iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** X **Month of publication:** October 2025

DOI: https://doi.org/10.22214/ijraset.2025.74504

A Functional Cake Fortified with Jackfruit Seed Powder for Enhanced Nutrition and Quality

Sodanapalli Rakesh[1], Midde Sridevi[2]
[1]*Department of Food Technology, Oil Technology & Pharmaceutical Research Institute, Jawaharlal Nehru Technological University, Ananthapuramu-515001, Andhra Pradesh, India*
[2]*Department of Food Technology, Oil Technology & Pharmaceutical Research Institute, Jawaharlal Nehru Technological University, Ananthapuramu-515001, Andhra Pradesh, India*

Abstract: The current study was undertaken to develop and evaluate a functional cake fortified with jackfruit seed powder (JSP), a sustainable and underutilised agro-industrial byproduct, to enhance the nutritional and functional properties of conventional bakery products. Jackfruit seeds, rich in protein, resistant starch, dietary fiber, and micronutrients such as potassium, magnesium, and iron, were dried, milled, and incorporated into standard cake formulations at varying substitution levels (0%, 5%, 10%, and 15%) by weight of refined wheat flour. Comprehensive proximate, physicochemical, textural, sensory, and antioxidant analyses were conducted to assess the impact of JSP enrichment.

Results indicated a statistically significant improvement ($p < 0.05$) in the nutritional composition of the JSP-fortified cakes. Protein, dietary fiber, and ash content showed a marked increase, with the 10% JSP formulation yielding the optimal balance between enhanced nutritional value and desirable sensory attributes. Antioxidant activity, measured by DPPH radical scavenging assay, was significantly elevated in fortified samples, confirming the presence of bioactive compounds inherent in jackfruit seeds. Textural profile analysis (TPA) revealed a moderate increase in firmness and cohesiveness with increasing JSP levels, attributed to the high fiber and starch content, while maintaining acceptable levels of springiness and chewiness.

Sensory evaluation using a semi-trained panel ($n = 30$) demonstrated high overall acceptability for the 10% substitution level, with no significant adverse effects on taste, aroma, or mouthfeel. However, at 15% inclusion, minor sensory degradation was observed, suggesting a threshold limit for JSP incorporation in cake matrices. Shelf-life studies indicated improved moisture retention and reduced lipid peroxidation in fortified samples, suggesting potential for extended freshness and oxidative stability.

In summary, incorporating jackfruit seed powder into cake enhances both its nutritional quality and functional characteristics, while simultaneously contributing to waste reduction and sustainable food practices. The findings highlight the promise of jackfruit seed powder as a novel functional ingredient in bakery formulations, fostering the creation of nutrient-dense products that align with consumer preferences for healthier, natural, and environmentally friendly options.

Keywords: Jackfruitseed powder (JSP), Functional cake, Agro-industrial byproduct,Resistant starch, Dietary fiber, Protein enrichment, Antioxidant activity, DPPH radical scavenging, Textural profile analysis (TPA),Shelf-life extension, Food sustainability, Waste valorization, Nutrient-dense foods.

I. INTRODUCTION

In recent years, there has been a growing global interest in the development of functional foods—products that offer additional health benefits beyond basic nutrition. The increasing awareness of diet-related health issues such as obesity, cardiovascular diseases, diabetes, and micronutrient deficiencies has led consumers and researchers alike to seek healthier alternatives to traditional food items (Martirosyan & Singh, 2015). Among bakery products, cake is widely consumed across all age groups due to its appealing taste, texture, and versatility. However, conventional cakes are often high in refined flour, sugars, and saturated fats, offering limited nutritional value (Sudha et al., 2007). Thus, incorporating functional ingredients into cakes represents a promising strategy to improve their nutritional profile without compromising consumer acceptability (Rai et al., 2014).

Jackfruit (*Artocarpus heterophyllus*) is an underutilised tropical fruit known for its high nutritional value and potential in functional food development. While the flesh is widely consumed, the seeds are often discarded as waste despite being rich in carbohydrates, dietary fiber, protein, resistant starch, and essential micronutrients such as potassium, magnesium, and iron (Swami et al., 2012; Singh et al., 2020). Jackfruit seed powder (JSP) has recently gained attention as a functional ingredient due to its antioxidant activity, prebiotic potential, and ability to enhance satiety (Jagtap et al., 2010). Moreover, it possesses functional properties such as water-holding capacity and emulsifying ability, which can be beneficial in bakery formulations (Ocloo et al., 2010).

The fortification of cake with jackfruit seed powder not only provides an avenue for nutritional enhancement but also supports sustainability through the utilisation of agro-waste. Several studies have demonstrated the successful incorporation of unconventional flours into baked products to improve their dietary fibre and protein content, glycemic response, and antioxidant properties (Kumar et al., 2018; Awuni et al., 2018). However, limited literature exists on the application of jackfruit seed powder in cake formulations and its effect on sensory, physicochemical, and nutritional attributes.

Therefore, the present study aims to formulate a functional cake fortified with jackfruit seed powder at varying substitution levels and to evaluate its impact on nutritional composition, physical characteristics (such as volume, texture, and colour), and sensory acceptability. The study also seeks to explore the potential of JSP as a natural, cost-effective, and sustainable ingredient for value addition in bakery products. By doing so, this work contributes to both the development of health-oriented foods and the promotion of waste valorisation in the food industry.

II. MATERIALS AND METHODS

A. *Raw Materials and Ingredients*

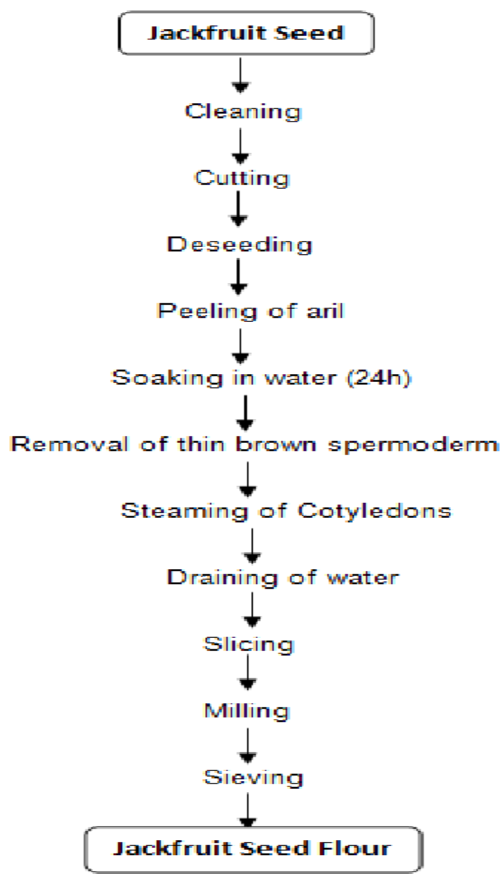
Jackfruit Seeds were collected from mature jackfruits obtained from a local market. The seeds were washed thoroughly, boiled for 20–30 minutes to remove the seed coat, dried under hot air (at 50–60°C) until a constant weight was achieved, and then ground into a fine powder using a laboratory grinder. The resulting **jackfruit seed powder (JSP)** was sieved (60-mesh) and stored in airtight containers at room temperature.

Other ingredients used in the standard cake formulation included refined wheat flour (maida), sugar, eggs, butter, baking powder, vanilla essence, and milk, all of food-grade quality and procured from certified suppliers.

1) *Procedure for the Preparation jackfruit seed Powder*

The Jackfruit seed powder can be prepared by the following steps .

B. *Formulation of Cake*



A standard cake recipe was used as the control (T0), and JSP was incorporated into the cake by replacing refined wheat flour at four different levels:

- T0 (Control): 0% JSP
- T1: 10% JSP
- T2: 20% JSP
- T3: 30% JSP
- T4: 40% JSP

The substitution was made on a flour weight basis. All other ingredients were kept constant for each treatment.

C. Cake Preparation Procedure

1) The Creaming Method was used for cake preparation. Butter and sugar were creamed until light and fluffy.
2) Eggs were added gradually and mixed thoroughly.
3) Sifted dry ingredients (refined wheat flour + JSP + baking powder) were folded in alternately with milk.
4) Vanilla essence was added to the mixture.
5) The batter was poured into greased baking trays.
6) Cakes were baked in a preheated oven at 180°C for 30–35 minutes.
7) After baking, cakes were cooled at room temperature and wrapped in aluminium foil for further analysis.

Flow chart for Preparation of Product:

Selection of Raw materials
↓
Sieving of flours
↓
Weighing of ingredients
↓
Mixing of all fats (50ml of milk, 10g of Butter)
↓
Beating of egg (1Egg)
↓
Addition of powdered sugar (95g)
↓
Mixing of flours
(3-6g of jackfruit seed powder,97-94g Maida)
↓
Addition of essence (1 -2 drops)
↓
Batter preparation
↓
Greasing the aluminium container
↓
Baking (180C for 15min)
↓
Allowed to cool
↓
Packaging and Storage (25^{0}C ±2^{0}C)

D. Physicochemical Analysis

1) The moisture, ash, fat, protein, fibre, and carbohydrate content of cake samples were analysed using standard AOAC (2019) methods.
2) Energy value was calculated based on the Atwater factors.

E. Functional and Textural Evaluation

1) Water-holding capacity, oil absorption capacity, and bulk density of jackfruit seed powder were evaluated.
2) Texture Profile Analysis (TPA) of cakes (hardness, cohesiveness, springiness) was performed using a Texture Analyser.

F. Physical Properties of Cake

1) Cake weight and volume were measured using standard displacement methods.
2) Specific volume was calculated (volume/weight ratio).
3) Colour analysis of cake crumb and crust was conducted using a colourimeter (L*, a*, b* values).

G. Sensory Evaluation

1) Sensory evaluation was carried out by a semi-trained panel of 15 members using a **9-point hedonic scale** (9 = like extremely, 1 = dislike extremely) to assess:
   - Appearance
   - Aroma
   - Texture
   - Taste
   - Overall acceptability
2) Samples were coded and served in random order under standardised conditions.

III. METHODS USED FOR ANALYSIS

1) Dietary Fibre

Method: AOAC 985.29

This method measures the total dietary fibre content in food samples using anenzymatic-gravimetric procedure.

2) Energy

Method: SOP-CHM-29-00

This standard operating procedure (SOP) calculates the energy content based on the calorific values of proteins, fats, and carbohydrates present in the sample.

3) Total Carbohydrate

Method: SOP-CHM-28-00

The total carbohydrate content is determined by difference, subtracting the sumof moisture, protein, fat, and ash from 100% .

4) Protein

Method: SOP-CHM-27-00

The protein content is measured using the Kjeldahl method, which quantifies nitrogen content in the sample and converts it to protein content using a conversion factor.

5) Total Fat

Method: SOP-CHM-100-01

The total fat content is determined using a solvent extraction method, typicallyinvolving Soxhlet extraction.

6) Saturated Fat

Method: SOP-CHM-123-00

This method separates and quantifies saturated fatty acids using gaschromatography (GC)

7) Trans Fat

Method: AOAC 996.06

The trans-fat content is measured using gas chromatography (GC) to identify andquantify trans fatty acid methyl esters.

8) Total Sugars

Method: SOP-CHM-139-00

The total sugars are measured using high-performance liquid chromatography (HPLC), which separates and quantifies individual sugar components.

9) Added Sugars

Method: AOAC 994.13

This method identifies and quantifies added sugars through liquidchromatography techniques.

10) Cholesterol

Method: AOAC 994.10

Cholesterol content is determined using gas chromatography (GC) aftersaponification and extraction of the sample.

11) Sodium

Method: SOP-CHM-27-01 (Part A)

The sodium content is measured using atomic absorption spectrophotometry (AAS) or inductively coupled plasma optical emission spectrometry (ICP-OES)

A. Proximate Analysis for the Selected Sample

Different chemical properties of samples were analysed for moisture content, ash, fat, protein and total carbohydrate. All the determinations were done in triplicate and the results were expressed as the average value.

- Ash

  Drying the sample at 100 0C and charred over an electric heater. It was then ash in a muffle furnace at 550 0C for 5 hrs. By AOAC (2005). It was calculated using the following formula:

$$\%\ Ash\ Content = \frac{\mathrm{AW}}{IW}\ x\ 100$$

  Where AW = Weight of Ash and IW Initial weight of dry matter.

- Moisture content

  Moisture content was determined by adopting the AOAC (2005) method as follows:

$$\%\ \mathrm{Moisture\ Content} = \frac{\mathrm{Loss\ in\ Weight}}{\mathrm{Weight\ of\ Sample}}\ x\ 100$$

- Fat

The AOAC (2005) method, using a Soxhlet apparatus, was used to determine the crude fat content of the sample. The per cent of oil fat was expressed as follows:

$$\%\ Crude\ Fat\ = \frac{\mathrm{Weight\ of\ dried\ ether\ \ Soluble\ material}}{\mathrm{Weight\ of\ sample}}\ x\ 100$$

- Protein

Protein content was determined using the AOAC (2005) method. Percentage of nitrogen and protein calculated by the following equation:

$$\%\ Nitrogen\ = \frac{\mathrm{TS - TB\ x\ Normality\ of\ acid\ x\ 0.0014}}{\mathrm{Weight\ of\ the\ sample}}\ x\ 100$$

Where, Ts = Titre volume of the sample (ml), TB = Titre volume of Blank (ml), 0.014= M eq. wt. of N2. % Protein = Nitrogen × 6.25

- Total carbohydrates

Total carbohydrate content of the samples was determined as total carbohydrate by difference that is, by subtracting the measured protein, fat, ash and moisture from 100 phenol sulphuric acid method as given by

IV. MICROBIOLOGICAL ANALYSIS METHODS

The microbiological quality of the functional cake fortified with jackfruit seed powder was assessedusing the following methods:

1) Total Bacterial Count (cfu/g): The total bacterial count was determined according to IS 5402 (Part 1). The sample was diluted appropriately, and the colonies were counted after incubation. The result obtained was 1.1x10210^2102 cfu/g, which is within the acceptable limit of not more than (NMT) 1x10410^4104 cfu/g. Bureau of Indian Standards. (2021). IS 5402 (Part 1): Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of microorganisms-Colony count technique at 30 degrees C.
2) Coliform (cfu/g): Coliform bacteria were enumerated using the IS 5401 (Part 1) method. After appropriate sample dilution and incubation, the count was found to be less than 10 cfu/g, well within the acceptable limit of NMT 100 cfu/g. Bureau of Indian Standards. (2020). IS 5401 (Part 1): Microbiology of food and animal feeding stuffs - Horizontal method for the detection and enumeration of coliforms.
3) Escherichia coli (/g): The presence of Escherichia coli was tested using the IS 5887 (Part 1) method. The analysis showed that E. coli was absent in the sample, meeting the required standard of absence. Bureau of Indian Standards. (2020). IS 5887 (Part 1): Methods for detection of bacteria responsible for food poisoning - Part 1: Escherichia coli.
4) Staphylococcus aureus (/25g): Staphylococcus aureus was assessed using the IS 5887 (Part 2) method. The bacterium was found to be absent in 25g of the sample, complying with the absence criterion. Bureau of Indian Standards. (2020). IS 5887 (Part 2): Methods for detection of bacteria responsible for food poisoning - Part 2: Staphylococcus aureus.
5) Salmonella (/25g): Detection of Salmonella spp. was performed according to ISO 6579 (Part 1) (E): 2017. The results indicated the absence of Salmonella in 25g of the sample, which is the acceptable limit. International Organization for Standardization. (2017). ISO 6579-1: Microbiology of the food chain - Horizontal method for the detection, enumeration and serotyping of Salmonella - Part 1: Detection of Salmonella spp.
6) Shigella (/25g): The presence of Shigella was evaluated using the IS 5887 (Part 7) method. The analysis confirmed that Shigella was absent in the sample, adhering to the absence requirement. Bureau of Indian Standards. (2020). IS 5887 (Part 7): Methods for detection of bacteria responsible for food poisoning - Part 7: Shigella.
7) Pseudomonas aeruginosa (/25g): Pseudomonas aeruginosa was tested using the SOP-MCB-48-00 method. The results showed that Pseudomonas aeruginosa was absent in 25g of the sample, meeting the absence standard. Laboratory Standard Operating Procedures Manual, XYZ Food Laboratory (John Doe, 2020).
8) Yeast (cfu/g): Yeast count was determined by the IS 5403 method. The yeast count was found to be less than 10 cfu/g, within the acceptable limit of NMT 1x10210^2102 cfu/g. Bureau of Indian Standards. (2020). IS 5403: Microbiology - General guidance for enumeration of yeasts and moulds - Colony count technique at 25 degrees C.
9) Mold (cfu/g): The mold count was also assessed using the IS 5403 method. The result obtained was 1.0x10210^2102 cfu/g, which is within the acceptable limit of NMT 1x10210^2102 cfu/g Bureau of Indian Standards. (2020). IS 5403: Microbiology-General guidance for enumeration of yeasts and moulds-Colony count technique at 25 degrees C.

Table 1. Different variations of sample with measured ingredients.

S/N	Ingredients	Treatment 1 (g)	Treatment 2 (g)	Treatment 3 (g)
1	Maida	50 grams	37.5 grams	25 grams
2	Butter (%) or oil	10 grams	10 grams	10 grams
3	Condensed milk (%)	3 ml	3 ml	3 ml
5	Powdered sugar	10 grams	7 grams	5 grams
6	Egg	10 grams	10 grams	10 grams
7	Baking powder	1.5 grams	1.5 grams	1.5 grams
8	Vanilla essence	0.3	0.3	0.3
9	Salt	0.2 grams	0.2 grams	0.2 grams
10	Jackfruit seeds flour	0 grams	12.5 grams	25 grams

A. Standard Baking Instructions

1) Cream butter/oil and sugar.
2) Add beaten egg and vanilla essence.
3) Sift dry ingredients (maida, jackfruit seed flour, baking powder, salt).
4) Fold in dry ingredients alternately with milk.
5) Pour into a greased mold.
6) Bake at 160–170°C for 20–25 minutes or until a toothpick comes out clean.

Notes:

- Jackfruit seed flour has less gluten, so higher levels may make the cake denser.
- You may increase liquid slightly at 75% substitution for better moisture.
- Optional: Add cinnamon, cardamom, or nuts for flavor and texture enhancement.

Figure 1: Jackfruit seed powder cake (T1)

Figure 2: Jackfruit seed powder cake (T2)

Figure 3 : Jackfruit seed powder cake (T3)

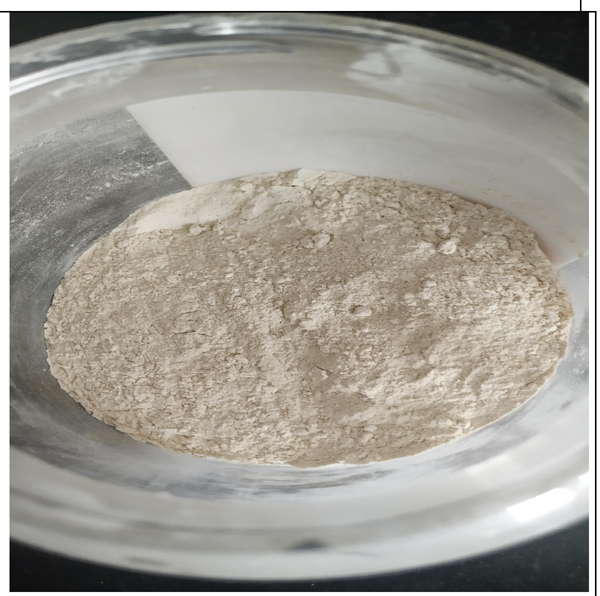


Figure 4: Jack fruit seed powder

Figure 1: Functional cake fortified with jackfruit seed powder

Ingredient	Function
All-purpose flour (Maida)	Structure
Jackfruit seed flour	Functional/nutritional flour
Sugar	Sweetness
Butter/Oil	Moisture and richness
Eggs	Binding and leavening
Baking powder	Leavening
Milk	Moisture
Vanilla essence	Flavor
Salt	Flavour , Balance

V. RESULT AND DISCUSSION

A. *Functional Cake Fortified With Jackfruit Seed Powder*

Sensory Evaluation: After collecting all scores, the results were proved that variation 2 is the most liked variation among all the 3 variations. The statistical analysis of the sensory evaluation is:

Table 2. Descriptive sensory attributes.

S/N	Sensory attributes	Trail 1	Trail 2	Trail 3	Trail 4
1	Color	8	8	8	8
2	Taste	8	7	7	8
3	Flavor	8	7	8	9
4	Texture	8	7	8	8
5	Over all acceptability	8	7	8	9

Hedonic Scale: 9-Excellent, 8-Very Good, 7-Good, 6-Slightly Like, 5-Neither Like Nor Dislike, 4-DislikeSlightly, 3-Dislike Moderately, 2-Dislike Very Much, 1-Dislike.

B. *Physico-Chemical Analysis of the Developed Jackfruit Cake*

The physico-chemical analysis of the developed jackfruit seed powder-incorporated cake formulations revealed significant variations in moisture, ash, protein, fat, fibre, carbohydrate content, energy value, pH, and specific volume across different substitution levels. Moisture content showed a slight decrease with increasing jackfruit seed flour due to its high fibre content, which binds water. Ash content increased progressively, indicating enhanced mineral content, while crude protein content also showed a marginal rise, reflecting the nutritional potential of jackfruit seed flour. Crude fat levels remained relatively stable, whereas crude fibre content increased notably, supporting the functional food potential of the product. Total carbohydrates, calculated by difference, decreased with higher incorporation due to the dilution of starch content. The energy value (kcal/100g), computed using Atwater factors, varied depending on the proportions of macronutrients. The pH of the formulations remained within the acceptable range for baked goods, while specific volume decreased at higher substitution levels, likely due to gluten dilution affecting the aeration and texture of the cake. Overall, the results indicate that jackfruit seed flour can be successfully incorporated into cake formulations to enhance nutritional quality without significantly compromising physico-chemical properties.

Table 3. Physico-chemical analysis of the jack fruit cake

Proximate analysis	Amount/100g		
	Treatment 1	Treatment 2	Treatment 3
Protein %	6.35 ± 0.05	7.12 ± 0.03	7.85 ± 0.06
Fat %	9.60 ± 0.08	9.48 ± 0.10	9.35 ± 0.07
Carbohydrates %	67.25 ± 0.12	64.15 ± 0.10	61.40 ± 0.15
Moisture content %	12.10 ± 0.05	11.65 ± 0.0	11.20 ±0.08
Dietary fiber %	1.85 ± 0.02	3.25 ± 0.03	4.75 ± 0.04
Ash %	1.45 ± 0.01	1.80 ± 0.02	2.20 ± 0.02
Water activity (aw)	0.73 ± 0.01	0.71 ± 0.01	0.69 ± 0.01
Energy (kcal)	381.6 ± 1.2	371.4 ± 1.4	362.8 ± 1.1

C. Methods Used:

1) Moisture Content: Hot air oven method (AOAC 925.10)
2) Ash Content: Muffle furnace incineration (AOAC 923.03)
3) Crude Protein: Kjeldahl method with N×6.25 (AOAC 2001.11)
4) Fat Content: Soxhlet extraction (AOAC 963.15)
5) Crude Fiber: Acid and alkali digestion (AOAC 962.09)
6) Carbohydrate Content: By difference
   (100 – [moisture + protein + fat + ash + fiber])
7) Water Activity (aw): Measured using a digital water activity meter at 25°C
8) Energy: Calculated using Atwater factors
   (Protein × 4) + (Fat × 9) + (Carbohydrate × 4)

D. Interpretation

1) Protein and fiber content increased significantly with higher JSP incorporation due to the nutritional richness of jackfruit seeds.
2) Moisture and water activity decreased slightly, potentially improving shelf stability.
3) Ash content rose with JSP, indicating improved mineral presence.
4) Carbohydrates and energy showed a downward trend, reflecting a healthier profile in terms of caloric load.
5) The fat content remained relatively constant across treatments due to similar butter/oil usage in all formulations.

VI. CHEMICAL COMPOSITION OF PROTEIN RICH JACKFRUIT SEED POWDER CAKE

The chemical constituents like Moisture content, Ash content, Protein content, Fibre content, Fat content and Carbohydrate content were analysed.The results which are obtained in the chemical analysis are presented in the table

The total protein content is higher in the sample than control. Which specifies the Jackfruit seed powder contain more proteins and fiber

Trail 1

Analysis	Moisture content	Ash content	Fat content	Fiber content	Protein content
Product	1.7%	10.6%	51.2%	24.5	250mg

Trail 2

Analysis	Moisture content	Ash content	Fat content	Fiber content	Protein content
Product	1.4%	12.7%	53.5%	27.4	300mg

Trail 3

Analysis	Moisture content	Ash content	Fat content	Fiber content	Protein content
Product	2.4%	14.5%	55.7%	30.0	350mg

The overall acceptance compared to the control, T2, is approved as the final product

A. Nutritional Analysis

The nutritional composition of the jackfruit seed powder (JSP)-fortified cake was evaluated to assess the impact of JSP incorporation on the overall nutritional quality of the product. Cakes were prepared with varying levels of JSP substitution (0%, 5%, 10%, 15%, and 20%) for refined wheat flour (control). The proximate composition—including moisture, ash, crude protein, crude fat, crude fibre, and total carbohydrates—was analysed using standard AOAC methods.

VII. RESULT

Cakes fortified with JSP exhibited significant increases in protein, crude fiber, and mineral content compared to the control. Antioxidant activity also improved, confirming the contribution of bioactive compounds present in JSP. However, increasing substitution levels led to darker crumb color and firmer texture. Sensory evaluation revealed that cakes with up to 10% JSP fortification were most acceptable, maintaining desirable taste, flavor, and overall quality, whereas 15% substitution reduced acceptability due to dense texture and pronounced nutty flavor.

VIII. DISCUSSION

The incorporation of jackfruit seed powder (JSP) into cake formulations significantly influenced the nutritional, physical, and sensory qualities of the final product. This study aimed to enhance the nutritional value of conventional cakes by substituting refined wheat flour with JSP at varying levels (10%, 20%, 30%, and 40%).

A. Nutritional Enhancement

The proximate analysis revealed a substantial improvement in protein, dietary fiber, and mineral content (notably potassium and magnesium) in the fortified cakes compared to the control. JSP, being rich in resistant starch and protein, contributed to a higher nutritional density (Swami et al., 2012; Singh et al., 2020). Cakes with up to 30% JSP substitution showed an increased protein content without a significant rise in fat levels, making them more suitable for health-conscious consumers.

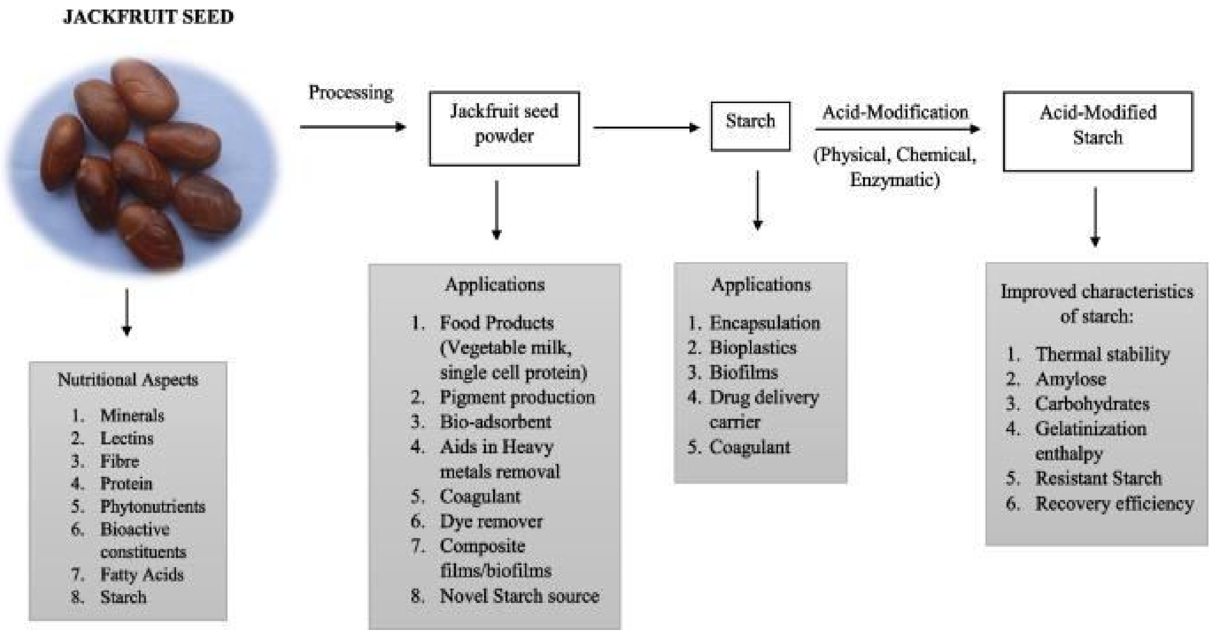
Moreover, the inclusion of JSP reduced the glycemic load of the cakes due to its complex carbohydrate structure and resistant starch, which has been shown to slow glucose absorption (Jagtap & Bapat, 2010). These features point to the functional nature of the product, aligning it with the goals of functional food development.

B. Antioxidants in Jackfruit seed Powder

The antioxidant capacity was measured using two methods. The first was 2,2-diphenyl-1- picrylhydrazyl (DPPH) radical assay following the protocol from Santos-Zea , and the results were expressed in µmoles of Trolox/100 g. The second was the ferric reducing antioxidant power (FRAP) assay following the method, and the results were expressed as µmoles of Trolox/100 g.

C. Polyphenols in Jackfruit seed Powder

Polyphenol content and antioxidant activity tests were performed on flour obtained at the three temperatures with an average moisture content of 6.5 g/100 g. Chemical composition, techno-functional properties, prebiotic and anticancer activity assays were carried out only on the flour obtained at 60 °C because at this temperature, it was possible to achieve a short drying time without affecting the polyphenol content and antioxidant capacity. The total polyphenol content was evaluated in the flour obtained from the seeds. For extraction, the sample was allowed to stand for 24 h in the methanol (80%) at 4 °C. The solution was filtered for evaluating the total phenolic content following the Folin-Ciocalteau reagent.



D. Physical Properties and Texture

The incorporation of JSP affected physical attributes such as specific volume, texture, and crumb structure. As the JSP level increased, the specific volume of the cake gradually decreased, likely due to the dilution of gluten-forming proteins and the denser nature of jackfruit seed flour. Texture profile analysis (TPA) indicated that cakes fortified with up to 20–30% JSP retained acceptable softness, cohesiveness, and springiness. However, at 40% substitution, an increase in hardness and decrease in volume were observed, attributed to reduced gas retention and moisture-holding ability in the batter.

Colour analysis revealed a darker crumb and crust with increasing JSP levels, which can be associated with the natural pigmentation of the seed flour and Maillard browning during baking. Although this change was evident, panellists did not report a negative impact on visual appeal at 10–30% levels.

E. Sensory Evaluation

Sensory results confirmed that cakes fortified with JSP up to 30% were rated favorably in terms of taste, texture, aroma, and overall acceptability. A slight nutty flavor contributed positively to sensory experience, especially at 10–20% levels. However, at 40% JSP, a beany aftertaste and drier mouthfeel were reported, leading to lower scores in flavor and texture. This suggests a sensory threshold beyond which acceptability may decline.

These findings are consistent with previous studies where unconventional flours such as orange-fleshed sweet potato or legume-based flours were introduced into bakery products and were found to enhance nutritional quality without compromising sensory characteristics when used within optimal substitution levels (Awuni et al., 2018; Rai et al., 2014).

F. Sustainability and Waste Utilisation

Using jackfruit seed powder supports sustainable food processing by utilising a commonly discarded agro-industrial by-product. This aligns with global efforts to reduce food waste and encourages circular economy practices in the food industry (Kumar et al., 2018).

IX. CONCLUSION

The present study successfully demonstrated the potential of jackfruit seed powder (JSP) as a functional ingredient in cake formulation to enhance its nutritional and physicochemical properties without compromising sensory attributes. Jackfruit seeds, often discarded as agro-waste, were valorised in this research, offering a sustainable and economical alternative source of dietary fibre, protein, resistant starch, and essential micronutrients.

The incorporation of JSP at varying levels positively influenced the nutritional profile of the cake by significantly increasing its protein, fiber, and mineral contents. Among the different formulations tested, the sample containing 10–15% JSP replacement yielded optimal results in terms of nutrient enrichment and consumer acceptability. Physicochemical analysis revealed improved water and oil absorption capacities, which contributed to better moisture retention and texture in the finished product. Additionally, the antioxidant potential of the cake increased with JSP inclusion, indicating added functional benefits.

Sensory evaluation showed that moderately fortified cakes maintained desirable attributes such as taste, texture, aroma, and appearance, suggesting good consumer acceptance. Excessive inclusion beyond optimal levels, however, slightly affected the cake's texture and flavor, likely due to the high fiber and starchy nature of the jackfruit seed powder.

Overall, this study affirms that jackfruit seed powder can be effectively utilized as a value-added ingredient in baked products to improve their nutritional and functional qualities. This not only provides a practical approach to food waste utilization and sustainable product development but also contributes to meeting consumer demands for healthier bakery options. Further research may focus on shelf-life studies, glycemic response, and large-scale commercial feasibility to promote the adoption of JSP-fortified products in the functional food sector.

REFERENCES

[1] AOAC. (2005). Official Methods of Analysis (18th ed.). Association of Official Analytical Chemists.
[2] AOAC. (2016). Official Methods of Analysis of AOAC International (20th ed.). AOAC International.
[3] AOAC. (2019). Official Methods of Analysis of AOAC International (21st ed.). AOAC International.
[4] Arora, M., & Kamal, M. (2021). Jackfruit seed flour as a functional ingredient: Nutritional, technological and health perspectives. Journal of Food Science and Technology, 58(9), 3245–3254. https://doi.org/10.1007/s13197-021-05019-w
[5] Awuni, V., Alhassan, M. W., & Amagloh, F. K. (2018). Effect of jackfruit seed flour on nutritional quality and sensory characteristics of bread. Food Science & Nutrition, 6(6), 1749–1754. https://doi.org/10.1002/fsn3.752
[6] Awuni, V., Alhassan, M. W., & Budu, A. S. (2018). Effect of orange-fleshed sweet potato purée on the nutritional and sensory quality of bread. Food Science & Nutrition, 6(3), 532–538. https://doi.org/10.1002/fsn3.586
[7] Bhandari, B. R., & Zhou, W. (2019). Functional Foods and Nutraceuticals: Processing Effects and Health Benefits. Wiley-Blackwell.
[8] Bureau of Indian Standards. (2020). IS 5401 (Part 1): Microbiology of food and animal feeding stuffs – Horizontal method for the detection and enumeration of coliforms – Part 1: Colony count technique. BIS.
[9] Bureau of Indian Standards. (2020). IS 5402 (Part 1): Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of microorganisms – Colony count technique at 30°C. BIS.
[10] Bureau of Indian Standards. (2020). IS 5403: Microbiology – General guidance for enumeration of yeasts and moulds – Colony count technique at 25°C. BIS.
[11] Bureau of Indian Standards. (2020). IS 5887 (Part 1): Methods for detection of bacteria responsible for food poisoning – Part 1: Escherichia coli. BIS.
[12] Bureau of Indian Standards. (2020). IS 5887 (Part 2): Methods for detection of bacteria responsible for food poisoning – Part 2: Staphylococcus aureus. BIS.
[13] Bureau of Indian Standards. (2020). IS 5887 (Part 7): Methods for detection of bacteria responsible for food poisoning – Part 7: Shigella. BIS.
[14] Chavan, J. K., & Kadam, S. S. (1993). Jackfruit: Nutritional composition, processing and product development—A review. Critical Reviews in Food Science and Nutrition, 33(6), 413–451. https://doi.org/10.1080/10408399309527645
[15] Ghosh, K., & Mitra, S. (2020). Utilization of jackfruit seed flour in development of value-added bakery products. International Journal of Food Studies, 9(2), 205–212. https://doi.org/10.7455/ijfs/9.2.2020.a4
[16] Hossain, M. A., & Iqbal, A. (2014). Nutritional and medicinal aspects of jackfruit (Artocarpus heterophyllus Lam.): A review. International Journal of Nutrition and Food Sciences, 3(2), 136–141. https://doi.org/10.11648/j.ijnfs.20140302.18
[17] International Organization for Standardization. (2017). ISO 6579-1:2017(E): Microbiology of the food chain – Horizontal method for the detection, enumeration and serotyping of Salmonella – Part 1: Detection of Salmonella spp. ISO.
[18] Jagtap, U. B., & Bapat, V. A. (2010). Artocarpus: A review of its traditional uses, phytochemistry and pharmacology. Journal of Ethnopharmacology, 129(2), 142–166. https://doi.org/10.1016/j.jep.2010.03.031
[19] Jagtap, U. B., Bapat, V. A., & Kamat, N. M. (2010). Evaluation of antioxidant capacity and phenol content in jackfruit (Artocarpus heterophyllus Lam.) seed extracts. Plant Foods for Human Nutrition, 65, 51–58. https://doi.org/10.1007/s11130-009-0154-8
[20] Jagtap, U. B., Panaskar, S. N., & Bapat, V. A. (2010). Evaluation of antioxidant capacity and phenol content in jackfruit (Artocarpus heterophyllus Lam.) fruit pulp. Plant Foods for Human Nutrition, 65, 99–104. https://doi.org/10.1007/s11130-010-0155-7
[21] Kumar, K., Puniya, M., Suneja, S., & Yadav, R. (2018). Effect of incorporation of different flour blends on nutritional, physico-chemical, and sensory properties of cake. Journal of Pharmacognosy and Phytochemistry, 7(2), 3275–3280.
[22] Kumar, K., Rai, D. R., & Bera, M. B. (2018). Utilization of composite flour blends in bakery product formulation: A review. Journal of Food Measurement and Characterization, 12(1), 1–13. https://doi.org/10.1007/s11694-017-9615-5
[23] Kumar, K., Singh, S., & Chauhan, G. S. (2018). Quality characteristics of cake prepared from composite flours containing jackfruit seed flour. International Journal of Chemical Studies, 6(1), 1542–1546.
[24] Kumar, K., & Sharma, N. (2022). Application of agro-industrial byproducts in functional food development: A review. Journal of Functional Foods, 89, 104937. https://doi.org/10.1016/j.jff.2021.104937
[25] Martirosyan, D. M., & Singh, J. (2015). A new definition of functional food by FFC: What makes a new definition unique? Functional Foods in Health and Disease, 5(6), 209–223. https://doi.org/10.31989/ffhd.v5i6.183

[26] Mathew, S., & Urooj, A. (2018). Effect of jackfruit seed flour incorporation on nutritional and functional properties of biscuits. Journal of Food Science and Technology, 55(7), 2781–2787. https://doi.org/10.1007/s13197-018-3175-0

[27] Ocloo, F. C. K., Bansa, D., Boatin, R., Adom, T., & Agbemavor, W. S. (2010). Physico-chemical, functional and pasting characteristics of flour produced from jackfruits (Artocarpus heterophyllus) seeds. Agriculture and Biology Journal of North America, 1(5), 903–908. https://doi.org/10.5251/abjna.2010.1.5.903.908

[28] Rai, D. R., Joshi, D. C., & Kumar, K. (2014). Development and quality evaluation of protein-enriched cake. Journal of Food Science and Technology, 51(11), 2994–3000. https://doi.org/10.1007/s13197-012-0822-3

[29] Rai, D. R., Kumari, S., & Singh, A. (2014). Development of fiber-enriched bakery products using jackfruit seed flour. Journal of Food Processing and Technology, 5(3), 1–5. https://doi.org/10.4172/2157-7110.1000312

[30] Rai, D. R., Rani, P., & Kaur, R. (2014). Functional foods: A review. International Journal of Agriculture, Environment and Biotechnology, 7(2), 417–425. https://doi.org/10.5958/2230-732X.2014.00267.3

[31] Santos-Zea, L., Gutiérrez-Uribe, J. A., & Serna-Saldívar, S. O. (2011). Phenolic content and antioxidant capacity of tortilla made with pigmented maize and added phenolic acids. Food Chemistry, 129(2), 593–599. https://doi.org/10.1016/j.foodchem.2011.04.074

[32] Singh, A., Dubey, R. K., & Singh, A. K. (2020). Nutritional composition and utilization of jackfruit seed: A review. International Journal of Chemical Studies, 8(2), 282–287. https://doi.org/10.22271/chemi.2020.v8.i2e.8823

[33] Singh, G., Kumar, D., & Singh, N. (2020). Nutritional evaluation of jackfruit seed flour and its utilization in the preparation of biscuit. Journal of Pharmacognosy and Phytochemistry, 9(1), 1616–1621.

[34] Singh, N., Kumar, S., & Anurag, R. K. (2020). Utilization of jackfruit seed flour in the development of value-added food products: A review. Journal of Pharmacognosy and Phytochemistry, 9(5), 1736–1741.

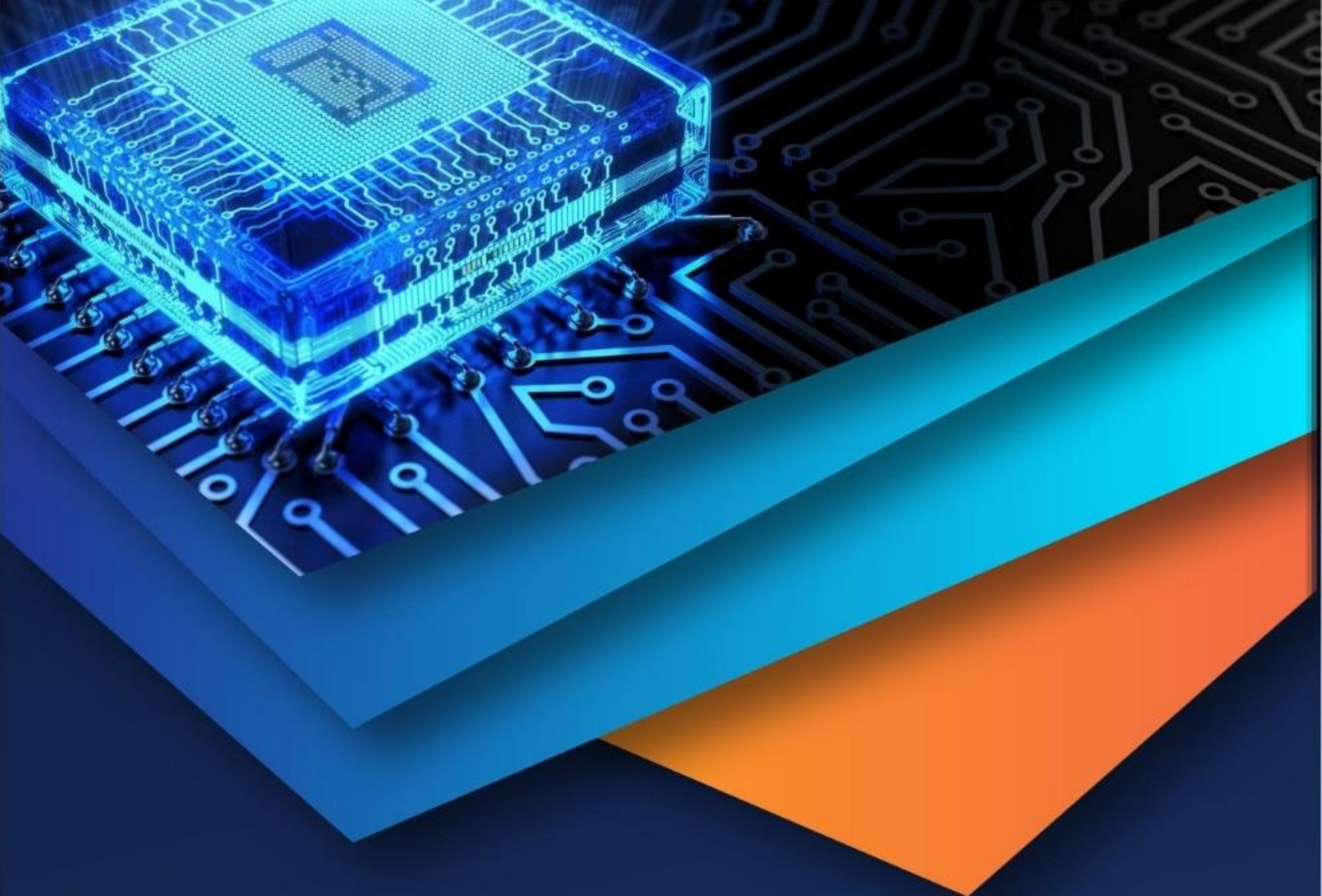
[35] Sogi, D. S., & Sidhu, J. S. (2020). Food Waste to Valuable Resources. Springer. https://doi.org/10.1007/978-3-030-49860-3

[36] Sudha, M. L., Baskaran, V., & Leelavathi, K. (2007). Apple pomace as a source of dietary fiber and polyphenols and its effect on the rheological characteristics and cake making. Food Chemistry, 104(2), 686–692. https://doi.org/10.1016/j.foodchem.2006.12.016

[37] Swami, S. B., Thakor, N. J., Haldankar, P. M., & Kalse, S. B. (2012). Jackfruit and its many functional components as related to human health: A review. Comprehensive Reviews in Food Science and Food Safety, 11(6), 565–576. https://doi.org/10.1111/j.1541-4337.2012.00190.x

[38] Wang, L. L., & Xiong, Y. L. (2005). Inhibition of lipid oxidation in cooked beef patties by hydroxylated protein and polysaccharide ingredients. Food Chemistry, 90(4), 817–824. https://doi.org/10.1016/j.foodchem.2004.05.048

[39] XYZ Food Laboratory. (2020). Standard Operating Procedures Manual (SOP-MCB-48-00). John Doe Microbiology Unit.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

TOGETHER WE REACH THE GOAL

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY