Development of Value-added Food Recipes with Mixed Seeds and Quality Evaluation

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Abstract

The present study aimed to develop and evaluate value-added mixed seed chikki as a nutrient-dense functional snack using combinations of amaranth, sunflower, flaxseed, sesame, pumpkin, halim (garden cress), and muskmelon seeds with jaggery and date syrup. Four formulations (P1, P2, P3, and P4) were standardized and evaluated for sensory acceptability using a 9-point hedonic scale. Based on the sensory scores, the most acceptable formulation was selected for nutritional analysis and storage stability studies. Nutrient composition was estimated using the Indian Food Composition Tables (IFCT, 2020), while calcium and iron contents were determined by titrimetric and Wong's methods, respectively. Storage stability was assessed through periodic sensory evaluation. Statistical analysis was performed using one-way ANOVA, independent t-test, and chi-square test to determine significant differences among formulations and during storage. The developed mixed seed chikki exhibited good sensory acceptability and was found to be rich in energy, protein, healthy fats, calcium, and iron. The selected formulation maintained acceptable sensory quality throughout the storage period with only minor changes. Significant differences ($p \leq 0.05$) were observed in selected sensory attributes among the formulations and during storage. The findings suggest that mixed seed chikki can serve as a nutritious, acceptable, and affordable functional snack for adolescents and young adults. Incorporation of multiple nutrient-rich seeds provides an effective strategy for enhancing the nutritional quality of traditional snack foods and promoting healthier dietary practices.

Key Words: Mixed seed chikki, Functional food, Value-added product, Sensory evaluation, Nutritional analysis, Shelf-life stability, Food product development.

Introduction

The increasing prevalence of lifestyle-related disorders and micronutrient deficiencies has created a growing demand for functional foods that provide health benefits beyond basic nutrition. Rising consumer awareness regarding healthy dietary practices has encouraged the development of value-added food products prepared from natural ingredients. Functional foods enriched with bioactive components have been reported to improve nutritional status and reduce the risk of chronic diseases (Granato *et al.*, 2020).

Edible seeds are recognized as nutrient-dense food ingredients because they are rich sources of high-quality protein, dietary fibre, essential fatty acids, vitamins, minerals, and antioxidant compounds. Seeds such as amaranth, sunflower, flaxseed, brown sesame, halim (garden cress), pumpkin, watermelon, and muskmelon contribute significantly to nutritional adequacy and support growth, immune function, bone health, and the prevention of micronutrient deficiencies. Their incorporation into commonly consumed foods is therefore considered an effective strategy for improving dietary quality (Chandrasekar *et al*., 2021; Goyal *et al.*, 2014).

Traditional Indian snack foods provide an excellent platform for nutritional enrichment due to their affordability, cultural acceptance, and widespread consumption. Chikki, a popular traditional confectionery prepared mainly from jaggery and roasted nuts or seeds, possesses desirable sensory characteristics, good shelf stability, and ease of preparation. Incorporation of multiple nutrient-rich seeds into chikki offers the opportunity to enhance its nutritional quality while retaining consumer acceptability, thereby transforming a traditional snack into a functional food (Jain *et al.*, 2017).

Food product development involves the systematic process of ideation, formulation, processing, commercialization, and sensory evaluation to produce products that satisfy consumer expectations while meeting nutritional requirements (Gilbert *et al*., 2021). Sensory evaluation plays a crucial role in this process because it determines consumer acceptance based on appearance, colour, flavour, texture, taste, aroma, and overall acceptability. Scientific sensory analysis provides valuable information for product standardization and quality improvement (Capillas *et al*., 2021).

Previous investigations have demonstrated the nutritional benefits of incorporating edible seeds into traditional food products. Yadav *et al.*, (2019) developed fortified chikki using sesame seeds, flaxseed, ragi flour, and jaggery and reported improved nutritional quality with good sensory acceptability. Pingale *et al.*, (2019) observed that amaranth-based chikki possessed high consumer acceptability and maintained satisfactory sensory quality during storage. Similarly, Mala *et al*., (2016) reported that incorporation of pumpkin seeds and flaxseed enhanced the nutritional composition and storage stability of chikki. These studies indicate that seed-enriched traditional foods can serve as nutritious and acceptable functional snack products.

Despite the nutritional potential of edible seeds, limited information is available on the development of mixed seed chikki prepared using different combinations of amaranth, sunflower, flaxseed, brown sesame, halim, pumpkin, watermelon, and muskmelon seeds. Furthermore, studies evaluating sensory acceptability, nutritional composition, laboratory estimation of iron and calcium, and storage stability of such products are limited.

Therefore, the present study was undertaken to develop value-added mixed seed chikki using different combinations of nutrient-rich edible seeds with jaggery and date syrup. The developed formulations were evaluated for sensory acceptability using a nine-point hedonic scale, nutritional composition, iron and calcium content, and storage stability. The study aimed to identify the most acceptable formulation and to develop a nutrient-dense functional snack suitable for adolescents and young adults.

Objectives of the Study

- Develop mixed seeds chikki products using- Amaranth, Flaxseeds, Sunflower seeds, Pumpkin seeds, Melon seeds, Halim seeds (Garden cress) and Brown Sesame seeds with jaggery and dates syrup in different seed combinations (P1, P2, P3, P4)
- To evaluate the sensory acceptability (9- point hedonic scale), nutritional composition (IFCT & Lab methods- Wong's method for iron estimation and titrimetric method for estimation of calcium) and shelf-life stability of most acceptable mixed seeds chikki product
- Development of nutrient dense functional chikki
- Identification of most acceptable seed combination, statistical significance in sensory scores, and potential as functional snack for the age group of 13-30yrs.

Methodology of the Study

<u>Study Design</u>

The present experimental study was carried out in the Department of Nutrition, Sarojini Naidu Vanita Mahavidyalaya, Hyderabad, Telangana, India, to develop and evaluate value-added mixed seed chikki as a nutrient-dense functional snack. The study involved product development, sensory evaluation, nutritional analysis, laboratory estimation of iron and calcium, and storage stability assessment.

<u>Raw Materials</u>

The raw materials used in the study included amaranth seeds, sunflower seeds, flaxseeds, brown sesame seeds, halim (garden cress) seeds, pumpkin seeds, watermelon seeds, muskmelon seeds, jaggery, date syrup, and ghee. All ingredients were procured from the local market in Hyderabad and were of good quality.

<u>Product Development</u>

Four formulations of mixed seed chikki were developed using different combinations of edible seeds:

- P1 (ASC): Amaranth and sunflower seed chikki.
- P2 (FSeC): Flaxseed and brown sesame seed chikki.
- P3 (HPC): Halim (garden cress) and pumpkin seed chikki.
- P4 (WMC): Watermelon and muskmelon seed chikki.

Each formulation consisted of 30 g of each seed (60 g total), 30 g jaggery, 10 mL date syrup, and 1 mL ghee. The seeds were cleaned and roasted separately over a low flame to enhance flavour and improve shelf life. Jaggery was heated until the hard-ball stage, after which date syrup was added. The roasted seeds were mixed thoroughly with the jaggery syrup, spread uniformly on a greased tray, flattened to a uniform thickness, allowed to cool at room temperature, and cut into equal-sized pieces.

Sensory Evaluation

The four formulations were evaluated for sensory quality using a 9-point Hedonic Scale by a panel of semi-trained judges. The sensory attributes assessed included appearance, colour, texture, flavour, taste, and overall acceptability. The formulation with the highest overall acceptability was selected for further nutritional analysis and storage studies.

Nutritional and Laboratory Analysis

The nutrient composition of the selected formulation was calculated using the Indian Food Composition Tables (IFCT, 2020). Energy, protein, fat, carbohydrate, iron, and calcium contents were estimated. Calcium content was determined by the titrimetric method, while iron estimation was carried out using Wong's method following standard laboratory procedures.

Storage Stability

The selected formulation was packed in airtight polyethylene pouches and stored under ambient conditions. Sensory evaluation was conducted at regular intervals during the storage period to assess changes in appearance, color, texture, flavour, taste, and overall acceptability.

Statistical Analysis

The data obtained from sensory evaluation and storage studies were analysed using appropriate statistical methods. Mean and standard deviation were calculated for all observations. One-way Analysis of Variance (ANOVA) was used to compare sensory scores among the four formulations. Independent sample t-test was employed to compare selected quality parameters, and the Chi-square test was used to evaluate changes in sensory attributes during storage. A p-value of ≤ 0.05 was considered statistically significant.

Results and discussion

1. Sensory Evaluation of Developed Mixed Seed Chikki Formulations

Four formulations of mixed seed chikki, namely ASC (Amaranth–Sunflower Chikki), FSeC (Flaxseed–Brown Sesame Chikki), HPC (Halim–Pumpkin Chikki), and WMC (Watermelon–Muskmelon Chikki), were developed and evaluated for sensory attributes including appearance/colour, flavour/aroma, texture/feel, taste/aftertaste, and overall acceptability using a 9-point Hedonic Scale.

Among the four formulations, ASC recorded the highest overall acceptability score (8.6 ± 0.73), followed by FSeC (8.4 ± 0.99), WMC (8.2 ± 0.95), and HPC (8.1 ± 1.18). All formulations received mean sensory scores above 8.0, indicating excellent consumer acceptability. The superior acceptability of ASC may be attributed to the balanced combination of amaranth and sunflower seeds, which imparted desirable flavour, crisp texture, and overall palatability. Similar findings were reported by Yadav et al., (2019) and Pingale *et al.*, (2019).

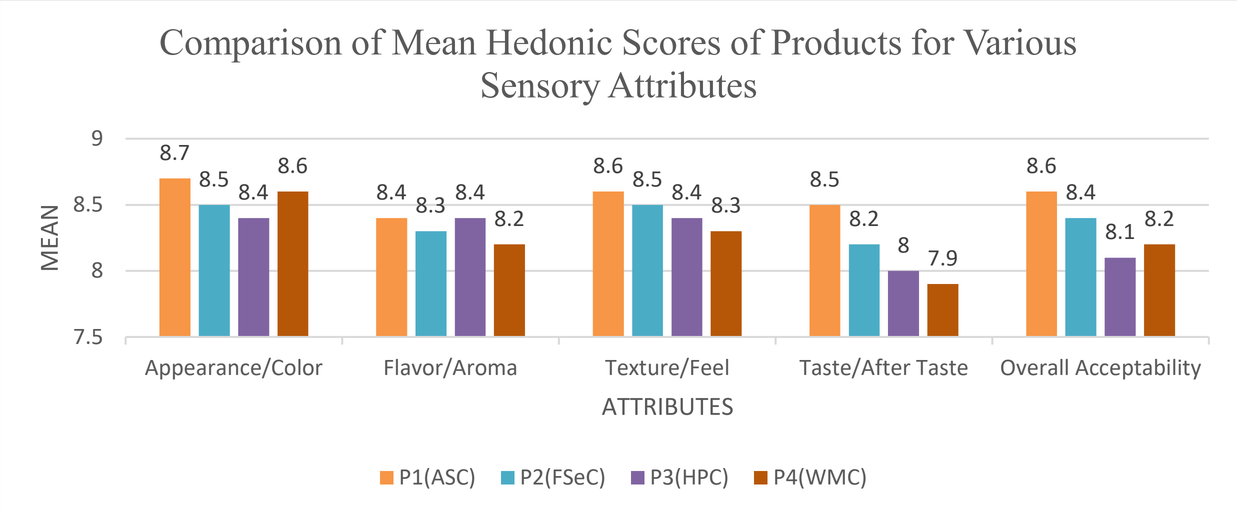

Figure 1: Comparison of mean sensory scores of products for various sensory attributes

2. Shelf-life Evaluation of the Most Acceptable Product (ASC)

Based on the sensory evaluation, ASC was selected for storage stability studies because it obtained the highest overall acceptability score. The product was stored under ambient conditions and evaluated weekly for four weeks using the 9-point Hedonic Scale.

The highest mean scores for appearance/colour were observed during Week 1 and Week 3 (8.8), whereas the lowest scores were recorded during Week 2 and Week 4 (8.6). Flavour/aroma decreased from 8.8 during Week 1 to 8.0 during Week 3, while Week 2 and Week 4 recorded similar scores of 8.4. Texture/feel showed the highest score during Week 1 (8.6) and the lowest during Week 3 (7.6). Taste/aftertaste decreased from 8.7 in Week 1 to 7.8 in Week 3, whereas Week 2 and Week 4 recorded scores of 8.1 and 8.2, respectively. Overall acceptability remained high throughout storage, ranging from 8.8 during Week 1 to 8.1 during Week 3.

Although a gradual decline in sensory scores was observed during storage due to moisture absorption and minor oxidative changes, the product remained within acceptable sensory limits throughout the four-week storage period, indicating satisfactory shelf stability. Similar observations were reported by Shakuntala *et al.*, (2016).

Table 1: Mean ± SD Sensory Scores of Most Acceptable Product (ASC) During Storage Period

Attributes	WEEK 1	WEEK 2	WEEK 3	WEEK 4
Appearance/Color	8.8±0.33	8.6±0.57	8.8±0.42	8.6±0.52
Flavor/Aroma	8.8±0.46	8.4±0.70	8.0±1.09	8.4±0.71
Texture/Feel	8.6±0.47	8.0±1.02	7.6±1.25	8.0±1.16
Taste/After Taste	8.7±0.45	8.1±0.74	7.8±0.98	8.2±0.86
Overall acceptability	8.8±0.38	8.4±0.64	8.1±0.99	8.4±0.75

3. Proximate Composition of the Most Acceptable Product (ASC)

The proximate composition of the selected formulation (ASC) was determined by laboratory analysis and compared with the calculated values obtained from the Indian Food Composition Tables (IFCT, 2020).

The calculated moisture content was 8.2 g/100 g, whereas the analysed moisture content was 7.0 g/100 g. Similarly, the calculated ash content was 2.7 g/100 g, while the analysed value was 1.0 g/100 g. The lower analysed moisture content may be attributed to moisture loss during roasting and processing, which contributes to improved shelf stability. The variation observed in ash content may be due to differences in ingredient composition, processing conditions, and analytical procedures. Similar findings were reported by Yadav *et al*., (2019).

Table 2: Calculated and Analyzed Proximate Composition (%g/100g) of Most Acceptable Product (ASC)

Proximate components	Calculated values (IFCT, 2020)	Analysed values
Moisture(%)	8.2	7
Ash(%)	2.7	1

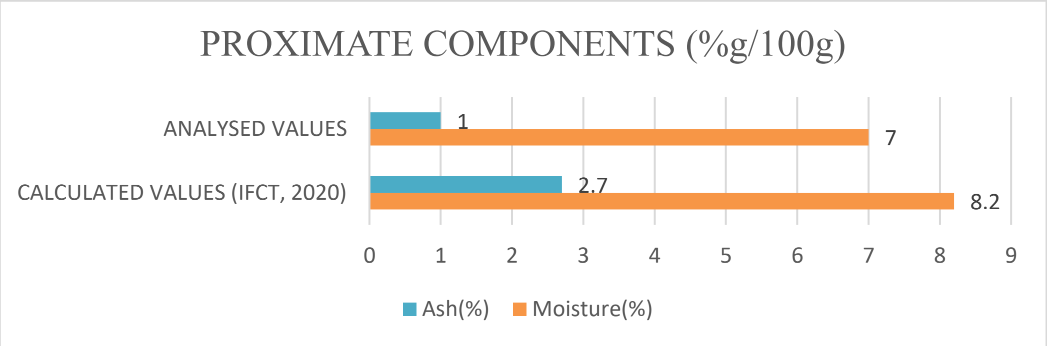

Figure 2: Comparison of Calculated and Analyzed Moisture and Ash Content (%g/100g) of Most Acceptable Product

4. Mineral Analysis of the Most Acceptable Product (ASC)

The analysed calcium content (506.5 mg/100 g) was considerably higher than the calculated value (140.11 mg/100 g), whereas the analysed iron content (5.5 mg/100 g) was slightly lower than the calculated value (6.04 mg/100 g). The variation may be attributed to processing conditions and differences between food composition table values and laboratory estimation methods.

A 10 g serving of ASC provided approximately 50.65 mg of calcium and 0.5 mg of iron, indicating that the product can contribute to daily mineral intake and serve as a nutritious supplementary snack for adolescents and young adults.

Table 3: Calculated and Analyzed Mineral Content (mg/100g) of Most Acceptable Product (ASC)

Mineral components	Calculated values (IFCT, 2020)	Analysed values
Iron(mg)	6.04	5.5
Calcium(mg)	140.11	506.5

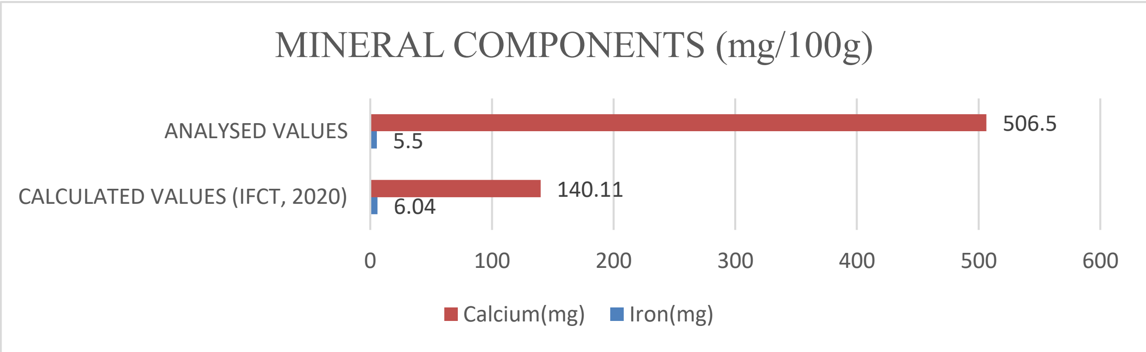

Figure 3: Comparison of Calculated and Analyzed Calcium and Iron Content (mg/100g) of Most Acceptable Product

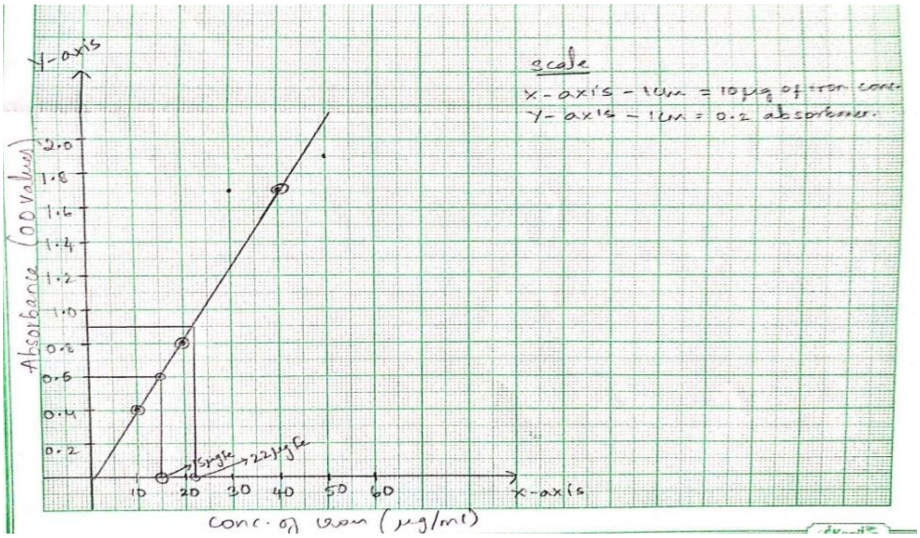

Figure 4: Standard Graph for the Estimation of Iron (mg/100g) content by Wong's Method (1928) in Most Acceptable Product

Figure 5: Estimation of Calcium (mg/100g) Content by titrimetric method (1960) in Most Acceptable Product (ASC)

5. Statistical Analysis

5.1 T-test Analysis

The t-test revealed significant differences in flavour/aroma, taste/aftertaste, and overall acceptability, whereas appearance/colour and texture/feel did not differ significantly among the four formulations.

Table 4: t-test Analysis of Sensory Attributes of Developed Product Formulations

	Appearance/ color	Flavor/aroma	Texture/feel	Taste/After taste	Overall acceptability
Product Formulation	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**	**Mean±SD**
ASC	8.7 ± 0.88^{ns}	8.4±1.11*	8.6 ± 0.99^{ns}	8.5±0.96*	8.6±0.73*
FSeC	8.5 ± 0.90^{ns}	8.3±1.05*	8.5 ± 0.94^{ns}	8.2±1.14*	8.4±0.99*
HPC	8.4 ± 0.96^{ns}	8.4±0.88*	8.4 ± 0.88^{ns}	8.0±1.17*	8.1±1.18*
WMC	8.6 ± 0.57^{ns}	8.2±0.94*	8.3 ± 0.85^{ns}	7.9±1.25*	8.2±0.95*

$t_{0.05}$ = t-table value at 5% level of significance

*= Significant difference

Ns = No significant difference

5.2 Paired t-test Analysis

Pairwise comparison showed significant differences between ASC and HPC and between ASC and WMC, while the remaining comparisons were not statistically significant.

Table-5: Pairwise Comparison of Overall Acceptability Scores of Developed Chikki Formulations

Comparison	Mean±SD	
ASC vs FSeC	8.6 ± 0.73^{ns}	8.4 ± 0.99^{ns}
ASC vs HPC	8.6±0.73*	8.1±1.18*
ASC vs WMC	8.6±0.73*	8.2±0.95*
FSeC vs HPC	8.4 ± 0.99^{ns}	8.1 ± 1.18^{ns}
FSeC vs WMC	8.4 ± 0.99^{ns}	8.2 ± 0.95^{ns}
HPC vs WMC	8.1 ± 1.18^{ns}	8.2 ± 0.95^{ns}

$t_{0.05}$ = t-table value at 5% level of significance

*= Significant difference

^{ns} = No significant difference

5.3 One-way ANOVA

One-way ANOVA indicated no significant difference in overall acceptability among the four formulations (F = 0.41; $p > 0.05$), suggesting that all developed products were well accepted by the sensory panel.

Table-6: Comparison of Overall Acceptability of Developed Chikki Formulations Using One-way ANOVA

Source of Variation	Sum of Squares SS	Degrees of freedom DF	Mean Sum of Squares MS	F-value	$F_{0.05}(2.60)$
Between groups	1.2	3	0.4	0.41	No Significant difference

Within groups	227.4	236	0.96		
Total	228.6	239			

$F_{0.05}$ = F-table value at 5% level of significance

5.4 Chi-square Analysis

Chi-square analysis demonstrated no significant change in appearance during storage (p = 0.23). However, flavour, overall acceptability, texture, and taste showed significant changes over the storage period. Despite these changes, the product remained acceptable throughout four weeks of storage.

Table-13: Evaluation of Sensory Changes During Storage of ASC Using Chi-square Test

Sensory Attributes	χ^2 value	DF	p-value
Appearance	7.99^{ns}	6	0.23
Flavor	23.53*	12	0.02
Texture	36.16*	15	0.001
Taste	27.33*	9	0.001
Overall acceptability	25.51*	12	0.021

*= Significant difference

^{ns} = No significant difference

$p \leq 0.05$ indicates statistical significance

Community Relevance and Nutritional Significance

The developed mixed seed chikki formulations exhibited good sensory acceptability and appreciable nutritional quality. Incorporation of nutrient-rich edible seeds improved the energy, protein, and mineral content of the products. Among the developed formulations, ASC demonstrated superior overall acceptability and nutritional value. The product may serve as a convenient, affordable, and nutrient-dense supplementary snack for adolescents and young adults. Furthermore, utilization of locally available edible seeds in traditional snack products may encourage healthier food choices, improve dietary diversity, and promote the consumption of functional foods within the community.

Conclusion

The present study successfully developed four value-added mixed seed chikki formulations using combinations of amaranth, sunflower, flaxseed, brown sesame, halim (garden cress), pumpkin, watermelon, and muskmelon seeds. Sensory evaluation revealed that all formulations were highly acceptable, with the Amaranth–Sunflower Chikki (ASC) receiving the highest overall acceptability score. Nutritional analysis demonstrated that the selected formulation was a good source of energy, protein, iron, and calcium. Laboratory estimation confirmed appreciable mineral content, indicating its potential as a nutrient-dense supplementary snack.

Storage studies showed that the product remained organoleptically acceptable for four weeks under ambient conditions, although slight changes in sensory attributes were observed during storage. Statistical analysis further supported the acceptability and quality of the developed products.

The findings suggest that mixed seed chikki prepared using locally available edible seeds can serve as an affordable, convenient, and nutritious functional food for adolescents and young adults. Incorporation of such value-added traditional foods into the daily diet may contribute to improved nutrient intake and promote healthier food choices. Further studies involving a larger consumer population and detailed biochemical evaluation are recommended to establish the long-term nutritional benefits of the developed product.

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