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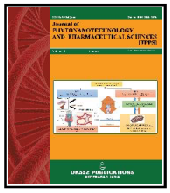

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Development and nutritional evaluation of gluten free ready to eat multimillet snack

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Abstract

Despite having an impressive nutritional profile, millets are still used only by the traditional consumers and members of the economically underprivileged portions of society. In order to achieve nutritional security and battle emerging climate change and rise of chronic diseases, it is crucial to diversify food resources by including millets. The Department of Agriculture and Farmers welfare aims to encourage the use of millet across the entire world by promoting its large-scale production and consumption. Therefore, the United Nations had declared 2023 to be the "International Year of Millet" at the initiative of the Indian Government. Millets, by nature being gluten-free and protein packed with high amounts of amino acids and micronutrients like calcium and iron are an ideal option for developing new healthy products. The aim of this study was to develop a gluten-free ready to eat snack using multimillet flour prepared with a combination of millets (25% each of pearl millet, sorghum, foxtail millet and finger millet), standardize the recipe and undertake its nutritional and sensory evaluation. According to Food Safety and Standards Regulations, the prepared multimillet namakpara can be claimed to be rich in protein, as both the product and flour are high in protein, calcium, iron and are gluten free. Sensory evaluation of the multimillet namakpara showed that it is well accepted by the panel members. These findings highlight the potential of the multimillet namakpara, supported by positive consumer feedback and their nutritional value, offering promising growth opportunities in the snack market and is suitable for consumption by all age groups.

1. Introduction

Prior to the change in eating habits in India caused by the Green Revolution of 1951, millet, pseudocereals, barley and some aged cereals were incorporated in ancient cuisine which were cultivated in India. Declining availability of legumes and millet in general is primarily due to greater attention being paid to wheat and rice production (Sharma *et al.,* 2020).

Millet is a group of crops with extremely small grains that are high in nutrients, tolerant to drought and adverse weather. They are able to grow on relatively less fertile soils with minimal fertiliser and pesticide input. These crops make a significant contribution to the country's nutrition and food supply. India is one of the world's largest producer of millets, contributing approximately to 80% of Asia's and 20% of the world's millets production, as per FAO (Food and Agriculture Organization, USA). In terms of vitamins, dietary fibre, protein, minerals like calcium and iron, and gluten-free options, millets are three to five times more nutrient-dense than most grains. Nutrient-rich millets can support the country's nutrition and food security while also potentially reducing the prevalence of undernutrition and metabolic diseases, which is on the rise (Chandra *et al.,* 2021). Therefore, millets were announced as 'nutri-cereals' by the Ministry of Agriculture and Farmers Welfare, Government of India in the year 2023, which was celebrated as 'The year of Millets'. The Department of Agriculture and Farmers Welfare aims to expand the use of millet across the entire world by promoting its larger-scale production and consumption. Therefore, the United Nations has declared 2023 to be the "International Year of Millet" at the initiative of the Indian Government (Millets 2023, 2023).

Millet has nutritional value similar to or higher than that of major grains. The added benefits of millets, such as gluten-free protein, high fibre content, low glycaemic index, and abundant bioactive compounds, make it an appropriate health food. Pigeon peas and chickpeas boast a commendable protein content rich in essential amino acids, albeit lacking in methionine and cysteine. On the other hand, millet exhibits a well-balanced amino acid profile, including methionine and cysteine at levels 50% higher, along with significant micronutrient content, but falling short in lysine when compared to pigeon pea and chickpea. According to research, the combination of millets and legumes naturally provides high quality, highly digestible and complete protein, iron and calcium when consumed in adequate amounts, such as in a ratio of 3 servings of millet to 1 serving of legume (Anitha *et al.,* 2019; Chuwa *et al.,* 2022 a; Chuwa and Dhiman, 2022 b).

Sorghum, pearl and finger millets are major millets while foxtail millet is considered as minor millet. Since finger millet has an 8-fold higher

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calcium content than wheat, it can help prevent osteoporosis. Pearl millet is the richest source of iron and contains high amounts of dietary fibre and niacin (Table 1). Foxtail millet is high in proteins, phosphorus, zinc and iron content along with thiamine. Sorghum is the fifth staple grain in India and is high in protein and fibre. Due to the high fibre content, millets are considered as low glycaemic foods and therefore they are a healthy option for diabetic patients (Bhat *et al.,* 2018; Mounika and Hymavati, 2021).

Table 1: Nutritional composition of selected millets per 100 g

S.No.	Name of millet	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Crude fiber (g)	Ca (mg)	Fe (mg)	P (mg)	Thiamine (mg)	Niacin (mg)
1.	Sorghum	334	9.9	1.73	67.7	10.2	27.6	3.9	274	0.35	2.1
2.	Pearl millet	347	10.9	5.43	61.8	11.5	27.4	6.4	289	0.25	0.9
3.	Finger millet	320	7.2	1.92	66.8	11.2	364.0	4.6	210	0.37	1.3
4.	Foxtail millet	331	12.3	4.30	60.1	8.0	31.0	2.8	188	0.59	3.2

(**Source:** Indian Food Composition Tables, NIN-2017; *Nutritive value of Indian foods, NIN-2007)

The number of celiac disease patients is rising and patients suffering from celiac disease can have millets safely since they are gluten free. Consumption of gluten damages the small intestine in celiac disease condition. One in 100 people worldwide have celiac disease, and in India it is more common in the north, where wheat is a common cereal (Verma *et al.,* 2022).

India's diverse culinary culture is reflected in its snack foods, which differ in taste and preparation techniques (Dixit *et al.,* 2011). Snacks are an essential part of Indian life, with a wide variety of flavours, shapes, and nutritional content available for different occasions and time of day. Factors such as urbanization and evolving food preferences have led to increase in demand for ready-to-eat snacks in India. The snack food industry in the country is growing significantly, with the Asia-Pacific region being the largest and fastest-growing market. Indian snacks are gaining popularity globally, presenting opportunities for market expansion. The snack industry has the potential to create jobs and contribute to economic growth. With their cultural significance and diverse flavours, Indian snacks have broad appeal and can cater to a wide range of tastes, driving the success of the snack food market (Bannerjee, 2021). Hence, ready-to-eat products prepared from millets can become a healthy option for society (Choudhury and Chaudhary, 2021).

2. Materials and Methods

Multimillet namakpara, a ready to eat snack, was prepared using the flour made up of sorghum, finger millet, pearl millet and foxtail millet. Different steps were involved in the new product development using multimillet flour from procurement of the raw ingredients up to checking consumer acceptability of the product. Nutritional analysis of the flour and the prepared product was performed along with the comprehensive sensory evaluation of the product.

2.1 Procurement of raw ingredients

Sorghum, finger millet, pearl millet, chick pea flour and spices were obtained from the local market of Parel, Mumbai. Foxtail millet was purchased through online portal namely FlipKart. The raw ingredients and the amount used in the preparation of multi millet namakpara is mentioned in Table 2.

Table 2: Ingredients and their quantity used in the namakpara

Ingredients	Quantity
Multimillet flour	75 g
Pearl millet (*Pennisetum glaucum)*	18.75 g (25%)
Finger millet (*Eleusine coracana)*	8.75 g (25%)
Sorghum (*Sorghum bicolor)*	118.75 g (25%)
Foxtail millet (*Setaria italica)*	18.75 g (25%)
Chickpea flour	25 g
Rice flour	7.5 g
Cumin	1.5 g
Carom seeds	1.5 g
Sesame	1.5 g
Red chilli powder	3.5 g
Black pepper powder	0.5 g
Salt	3 g
Sunflower oil	15 ml in dough 50 ml for frying
Water	75 ml

2.2 Preparation of multimillet flour

Sorghum, finger millet, pearl millet and the foxtail millet were taken and then cleaned. Equal portion of all the millets was taken which is 25% of each millet as shown in Figure 1. Each millet was then roasted in a pan on a low flame for 2 min and then transferred into the container. After milling the millets, multimillet flour is obtained.

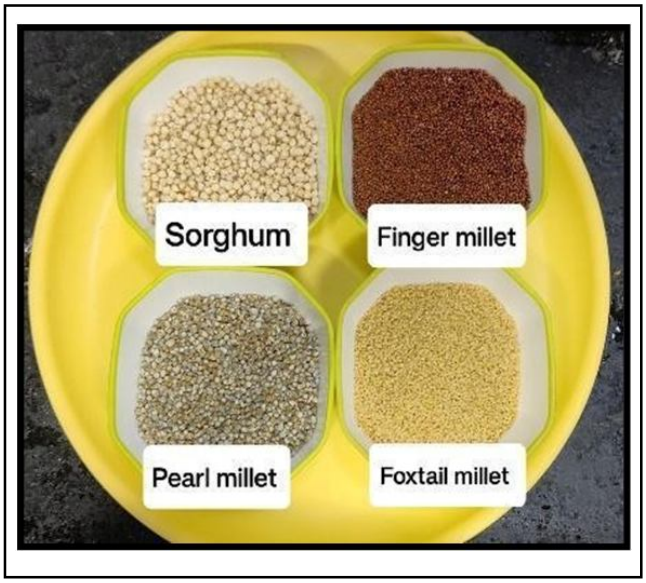

Figure 1: Millets used to make multimillet flour.

2.3 Preparation of multimillet namakpara

To the prepared multimillet flour, chickpea flour was added in the ratio of 3:1. Oil and spices mentioned in the Table 2 were added in the flour. The dough was made by adding water and it was rested for 15 min. Small balls of the dough were made and rolled down on a greased rolling area. Diamond shaped namakpara's were then made using two methods.

i. To make multimillet namakpara healthier, the namakpara's were baked in an air fryer at 180°C for 15 min.

ii. The namakpara were deep fried in hot oil on a medium flame for 4 min until their colour turns golden brown. The excess oil was removed by placing the product on a kitchen tissue paper. The product was transferred into an air tight container after attaining room temperature. The method of preparation of the millet snack is as depicted in Figure 2.

2.4 Nutritional analysis of multimillet flour and namakpara

The nutritional analysis of the multimillet flour and namakpara was carried out using AOAC methods. Estimation of protein is performed using Kjeldahl method (AOAC Official Method 2001.11). The determination of total reducing sugar in the product and flour was estimated by Lane and Eynon method. The fat content was determined using Soxhlet method (AOAC, 2005). The iron and calcium content were estimated using Ramsay's method and EDTA method, respectively. The moisture content of flour and product was determined using hot air oven method.

2.5 Shelf-life analysis of the multimillet namakpara

Shelf-life study of the product was done using two methods as follows; namely, microbial analysis and real time study.

2.5.1 Microbial analysis

Microbial analysis of the multimillet namakpara from day 1 to day 45 was done. Total plate count, yeast and mould count, coliform count test was performed using both samples.

2.5.2 Real time study

Shelf-life evaluation was done at household level as the product was stored in the air tight container for the duration of 45 days and then it was examined on the regular interval of time and the changes were recorded accordingly. Checking of the product was done on a on a weekly basis considering the attributes like colour, texture and aroma.

2.6 Sensory evaluation

A semi-trained panel, consisting of 30 members, evaluated the product's sensory qualities using a 7-point hedonic scale, taking into account the product's colour, texture, aroma, taste, aftertaste, and overall acceptability. The panellists were asked to fill a consent form prior to sensory evaluation session, and consequently were asked to rate the product based on six attributes mentioned in Figure 5.

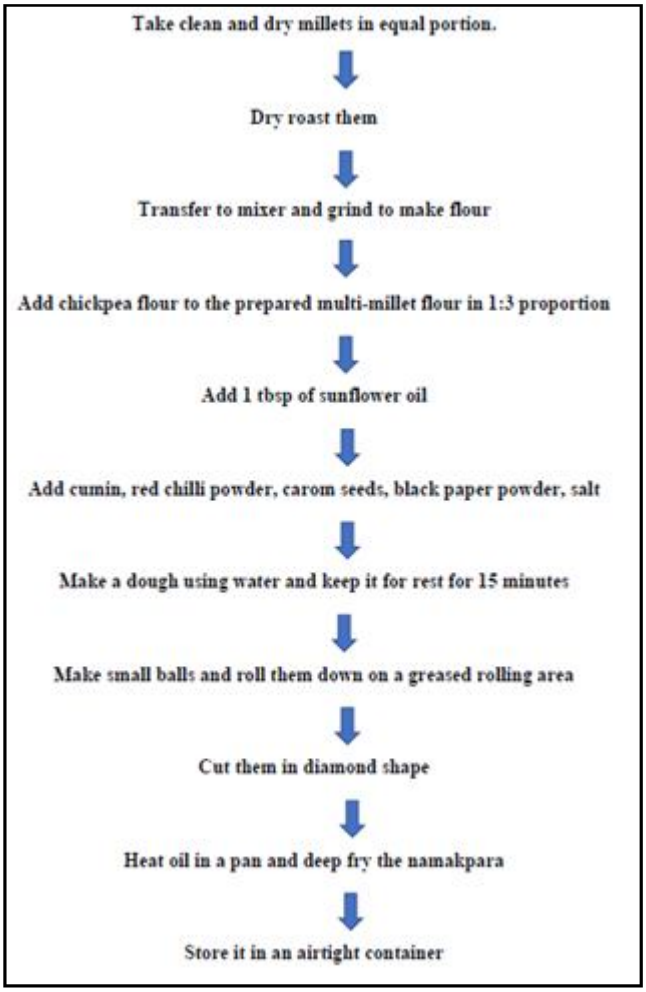

Figure 2: Flowchart of preparation of namakpara.

3. Results

3.1 Standardization of the recipe

Trials were carried with two different cooking procedures to develop multimillet namakpara.

These two methods were:

3.1.1 Air frying using an air fryer

The namakpara made using an air fryer were crispy but the texture was crumbly and was unsatisfactory. As shown in the Figure 3a, the product was dry and the taste of flour and spices was strong. Hence, this method of cooking the multimillet namakpara was not considered.

Figure 3: (a) Air fryer baked multimillet namakpara, (b) Deep fried multimillet namakpara.

3.1.2 Deep frying in oil

The texture or the product (Figure 3b) made using this method was crispy and having more flavour and was better than that of the normal namakpara made with refined wheat flour. Hence, this method of frying was used to standardize the recipe of the multimillet namakpara.

3.2 Nutritional analysis

The results of nutritional analysis performed on multimillet flour and namakpara is shown in Table 3 and Figure 4. As shown in the graph (Figure 4), the overall nutritional content of the product is more than that of multimillet flour except for the iron content. The significant increase in protein and calcium content is due to addition of chickpea flour in the dough during the preparation of multimillet namakpara. The multimillet namakpara is protein rich, high in calcium and gluten free.

3.3 Shelf-life evaluation

Total plate count, yeast and mould count, coliform count test was performed using both samples. No growth was observed in any of the test results which indicates that the namakpara sample from day 1 and day 45 is free from yeast and mould, coliform and pathogens.

Shelf-life evaluation of multi millet namakpara was carried out to attributes like colour, texture and aroma. The results of the analysis are as given in Table 4.

The product on the day numbers 7, 14, 21 and 28 has not shown any significant changes in colour, texture and aroma. However, on day number 35, there was a slight change in the texture. On day 42 a decrease in the crispy texture and rancid odour was noticed. Hence, the multimillet namakpara sample from day 35 is unacceptable for consumption as it would taste different as compared to freshly prepared snack. Hence, it can be considered that the multimillet namakpara is suitable for consumption for a month when stored in air tight container.

Table 3: Summary of nutritional analysis for multimillet flour and namakpara

S. No.	Nutrients	Multimillet flour/100 g	Multimillet namakpara/100 g
1.	Protein	11.19 g	12.93 g
2.	Fat	4.26 g	24.35 g
3.	Total sugar	0.94 g	2.63 g
4.	Calcium	10.4 g	15.2 g
5.	Iron	13 mg	9 mg
6.	Moisture content	7.93 %	4.98 %

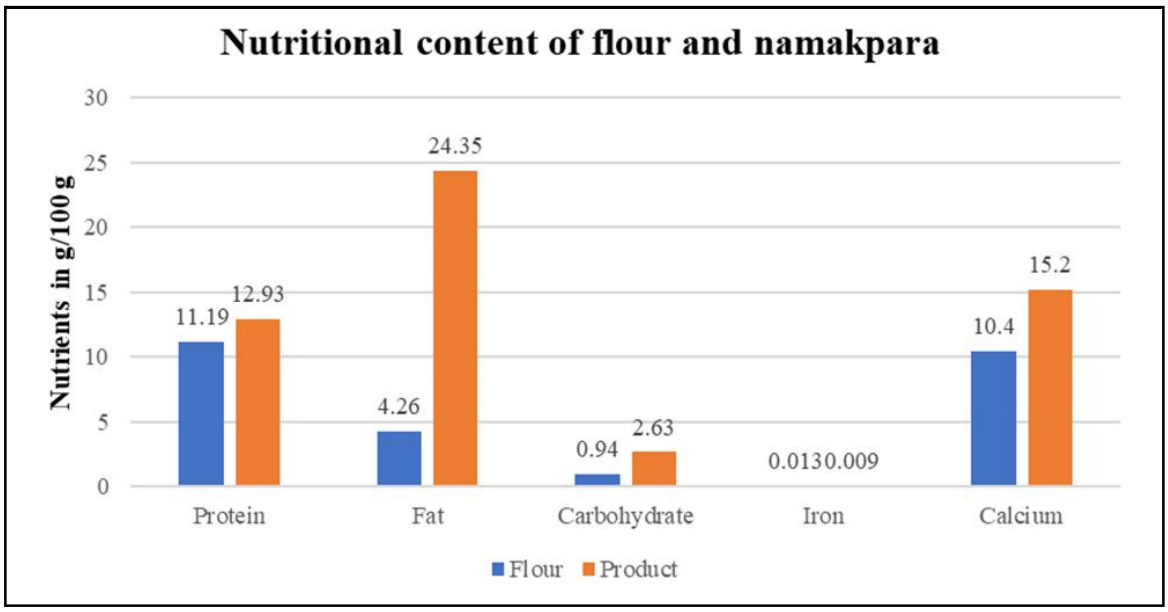

Figure 4: Bar graph showing comparison between multimillet flour and namakpara.

Table 4: Shelf-life evaluation of multimillet namakpara

Day	Colour	Texture	Aroma
7	No change	No change	No change
14	No change	No change	No change
21	No change	No change	No change
28	No change	No change	No change
35	No change	Decrease in the crispy texture	No change
42	No change	Decrease in the crispy texture	Rancid odour

3.4 Sensory evaluation of the product

The sensory evaluation of sample was conducted in College of Home Science, Nirmala Niketan, Mumbai, with 30 semi-trained panellists using seven-point hedonic scale using several attributes of the product such as colour, texture, aroma, taste, aftertaste and overall acceptability.

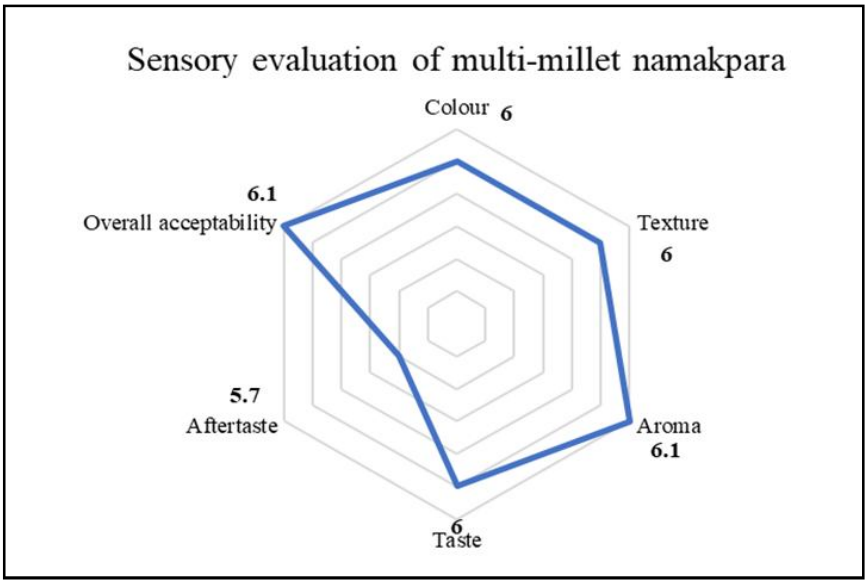

Figure 5: Radar chart showing sensory evaluation of multimillet namakpara.

The above radar chart (Figure 5) shows different attributes of multi millet namakpara with the average score. Colour, taste and texture of the multimillet namakpara has the mean value of 6 which is well above the overall average. This indicates that, colour, taste and texture of the multimillet namakpara is very much liked by the participants. Aftertaste of the multimillet namakpara gets the least score among the others which means that the aftertaste of the product is not greatly approved by the panellists. Overall acceptability of the multi-millet namakpara has the average score of 6.1 which is highest among all the categories. Therefore, it can be concluded that the multimillet namakpara is overall found tasty and acceptable by the participants.

4. Discussion

The research project focused on the development of multimillet namakpara, a traditional gluten-free Indian snack made from multi-millet flour. The project underwent various stages, including the procurement of raw materials and the standardization of the recipe. The final product was evaluated through nutritional, microbial analysis, and sensory evaluation. The overall acceptance of the snack by the participants supports the notion that it has the potential to be scaled up for commercial production. The produced namakpara was found to be rich in protein as well as high in calcium and iron content. The results of the research project indicate that the multi-millet namakpara was well-received by the participants.

The multimillet namakpara is a gluten-free option suitable for individuals with celiac disease. This product offers an alternative to gluten-containing snacks, which are not only more expensive but also less nutritious. Millets, the key ingredient, contribute to the snack's low glycaemic index, making it a favourable choice for diabetic patients by preventing sudden spikes in blood sugar levels. Moreover, the cost-effectiveness of this ready-to-eat snack stems from the relatively lower prices of millets compared to other cereals and grains.

5. Conclusion

This research work has involved in crafting a gluten-free Indian snack abundant in protein, calcium, and iron. The positive reception from participants implies its potential for widespread commercial production. With additional investment and refinement, the multi-millet namakpara could emerge as a popular and economically viable product in the competitive snack market. The following recommendations are based on the findings and analysis of the multi-millet snack

i. The multimillet flour can be used as gluten free flour and as a replacement to wheat flour/ refined flour.

ii. Strong aftertaste of the carom seed was observed in the product which can be eliminated by decreasing its level during preparation of the product and different flavours like pani puri, cream and onion, tomato, chat masala can be incorporated.

iii. Various products such as thalipeeth, dosa, chakali sticks, ladoo can be made using multimillet flour.

iv. The stable, extended shelf-life product can be obtained using various processing and packaging techniques along with addition of antioxidants.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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