Mango Peel Pearl Millet Nut Bar: A Novel Snack Rich in Vitamin C, Protien and Fiber

Chetyala Bhavana Bai^{*1}; Dr. A. Swaroopa Rani²; G. Mahesh³

¹Student, Department of Food Technology, Oil Technological & Pharmaceutical Research Institute, JNT University. Ananthapuramu 515001, Andhra Pradesh, India

²Professor Head & Chairman- Board of Studies, Department of food Technology, Oil Technological & Pharmaceutical Research Institute, J.N.T University, Ananthapuramu 515001, Andhra Pradesh-India

³Quality Manager, Srini Food park, Mogili Village, Bangarupalyem Mandal, Chittoor District - 517416, Andhra Pradesh, India

Corresponding Author: Chetyala Bhavana Bai^{*1}

Publication Date: 2025/05/21

Abstract: This study aimed to develop and evaluate a novel functional snack bar incorporating mango peel, pearl millet, and assorted nuts, designed to be rich in vitamin C, protein, and dietary fibre. Mango peel, an underutilized by-product of mango processing, was selected for its high antioxidant and fibre content, while pearl millet and nuts contributed to the bar's protein and healthy fat profile. The preparation involved blending these ingredients with natural binders like jaggery to produce a nutrient-dense, palatable product. Proximate analysis revealed the bar contained 16.4 % protein, , 16.2% crude fibre, and 9 mg/100g of vitamin C. Sensory evaluation by a semi-trained panel indicated high acceptability across all attributes, with an overall rating of 9.0 on a 10-point hedonic scale. The product's low moisture content suggested good shelf stability. The use of mango peel also demonstrated a sustainable approach to reducing fruit waste. These findings confirm the potential of the Mango Peel Pearl Millet Nut Bar as a functional, eco-conscious snack suitable for health-focused consumers. The study highlights the scope for further innovation in using agro-industrial by-products to develop nutrient-rich, market-ready food products that align with sustainability and public health goals.

Keywords: Mango Peel Powder, Pearl Millet Flakes, Functional Snack bar, Nutritional Analysis, Sustainable food.

How to Cite: Chetyala Bhavana Bai; Dr. A. Swaroopa Rani; G. Mahesh. (2025) Mango Peel Pearl Millet Nut Bar: A Novel Snack Rich in Vitamin C, Protien and Fibre. *International Journal of Innovative Science and Research Technology*, 10(5), 805-810. https://doi.org/10.38124/ijisrt/25may957

I. INTRODUCTION

In recent years, the demand for healthy snack alternatives has surged, driving innovation in functional food development. Functional snacks provide basic nutrition and offer health benefits beyond their nutritional value. Mango peel, often discarded as waste, is rich in dietary fibre, antioxidants, and vitamin C, making it a valuable ingredient for sustainable food products. Pearl millet, known for its high protein and fibre content, combined with nutrient-dense nuts, creates a wholesome snack option. This study aims to develop a novel nut bar incorporating mango peel and pearl millet, enhancing its nutritional profile while promoting food waste utilisation.

A. Problem Definition

The modern food industry faces increasing challenges related to both nutritional deficiencies and food waste. Many commercially available snack bars are calorie-dense but lack functional ingredients such as fibre, antioxidants, and micronutrients. Simultaneously, a substantial amount of fruit waste, particularly mango peel, is discarded despite its rich nutritional content. This underutilization presents an

opportunity to innovate a sustainable and healthfocused snack product.

B. Scope and Significance

This study aims to develop a functional snack bar incorporating mango peel powder, pearl millet flakes, and nuts to deliver enhanced vitamin C, dietary fibre, and protein. Mango peel, a rich source of antioxidants and fibre, is valorised to reduce food waste. Pearl millet contributes protein, complex carbohydrates, and micronutrients, while assorted nuts add healthy fats and sensory appeal. The formulation supports consumer demand for clean-label, plant-based nutrition and sustainable food choices.

II. LITERATURE REVIEW

A. Mango Peel Utilisation in Food Products

Mango peel has recently attracted attention for its possible application in food formulations because of its high quality of dietary fibre, polyphenols, and vitamin C, being a main by-product of mango processing. Researches demonstrate that mango peel powder can be used to add nutritional and functional qualities in bakery products, cereals Volume 10, Issue 5, May - 2025

ISSN No:-2456-2165

and beverages (Ismail et al., 2024). The antioxidant in the peel of mango is useful in decreasing oxidative stress, hence enhancing the shelf life and health value of the food products. It not only increases the value of waste material but also conforms to the sustainable production of food.

B. Nutritional Benefits of Pearl Millet and Nuts

Pearl millet (Pennisetum glaucum) is a nutrient-rich grain, identified for its higher protein level, dietary fibre, iron, magnesium, and B vitamin levels. It is more beneficial for those who have gluten intolerance and have a low glycaemic index, and is therefore suitable for diets for the diabetic (Mawouma et al., 2022). Nuts like almonds, cashews, and peanuts contain healthy fats, protein, vitamins (vitamin E in particular), and minerals of zinc and magnesium. When combined, pearl millet and nuts combine for increased satiety, cardiovascular benefits, and better metabolic health, making them the perfect components of functional snacks (Kaur et al., 2023).

C. Innovations in Healthy Snack Bar Development

Increased consumer demand for nutritious, eatanywhere foods has inspired the emergence of snack bars based on nutritional reasons. Researchers have tried different base ingredients, including cereals, legumes, and fruits, as well as by-products such as fruit peels and pulp. The new trend has been to introduce bioactive compounds and superfoods to increase the functional nature of these snacks. Product development studies are commonly based around sensory acceptability, texture, shelf stability, and nutrient retention. The latest inventions include glutenfree, highprotein and fibre-enriched bars that meet the demand of specific needs of our genes (Sibanda, 2024).

D. Gaps in Existing Research

Current research, despite its advancements, has not thoroughly explored the combination of mango peel with traditional sources of grain, such as pearl millet, in snack bars. Major research is concerned with either fruit byproducts or millet-based snacks only. It is notable that lack of integrated approaches that simultaneously target nutritional elevation, food waste minimisation and new product development (Hussain et al., 2024). Moreover, both consumer perception and sensory acceptability of such novel combinations need further empirical study. This study aims to fill these gaps by formulating a nutrient-rich snack bar from the mango peel and pearl millet, which is functionally as well as sustainably.

III. MATERIALS AND METHODS

https://doi.org/10.38124/ijisrt/25may957

A. Materials

The key ingredients used in the preparation of the nut bar recipe were mango peel, pearl millet, assorted nuts and natural binding agents. The nearby fruit markets were the source of collection of Mangifera indica (ripened mangoes). First, the peels of mango were washed well and drying in hot air oven 50-60°c for 34 hrs and then finely ground to be used as a functional ingredient. Pearl millet flakes are coarsely grind & include walnuts. Almonds, peanuts and cashews were selected based on nutritional values and availability. Cohesiveness and sweetness were formed using natural binders such as jaggery in the bar formulation.



Fig 1 Ingredients

B. Preparation Method

Pearl Flakes , mangoes and other ingredients were procured from the local market of Palmaner. The mangoes were washed and cleaned. Mango peel was removed with the help of the peeler. Then, they were dried in the hot air oven at the temperature of 50- 60° C for 34 hrs. After 34 hrs. they were brought down to room temperature and made into fine powder with the help of mixture. The calculated weight of pearl flakes is taken and then grounded coarsely. Other ingredients are weighed according to the formulation (Table) to create variations in the samples. All the weighed nuts were roasted separately until the raw aroma reduces and keeps them to cool at room temperature.

INGREDIENTS	QUANTITY(G)		
Pearl millet flakes	30		
Mango peel powder	45		
Peanuts	10		
Almonds	10		
Wal nuts	5		
Cashew nuts	5		
Jaggery	50		
Flax seeds	5		

Table 1 Formulation of Millet nut bar Made with Fruit Peel

Volume 10, Issue 5, May - 2025

ISSN No:-2456-2165

C. Analytical Methods Proximate

> Analysis:

The proximate composition of the nut bars was determined using the standard AOAC (Association of Official Analytical Chemists) procedures. Moisture content was determined using oven drying at a temperature of 105°C until a constant weight was reached. Accurate protein, fat, and crude fibre were determined respectively using Kjeldahl procedures, Soxhlet extraction and acid-alkali digestion. The content of ash was established based on incineration within a muffle furnace at 550°C.

International Journal of Innovative Science and Research Technology

https://doi.org/10.38124/ijisrt/25may957

D. Vitamin C Determination:

Vitamin C (ascorbic acid) was determined using the 2,6-dichlorophenolindophenol titration. The concentrations used were presented in mg per 100 g of sample.

Sensory Evaluation:

A panel of 2 semi-trained members tested the bars for appearance, texture, taste, aroma, and overall acceptability using a 9-point hedonic scale (1 = dislike extremely, 9 = like)extremely). Average results to determine the level of consumer acceptability were obtained.

IV. RESULTS

This section presents the outcomes of the nutritional analysis, sensory evaluation, and statistical interpretation of the Mango Peel Pearl Millet Nut Bar. The results are discussed in terms of the proximate composition, vitamin C content, sensory acceptability, and statistical significance of observed differences.

· 1 D

. .

Table 2 Physicochemical Properties				
Parameter	Control		Results	
Energy (kcal)	420-450	417		
Protein (%)	9-11	16.4		
Carbohydrates (%)	55-58	64		
Crude Fibre (%)	6-8	16.2		
Fat (%)	18-22	10.7		
Vitamin C (mg)	4-8	9		
Moisture (%)	8-10	7.6		
Ash (%)	2-3	1.5		

A. Proximate Composition

The proximate analysis of the nut bar showed a rich nutritional profile, indicating its potential as a functional snack. The average composition per 100g of the product is presented in Table 1 Above.

The fact that the moisture content is low (7.6%) implies that there is good shelf stability. Significantly enhanced in terms of protein content (eg, 16.4%) is the presence of pearl millet and nuts, which makes the bar a good option for someone wanting to supplement based on protein. The fat content (10.7%) is particularly unsaturated from nuts. Crude fibre 16.2%) is increased by the addition of mango peel powder, with its digestibility advantages. Such results demonstrate the balanced composition of the macronutrients of the nut bar, which is not suitable for health-conscious consumers.

B. Vitamin C Content

The mango peel played a great role in the presence of vitamin C in the product. The analysis showed that the quantity of vitamin C was 9 mg per 100 grams of the nut bar. In comparison to the more traditional cereal-based snack bars, this amount is rather high since there are almost no natural sources of the nutrient in these products. The presence of vitamin C increases antioxidant potential and enhances immune function to further confirm the functional food claims of this novel bar.

C. Sensory Evaluation of the Product :-

Parameters	Panel member - 1	Panel member - 2	
Appearance	9	8	
Texture	8	9	
Colour	8	8	
Taste	9	9	
Smell	9	9	
Overall acceptability	9	9	

Table 2 Sancory Evolution

The visual evaluation of millet nut bar by two panel members is seen in the table. Based on five parameters, they judged the product: appearance, colour, taste and smell and general acceptability. Every indicator was marked on the scale (probably out of 10) with greater numbers indicating higher quality.

Volume 10, Issue 5, May – 2025

International Journal of Innovative Science and Research Technology

ISSN No:-2456-2165

> Appearance:

Panel Member one had a score of 9, Member Two 8 that meant both were satisfied in terms of how the bar looked.

- Taste :- Member 1 rated 8 and tasted the bar while 9 by member 2 indicating it tasted pleasant.
- Smell:- Both gave 9 which means that both liked the aroma.
- Overall Acceptability:- Both had 9 meaning that the product was very highly accepted and liked.

This assessment is proof that the millet nut bar is of high quality in terms of look, taste, and experience in general

D. Comparative Analysis with Commercial Bars:

In comparison with similar commercial snack bars, the developed nut bar had higher vitamin C and fibre content. Though many of the market-available bars use refined sugars

and synthetic vitamins, the present formulation uses natural constituents with minimal processing. The protein and fats are adjacent in that one can come from nuts and the other from a dairy source, with the nutrients being closer than that of a developer makes it (Duarte et al., 2025).

https://doi.org/10.38124/ijisrt/25mav957

E. Shelf Life Observation (Preliminary):

A basic test was performed on the shelf life for 14 days at room temperature. No observable microbial growth or textural degradation was observed in the observations. Moisture was also stable, providing support for past observations of its good shelf stability. A longer-term analysis of the shelf life is suggested for future stud

F. Colour Evaluation by Spectrophotometer:

Color parameters were measured using a HunterLab spectrophotometer. The values are reported in terms of L*, a*, and b*, which represent lightness, red-green balance, and yellow-blue balance, respectively.

Table 4	Colour	Parameters	of	Nut	Bai

Sample	L*	a*	b*	a*/b Ratio	Total Colour Value	Colour Tone
Standard (Ref.)	48.00	-4.50	12.00	-0.375	49.55	Greenish-yellow
Trial 2 Bar	47.00	-4.20	11.50	-0.365	48.31	Slight greenish-brown

> Key Findings:

- The nutritional make-up of the Mango Peel Pearl Millet Nut Bar is quite wholesome, especially high in fibre, protein and vitamin C.
- Sensory attributes were given high scores, indicating good consumer acceptability.
- The product aims to counteract the issue of food waste by utilising the mango peel, contributing to sustainability.
- Vitamin C levels were greatly higher than those found in conventional snack bars, and added functional value.
- Low moisture content underlies good shelf stability and product safety. Statistical homogeneity from
- batch to batch speaks for reliability in the production process.

V. DISCUSSION

The development and evaluation of the Mango Peel Pearl Millet Nut Bar present significant insights into the potential of functional snack innovation. This discussion interprets the key results in relation to existing literature, emphasising the product's nutritional, functional, and sustainability contributions.

A. Nutritional Enhancement through Ingredient Integration

The nutrient profile of the nut bar was significantly enhanced through synergistic pairing of mango peel, pearl millet, and nuts. The value of protein (16.4 %) corresponded to that of high-protein functional snacks, especially because of the addition of pearl millet and assorted nuts. Pearl millet is of good quality due to its high ammonia acid profile and digestibility and may be used for fortification of proteinenhanced foods (Tariq et al., 2023). The fat content (10.7%) was within acceptable limits for snack bars and was mostly from unsaturated fats present in almonds, peanuts, and cashews. These fats, especially monounsaturated and polyunsaturated fatty acids, have been associated with lowered risk of cardiovascular diseases (Agwu, Ezihe and Kaigama, 2023). In addition, the carbohydrate content (64%) helped to calculate the energy value of the bar, which provided a practical supply of nourishment on the go.

Crude fibre levels (16.2%) were much influenced by the inclusion of mango peel powder. The previous studies have noted that mango peel is an excellent source of dietary fibre and phytochemicals and can help with digestive health and regulation of glycaemic response (Aamir et al., 2022). In this manner, the fibre enrichment of the developed product matches perfectly with the rising demand of consumers for gut-friendly products.

B. Consumer Acceptance and Market Potential

Sensory evaluation was overall positive, and 8.0 (on a 9-point scale) was the average for overall acceptability for all tested attributes. Appearance and taste were very appreciated, as an effective mixture of food ingredients was visible through the front of the packaging and its taste. A mild sweetness created by the jaggery, with the nutty and fruity notes, made the bar palatable (Zuñiga-Martínez et al., 2022).

Texture performed slightly below other parameters but was within acceptable limits. The slightly firm consistency was in part favoured by the fibre-rich mango peel and the roasted millet content, which may be favoured by the consumers as a wholesome chewy snack. These observations imply that the product will be appealing to healthconscious consumers who seek natural vitamins and nutrients in minimally processed foods.

ISSN No:-2456-2165

In contrast to commercial snack bars, the introduced product is a clean-label alternative, free of synthetic preservatives, artificial sweeteners and refined sugars (Thakur, Islam and Rastogi, 2024). The formulation suggests that the available trends globally on plant-based, sustainable and functional foods and hence has a strong possibility of consumer acceptance in various markets.

C. Sustainability and Waste Reduction Impact

The considerable strength of the nut bar is found to exist in its ability to enhance sustainable food practices. The mango peel, which is commonly treated as waste during fruit processing, was successfully upcycled into a highvalue antioxidant ingredient. This approach not only minimises organic waste but also helps to support the circular economy in the food business.

Studies have revealed the increasing necessity of applying strategies for waste valorisation to reduce environmental impacts and increase resource efficiency (Jakha et al., 2024). Through the use of mango peel in an enduser cereal-based product, this research demonstrates the ability to transform agricultural by-products into value-laden food innovation more obviously. This establishes a groundwork for products going forward that will link the enhancement of nutrition to ecological responsibility.

D. Implications for Future Research and Invention

The findings of this study leave us with a number of research avenues to explore. Other fruit peels or seed powders as the source of nutritional enrichment could be combined with different grains or legumes. Further research on the effects of various types of drying on the retention of micronutrients, such as vitamin C, could be done. Further, consumer studies that focus on willingness to pay and perception of waste in food products can be helpful in constructing marketing strategies and product positioning (Jahangeer et al., 2025).

In addition, there is a possibility of investigating fortification with other functional compounds like probiotics, omega-3 fatty acids, or plant-based proteins, which may add more value to the bar. Collaborations with industry partners and food technologists can help in the production of a product line that will target a particular population, and this includes athletes, children or the elderly.

VI. CONCLUSION

The development of the Mango Peel Pearl Millet Nut Bar points to the successful combination of nutrition, sustainability and consumer appeal into one functional food product. The bar exhibited a balanced composition high on protein, fibre and vitamin C, which helped meet important nutritional requirements. The utilisation of mango peel also augmented the dietary fibre and antioxidant levels, as well as supporting the value addition of food waste. Sensory analysis revealed high levels of acceptability, meaning high potential in the market. The ingredient profile of the product fits with today's direction of natural, minimally processed snacks, as does the clean-label formula of the product. While the preliminary findings are encouraging, other studies with regard to an increased shelf life, packaging solutions, and mass production are recommended to facilitate commercial application. The nut bar serves as an example of forwardlooking food products that provide not only functional health benefits but sustainable production as well, towards more general efforts in nutrition, waste prevention, and responsible food innovation.

https://doi.org/10.38124/ijisrt/25may957

REFERENCES

- S. Ismail, P. K. Dubey, A. A. Mishra and F. Ashka, "Valorisation of banana peel and mango peel as functional ingredients in baked products: a review," *Int. J. Food Sci. Technol.*, vol. 59, no. 9, pp. 5938-5950, 2024.
- S. Mawouma et al., "Chemical composition and antioxidant profile of sorghum (Sorghum bicolor (L.) Moench) and pearl millet (Pennisetum glaucum (L.) R. Br.) grains cultivated in the far-North region of Cameroon," *Foods*, vol. 11, no. 14, p. 2026, 2022.
- [3]. F. Sibanda, "Nutritional, biochemical and physicochemical properties of Pearl millet and Moringa oleifera composite food products," Doctoral dissertation, Cape Peninsula Univ. of Technol., 2024.
- [4]. Hussain et al., "Evaluation of peel, flesh, and kernel of mango (Mangifera indica L.) for phytochemicals and application as functional ingredients in bakery formulation," *Nutrire*, vol. 49, no. 2, p. 45, 2024.
- [5]. M. Guasch-Ferré et al., "Effects of nut consumption on blood lipids and lipoproteins: A comprehensive literature update," *Nutrients*, vol. 15, no. 3, p. 596, 2023.
- [6]. Tariq et al., "Extraction of dietary fiber and polyphenols from mango peel and its therapeutic potential to improve gut health," *Food Biosci.*, vol. 53, p. 102669, 2023.
- [7]. E. Agwu, C. Ezihe and G. Kaigama, "Antioxidant roles/functions of ascorbic acid (vitamin C)," in *Ascorbic Acid-Biochemistry and Functions*, IntechOpen, 2023.
- [8]. M. Aamir et al., "Functional utilization of mango waste for improving the nutritional and sensorial properties of multigrain cookies," *J. Food Process. Preserv.*, vol. 46, no. 12, p. e17173, 2022.
- [9]. P. Roy, A. K. Mohanty, P. Dick and M. Misra, "A review on the challenges and choices for food waste valorization: environmental and economic impacts," *ACS Environ. Au*, vol. 3, no. 2, pp. 58-75, 2023.
- [10]. S. Zuñiga-Martínez et al., "Agro-industrial fruit byproducts as health-promoting ingredients used to supplement baked food products," *Foods*, vol. 11, no. 20, p. 3181, 2022.
- [11]. Thakur, Z. Islam and M. Rastogi, "Application of fruit and vegetables peels as functional ingredients in baked cookies: A review," *Food Sci. Technol.*, vol. 13, no. 2, 2024.
- [12]. K. H. Jakha et al., "Characterization of Langra mango peel powder and assessment of its prebiotic and antioxidant potential," *J. Food Biochem.*, vol. 2024, no. 1, p. 9026617, 2024.

ISSN No:-2456-2165

- [13]. Santos, M. Pintado and J. A. L. da Silva, "Potential nutritional and functional improvement of extruded breakfast cereals based on incorporation of fruit and vegetable by-products—A review," *Trends Food Sci. Technol.*, vol. 125, pp. 136-153, 2022.
- [14]. M. E. Chulibert et al., "Exploring the addition of mango peel in functional semolina sourdough bread production for sustainable bio-reuse," *Antioxidants*, vol. 13, no. 11, p. 1278, 2024.
- [15]. Jahangeer et al., "Development and characterization of a plant based ready-to-serve functional drink of pumpkin-mango juice blend added with defatted pomegranate seed extracts," *Food Chem. Adv.*, p. 100997, 2025.
- [16]. V. Tirado-Kulieva, S. Atoche-Dioses and E. Hernández-Martínez, "Phenolic compounds of mango (Mangifera indica) by-products: Antioxidant and antimicrobial potential, use in disease prevention and food industry, methods of extraction and microencapsulation," *Scientia Agropecuaria*, vol. 12, no. 2, pp. 283-293, 2021.
- [17]. L. G. Duarte et al., "Mango (Mangifera indica L.) byproducts in food processing and health promotion," *Nutr. Rev.*, p. nuae214, 2025.
- [18]. S. Kaur, P. A. Sachdev, A. Singh and V. K. R. Surasani, "Utilisation of Kinnow peel as a functional ingredient in bread: Physicochemical, functional, textural and sensory attributes," *Int. J. Food Sci. Technol.*, vol. 58, no. 5, pp. 2706-2714, 2023.