

Rediscovering THEKUA: An Innovative Nutritional Fusion of Neera, Jaggery, And Super Seeds for Sustainable Rural Entrepreneurship

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ABSTRACT:

Traditional Indian foods possess considerable cultural and nutritional value, yet many have received limited attention in terms of value addition and functional food development. The present study aimed to develop a nutritionally enriched variant of the traditional Bihar sweet Thekua by incorporating Neera, jaggery, and nutrient-rich super seeds (sesame, flaxseed, chia, pumpkin, and sunflower) while evaluating its nutritional quality, sensory acceptability, economic feasibility, and entrepreneurial potential. A mixed-method research design was adopted, involving product formulation, nutritional analysis, sensory evaluation using a 5-point hedonic scale, consumer acceptability assessment, and cost estimation. Three formulations were developed and compared. The mixed-seed variant demonstrated the highest nutritional value, providing superior protein, dietary fibre, calcium, and iron content compared with the other formulations. Sensory evaluation showed that the mixed-seed formulation achieved the highest overall acceptability score (4.8 ± 0.2), with statistically significant differences among formulations ($p < 0.05$). Consumer responses indicated high market acceptance, with 92% of participants liking the product, 90% recognizing its health benefits, and 95% expressing willingness to purchase it at a reasonable price. The estimated production cost of ₹21 per 100 g further supports its commercial feasibility. Overall, the developed Neera Thekua represents a nutritious, culturally acceptable, and economically viable functional food with promising potential for commercialization through women-led enterprises and Self-Help Groups, thereby contributing to sustainable rural entrepreneurship and food innovation.

Keywords: Thekua, Neera, Jaggery, Super Seeds, Food Innovation, Rural Women, Entrepreneurship, Functional Food

1. Introduction

Traditional foods form a significant element of the culture of India as they represent regional identities, indigenous knowledge, and traditional

dietary habits. Traditional Indian sweets are valued not only because of the distinct sensory attributes of such products but also due to their nutritional and cultural value. However, fast-paced urbanization, changes in the lifestyle of

people, and an increased interest in convenience foods have led to the decreased popularity of many indigenous foods. Therefore, there is a growing need for the revival of traditional recipes by enhancing their nutritional value without losing their authentic character and appeal among consumers. The production of functional foods fortified with natural bioactive compounds has proved to be an efficient approach to encourage healthy dietary behavior while maintaining traditional foods systems (Dwivedi et al., 2024; Granato et al., 2020). Thekua is an age-old sweet snack relished in Bihar and adjacent areas especially during Chhath Puja. The conventional preparation of Thekua includes wheat flour, jaggery, and ghee, and it is considered valuable because of its good taste, longer shelf-life, and cultural significance. However, it lacks functional nutrients despite its high popularity. New advancements in the field of functional baked products show that the inclusion of nutrient dense natural ingredients in the traditional recipes will significantly increase their nutritive value without affecting their sensory properties (Guiné & Florença, 2024; Siró et al., 2008).

One of the ingredients which can be added value through such an approach is Neera which is an unfermented juice extracted from coconut and palmyra palm inflorescences. According to the Central Plantation Crops Research Institute (2018), Neera has high contents of sugar, vitamin, mineral, and antioxidant components, making it a nutritious alternative to refined sweeteners. In a similar vein, Upadhyaya and Sonawane (2023), and Ramesh et al. (2024) emphasized its ability to promote health and its suitability in preparing value-added functional foods. Besides being a source of important minerals like iron and calcium, jaggery acts as an alternate and healthier source to replace white sugar. The benefits of non-centrifugal sugar as far as the improvement in quality of traditional foods is concerned have been well acknowledged (Rao & Singh, 2022; Venkatesh & Talakala, 2025). Nutritional properties of Thekua could be improved by adding super seeds like flaxseed, sesame, pumpkin, chia, and sunflower seeds. All these seeds are good sources of protein, fiber, healthy

fatty acids, minerals, and antioxidants. It has been found in research that seed addition not only adds nutritionally but also improves the functionality and processing qualities of bakery products without compromising sensory aspects (Motyka et al., 2023; Alasalvar et al., 2021). Similarly, Olombrada et al. (2023) and Singh and Gaur (2024) have reported that seed addition significantly improves the nutritional aspect of bakery products and enhances consumer acceptance.

Apart from improving the nutritional profile, development of innovative traditional foods also leads to sustainable rural entrepreneurship. The production of value-added foods using locally available agricultural inputs helps in generating income by self-help groups (SHGs) and rural women along with promotion of indigenous food culture. Support for women empowerment and rural entrepreneurship development activities adds another dimension to the commercial viability of such products (UN Women, 2024; National Bank for Agriculture and Rural Development, 2026). Adherence to the food quality and safety guidelines defined by Food Safety and Standards Authority of India (2021) is equally essential for maintaining the quality of the product. In this regard, the current study has developed an innovative version of traditional Thekua by adding Neera, jaggery, and nutritious super seeds for improving its nutritional content without compromising its indigenous nature. The developed product was further evaluated for its nutritional composition, sensory acceptability, cost-effectiveness, and potential for commercialization as a sustainable rural enterprise.

Study Objectives

1. To document and preserve the traditional Thekua preparation method.
2. To develop a nutritional variant using Neera, jaggery, and super seeds.
3. To analyze its nutritional quality and consumer acceptability.
4. To assess cost and entrepreneurship potential, especially for rural women.

2. Review of Literature

An increasing demand for healthy foods has prompted research into functional food development in which conventional foods have been fortified with bioactive ingredients to enhance their nutritional value without affecting consumer acceptability. Functional foods deliver additional health benefits than just nutrition and have become an efficient means of meeting changing food preferences (Granato et al., 2020). Likewise, according to the World Health Organization (2020), healthier food intake based on nutrient-dense foods is important to prevent diet-induced diseases. According to Guiné and Florença (2024), there has been an increased use of natural ingredients in the development of functional bakery products that offer improved nutritional value and desirable sensory properties. Traditional Indian foods have tremendous potential in terms of this innovation due to their nutritional and cultural importance. As Dwivedi et al. (2024) argued, scientific improvement of traditional foods can help people develop healthier eating habits while preserving the traditional food culture. Among such ingredients, Neera can be considered as a good functional ingredient because of its presence of natural sugars, vitamins, minerals, and antioxidants (Central Plantation Crops Research Institute, 2018). Nutritional and commercial aspects were also brought into focus by Upadhyaya and Sonawane (2023), whereas coconut inflorescence sap was characterized by Ramesh et al. (2024) as a valuable source for developing nutraceuticals. Moreover, the Indian Council of Medical Research–National Institute of Nutrition (2024) suggested incorporating nutrient-rich traditional foods into the diet as one of the elements for a balanced diet aimed at improving nutritional status. Jaggery also became known as an alternative to refined sugar due to higher amounts of minerals and antioxidants it contains. The possibility of developing a functional food product using jaggery was shown by Rao and Singh (2022), whereas Venkatesh and Talakala (2025) noted that jaggery could be characterized by its nutritional value and industrial application. In addition, there are various nutrient-rich seeds

including chia, flax, sesame, pumpkin, and sunflower, which could be characterized by high content of proteins, fibers, fatty acids, minerals, and bioactive compounds. Nutritional importance of the above-mentioned seeds was proven in research by Alasalvar et al. (2021) and Motyka et al. (2023), and the feasibility of their use for making bakery products and improving their nutrition without loss of sensory qualities was proven by Olombrada et al. (2023) and Singh and Gaur (2024). Moreover, the use of bioactive compounds as additives for bakery products increases the antioxidant ability of food, without changing its structure and sensory qualities (Czajkowska-González et al., 2021). Numerous researches prove the possibility of functional ingredient fortification of traditional foods. Gojiya et al. (2024) created jaggery-based sesame spread with high consumer acceptance, and Katara et al. (2025) proved the possibility of fortification of traditional Indian sweets with nutrient-rich ingredients and improvement of their nutritional value. In the same way, Pandey and Anand (2024) showed the high nutritional value and consumer acceptance of cereal-based snacks fortified with nutrient-rich ingredients. The effectiveness of fortification approaches in enhancing the nutritional and technological qualities of bakery products was additionally confirmed by Zupo et al. (2026).

Consumer acceptance continues to be a critical factor in the commercialization of functional foods. According to Siró et al. (2008), nutritional enhancement should go hand-in-hand with appealing sensory attributes, while Pappalardo and Lusk (2016) concluded that health beliefs of consumers impact their buying behavior significantly. Hence, standardized sensory assessment techniques continue to play an important role in the development of products (Stone et al., 2012). In addition, compliance with international standards of quality and safety of food products is necessary for the assurance of product quality and consumer satisfaction in commercialization (Food Safety and Standards Authority of India, 2021). Though past research studies have separately focused on Neera, jaggery, specialty seeds, and bakery fortified products, few

studies have combined all these ingredients in a traditional product like Thekua. The current study aims to fill this void by designing a nutrient-enriched Thekua using Neera, jaggery, and super seeds.

3. Methodology

The current study was carried out in Gaya district of Bihar, which adopted a combined research approach encompassing product development, nutritional evaluation, sensory evaluation, and costing. This research method was aimed at developing a nutritionally improved form of the traditional Thekua through incorporation of Neera, jaggery, and super seeds along with nutritional evaluation, consumer acceptance and commercialization.

3.1 Product Development

Three distinct formulations of Thekua were developed by using Neera, jaggery, and super seeds in order to improve the nutritional profile of the traditional product. These formulations comprised of Thekua fortified with sesame seeds, Thekua fortified with flaxseed and sunflower seeds, and Thekua fortified with a mixed seed combination of flaxseed, sesame, pumpkin, chia, and sunflower seeds. The ingredients required for the formulation of Neera based Thekua, including wheat flour, Neera, jaggery, and the selected super seeds were collected and prepared before the product formulation as illustrated in Figure 1.



Figure 1. Ingredients used for the preparation of Neera Thekua

The mixture of Neera and jaggery was made in a ratio of 2:1 in order to make a homogenous mixture. The selected seeds were dry roasted in order to enhance the taste and overall sensory profile of the selected seeds before adding to the dough. The mixing of ingredients gave a homogenous dough, which was then manually

moulded in the form of Thekua and deep fried to give the desired golden brown coloration and texture. The steps taken in making the fortified Thekua, that is, the dry roasting of selected super seeds, mixing of ingredients, shaping of dough, and frying, have been depicted in Figure 2(a-d).



(a)



(b)



(c)



(d)

Figure 2. Sequential stages involved in the preparation of fortified Neera Thekua: (a) Roasting of super seeds, (b) Mixing of ingredients, (c) Shaping of Thekua, and (d) Frying of Thekua

The optimized product was achieved after undergoing the above processing techniques, and the sample was ready for further analysis to determine its nutritional and sensory attributes. The developed Neera Thekua made from Neera, jaggery, and super seeds is shown in Figure 3.



Figure 3. Final developed Neera Thekua

The developed Neera Thekua had consistent golden brown colour, unique traditional shape and required surface texture, which showed that the product formulation has been successfully carried out and is now ready for further nutrition analysis, sensory evaluation and costing.

3.2 Nutritional Analysis

Nutrition content of each variant of the developed Thekua was determined to identify the influence of various combinations of seeds on nutrition content of the product. The nutrition analysis was done on a per 100g basis, and the following parameters were assessed – energy, protein, fat, calcium, iron and dietary fibre content. This helped us in determining which of the formulations has maximum nutritional value.

3.3 Sensory Evaluation and Consumer Survey

The consumer acceptability of the developed Thekua variants was determined by performing sensory evaluation by use of hedonic rating scale of 5, where 1=Dislike Extremely, 2=Dislike, 3=Neither Like nor Dislike, 4=Like and 5=Like Extremely. Five parameters of quality were considered for this test, viz., taste, texture, color, flavor and overall acceptability.

There were 50 female participants who were home scientists, postgraduate students, and local shopkeepers who evaluated the product. The participants evaluated the different variants individually and gave their views on taste preference, nutritional value, purchase intention, and market acceptability of the product. The sensory evaluations are illustrated in Figures 4 (a-c).



Figure 4. Sensory evaluation of the developed Neera Thekua: (a) evaluation by a local shopkeeper, (b) sensory assessment by home scientists, and (c) recording of sensory evaluation responses by home scientists and postgraduate students

3.4 Cost Estimation

An economic evaluation was performed for the determination of the feasibility of the newly developed product in terms of its economics. All the components that contribute to the cost of production such as cost of raw materials, labour costs, cost of energy used, and cost of packaging were taken into consideration for the estimation of the cost. The cost of production was considered in order to estimate the retail price of the newly developed Thekua in the light of its feasibility and marketing potential.

4. Results and Discussion

4.1 Sensory Evaluation

Sensory evaluation of the three formulations of the Thekua was done on the basis of a structured five point hedonic scale which helped to evaluate the preference for taste, texture, colour, aroma, and acceptability of the products. The mean sensory scores (Mean $\pm$ SD) for each of the formulation is shown in Table 1.

Table 1. Sensory evaluation scores (Mean $\pm$ SD) of the developed Thekua variants

Variant	Taste (Mean $\pm$ SD)	Texture (Mean $\pm$ SD)	Color (Mean $\pm$ SD)	Aroma (Mean $\pm$ SD)	Overall Acceptability (Mean $\pm$ SD)
Thekua + Sesame	3.7 $\pm$ 0.6	3.8 $\pm$ 0.5	3.6 $\pm$ 0.5	3.5 $\pm$ 0.4	3.8 $\pm$ 0.5
Thekua + Flax/Sunflower	4.2 $\pm$ 0.5	4.3 $\pm$ 0.4	4.1 $\pm$ 0.3	4.0 $\pm$ 0.4	4.3 $\pm$ 0.4
Thekua + Mixed Seeds	4.8 $\pm$ 0.3	4.7 $\pm$ 0.4	4.6 $\pm$ 0.3	4.5 $\pm$ 0.3	4.8 $\pm$ 0.2

The mixed-seed Thekua had the best scores for all sensory attributes, with an overall acceptability of 4.8 ± 0.2 , followed by the flaxseed-sunflower seed formulation (4.3 ± 0.4) and the sesame seed formulation (3.8 ± 0.5). The results from one-way ANOVA revealed significant differences ($p < 0.05$) between the three formulations, proving that the addition of different seed combinations significantly influenced consumer preferences.

The better sensory attributes exhibited by the mixed-seed formulation could be attributed to the complementary effect of the different seeds' flavour, texture, and mouth feel. Similar observations were made by Pandey and Anand (2024) concerning sensory acceptance of

nutritionally enriched traditional snack products. Likewise, Gojiya et al. (2024) noted that the nutrient-rich jaggery-based products exhibited consumer acceptability. Such observations are in agreement with those of Stone et al. (2012) on sensory quality being one of the factors determining consumer acceptance and those of Siró et al. (2008) on successful functional foods having desirable sensory attributes.

4.2 Nutritional Comparison (per 100g)

Analysis of the nutritional content of the three Thekua formulas was conducted to determine the impact of seed mixtures on the nutritional value of the product. Table 2 shows the comparative nutritional values per 100g.

Table 2. Nutritional composition of the developed Thekua formulations (per 100 g)

Nutrient	Thekua + Sesame	Thekua + Flax/Sunflower	Thekua + Mixed Seeds
Energy (kcal)	320	310	330
Protein (g)	5.4	6.2	6.8
Fat (g)	7.8	8.2	8.9
Calcium (mg)	140	160	180
Iron (mg)	2.5	2.8	3.2
Fiber (g)	3.1	3.6	4.0

The nutrition value was highest in the case of the mixed seeds formulation, where it provided energy of 330 kcal, protein content of 6.8 g, fat content of 8.9 g, calcium content of 180 mg, iron content of 3.2 mg, and fiber content of 4.0 g/100 g. The mixed seeds formulation showed better

nutritional value as compared to the sesame formulation by 25.9%, 28.5%, 28.0%, and 29.0% for protein, calcium, iron, and fiber, respectively. The nutritional comparison is presented through Figure 5.

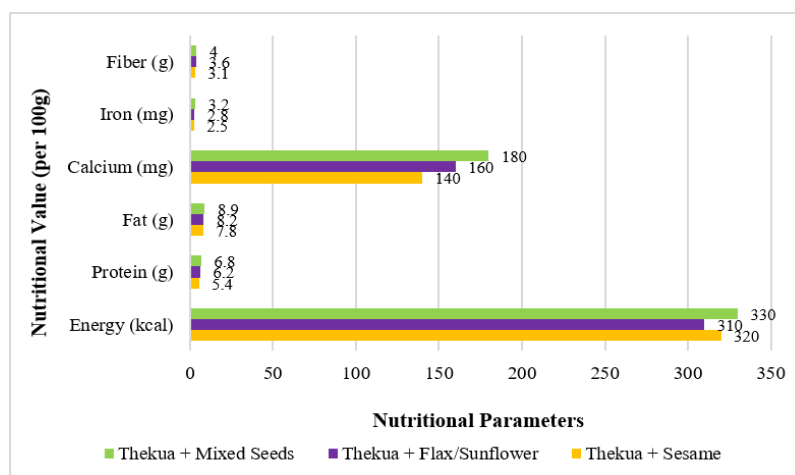


Figure 5. Nutritional comparison of the developed Thekua formulations (per 100 g)

Enhancement of nutritional value in Thekua with the addition of mixed seed is due to the combination of flaxseed, sesame, pumpkin, chia, and sunflower seeds, which are rich in proteins, fibers, minerals, and healthy fats. The same results have been obtained in Alasalvar et al. (2021) and Motyka et al. (2023), where authors discussed about the benefits of adding specialty seeds in the food products. Similarly, Rao and Singh (2022) and Venkatesh and Talakala (2025) have stressed on the usage of jaggery as a source of nutritionally rich material instead of refined sugar, where jaggery acts as an important source of mineral content. Also, Upadhyaya and Sonawane (2023) and Ramesh et al. (2024) have shown that the Neera contains important

vitamins and minerals for functional foods. These findings demonstrate that the combined use of Neera, jaggery, and super seeds effectively enhanced the nutritional quality of traditional Thekua, supporting its potential as a functional snack.

4.3 Consumer Acceptability

Consumer reaction analysis was performed to study the market acceptability of the Neera Thekua formulated. The distribution of consumer reactions related to taste, health benefit perception, buying intent, appropriateness for kids and elders, and buying willingness at affordable prices is provided in Table 3.

Table 3. Consumer acceptability of the developed Neera Thekua

Parameter	% of Respondents
Liked the taste	92%
Considered it healthy	90%
Willing to purchase	86%
Suitable for children & elderly	88%
Would buy at reasonable price	95%

Results have shown that there was a high degree of consumer acceptance in the development of the Neera Thekua. Most of the participants (92%) liked the taste of the product, while 90% thought of it as a healthy food item. In addition to this, 88% found it appropriate for consumption by both kids and the old generation, while 95% of them were ready to buy the product if it were sold

at an acceptable price. Even though the buying intent (86%) was a little lower compared to overall liking, there are promising indications regarding the consumer acceptance of the product. The percentage distribution of consumer responses is graphically presented in Figure 6.

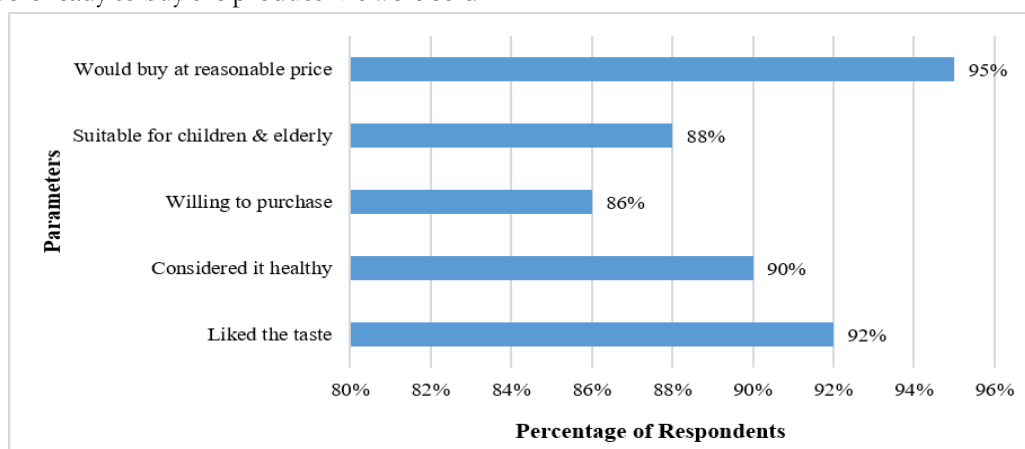


Figure 6. Consumer acceptability of the developed Neera Thekua based on responses from 50 participants

Chi-square test showed that there was a significant relationship between product liking and purchase intentions ($\chi^2(2) = 12.42, p < 0.01$). Therefore, greater consumer satisfaction contributed to the purchasing intent of the consumer. It is similar to the findings of Siró et al. (2008), who found that acceptance of the consumer influences the successful marketing of functional foods. In addition, Pappalardo and Lusk (2016) have found that the perception of health and quality of the product affects

consumers' purchasing decisions, and according to Granato et al. (2020), functional foods with positive sensory attributes are more likely to succeed in their market.

4.4 Cost Analysis (per 100g)

The cost of production of the developed Neera Thekua was determined based on the costs of the raw material, labour, energy consumption, and packaging. Costing of the product is shown in Table 4.

Table 4. Cost estimation of the developed Neera Thekua (per 100 g)

Cost Component	Cost (₹/100 g)
Raw materials	14.00
Gas/Electricity	2.00
Labour	3.00
Packaging	2.00
Total Production Cost	21.00
Suggested Retail Price	₹30–₹35

Total production cost of Thekua developed was found out to be ₹21.00 per 100 g, where the cost of the raw materials was ₹14.00, energy cost was ₹2.00, labour cost was ₹3.00, and cost of packing was ₹2.00. According to the production cost, the suggested retail price was found to be ₹445-455 per 100 g. The results suggest that the developed product has economic feasibility for small-scale productions. Use of locally available ingredients and simple processing procedure would help reduce the production cost and add value to traditional foods. Adherence to the standards of food quality and safety is important for commercializing the product successfully (Food Safety and Standards Authority of India, 2021). Based on its economic feasibility, the developed product has a good commercialization potential among small-scale food industries and self-help groups.

4.5 Entrepreneurial Scope

These findings revealed substantial entrepreneurial potential in relation to the Neera Thekua developed. First of all, the overwhelming majority of the respondents (80%) believed that the product could be marketed successfully via Self-Help Groups (SHGs), and 70% of women

were willing to undergo necessary training for producing and selling the product. In addition, the local shopkeepers displayed their willingness to stock the product which indicates a positive market potential. Overall, these findings show that the product has the potential of helping small-scale food enterprises to combine nutritional values of their products with successful entrepreneurship. This positive response from consumers and retailers indicates the opportunity to create income generating food products through traditional value added foods. Such efforts to promote women-owned food enterprises and community based production processes have already proved their effectiveness (UN Women, 2024). Moreover, this approach to developing such product correlates with the goals of the NABARD Self Help Group-Bank Linkage Programme aimed at encouraging rural enterprise development. Consequently, the developed Neera Thekua has great potential to become a sustainable functional food product.

4.6 Limitation and Future Aspects

Limitations associated with the current study must be kept in mind while interpreting the results obtained. Firstly, the sensory test was

conducted using a fairly limited number of 50 consumers belonging to one particular geographical location only. The current study was concerned mostly about the nutritional value, acceptability, cost assessment, and business feasibility of Neera Thekua produced, while shelf life testing, microbiological quality, storage ability, and antioxidant analysis have not been done at all. Also, the business potential of the product was analyzed based on the perception of the consumer group and not through pilot scale production or market testing. In future, there is a need to analyze the shelf life, packaging stability, microbiological quality, and antioxidant property of the developed Neera Thekua for making it commercially viable. Conducting studies on larger consumer groups is advised for confirming its acceptability by consumers. The development of flavoured versions and pilot plant production trials will further increase the potential of this product in the market. For entrepreneurs, training the rural women about the production of the product in hygienic conditions along with good quality control measures could help to manufacture the product on a community basis. This product can also be marketed via various government schemes like the PM-FME (PM Formalization of Micro Food Processing Enterprises), NRLM (National Rural Livelihood Mission), and Mission Shakti, among others. Moreover, marketing of the product through fairs, schools' nutrition programs, ICDS centers, and online marketing channels can help in increasing the popularity and reach of this product. Further, GI tagging and export possibilities can also be considered in future.

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5. Conclusion

The current study was successful in reinvigorating the traditional Indian sweet "Thekua" by formulating a nutritious product through the use of Neera, jaggery, and super seeds. Of the three formulations which were formulated during the study, the mixed seed formulation was observed to have shown better results on account of higher scores in sensory qualities, good nutritional value, and higher consumer acceptability. By adding flaxseed, sesame, pumpkin, chia, and sunflower seeds, the protein, dietary fiber, calcium, and iron values have been enhanced in this sweet, making it more nutritious without affecting its traditional flavor and appearance. The good sensory scores and consumer acceptability prove that this product has excellent market acceptability potential and can be used as a functional snack. The economic analysis showed that the product could be produced economically, making it viable for commercialization. Consumers' positive attitude towards marketing through SHG as well as women's participation in production processes show the ability of the process to facilitate entrepreneurship development and women empowerment in the rural context. As a result of integration of traditional knowledge about food products with functional ingredients, a new Neera Thekua became a sustainable value-added product which not only keeps cultural tradition but solves modern nutritional issues as well. Therefore, it may be concluded that innovations in traditional food products have an opportunity to enhance the health status of people and provide sustainable enterprise development.

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