International Journal of Food Science and Nutrition
www.foodsciencejournal.com
ISSN: 2455-4898
Received: 19-04-2025, Accepted: 20-05-2025, Published: 04-06-2025
Volume 10, Issue 3, 2025, Page No. 31-34

Development and quality evaluation of popped millet-based snack bar as a nutrient dense snack bar

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Abstract
Growing demand for healthy, convenient, and ready-to-eat (RTE) foods has spurred a great interest in the formulation of nutrient-dense snack options. This study is centered on the development and quality assessment of a popped millet-based snack bar, taking advantage of the nutritional advantages of ancient grains like sorghum, pearl millet, and amaranth. The research has produced a shelf-stable, organoleptically acceptable product that will be a healthier alternative to traditional snack bars, which depend on processed foods and additives. By a systematic method, different trials were carried out to maximize the formulation, binding agents, and drying conditions. The final formulation contained 7.5% popped sorghum, 15% popped pearl millet, 15% popped amaranth, 15% rice flakes, 5% piri piri mix, 6.8% proprietary spicy mixture (ujjaini sev), 15.7% dhundh ki sev, and 20% sugar. Sensory evaluation on a 9point hedonic scale revealed that the third trial formulation had the highest acceptability scores, especially in taste and texture. Nutritional content analysis showed that the protein level was 10.5%, fat level was 25.26%, moisture level was 8.04%, and ash level was 2.58%. These results indicate that the snack bar developed not only complies with consumer demand for flavor and texture but also has a high nutritional content, making it a suitable product for health-oriented consumers. The study emphasizes the viability of using indigenous millets in snack foods, enhancing health advantages as well as utilization of underutilized grains.

Keywords: Popped millets, pseudo millets, millet-based bar, sugar syrup

Introduction

In the modern fast-moving world, changing eating patterns, increased health awareness, and urban lifestyle changes have strongly driven demand for convenience, healthy, and ready-toeat (RTE) foods. Snack bars, which are praised for their convenience, long shelf life, and twoway role as meal substitutes and instant energy sources, are a prime example. However, much of the commercially sold snack bar is dependent on processed grains, sugar, artificial components, and preservatives in a manner that undermines their nutritional quality. Latching on to the emerging consumer trend toward snacking on natural, nutrient-rich, and additive-free foods, the incorporation of ancient grains like millets into new snack products is an interesting and win-win opportunity to meet this market demand [1]. This research paper discusses the prospect of using millets in the formulation of healthy and flavorful snack bars, investigating their nutritional composition, functional attributes, and potential for developing healthy alternatives to traditional choices. [2]

Millets are cereal crops with small grains that have been cultivated for more than thousands of years, primarily in the semiarid and arid regions of Asia and Africa. These cereals, popularly known as "Nutricereals," consist of grains such as sorghum (jowar), pearl millet (bajra), finger millet (ragi), and amaranth (rajgira). Rich in complex carbohydrates, dietary fiber, antioxidants, and essential micronutrients such as iron, calcium, magnesium, and Bcomplex vitamins, millets play an important role in countering malnutrition and lifestyle-related disorders such as obesity, diabetes, and heart diseases. [3] Being gluten-free naturally, millets are also beneficial for individuals with celiac disease or gluten intolerance. [4], [5]

The aim of this study is to develop a milletbased snack bar that is nutritionally sufficient, shelf-stable, and organoleptically acceptable and also to encourage the utilization of indigenous, underutilized millets. [6] By combining traditional ingredients with contemporary snack fashions, this study seeks to provide a health-improving alternative to existing market offerings. The study addresses the process of formulation, selection of suitable binding and flavoring agents, and evaluates the bar based on sensory characteristics such as taste, texture, aroma, and general acceptability. Limited nutritional testing is also conducted to ensure the macronutrient content and potential health benefits of the end product. [2]

Materials and Methodology

Raw Material:

The Raw material popped- sorghum millet, pearl millet and amaranth millet and rice flakes. was been procured from the local market of Baner, Pune, Spicy mixture proprietary food (ujjaini sev) was procured from Ghasiram Namkeen, Ratlam, Madhya Pradesh, dhundh ki sev was procured from Jalaram sweets, Ratlam, Madhya Pradesh, Madhur pure and hygienic sugar and was procured from local shops in Loni Kalbhor, Pune, Maharashtra. [7], [8]

Table 1: Trial Formulation of Popped Millet Snack Bar

Ingredients	Trial-1	Trial-2	Trial-3
Popped Sorghum	7.5gm	7.5gm	7.5gm
Popped Pearl	15gm	15gm	15gm
Popped Amaranth	15gm	15gm	15gm
Rice Flakes	15gm	15gm	15gm
Piri Piri mix	3gm	4gm	5gm
Spicy mixture proprietary food	3gm	5gm	6.8gm
dhundh ki sev	15gm	20gm	15.7 g m
Sugar	30gm	40gm	20gm

Methodology

Popped millets and proprietary food based multi millet bar was developed using different popped millets, sugar, piri

piri mix and spicy proprietary food (ujjaini sev) and dhudh ki sev. The different popped millets were mixed and weighed according to their presence and were weighed accordingly with proper ratio, different type of spicy proprietary food (ujjaini sev) and dhudh ki sev were mixed. Sugar syrup was prepared with 1:1 ratio and heating method, eg: 20ml water with 20gm sugars crystals, after mixing and formation of syrup, piri piri mix was added according to taste then slowly sugar syrup was added to the mixture to bind the product. [9] After, binding the prepared, mixture was transferred to the tray with butter paper on the bottom, the mixture was settled on the butter paper and was given a proper shape and kept for drying in Cabinet dryer at 70oC for 1.5-2 Hours, after 1.5 hours product was checked for the final drying stage. After three trials composition was finalized [10]. In Trial 1 spicy and sugar taste were lacking making it less spicy, Trial 2 the product was made more sweeter which makes the product too sweet, Trial 3 refinements done to the ratio of spicy proprietary food (Ujjaini sev) and dhudh ki sev, also to the sugar and piri piri mix weighments were refined and it provided us the enhanced and standard formulation.

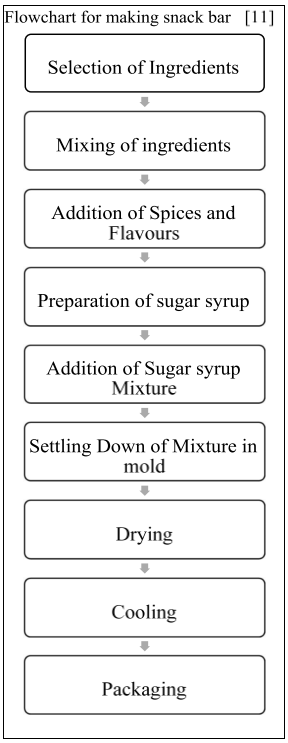

Fig 1: Flow chart showing preparation of snack bar

Formulation of the multi millet-based snack bar

Table 2: Standardized Formulation of Product in %

Ingredients	QTY (%)
Popped Sorghum	7.5%
Popped Pearl	15%
Popped Amaranth	15%
Rice Flakes	15%
Piri Piri mix	5%
Spicy mixture proprietary food	6.8%
dhundh ki sev	15.7%
Sugar	20%

Results and Discussion

The development of the multi millet snack bar involved several trials to determine the most suitable binding agent, drying conditions, and textural attributes. The key findings were as follows:

1. Binding Agent Trials:

Several materials were used to bind the product including Jaggery syrup, glucose syrup, guar gum and sugar syrup. The binding quality and product integrity was observed while selecting the binding agent. Out of these, sugar syrup was found to be most suitable. It provided uniform coating with a desired sweetness to the product. [11] 2. Drying Temperature Trials:

a. 60°C for 2 hours: Resulted in insufficient drying. The snack bar retained moisture, leading to a chewy and soft texture.

b. 70°C for 1.5 hours: Achieved a crispy texture, indicating effective moisture removal while maintaining product structure.

c. 75°C for 2 hours: Produced the best results, delivering a consistently crispy texture and improved firmness, making it the most suitable drying condition for the snack bar. [12]

These trials conclude that optimum conditions for drying the product are 75°C for 2 hours, which give the balance between product integrity, crispness and moisture reduction. [13]

Results of Sensory Evaluation

Table 3: Sensory Evaluation of different trials

Sensory Attribute	Trial-1	Trial-2	Trial-3
Appearance	7.2	8.0	8.5
Texture	6.8	8.2	8.8
Taste	6.5	8.4	9.0
Flavour	7.0	8.6	9.2
Overall Acceptability	6.9	8.3	9.1

Three separate formulations were designed to carry out sensory analysis for the final formulation of millet-based snack bar. The base ingredients were kept constant, ingredients which varied were peri-peri mix, Ujjaini sev, dhundh ki sev and sugar. To evaluate each formulation sensory qualities, which include characteristics like overall acceptability, taste, texture, appearance, and flavour. Trial 3 was found to be the most acceptable using the 9-point hedonic scale. [14] It was observed that trial 3 had highest scores due to balanced flavour and crispy texture. Trial 2 had improved characteristics over trial 1 but less flavour profile. Trial 1 was rated lowest due insufficient flavour intensity. These observations helped us make the final formulation considering sensory characteristics. Panelists were asked to rate various sensory attributes (such as appearance, taste, texture, aroma, and overall acceptability) based on their personal preferences. The hedonic scale provides quantitative data to assess consumer acceptability of food products.

Table 4: Final product sensory evaluation by 6 panelist

Panelists	1	2	3	4	5	6
Colour	8	7	8	7	6	8
Flavour	8	9	8	8	7	6
Texture	7	9	8	8	9	9
Taste	9	8	7	9	7	8
Mouthfeel	9	8	8	7	8	6
Overall acceptability	8.2	8.2	7.8	7.8	7.4	7.4

The product achieved good score from various panelists. This confirms that the product was very well accepted by the panelists.

Hedonic scale: The hedonic scale is a commonly used sensory evaluation tool designed to measure a consumer's degree of liking or disliking of a product. It typically ranges from 1 to 9, where:

1. Like extremely
2. Like very much
3. Like moderately
4. Like slightly
5. Neither like nor dislike
6. Dislike slightly
7. Dislike moderately
8. Dislike very much
9. Dislike extremely

Results of Physicochemical analysis

Moisture content: The moisture content was found to be within acceptable limits for dry snack bars, which typically ranges below 10% to ensure product stability and we were able to achieve a moisture content of 8.04%. [15] This value indicates that the drying process (conducted at 75°C for 1.5 hours) was effective in reducing water content, which in turn helps improve shelflife and reduces the risk of microbial spoilage. [16] Protein content: The protein content was calculated using kjeldahl method, where the nitrogen content in the sample is measured and then converted into protein using a standard conversion factor. The protein content was found to be 10.5%. It was comparatively found to be higher than other millet-based snack bars primarily due to the inclusion of popped millets such as sorghum, pearl millet, and amaranth. The protein level makes this snack bar suitable for consumers looking for plant-based, protein-rich snack alternative. [16] Ash content: The ash content was determined by burning the sample in muffle furnace at a temperature of 550℃ for 5 hours. The ash content was found to be 2.58%. The ash content reflects the total mineral content present in the product. The presence of minerals comes from the whole grains and spice mixes used in the formulation, adding to the micronutrient density of the snack. [17]

Fat content: The fat content was determined using Soxhlet extraction method using petroleum ether as a solvent. The fat content determined was 25.26%. Fats are essential for satiety and energy, especially in snack products as well as for flavour distribution. [17], [18]

Table 5

Parameter	Value Obtained
Protein Content	10.5%
Fat Content	25.26%
Moisture Content	8.04%
Ash Content	2.58%

Table 6: Methods/Equipment used

Parameter	Method Used	Equipment/Procedure
Protein Content	Kjeldahl Method	Digestion, distillation, titration
FatContent	Soxhlet Extraction	Using petroleum ether as solvent
MoistureContent	Hot Air Oven Method	Oven drying at 105°C until constant weight
Ash Content	Muffle Furnace	Ignition at 550°C for 4–6 hours

Conclusion

Our research successfully developed and standardized a snack bar made from popped pearl millet, popped sorghum, popped amaranth, rice flakes, and sev seasoned with peri peri. Sensory evaluation indicated that this bar was well-received by the testers, showcasing strong overall acceptability. This suggests that popped millet serves as an excellent foundation for crafting tasty and enjoyable snack bars. Furthermore, our findings suggest that this homemade popped millet bar is likely to be nutritious, easy to make, and more affordable than similar store-bought options. Overall, this study highlights the potential of using readily available popped millets to create appealing and costeffective snack foods. [16], [19]

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