of jackfruit seed powders was observed to be improved from 23.2% to 27.1% in case of germination and 25.1 % in roasting treatment. The decrease in oil absorption capacity from 14.8% to 12.4% and 9.8% for germination and roasting respectively, indicates less oil uptake potential in the jackfruit seed powder incorporated food products. Swelling index was observed to be highest in germinated jackfruit seed powder (6.1%) followed by roasted (5.8%) and raw (5.2%). Theses functional properties enhancement in germinated seeds powder alterations might be due to germination process driven increased protein content leading to hydrophilic subunits rise. The results of functional properties of raw jackfruit seed powder are in good agreement with values reported by Ocloo *et al*., (2010) [9], Chowdhari *et al*., (2012) [20] and Eke-Ejofer *et al*., (2014) [4].

3.5. Effect of pre-treatment on antioxidant activity, total phenol content and flavonoid content of jackfruit seed powder

Table 5 Antioxidant activity, total phenol and flavonoid content of jackfruit seed powders



*Each value represents the average and standard deviation of three determinations

Antioxidant activity of raw jackfruit seed powder was observed as 52.34% and found to be increased by germination to 58.24% but roasting seeds lowers antioxidant activity to 41.31%. Total phenol content of jackfruit seed powders was observed in the range of 51.3to 79.7 mg GAE / 100gm. Germinated seed powder exhibited highest phenolic content (79.7 mg GAE / 100gm) than raw (67.1 mg GAE/100gm) and roasted seed powder (51.3mg GAE / 100gm). The highest flavonoid content was observed in germinated seed powder (3.2mg CE / 100gm) followed by raw (2.9 mg CE / 100gm) and roasted (0.9 mg CE / 100gm). This increase in antioxidant activity, phenol content and flavonoid may be ascribed to metabolic changes during germination process. Antioxidant activity, phenol content and flavonoid reduction might be related to heat or high temperature driven phenolic compounds denaturation. Similar increasing trend of antioxidant activity was observed in germinated jackfruit seed powder in Trejo *et al.*, 2021 [2].

Two pre-treatments (germination and roasting) were employed on jackfruit seed to provide an option for powder preparation. The germination treatment exhibited overall better results for nutrient updation, functional properties, antioxidant activity, total phenol content and flavonoid content enhancement of jackfruit seed powder. Hence, the germinated jackfruit seed powder (GJSP) is further selected for cracker development at different levels.

3.6. Organoleptic assessment of germinated jackfruit seed powder incorporated crackers

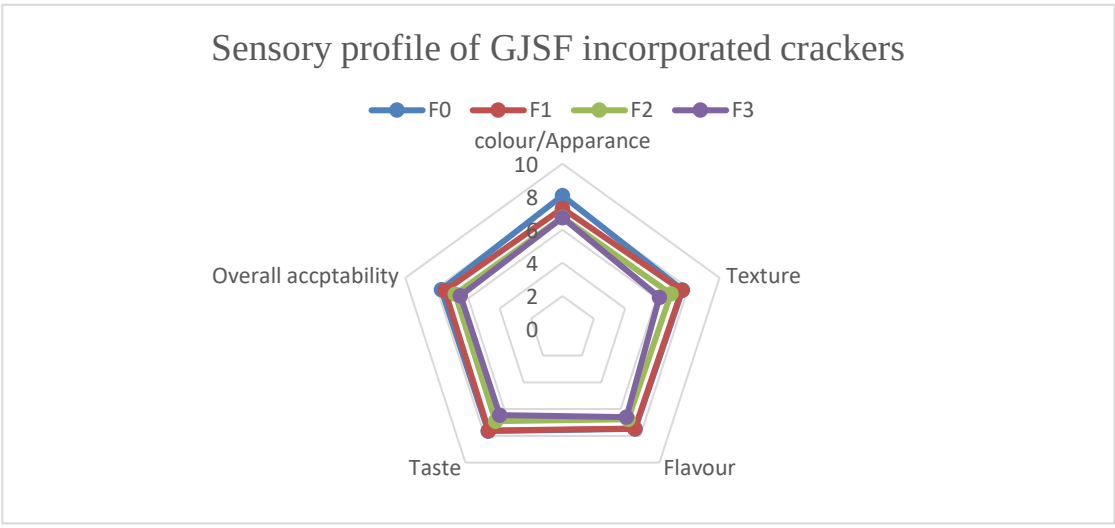


Fig. 2 Sensory profile of GJSP incorporated crackers

Jackfruit seed powder incorporated crackers were developed by replacing whole wheat flour with 20%, 25% and 30% germinated jackfruit seed powder, and control sample was prepared by 100% whole wheat flour. Overall acceptability

of 20% GJF incorporated cracker was found to be highest with 7.48 score. Batool *et al.,* (2013)[21] also found similar observations for overall acceptability in case of jackfruit seed powder incorporated bread.

3.7. Proximate composition of jackfruit seed powder incorporated crackers

Germinated jackfruit seed powder incorporated cracker analyzed for selective nutritional proximate parameter and results depicted in table 9., indicated nutritional upgradation of crackers.

Table 6 Nutritive profile analysis of GJSP incorporated crackers

Samples	Parameters (%)				
	Moisture	Protein	Fat	Ash	Carbohydrate
F0	6.30±0.33	11.40±0.36	3.59±0.02	0.94±0.02	77.76±0.44
F1	6.72±0.09	16.46±0.40	3.33±0.03	1.01±0.01	72.44±0.40
F2	7.27±0.21	16.73±0.15	3.28±0.09	1.03±0.01	72.02±0.43
F3	7.43±0.18	17.20±0.17	2.94±0.02	1.06±0.01	71.05±0.80

*Each value represents the average and standard deviation of three determinations

F_0- 100% whole wheat flour, F_1- 20% GJSP and 80% whole wheat flour, F_2- 25% GJSP 75% whole wheat flour, F_3- 30% GJSP 70% whole wheat flour.

Developed crackers with incorporation of germinated jackfruit seed powder in different variations were analyzed for different nutritive compositions and obtained results are tabulated in table 9. The addition of jack fruit seed flour boosts the protein, ash, and moisture in the crackers' formulation, according to the results of the chemical analyses. The higher protein and mineral content of the seed flour may be responsible for the higher protein and ash level. Additionally, a decrease in fat content was noted.

3.8. Antioxidant activity, total phenol content and flavonoid content of jackfruit seed powder crackers

Table 7 Functional properties of GJSP incorporated crackers

Sample	Total phenol content (mg GAE / 100gm)	Flavonoid content (mg CE/100gm)	Antioxidant activity (% inhibition)
F_0	0.59±0.13	0.05±0.001	22.34±0.35
F_1	0.79±0.24	0.11±0.001	27.54±0.94
F_2	0.83±0.28	0.13±0.001	28.46±0.55
F_3	0.93±0.81	0.14±0.001	29.38±0.64

*Each value represents the average and standard deviation of three determinations

F_0- 100% whole wheat flour, F_1- 20% GJSP and 80% whole wheat flour, F_2- 25% GJSP 75% whole wheat flour, F_3- 30% GJSP 70% whole wheat flour.

With the increase in GJSP level from F0 (0.59 mg GAE / 100gm) to F3 (0.93 mg GAE/100gm), the total phenolic content was noticeably higher. The F3 variety had the highest flavonoid concentration (0.14 mg CE/100g), followed by the F2 and F1 (0.13 and 0.11 mg/100g, respectively), and the F0 (0.05 mg/100g). With an increase in GJSP from 0% to 30%, the increase in phenolic and flavonoid content led to an improvement in antioxidant activity from 22.340.35 to 29.380.64. Therefore, jackfruit seed powder has the potential to improve the functionality of processed crackers.

4. Conclusion:

Both pre-treatments showed positive effect on nutritional, antinutritional and phytochemical profile of jackfruit seed powder. Protein content in jackfruit seed powder is 11.4 % in raw; roasting and germination increase this to 13.1 percent and 16.3 %, respectively. From 0.77 % to 0.27 % and 0.13 percent, the fat content was decreased. Functional properties also underwent positive modifications, with an improvement in swelling index and water absorption capacity, and a notable decrease in oil absorption capacity. Both treatments successfully lowered antinutritional factors to acceptable levels. Germination raised total phenolic content and flavonoid content more effectively than roasting.

20% GJSP incorporated crackers (F_1) exhibited the higher overall acceptability scores (7.4) against rest levels. The developed crackers analysed for proximate composition and results showed that moisture content 6.72%, protein content 16.46%, fat content 3.33%, 1.01% ash and 72.44% carbohydrate content which was better than control sample. Data also revealed that incorporation also helped in improving total phenol content from 0.5 to 0.79 mg/100gm GAE and flavonoid content from 0.05 to 0.11 mg CE/100gm which led to improve antioxidant activity from 22.34% to 27.54%.

5. References:

[1] Mandave, P., Bobade, H. & Patil, S. Jackfruit seed flour: Processing technologies and applications. **11**, 149–154 (2018).

[2] Trejo Rodríguez, I. S., Alcántara Quintana, L. E., Algara Suarez, P., Ruiz Cabrera, M. A. & Grajales Lagunes, A. Physicochemical properties, antioxidant capacity, prebiotic activity and anticancer potential in human cells of jackfruit (Artocarpus heterophyllus) seed flour. *Molecules* **26**, (2021).

[3] Butool, S. & Butool, M. Nutritional Quality on Value Addition to Jack Fruit Seed Flour. **4**, 2406–2411 (2015).

[4] Eke- Ejiofor, J., Beleya, E. A., Onyenorah, N. I. The Effect of Processing Methods on the Functional and Compositional Properties of Jackfruit Seed Flour. *Int. J. Nutr. Food Sci.* **3**, 166 (2014).

[5] Waghmare, R. *et al.* Jackfruit seed: An accompaniment to functional foods. *Brazilian J. Food Technol.* **22**, 1–9 (2019).

[6] Zuwariah, I., Noor Fadilah, M. B., Hadijah, H. & Rodhiah, R. Comparison of amino acid and chemical composition of jackfruit seed flour treatment. *Food Res.* **2**, 539–545 (2018).

[7] Kumar, Y., Sharanagat, V. S., Singh, L. & Mani, S. Effect of germination and roasting on the proximate composition, total phenolics, and functional properties of black chickpea (Cicer arietinum). *Legum. Sci.* **2**, 1–7 (2020).

[8] Official Methods of Anal y sis of AOAC IN TER NA TIONAL. *Aoac* (2005).

[9] Ocloo, F., Bansa, D., Boatin, R., Adom, T. & Agbemavor, W. Physico-chemical, functional and pasting characteristics of flour produced from Jackfruits (Artocarpus heterophyllus) seeds. *Agric. Biol. J. North Am.* **1**, 903–908 (2010).

[10] El-Ghorab, A. H., Nauman, M., Anjum, F. M., Hussain, S. & Nadeem, M. A Comparative study on chemical composition and antioxidant activity of ginger (Zingiber officinale) and cumin (Cuminum cyminum). *J. Agric. Food Chem.* **58**, 8231–8237 (2010).

[11] Chakraborty, C., Ray, P. R., Ghatak, P. K. & Bandyopadhyay, A. K. Phenolic Content and Antioxidant Properties of Herbal Sandesh. *Int. J. Curr. Microbiol. Appl. Sci.* **6**, 729–737 (2017).

[12] Adom, K. K., Sorrells, M. E. & Liu, R. H. Phytochemical Profiles and Antioxidant Activity of Wheat Varieties. *J. Agric. Food Chem.* **51**, 7825–7834 (2003).citation-229631430.

[13] Joshi, P. & Varma, K. Effect of germination and dehulling on the nutritive value of soybean Nutrition & Food Science Article information : (2016) doi:10.1108/NFS-10-2015-0123.

[14] Ocloo, F. C. K., Bansa, D. & Adom, T. Physico-chemical , functional and pasting characteristics of flour produced from Jackfruits (Artocarpus heterophyllus) seeds. (2010) doi:10.5251/abjna.2010.1.5.903.908.

[15] Kumar, B. V., Venkata, S. & Vijayendra, N. Trends in dairy and non-dairy probiotic products -a review. (2015) doi:10.1007/s13197-015-1795-2.

[16] Faridah, S. & Aziah, N. Development of reduced calorie chocolate cake with jackfruit seed (Artocarpus heterophyllus Lam .) flour and polydextrose using response surface methodology (RSM). **19**, 515–519 (2012).

[17] Sharma, K. *et al.* Health effects , sources , utilization and safety of tannins : a critical review. *Toxin Rev.* **0**, 1–13 (2019).

[18] Kumar, V., Sinha, A. K., Makkar, H. P. S. & Becker, K. Dietary roles of phytate and phytase in human nutrition : A review. *Food Chem.* **120**, 945–959 (2020).

[19] A Roy Chowdhury1*, A. K. B. and P. C. & 1Department. Study on functional properties of raw and blended Jackfruit seed flour (a non-conventional source) for food application. *Indian J. Nat. Prod. Resour.* **3**, 347–353 (2012).

[20] Butool, S. & Butool, M. Nutritional Quality on Value Addition to Jack Fruit Seed Flour. *Int. J. Sci. Res.* **4**, 2406–2411 (2013).