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Development And Evaluation Of Nutribite Crackers Using Lotus Root (Nelumbium Nelumbo)

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ABSTRACT

With increasing nutritional awareness among consumers, the value addition of snacks is gaining importance. The development and availability of value-added, nutridense snacks encourage consumers to make healthy snack choices. Value-added and nutridense snacks consumed by school-going children can contribute to a significant source of energy and nutrients. Lotus root is a less utilized vegetable containing various nutrients. It is a rich source of polyphenols, antioxidants, and dietary fiber. Lotus root is a versatile, culinary delicacy that can be cooked in different ways by stir-frying, boiling, braising, steaming, or deep-frying. This investigation was undertaken to develop a value-added, nutritious Nutribite Crackers, crispy textured and attractive lotus root-based snack for all age groups, especially preschool and school children. Regular maize flour-based crackers were prepared and standardized as a control sample (MFC). Nutribite Crackers in three different variations (V-1, V-2, and V-3) were prepared using a combination of Lotus root, Maize flour, Wheat flour, Bajra flour, and Jowar flour. The developed crackers (Control: MFC and Variations: V-1, V-2, and V-3) were subjected to sensory evaluation, using a 9-point hedonic rating scale, to study the acceptability by 50 semi-trained panelists. Sensory evaluation results revealed that Nutribite Crackers prepared using Wheat flour, Maize flour, and Lotus root (V-1) were found to be most acceptable with total mean score of (52.02) out of (54), followed by (V-2) prepared using Jowar flour with a total mean score of (49.92) out of (54), then followed by (V-3) prepared using Bajra flour with total mean score of (47.84) out of (54). 100 g of best-rated Nutribite Crackers (V-1) has 545.85 kcal, 4.93 % crude protein, 20.37 % crude fat, 69.80 % carbohydrate, 1621.00 mg/kg potassium, 380.78 mg/kg calcium and 46.77 mg/kg iron. Control and all three variations showed a shelf life of more than 30 days under normal storage conditions. Lotus root incorporated Nutribite crackers (V-1) developed and standardized in this investigation serve as an ideal snack with several health-promoting nutrients for consumers.

Key words: Lotus root, Wheat flour, Maize flour, Healthy snack, Value addition, Nutridense.

Introduction

The most popular snack foods nowadays include fruit, cookies, chips, ice cream, sweets, popcorn, soft drinks, crackers, cake, milk, nuts and seeds, tea, yogurt, etc. Snacks have been connected to several diet quality factors, such as weight gain, weight maintenance, and diet quality. Healthy snacks help manage an individual's hunger and boost nutrition. Snacks can keep individuals from getting so hungry that they get cranky. Snacks may help prevent overeating at meals. And for picky eaters of all ages, snacks are a chance to add more nutrients to their diets. (1)

Lotus root is an unfamiliar vegetable in Karnataka and is known as Kamal Kakdi, or lotus stem, it has played a significant role in many Asian cuisines. Lotus root is referred

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to as Renkon in Japanese. Lotus root can be eaten raw or cooked in a variety of ways, such as boiling, braising, or stir-frying. Paste of lotus root can be used in dessert recipes. Lotus root have been used to make some of the tastiest foods, from pickles to curries to fries. Even though lotus only grows in dirty ponds, which prevents many people from benefiting from this exceptionally healthy vegetable, it is still extremely beneficial and safe to consume. As the name implies, lotus root is the root of the aquatic lotus plant. Before use, the root is removed, cleaned, and washed. This root vegetable, which has a squash-like form, is peeled and requires careful cleaning to ensure that no mud gets lodged between its pores.

This root vegetable has a distinct flavour due to its unusually woody and crunchy texture. Lotus root dishes can be made in a variety of ways according to cuisine. Lotus root is tossed with a variety of spices in Japanese and other oriental cuisines, whilst in Indian homes; lotus root is cooked in the shape of curries or pickles. Fresh lotus root has a mild sweet taste and a starchy and crunchy texture, making it a suitable addition to stir-fry dishes.

Vitamins and minerals such as vitamin B6, vitamin C, thiamine, pantothenic acid, zinc, potassium, phosphorus, copper, iron, and manganese are abundant in lotus root. The addition of lotus root to the diet is thought to considerably lower bad cholesterol levels and the risk of cardiovascular illnesses because it is low in calories. Healthy dietary fibers aid in better digestion, ease conditions like constipation, and finally aid in weight loss. [(2)] Table 1 shows the nutritional composition of lotus root.

Table 1: Nutritional Composition of Lotus Root (100 g). Source: Indian Food Composition Table Book, 2017. [(3)]

Nutrient	Content (per 100 g)
Energy	79.35 (kcal)
Protein	1.94 g
Fat	0.93 g
Carbohydrates	14.67 g
Fiber	4.70 g
Calcium	37.71 mg
Iron	3.34 mg
Vitamin C	26.63 mg
Folic acid	26.49 µg
Potassium	611 mg
Sodium	20.63 mg

Lotus root is a wonderful vasodilator because it contains potassium, which lowers the levels of harmful cholesterol in the blood. Additionally, it decreases the risk of heart attacks and keeps arteries from being blocked. The lotus root contains pyridoxine, which aids in controlling blood homocysteine levels and protects the heart. [(5)] Allergies, infections, and fungal illnesses, including ringworm, smallpox, and leprosy, can be avoided by including lotus root in the diet. The leaves of this plant are also used to treat excessive perspiration, clotting issues, nosebleeds, and blood in the urine. Lotus root is a healthy source of antioxidants and can both prevent and treat several diseases due to the presence of vitamin C. [(2)] Lotus root has been used medicinally in Japan for centuries. Japanese eat meals that contain powdered lotus root. The lotus root slices are added as a garnish to soups, stews, and salads to enhance the flavour of meals, or deep frying them for a crunchy healthy snack.

Millets contain particular bioactive substances with antioxidant, DNA-protective, anti-diabetic, anti-inflammatory, and other health-enhancing characteristics. [(4)] Millets are a good source of vitamin B, magnesium, antioxidants, manganese, phosphorus, and iron. Millets are good sources of essential amino acids except for lysine and threonine but are relatively high in sulfur-containing amino acids methionine and cysteine. [(5)]

Certain characteristics of sorghum or jowar make it suitable for consumption by those with chronic illnesses. Each sorghum nutrient has a distinct nutritional role and may help prevent or manage certain lifestyle diseases and disorders, including cancer, celiac disease, obesity, diabetes, coronary heart disease, and oxidative stress. Except for vitamin B12, sorghum is an excellent source of B vitamins and minerals.

Pearl millet has various health benefits given its high mineral and protein content. Pearl millet has the highest protein content. It contains a variety of important minerals, including zinc, phosphorus, and magnesium. Moreover, it includes vitamins and essential amino acids, which promote its therapeutic properties. It benefits in bone growth, development, and repair, helps with heart health and diabetes, helps in healing stomach ulcers, helps prevent gall stones, etc. [(6)] The low glycaemic index of pearl millet makes it an effective alternative meal for managing weight and lowering the risk of chronic illnesses like diabetes. [(7)] [(8)]

The rhizome of lotus has good nutrient profile, medicinal and functional properties. It has a good scope for use as food supplements to improve human health and wide usage in the food Industry.[(9)]

Thus, this study aims to develop and evaluate Nutribite Crackers using lotus root for all age groups, especially preschool, and school children.

Methodology

Study Design

Figure 1 shows the steps of development of Nutribite Crackers using lotus root.

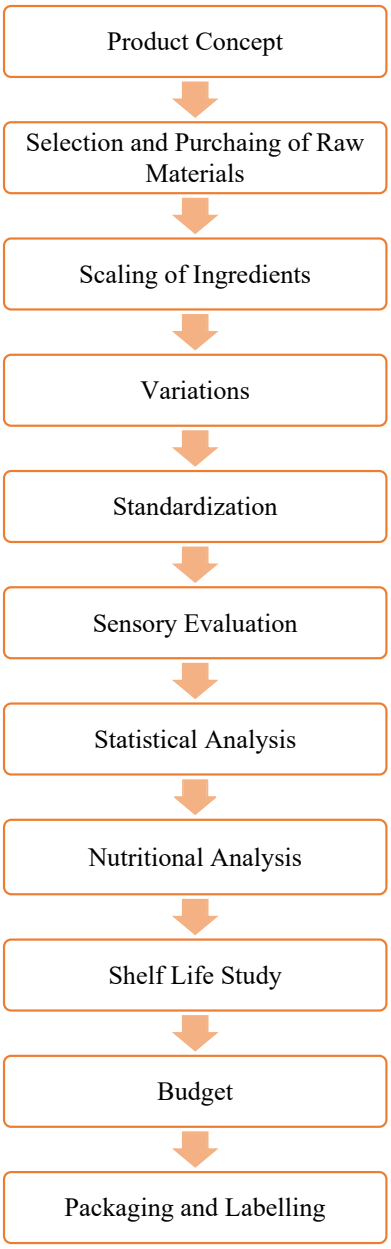

Fig. 1: Steps of Development of Nutribite Crackers Using Lotus Root.

Selection and Purchasing of Raw Ingredients

Nutribite Crackers can be consumed by individuals throughout their lifespan right from growing children, adolescents, pregnant and lactating women, adults, and geriatric, as it is a healthy snack option it also provides proteins, fiber, and potassium. It is also easy to carry and will be accepted by individuals of all age groups. High-quality ingredients were purchased from the Shoppy Mart PFC branch, except for lotus root, which was ordered online through the Dunzo application. The selected ingredients were of good quality.

Development of Nutribite Crackers

Control and three different versions of Nutribite Crackers were developed, each incorporating different ingredient ratios. These variations aimed to optimize taste, focusing on producing a flavorful product ideal for all age groups.

Development and Standardization of different variations of Nutribite Crackers using lotus root

Three different versions of Nutribite Crackers (V-1, V-2, and V-3) were developed and standardized to maintain consistent flavor. Each variation was carefully designed with unique combinations of flours to provide a variety of sensory experiences for sensory evaluation.

Fig. 2: Different variations (V-1, V-2, and V-3) of Nutribite Crackers using lotus root.

Sensory evaluation of different variations of Nutribite Crackers (V-1, V-2, and V-3)

Nutribite Crackers were evaluated by 50 semi-trained panelists using 9 - a point hedonic scale to assess the sensory qualities of the Nutribite Crackers control and variations (V-1, V-2, and V-3) including taste, colour, texture, and flavour, as well as the overall acceptability.

Statistical analysis

Sensory evaluation results were entered and examined using EXCEL Microsoft to compare the mean scores for appearance, colour, texture, flavour, taste, odour, and overall acceptability. Mean, standard deviation (SD), and One-way ANOVA tests were conducted to identify any significant difference between the variations.

Nutritional analysis

The nutritional analysis of standardized Nutribite Crackers was determined by conducting proximate analysis in which Protein % of the snack was obtained through IS1155: 1968 test method, Fat % of the snack was obtained through IS1155: 1968 / 4333 (2): 2022 test method, Carbohydrate % was obtained by using IS 1656 - 2007 test method, Energy in kcals was obtained by Mullan (2008) method, Potassium and Calcium estimation were carried out using AOAC 985.01 (3.2.06) test method, and Iron estimation was carried out using AOAC 953.01 (3.2.01). These tests were performed in MFPI - quality control laboratory, Hyderabad.

Packaging

A stand-up pouch was selected for packaging Nutribite Crackers which is a type of flexible packaging designed to stand upright on its bottom, allowing for convenient use, storage, and display. It comes with a resealable zip lock at the top, allowing for easy opening and closing, which helps keep the contents fresh for longer periods. This type of paper bag is a popular choice for eco-friendly packaging commonly used for storing dry foods such as nuts and crackers, or beverages like ready-to-go juices. Its ability to protect products from moisture, odor, and other environmental factors makes it highly suitable for various applications. Stand-up pouches can be easily customized with printed designs, labels, or stickers, allowing brands to showcase their logo and product information effectively.

Shelf life study

The best way to determine a food's shelf life is through a shelf life study. This approach reveals how long the food will remain nutritious, enjoyable, and safe up to the end of its shelf life.

Budget

The budget for developing Nutribite Crackers was determined by considering the wholesale prices of ingredients obtained from various wholesale stores. Cost calculations included all expenses associated with ingredient purchasing, equipment usage, packaging materials, and any additional costs incurred during the study.

Result and Discussion

Development and standardization of different variations of Nutribite Crackers using lotus root

The development and standardization process for Nutribite Crackers required careful ingredient selection and precise preparation techniques. High-quality ingredients were blended in exact proportions to craft delicious and nutritious crackers. Table 2 displays the ingredients and their respective percentages for the different variations of Nutribite Crackers.

Table 2: Composition of control and different variations of lotus root-based crackers (V-1, V-2, And V-3) in %.

Ingredients	Quantity (%)			
	Control	Variation (1)	Variation (2)	Variation (3)
Lotus root (paste)	-	33	33	33
Maize flour	72	40	40	40
Wheat flour	16.5	10.5	-	-
Bajra flour	-	-	10.5	-
Jowar flour	-	-	-	10.5
Oil	10	10	10	10
Salt	1.5	1.5	1.5	1.5
Dried herbs	-	5	5	5
Total	100	100	100	100

Figure 2 shows the method of preparation of Nutribite Crackers using lotus root.

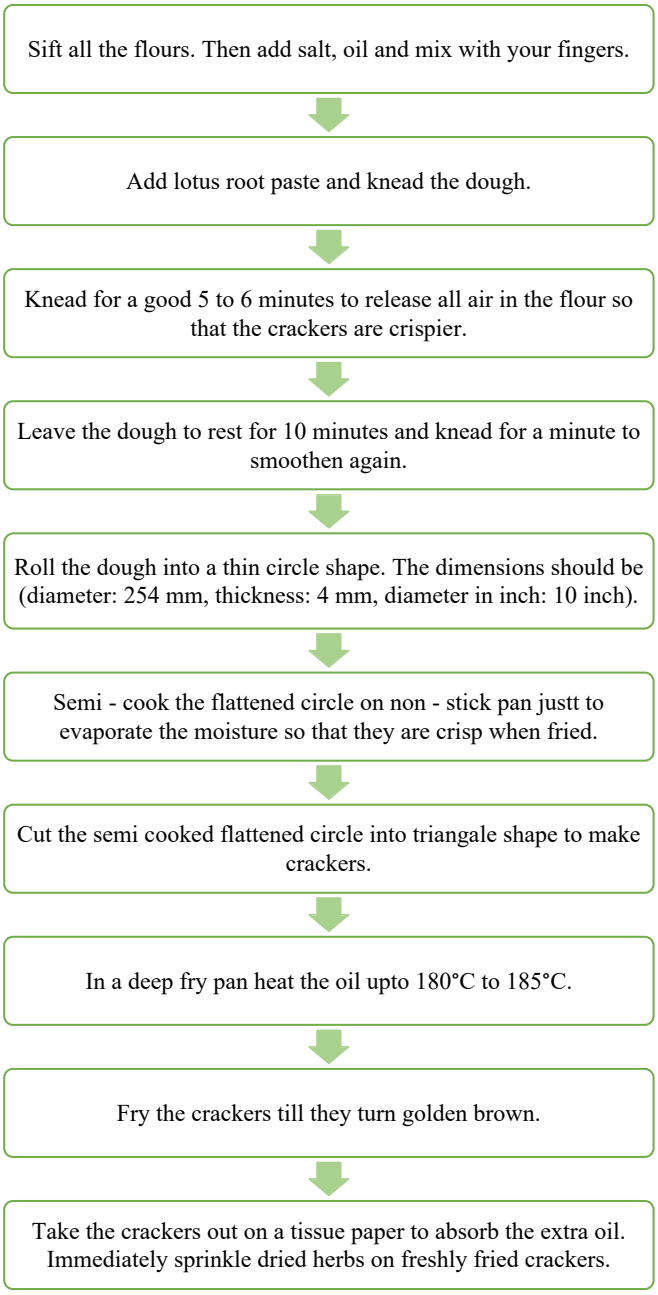

Fig 2: Preparation method of different variations of Nutribite Crackers using lotus root.

Statistical analysis of sensory evaluation

Mean and Standard Deviation (SD)

The sensory evaluation results of Nutribite Crackers variations (V-1, V-2, and V-3) were compared to the control, as shown in Table 3. The overall mean scores of Nutribite Crackers ranged from 7.98 to 8.7, indicating that all variations fell within the category of "liked extremely to like very much". Variation (V-1) of Nutribite Crackers obtained the highest scores in all sensory characteristics: Appearance (8.64 ± 0.63), Colour (8.6 ± 0.61), Texture (8.7 ± 0.54), Flavor (8.68 ± 0.65), and Taste (8.7 ± 0.65). The overall acceptability score of Variation (V-1) was 8.7 ± 0.58, compared to the control (8.02 ± 1.25), V-2 (7.98 ± 1.19), and V-3 (8.34 ± 1.14). However, the other variations were also found to be acceptable. Table 3 shows the mean and standard deviation scores of different variations of Nutribite Crackers (V-1, V-2, and V-3).

Analysis of Variance (ANOVA) and Post-Hoc Comparison

There is a significant difference in the mean panelist responses on the appearance with respect to the different variations of components with F = 5.354, P = .001. A post hoc comparison was performed to find among which pair of variations the mean difference exists. A least significance difference (LSD) post hoc test was used showing a significant mean difference between Basic and Variation 1 (P-value = .0031), Variation 1 and Variation 2 (P - value = 0.0037), and Variation 2 and Variation 3 (P - value = 0.120) with respect to appearance. Variation 1 had a significantly higher mean score of 8.64 ($p<.005$) with respect to appearance.

At a 5% level of significance, there is a significant difference in the mean panelist responses on the colour with respect to the different variations of components with F = 4.663, P - value = 0.003. (LSD) post hoc test showed a significant mean difference between Basic and Variation 1 (P - value = 0.437), Variation 1 and Variation 2 (P - value = 0.002), and Variation 2 and Variation 3 (P - value = 0.099) with respect to colour. Variation 1 had a significantly higher mean score of 8.6 ($p<0.05$) with respect to colour. There was no significant difference with respect to texture among the variations ($p> 0.05$).

Table 3: Mean ± SD of sensory evaluation scores of Nutribite Crackers control and variations (V-1, V-2, and V-3).

Products	Appearance	Colour	Texture	Flavour	Taste	Overall
Control	7.84 ± 1.25	7.88 ± 1.06	8.16 ± 1.18	7.94 ± 1.30	7.88 ± 1.32	8.02 ± 1.25
Variation (1)	8.64 ± 0.63	8.6 ± 0.61	8.7 ± 0.54	8.68 ± 0.65	8.7 ± 0.65	8.7 ± 0.58
Variation (2)	8 ± 1.25	8.06 ± 1.25	8.06 ± 1.24	7.88 ± 1.35	7.86 ± 1.29	7.98 ± 1.19
Variation (3)	8.34 ± 1.12	8.32 ± 1.08	8.36 ± 1.16	8.26 ± 1.16	8.3 ± 1.11	8.34 ± 1.14

There was a significant difference with respect to flavour among the variations (P - value = 0.002) at a 5% level of significance with F = 5.098. (LSD) post hoc test showed that there was a significant mean difference between Basic and Variation 1 (P - value = 0.30) with respect to flavour.

There was a significant difference with respect to taste among the variations (P - value = 0.0004) at a 5% level of significance with F = 6.276. (LSD) post hoc test showed that there was a significant mean difference between Basic and Variation 1 (P - value = 0.027) with respect to taste.

It is evident from Table 4 that there was a significant difference with respect to overall acceptability among different variations of components with F = 4.863, P - value = 0.002. (LSD) post hoc test showed that there was a significant mean difference between Basic and Variation 1 (P - value = 0.020) concerning overall acceptability. Table 4 shows the statistical analysis mean, standard deviation, F-value, significance level (P-value), and least significance difference (LSD) post hoc comparisons for the sensory characteristics of different variations of the Nutribite Crackers.

Nutritional analysis of the best-rated variation of Nutribite Crackers

The nutrient content of Nutribite Crackers per serving is as follows: they provide approximately 545.85 (kcal) of energy, with a protein content of 4.93% and a relatively fat

Table 4: Analysis of Variance (ANOVA) and Least Significant Difference (LSD) Post-Hoc comparison of different variations of Nutribite Crackers (V-1, V-2, and V-3).

Sensory characteristics	Variation	Mean	Standard Deviation	F	P-value	Post Hoc comparisons
Appearance	Basic	7.84	1.25	5.354	P<0.001	0.0031
	Variation (1)	8.64	0.63			0.0037
	Variation (2)	8	1.25			0.12
	Variation (3)	8.34	1.12			0.17
Colour	Basic	7.88	1.06	4.663	P<0.003	0.437
	Variation (1)	8.6	0.61			0.002
	Variation (2)	8.06	1.25			0.099
	Variation (3)	8.32	1.08			0.015
Texture	Basic	8.16	1.18	3.495	P<0.016	NA
	Variation (1)	8.7	0.54			
	Variation (2)	8.06	1.24			
	Variation (3)	8.36	1.16			
Flavour	Basic	7.94	1.30	5.098	P<0.002	0.030
	Variation (1)	8.68	0.65			
	Variation (2)	7.88	1.35			
	Variation (3)	8.26	1.16			
Taste	Basic	7.88	1.32	6.276	P<0.0004	0.027
	Variation (1)	8.7	0.65			
	Variation (2)	7.86	1.29			
	Variation (3)	8.3	1.11			
Overall acceptability	Basic	8.02	1.25	4.863	P<0.002	0.020
	Variation (1)	8.7	0.58			
	Variation (2)	7.98	1.19			
	Variation (3)	8.34	1.14			
Total	Basic	47.72	7.37	29.749	P<0.0244	0.517
	Variation (1)	52.02	3.66			0.005
	Variation (2)	47.84	7.56			0.21
	Variation (3)	49.92	6.76			0.18

Note: Mean values represent the average of 50 panelists. In F value level of significance in increasing order *P<0.05, **P<0.01, ***P<0.001

content of 20.37%. Carbohydrates make up the majority of the composition, accounting for about 69.80%. In terms of micronutrients, Nutribite Crackers are notably rich in potassium, containing 1,621.00 mg/kg. Additionally, each kilogram of Nutribite Crackers contains approximately 380.78 mg of calcium and 46.77 mg of iron, making them a good source of these essential minerals for a balanced diet. Table 5 shows the nutritional analysis of Nutribite Crackers' best-rated variation (V-1).

Table 5: Nutritional analysis of Nutribite Crackers best-rated variation (V-1) using lotus root.

Nutrient	Content
Energy	545.85 kcal
Protein	4.93 %
Fat	20.37 %
Carbohydrate	69.80 %
Potassium	1,621.00 mg/kg
Calcium	380.78 mg/kg
Iron	46.77 mg/kg

Packaging

A short market survey was conducted to select the best package for Nutribite Crackers to maintain freshness and prevent contamination, a stand-up pouch was chosen as the ideal option. This selection guarantees that Nutribite Crackers retain their premium quality and stay safe for consumption for an extended period. Figure 3 shows the selected package for Nutribite Crackers.

Fig. 3: Packaging of the best-rated variation (V-1) of Nutribite Crackers.

Shelf life study of Nutribite Crackers best-rated variations (V-1)

A physical examination was conducted to study the shelf life of the best-rated variation of Nutribite Crackers (V-1). The product was stored at room temperature in an air-tight container in a cool, dry, and hygienic place. It was observed that the quality of the best-rated variation (V-1) was obtained for 30 days without any changes in its appearance, colour, texture, flavour, and taste. Also, microbial growth was absent. Table 6 shows the shelf life study of the best-rated variation (V-1) of Nutribite Crackers stored at room temperature (25°C).

Table 6: Shelf Life Study of the best-rated variation (V-1).

Sensory characteristics	1 to 5 days	6 to 10 days	11 to 15 days	16 to 20 days	21 to 25 days	26 to 30 days
Appearance	Good	Good	Good	Good	Good	Good
Colour	Golden brown	Golden brown	Golden brown	Golden brown	Golden brown	Golden brown
Texture	Crispy	Crispy	Crispy	Crispy	Crispy	Crispy
Flavour	Good	Good	Good	Good	Good	Good
Taste	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Overall	Good	Good	Good	Good	Good	Good
Visible microbial growth (Physical examination)	Absent	Absent	Absent	Absent	Absent	Absent
Remark	The product has retained its appearance, colour, texture, and flavour.	The product has retained its appearance, colour, texture, and flavour.	The product has retained its appearance, colour, texture, and flavour.	The product has retained its appearance, colour, texture, and flavour.	The product has retained its appearance, colour, texture, and flavour.	The product has retained its appearance, colour, texture, and flavour.

Budget

The budget analysis for the best-rated variation (V-1) of Nutribite Crackers, per 100 grams, is as follows: 33 g of lotus root costs 7.26 Rs.; 40 g of maize flour costs 3.40 Rs.; 10.5 g wheat flour valued as 0.61 Rs.; 10 ml of oil costs 1.87 Rs.; 1.5 g of salt amounts to 0.03 Rs.; and 5 g of dried herbs are priced at 5.11 Rs. The total cost for raw ingredients is 18.28 Rs. Additional costs include a 20% labor and maintenance charge of 3.66 Rs., a 60% markup cost of 10.97 Rs., and a packaging cost of 10.20 Rs. The total expenditure for the best-rated variation (V-1) amounts to approximately 43.10 Rs., rounded to 43 Rs. Table 7 shows the budget analysis of the best-rated variation (V-1).

Table 7: Budget Analysis for Nutribite Crackers Best-Rated Variation (V-1) per 100 g.

Ingredients	Quantity %	Cost in Rs.
Lotus root	33 g	7.26
Maize flour	40 g	3.4
Wheat flour	10.5 g	0.61
Oil	10 ml	1.87
Salt	1.5 g	0.03
Dried herbs	5 g	5.11
Total raw ingredients cost per 100 g		18.28
Labor and maintenance cost (20%)		3.66
Markup cost (60%)		10.97
Packaging cost		10.2
Total		43.10 ≈ 43

Summary and Conclusion

The development and evaluation of Nutribite Crackers using lotus root resulted in promising results in the areas of sensory acceptability, nutritional composition, and shelf life. The study aimed to develop a value-added, nutritious snack suitable for all age groups, especially preschool and school children, to promote healthy eating habits.

Nutribite Crackers in 3 different variations (V-1, V-2, and V-3) were developed using a combination of Lotus root, Maize flour, Wheat flour, Bajra flour, and Jowar flour. The developed crackers (Control: MFC and Variations: V-1, V-2, and V-3) were subjected to sensory evaluation, using a 9-point hedonic scale, to study the acceptability by 50 semi-trained panelists. The sensory evaluation results presented for this product were evaluated by a panel of 50 semi-trained individuals and revealed that (V-1) prepared using Wheat flour, Maize flour, and Lotus root had a high level of acceptance. (V-1) showed a shelf life of 30 days under normal storage conditions. This variation not only had high acceptability, but it also included essential nutrients such as protein, fat, carbohydrates, potassium, calcium, and iron. Furthermore, it had a shelf life of more than 30 days under standard storage conditions.

The successful development of Nutribite Crackers provides a convenient and nutritious snacking option that is rich in antioxidants, dietary fiber, and essential minerals, which is especially beneficial to consumers looking for healthier snack options and serves as an ideal snack with several health-promoting nutrients for consumers. Furthermore, the addition of lotus root vegetables, which have several health benefits, enriches the snack while boosting the consumption of underutilized nutritious products. Thus, Nutribite Crackers are a promising development in the field of healthy snack choices, fulfilling the different nutrient needs of customers of all ages. Further research into production development and market viability may enhance the availability of this healthy snack to a larger group of customers.

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