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Development and quality evaluation of pumpkin seed-based nutri spread fortified with sweet potato and jackfruit seed flour

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Abstract
The present study was carried out with the objective of developing and standardizing a functional Nutri spread using pumpkin seed powder, jackfruit seed flour and biofortified sweet potato flour as main ingredients along with honey, sunflower oil and cinnamon powder. Different formulations were prepared by changing the quantities of jackfruit seed flour (0-20 g) and biofortified sweet potato flour (0-20 g) while maintaining pumpkin seed powder at 40 g. Treatment T_3 (40g pumpkin seed+15g jackfruit seed flour+15g biofortified sweet potato flour) was found to be the most acceptable formulation as per sensory evaluation using a nine-point hedonic scale and subjected to nutritional, microbial and shelf-life analysis. T_3 recorded the highest total mean sensory score of 8.78 with superior appearance, colour, flavor, taste and spreadability. Nutritional analysis showed that the optimized spread had a good nutritional value with carbohydrate (31.86 g/100), protein (9.13 g/100), fat (27.20 g/100) and moisture (28.70%), along with with good amounts of dietary fiber, minerals and carotenoids from the biofortified and underutilized ingredients used. These findings suggested the possibility of utilizing these underutilized nutrient dense ingredients in preparing a nutritious, consumer acceptable and shelf stable functional spread with potential as a value-added food product.

Keywords: Nutri spread, pumpkin seed, jackfruit seed flour, biofortified sweet potato, Bhu Krishna variety, functional food

Introduction
In recent years Nutri spreads have taken a good position in the functional food arena due to their unique combination of daily convenience, substantial nutritional benefits and wide acceptance among consumers. This growing interest is in the context of ongoing malnutrition, widespread micronutrient deficiencies and an increasing burden of lifestyle-related disorders, all of which have increased the demand for nutrient-dense foods from underutilized plant sources. Of such sources, pumpkin seeds are notable for their impressive profile of proteins, unsaturated fatty acids, minerals, and antioxidants, which have made them valuable functional ingredients (Patel & Rauf, 2017) [19]. However, the seeds of jackfruit, usually thrown away as waste in processing, have high levels of carbohydrates, dietary fiber, proteins and bioactive compounds with real health benefits (Ranasinghe *et al.,* 2019) [20]. According to Dotto & Chacha (2020) [26], pumpkin seed incorporation in food products enhances nutritional quality and antioxidant properties, while Brahma and Ray (2023) [5] showed that jackfruit seed flour can be effectively integrated into value-added functional food formulations.
Biofortified sweet potato (Bhu Krishna) has also emerged as a promising ingredient in the development of functional foods. It has the proven antioxidant activity and is rich in carbohydrates, carotenoids, anthocyanins, vitamins and minerals, making it a strong candidate for improving the nutritional quality of food products. And also, sweet potato-based ingredients improve the functional and sensory characteristics of developed foods due to their natural pigments and bioactive compounds. (Alam, 2021) [3]. According to Granato *et al.,* (2020) [12] Increasing consumer preference for plant-based, health-oriented, and sustainable food products has further encouraged the incorporation of nutrient-dense ingredients into ready-to-eat formulations. Honey, sunflower oil, and cinnamon powder were included as complementary ingredients to improve sweetness, spreadability, flavor complexity, and oxidative stability, while also contributing their own functional properties including antimicrobial, antioxidant, and anti-inflammatory activities (Mandal and Mandal, 2011; Song *et al.,* 2023) [15, 24].
Therefore, the present study aimed to develop and evaluate a nutritionally enriched Nutri spread using pumpkin seed powder, jackfruit seed flour, and biofortified sweet potato flour. And also, to assess its sensory, nutritional, microbiological, and shelf-life quality to determine its potential as a functional, acceptable, and shelf-stable functional food product for health-conscious consumers.

Material and Method
Materials and Chemicals
Jackfruit seeds and Biofortified sweet potato tubers of the Bhu Krishna variety were procured from Krishi Vigyan Kendra, Mele Pattambi, Palakkad. Pumpkin seed, Honey, cinnamon powder, and sunflower oil were obtained from a reliable commercial supplier. Food-grade preservatives — potassium sorbate (E202) and sodium benzoate (E211) — were purchased from a local market. All chemicals and reagents used in the nutritional analyses were of analytical grade.

Method
Raw Materials
Jackfruit seeds were processed following the method described by Ocloo *et al.* (2010) with minor modifications,

Jackfruit seeds were washed to remove impurities. Peels were removed manually and sliced into thin pieces. They were subjected to drying in hot air oven at 60°C for 6-10 hours until moisture was below 10%. The dried slices were lightly roasted and pulverized into flour, sieved and then stored in airtight containers.

Fresh, mature, and disease-free Bhu Krishna biofortified sweet potato tubers were selected and washed thoroughly to remove adhering soil and impurities. The tubers were manually peeled, sliced into thin pieces, and dried in a hot air oven at 55–60°C until the moisture content was reduced below 10%. The dried slices were grounded into flour and sieved, then stored in airtight containers under cool and dry conditions to preserve nutritional quality and stability (Ahmed *et al.,* 2010) [1].

The preparation method of Nutri Spread was carried out with slight modifications from previously reported seed spread formulations (Rohini *et al.,* 2022; Chien & Pascall, 2021) [7, 21]. Pumpkin seeds were roasted for 5–6 minutes. The roasted seeds were ground into a fine powder, then Jackfruit seed flour and biofortified sweet potato flour were incorporated according to the respective formulation ratios (Table1). Constant amount of honey (25g), sunflower oil (8g), cinnamon powder (1g) and 5 ml of water were added to the blended mixture, and the entire blend was homogenized thoroughly until a spreadable consistency was obtained. Approved preservatives — potassium sorbate and sodium benzoate — were dissolved in the water portion and added during mixing. The final Nutri spread was packed into sterilized airtight glass containers and stored under refrigerated conditions (4°C) for further evaluation.

Table 1: Ingredient composition of the six Nutri spread formulations (per batch)

Ingredients	T_0 (Control)	T_1	T_2	T_3	T_4	T_5
Pumpkin seed (g)	40	40	40	40	40	40
Jackfruit seed flour (g)	–	25	20	15	10	5
Sweet potato flour (g)	–	5	10	15	20	25
Honey (g)	25	25	25	25	25	25
Sunflower oil (g)	8	8	8	8	8	8

Sensory Evaluation

Sensory evaluation of developed nutri spread samples was evaluated by using a 9- point hedonic scale with 15 semi trained panelists. Product was evaluated on the basis of spreadability, color, taste, flavor, appearance and overall acceptability. Scores ranged from 9 indicated 'like extremely' and 1 indicated 'dislike extremely'.

Nutritional Analysis

Proximate Analysis

Moisture content is commonly determined by hot air oven drying method according to (AOAC 2023) [4]. About 2g of sample weighed and dried in hot air oven at 105℃ until constant weight is obtained, and the loss in weight was recorded as moisture percentage.

The carbohydrate content was determined by the Fehling's titration method following acid hydrolysis of the sample with dilute hydrochloric acid under reflux conditions following procedure described by (AOAC 2023) [4].

Protein content was determined by Kjeldahl method (AOAC 2023) [4] in which nitrogen content obtained after digestion, distillation, and titration was multiplied by a factor of 6.25.

Total Fat content was obtained by Soxhlet extraction method (AOAC 2023) [4]. The sample was extracted with petroleum ether.

Crude fiber was determined by acid and alkali digestion method followed by gravimetric analysis as described by (AOAC 2023) [4].

Energy value of the samples was calculated using Atwater conversion factors: protein and carbohydrate at 4 Kcal/g, fat at 9Kcal/g.

Mineral Analysis

Calcium content was determined by EDTA titrimetric method using murexide indicator according to the method of (AOAC,2023) [4].

Iron content was by 1,10-phenanthroline calorimetric method using spectrophotometric measurement at 510 nm following the method (AOAC,2023) [4].

Bioactive Compound Analysis

Carotenoid content was determined by acetone and petroleum ether extraction followed by spectrophotometric analysis at 450 nm as described by Nagata and Yamashita (1992) [17].

Microbial Analysis

Microbiological quality of the Nutri spread optimized (T_3) was evaluated during production in order to ensure that the food product is safe for consumption. TPC analysis was carried out using the pour plate technique in which PCA media was used and incubated at 37°C for 24 hours. Coliforms were detected using MacConkey agar and incubated at 37°C for 24 hours. Yeast and molds were counted using PDA, which was incubated at room temperature for 3-5 days. The results obtained were reported in CFU/g and were compared with permissible limits set by the FSSAI for ready-to-eat foods.

Shelf-Life Study

Sensory quality changes over time were observed by storing the optimized Nutri spread (T_3) refrigerated at 4 °C and conducting sensory analysis on day 0, 15, 30, 45, and 60. Fifteen semi-trained panelists tasted the product and scored the product for the six sensory properties using a nine-point hedonic scale at 15-day intervals for sixty days. Appearance, colour, taste, flavor, spreadability, and overall liking were scored and summed to obtain the total average score.

Result

Sensory Evaluation of Nutri Spread Formulations

The sensory evaluation for the six Nutri Spread formulations was variable as to appearance, colour, taste, flavor, spreadability, and acceptability. T_3 had the highest average score (8.78) of all formulations and was thus considered to have superior sensory attributes and a higher level of acceptance by consumers. There was progressive increase in sensory scores from T_0 to T_3 and declining in T_4 and T_5 indicating that increasing use of sweet potato flour negatively affected sensory qualities.

Table 2: Mean sensory scores of the six Nutri spread formulations (nine-point hedonic scale)

Treat-ment	Appearance	Colour	Taste	Flavor	Spread-ability	Overall Accept-ability	Total Mean Score
T_0	7.4	7.5	7.4	7.3	7.6	7.4	7.43
T_1	7.7	7.8	7.6	7.5	7.9	7.7	7.70
T_2	8.2	8.3	8.1	8.0	8.4	8.2	8.20
T_3	8.8	8.9	8.7	8.6	8.9	8.8	8.78
T_4	7.1	7.0	6.9	6.8	7.2	7.0	7.00
T_5	6.5	6.4	6.3	6.2	6.5	6.3	6.37

Nutritional Composition of the Optimized Nutri Spread (T3)

The nutrient content of the optimized Nutri spread formulation (T_3) is given in Table 3. The formulated food product showed a total energy content of 408.76 kcal/100 g containing 31.86 g/100 g carbohydrates, 9.13 g/100 g proteins, 27.2% fats, 4.975% crude fiber, and 28.7% moisture. The minerals and phytochemical contents were found to be 221.64 mg/100 g of calcium, 3.10 mg/100 g iron, and 4.6 mg/g of carotenoids.

Table 3: Nutritional composition of the optimized Nutri spread formulation (T3)

Nutrient / Parameter	Value
Moisture (%)	28.7 (%)
Carbohydrates (g/100 g)	31.86 (g/100 g)
Protein (g/100 g)	9.13 (g/100 g)
Total Fat (%)	27.2 (%)
Crude Fiber (%)	4.975 (%)
Calcium (mg/100)	221.64 (mg/100)
Carotenoid (mg/g)	4.6 (mg/g)
Iron (mg/100)	3.10 (mg/100g)
Energy (kcal/100 g)	408.76 (kcal/100 g)

Microbial Analysis

The microbial analysis of selected Nutri spread treatment (T_3) during storage was given in the Table 5. The total plate count observed was $3x10^3$ CFU/g. Yeast, mold and coliform counts were not detected.

Table 4: Microbial analysis of the optimized Nutri spread (T3)

SI No	Microbial Parameter	Observed Value	FSSAI Safe Limit
1	Total Plate Count	3×10^3 CFU/g	≤10,000 CFU/g
2	Yeast and Mould	0 CFU/g	≤100 CFU/g
3	Coliform	0 CFU/g	≤10 CFU/g

Shelf-Life Study

Table 5. shows the variations in sensory qualities of the Nutri spread (T_3) after 60 days of refrigeration storage period. Overall, the mean value decreased from 8.78 at day 0 to 8.38 at day 60. No sensory attribute score was lower than 8.2 for the entire 60 days, which shows that the sensory quality was high throughout the storage period.

Table 5: Changes in sensory quality of the Nutri spread (T3) during 60 days of refrigerated storage

Sensory Attribute	Day 0	Day 15	Day 30	Day 45	Day 60
Appearance	8.8	8.7	8.6	8.5	8.4
Colour	8.9	8.8	8.7	8.6	8.5
Taste	8.7	8.6	8.5	8.4	8.3
Flavor	8.6	8.5	8.4	8.3	8.2
Spreadability	8.9	8.8	8.7	8.6	8.5
Overall Acceptability	8.8	8.7	8.6	8.5	8.4
Total Mean Score	8.78	8.68	8.58	8.48	8.38

Discussion

The sensory results clearly revealed that the balanced ratio of 1:1, jackfruit seed flour and sweet potato flour (T_3, 15 g each) was the most acceptable in all attributes. The high water and oil absorption capacity and gel-forming starch of jackfruit seed flour led to a smooth, spreadable texture (Akter & Haque, 2018; Kaur *et al.,* 2024) [2]. Bhu Krishna sweet potato flour improved colour, mouthfeel and natural sweetness — qualities strongly associated with consumer preference in spread-type products. Similar results have been reported by Demir Özer *et al.* (2022) [9]. They reported that optimized ingredient composition of pumpkin seed spread formulations resulted in better sensory and textural scores.

Sensory scores decreased from T_4 onwards as the amount of sweet potato flour exceeded 15 g producing a denser and coarser spread due to the higher starch to fat ratios. This agrees with Mohammed *et al.,* (2024) [16] who reported that incorporation of excess flour in jackfruit seed-based products reduced the acceptability through adverse textural changes. Higher levels of sweet potato flour also increased the earthy, starchy notes at the expense of the preferred nutty-sweet flavour of T_3 as is generally observed in flour dominant spread systems (Spada *et al.,* 2018) [25].

From a nutritional point of view, T_3 is a real functional food. The protein content of the stems (9.13 g/100 g) is from pumpkin seeds (14–40% protein with a well-balanced amino acid profile of arginine, glutamic acid and leucine (Hadidi *et al.,* 2025; Xie *et al.,* 2025) [13, 27]. It has a fat content of 27.2% and is rich in linoleic and oleic acids that have cardioprotective benefits and increase the bioavailability of carotenoids (Hadidi *et al.,* 2025) [13]. The most distinct nutritional feature is its carotenoid content of 4.6 mg/g, which is derived mainly from biofortified sweet potato flour, which is known worldwide for its provision of meaningful amounts of provitamin A and antioxidant phytochemicals (Severo *et al.,* 2021; Neela & Fanta, 2019; De Moura *et al.,* 2015) [8, 18]. The dietary fat in the same matrix further enhances carotenoid bioavailability during digestion.

The presence of calcium of 221.64 mg/100g (about 22% of adult Recommended Dietary Intake) and iron of 3.10 mg/100g is a result of synergistic interaction between minerals present in all three flours used in the recipe (Hadidi *et al.,* 2025; El-Adawy & Taha, 2001) [10, 13]. Hence, this formulation will be especially valuable in regions where dairy products are not available.

Microbiological analysis resulted in the identification of a total count of 3×10^3 CFU/g without any yeasts, moulds or coliform bacteria, which can be explained by strong antimicrobial properties of honey (Mandal & Mandal, 2011) [15] and cinnamon (Burt, 2004) [6]. During more than two months of refrigerated storage, there was only a slight decrease in sensory quality attributed to fat oxidation, starch retrogradation, and volatilization of volatile aromatics, but

even after 60 days, the mean sensory score was equal to 8.38, significantly exceeding the limit of acceptability and proving good shelf-life potential in line with the results obtained by Demir Özer *et al.* (2022) [9] for seed spreads.

Conclusion

This study has resulted in the successful development of a nutritionally enriched, acceptable in sensory attributes, and shelf-stable functional Nutrispread made from pumpkin seed powder, jackfruit seed flour, and biofortified Bhu Krishna sweet potato flour. In terms of sensory evaluation among all formulations, T_3 (40 g of pumpkin seed powder, 15 g of jackfruit seed flour, 15 g of sweet potato flour added with honey, sunflower oil, cinnamon, and permitted preservatives) was found to be the optimum formulation as it received the highest sensory score of 8.78. T_3 has also proved to have an excellent nutritional profile with protein content of 9.13 g/100g, carotenoids of 4.6 mg/g, calcium of 221.64 mg/100 g, and iron of 3.10 mg/100 g. Microbial analysis results confirm the safety of the product by not showing any presence of yeast, mould, or coliforms; the sensory qualities were also acceptable during the 60 days of storage period at refrigerated conditions, with a mean sensory score of 8.38 on the 60th day. The total production cost was estimated at Rs. 175.00/100g, which makes the formulation economically viable.

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