RESEARCH ARTICLE

Sensory Evaluation of a Dairy-Based Millet Nutri-Mix: A Preliminary Consumer Study

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Abstract

The increasing interest in functional foods with enhanced nutritional benefits has prompted the exploration of traditional grains and dairy products as foundational ingredients. This study focuses on developing a millet-enriched, milk-based nutri-mix designed to offer a nutrient-dense beverage suitable for consumers of all age groups. Minor millets, such as Kodo (*Paspalum scrobiculatum*) and little millet (*Panicum sumatrense*), are rich in dietary fiber, protein, and minerals, contributing to improved digestion, glycemic control, and cardiovascular health. Jaggery provides natural sweetness along with iron, while milk powder—high in calcium and protein—supports bone health and overall growth.

The formulation was developed using germinated Kodo (*P. scrobiculatum*) and little millets (P. sumatrense), which were dehydrated and milled under controlled conditions. The resulting malt was combined with milk powder to prepare the nutri-mix. Three variations were tested, each containing 20% Kodo millet (*P. scrobiculatum*) malt, 20% little millet (*P. sumatrense*), malt, 30% milk powder, 10% flavouring, and 20% jaggery powder. Flavor types included flaxseed (T1), cocoa (T2), and almond (T3). Sensory evaluation was conducted through a 9-point hedonic scale by a panel of 10 semi-trained members. Treatments T1 and T3 received overall acceptability scores of 5.96 ± 0.50 and 6.00 ± 0.40, respectively, while T2 (cocoa) achieved the highest score of 7.26 ± 0.33 and was statistically distinct from the other samples ($p < 0.001$).

These findings suggest that the cocoa-flavored nutri-mix (T2) was the most preferred among consumers, highlighting its potential as an appetizing and nutritionally augmented health beverage.

Keywords: Milk powder, Health drink, Nutri-mix, Consumer preference, Millet, Sensory analysis.

Highlights

- Nutri-cereals in the diet can improve immunity.
- Consumers widely accept milk-based products.
- Health drinks are popular for their ease of use and high nutritional content.
- Malt-based products have high consumer acceptance.
- Replacing conventional grains with millet helps reduce gluten-targeted diseases.

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Introduction

Nutri-cereals have become popular in the past decade due to their excellent nutritional profile and ability to thrive in extreme environments. So, in recent years, millet's popularity has reached its peak. Dairy-based products have a wide consumer acceptance in the market. Also, dairy is part of the day-to-day life of an individual. Value addition using millets in the dairy sector not only increases customer acceptance but also provides essential nutrients that the Indian populace needs daily.

The dietary requirements of people with metabolic illnesses such as obesity, hypertension, diabetes, and dyslipidemia are satisfied by novel foods and drinks. (Jana & Sarraf, 2022). Eating millet also helps reduce blood pressure, inflammation, and heart disease risk. It may also help prevent cancer and help control weight by encouraging satiety. They are a good dietary choice for those with celiac disease because they are gluten-free. Furthermore, their antioxidant qualities help to control oxidative stress and provide anti-aging effects. When it comes to culinary applications, millet has several uses. It may be added to traditional recipes, processed into goods like millet milk, flakes, and snacks, or even blended with dairy products to improve their nutritional content (S. Sujith et al., 2023)

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Nutritional benefits of Millets

Minor millets like kodo millet (*Paspalum scrobiculatum*) and little millet (*Panicum sumatrense*) are cultivated in various parts of India. Kodo millet (*P. scrobiculatum*), often called cow grass, is a member of the Poaceae family, which is also referred to as the grass family. It is a crop that lasts a long time. The stiff, persistent, sticky husks preserve the grain (Gupta *et al*., 2012). *P. scrobiculatum var. scrobiculatum* is cultivated as a significant crop in India, whereas *P. scrobiculatum var. commersonii* is a wild

variety indigenous to Africa (Shukla *et al*., 2022). Kodo millet (*P. scrobiculatum*) is rich in bioactive compounds like Naringin, Catechin, Ferulic acid, Sinapic Acid, and *P*-coumaric acid (Khare *et al.,* 2020). According to Bunkar *et al*. (2021), kodo grains include 2.95% ash, 10.2% dietary fiber,1.45% fat, 65.65% carbohydrates, and 8.35% protein.

In dry and semiarid parts of the world, little millet (*P. sumatrense*) is a significant food source. Minerals, protein, dietary fiber, and fat are all present in good amounts in little millet (*P. sumatrense*). The proteins of small mill*et al*so contain certain sulfur-containing amino acids, like cysteine and methionine. Despite its restricted use, little millet (*P. sumatrense*), like all other millets, offers a better nutritional profile than cereals. Nutraceuticals such as phenolics, sterols, resistant starch, phytates, as well as lignans are also abundant in it. Little millet (*P. sumatrense*), is predominantly composed of carbohydrates, which account for 73.40% of its composition. This high carbohydrate level suggests that the food is a significant source of energy. Additionally, it contains 7.72% total dietary fiber, which is beneficial for digestive health and may help in regulating blood sugar levels. The total energy provided by Little Millet (*P. sumatrense*) is 1449 kilojoules (kJ), which reflects its potential contribution to daily energy requirements. Overall, the food item appears to be a carbohydrate-rich, low-fat option with moderate protein and dietary fiber, suitable for energy provision and general nutrition (Kumari *et al*., 2025). All these qualities of Kodo (*P. scrobiculatum*) and little millet (*P. sumatrense*) make it an excellent tool for value addition in the dairy sector.

Processing of millets

In the past five to six years, value-added millet products have gained increasing popularity. Throughout the last decade, researchers have developed a variety of millet-based items, including weaning foods, nutritional beverages, and dairy alternatives made from millet. Despite being nutrient-dense, millets must be treated to maximize their nutrient availability and eliminate antinutrient components. These days, a variety of food processing techniques are used to transform millets into an edible form that is suitable for human consumption, such as de-husking, soaking, germination, milling, fermentation, malting, and so on (Mahajan *et al.,* 2023)

Traditional processing methods like soaking and germination, which are known to improve the nutritional profile and lower the anti-nutritional components of millets, have drawn more attention in recent years. In particular, germination has become a viable and affordable way to increase the functioning of millet in human diets. The rise in protein content is one of the most important results of millet germination. The germination of Kodo (*P. scrobiculatum*) , barnyard, and little millet (*P. sumatrense*) for 24 to 48 hours resulted in a significant rise in crude protein levels, as shown in a study by Iralepatil *et al.,* (2024). This increase is ascribed to enzyme activity during germination, particularly protease activity, which increases the availability of storage proteins by breaking them down into simpler forms of amino acids and peptides. Malting, which combines soaking, germination, and drying, also raised the protein content in finger millet from 7.52 g to 8.64 g per 100 g. The metabolic processes initiated during germination also deplete carbohydrate stores and cause the formation of amino acids from simpler nitrogen-containing substances. Additionally, germination causes a noticeable drop in fat content. The investigations' conclusions indicate that lipase activation, which starts fatty acid oxidation and lipid hydrolysis, is what causes this reduction. These metabolic alterations contribute to the growing embryo's energy supply, which lowers the overall fat level. For example, following malting, the fat content of finger millet decreased from 1.9 to 1.3 g. By lowering the chance of rancidity, the decreased fat not only improves the nutritional profile but also prolongs shelf life (Sahoo *et al.,* 2024).

Enzymatic hydrolysis transforms complicated carbohydrates into simpler, easier-to-digest forms, such as reducing sugars, during germination. Total reducing sugars in finger millet (var. Kabre-1) increased dramatically with germination time, peaking at 9.22 mg/100 g after 48 hours. The millet's energy value increased to 386.9 Kcal/100 g in the same study, reflecting the breakdown of starch. Germination also decreased the total phenolic content of finger millet by 42.43%, tannins by 32.23%, and phytic acid by 48.38%. This increases protein digestibility as well as mineral bioavailability, particularly for iron, calcium, and zinc. Additionally, baked foods have successfully used millet flours that have been germinated. For instance, biscuits produced with up to 25% malted finger millet flour scored highly in sensory evaluations and were proven to be more appealing and healthier. These results highlight the potential of products made from germinated millet in food formulations with added value (Karki *et al*., 2024)

An increase in ash content, which is frequently employed as a gauge of overall mineral content, shows that malting significantly improves the mineral content of finger millet. Longer malting times resulted in a considerable rise in the ash content of both light brown (LB) and dark brown (DB) finger millet flours, according to the study by Murungweni *et al*. (2023). After 72 hours of malting, the ash concentration increased from 1.57% (control) to 2.27%. This enhancement is attributed to enzymatic activity during germination, which breaks down complex compounds in the grain, thereby releasing more minerals into the flour. These changes suggest that malting not only improves the digestibility and functional qualities of finger millet but also boosts its micronutrient profile, potentially making it more effective in addressing mineral deficiencies in the diet (Murungweni *et al.,* 2023)

So, millet's nutritional and functional qualities are greatly enhanced by germination and soaking. These pre-treatment techniques improve digestibility, lower fat and antinutrients, boost protein content, and foster improved sensory attributes. The end products are better suited for a variety of food uses, such as baked items and baby food. These methods offer a straightforward yet effective means of maximizing millets' potential, transforming them into a nutrient-dense food option that combats malnutrition and micronutrient deficiencies in addition to being a sustainable crop.

Consumer Trends

The present food options are various, but the lack of time for consumers makes them more prone to use ready-to-eat food mixes. Health mixes are not a new product to consumers, but

presently, most of the health mixes are made from conventional crops like wheat. Replacing conventional crops with millet is already a trend. But there are not many studies done on minor millets. A recent study done on consumers of Chennai city by Babu *et al*. (2021) explores the reasons behind consumer preferences for RTE foods. Convenience, mood, quality, taste, affordability, and stress-free consumption are the six main criteria that are identified as having a substantial impact on purchasing decisions. The most significant criteria were found to be convenience, including the ease of preparation and time-saving advantages, as well as the stress-free nature of RTE foods. The nutritional value of these items, as well as their sensory appeal—which includes pleasing flavor, aroma, and appearance—also greatly influences consumer behaviour. Purchases are further encouraged by reasonable prices and the impression of good value for money. The majority of consumers, according to the report, are young, working professionals from nuclear families, underscoring the effects of urbanization, hectic lifestyles, and the growth in dual-income homes. The trend toward ready-to-eat food items ultimately reflects the modern consumer's need for easy, quick, and healthful meal options.

The health mix provided fit all the criteria mentioned above. The ingredients of a health mix can vary according to need. Dairy, being an excellent source of minerals like calcium and phosphorus, is preferred due to its wider acceptability by consumers due to its palatability. Minor millets can be used to replace cereals like wheat and barley; kodo and little millet (*P. sumatrense*) are also gluten-free, which is becoming another concern of some target consumers. We can also add other functional ingredients for enhancing flavor as well as targeting some specific diseases. According to Doykina *et al*. (2024), products that combine different components to offer particular health benefits are referred to as functional blends, and they are sold commercially. Since health mixes are typically in powdered form, adding them to dishes or drinks is simple. Depending on the particular product and its intended use, powdered functional mixes can contain a wide range of substances.

Doing a pilot study to check consumer acceptance is always better before starting a new line of products. It helps us to find faults and, at the same time, reflects consumers' preferences. Since sensory analysis is a big part of the food industry, the aim was to develop a dairy-based Nutri-mix using different flavors and check its consumer acceptance. The main goal is to check which flavour is more acceptable to the consumer. The flavors were roasted flaxseeds, almonds, and Cocoa powder. The availability of α-linolenic acid for vegetarians has led to a significant increase in the demand for flaxseeds in food and drinks, functional foods, and nutritional supplements. Flaxseeds are regarded as a completely functional food. Additionally, it has favorable effects on the prevention of illness with components that are helpful to health. Flaxseeds are rich in ω-3 fatty acids, including α-linolenic acid (ALA), short-chain polyunsaturated fatty acids (PUFA), proteins, soluble and insoluble fibers, phytoestrogenic lignans (secoisolariciresinol glycoside, or SDG), and micronutrients (Raole & Raole, 2022). Almonds are considered to be nutritious and are high in protein, dietary fiber, monounsaturated fatty acids, vitamin E, riboflavin, and vital minerals (Barreca *et al*., 2020). Almonds are being used in various processed products in order to enhance taste and improve nutritional profile. Almonds have therapeutic properties and are an excellent source of vitamin E, minerals, phytochemicals, mono- and unsaturated fatty acids, polyphenols, and phytosterols (Ozcan, 2022). Also, one of the most well-known raw commodities in the world, cocoa, satisfies customer expectations about health. Children are drawn to beverages made with cocoa because of its excellent color, rich flavor, and scent. Due to its sensory qualities and simplicity of preparation and consumption, beverages containing cocoa are widely accepted. These days, a variety of cocoa-based drinks are available in the market, either hot or cold, with milk or water, instant or ready-to-drink. Because cocoa and its derivatives include a high concentration of bioactive substances with antioxidant properties, including methylxanthines and flavonoids, their health advantages are well established (Barisic *et al*., 2023).

Material and Methods

Kodo millet (*P. scrobiculatum*) grain, Little millet (*P. sumatrense*) grain, milk powder, Flaxseed, Cocoa powder and Almonds were purchased from the local market of Dehradun. Millets were soaked overnight in separate containers and water was drained the next day. The millets were germinated at 90% RH at room temperature (Figs 1 and 2). The germinated millets were washed and dehydrated at 65°C (Figs 3 and 4) for 3 to 4 hours and milled separately. The malt was stored in PET jars for use. The flaxseed was roasted and milled before being added to the product. Almonds were ground. The treatments (Fig. 5) were made according to the ratio given in Table 1. The treatments (5 g each) were mixed with 100 mL of hot water (Fig. 6) and sensory analysis was conducted by a semi-trained panel of 10 members using a 9-point hedonic rating test for color, taste, flavor, aroma, and overall acceptability (OAA). Since this was a preliminary study to check only consumer preference, only 10 members were chosen to do the test. A new product will be developed in the future according to the results of this study.

Result and Discussion

All three treatments: T_1 (Flaxseed), T_2 (Cocoa Powder), and T_3 (Almond) were packed and analyzed using a 9-point hedonic rating test. A semi-trained panel of 10 members was selected to give a rating on color, taste, flavor, aroma, and texture (Table 2). The data was analyzed for variance using OPSTAT software. The Critical difference (C.D.) and *p-value* were calculated at a 0.05 significance level to check the significance between treatments

Table 1: Composition of nutri-mix treatments with varying flavouring agents

Treatment	*Kodo millet malt (%)*	*Little millet malt (%)*	*Jaggery (%)*	*Milk powder (%)*	*Flavour (%)*
T1 (Flaxseed)	20	20	20	30	10
T2 (Cocoa Powder)	20	20	20	30	10
T3 (Almond)	20	20	20	30	10

The methodology of preparation of Nutri-mix is given below: -

Procuring millets

⬇

Washing and Soaking

⬇

Draining excess water and germination at 90% RH for 2-3 days (Figs 1 and 2)

⬇

Drying the germinated millets at 65°C for 3-4 hours (Figs 3 and 4)

⬇

Milling the dehydrated millet to form malt and Store in PET jars

⬇

Blending the malt with Milk powder according to ratio given in Table 1.

⬇

Addition of Different Flavouring agents (Figs 5 and 6)

⬇

Sensory Analysis of the Nutri Mix using 9-point Hedonic Rating Scale

Fig. 1: Germinated Little millet (*P. sumatrense*) after 2-3 days

Fig. 2: Germinated Kodo millet (*P. scrobiculatum*) after 2-3 days

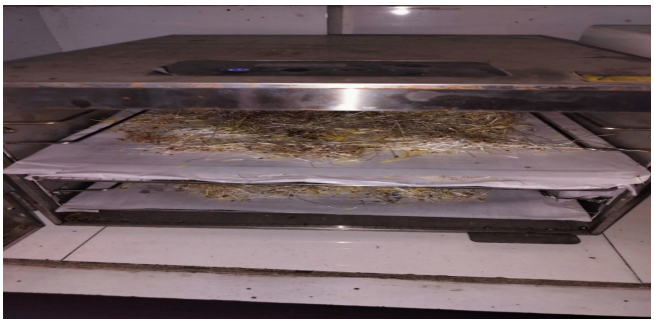

Fig. 3: Dehydration of germinated millets in tray drier

Fig. 4: Dehydrated millets at 65°C for 3-4 hours

Fig. 5: Nutri Mix with Different Flavours are packed in LDPE packaging

Fig. 6: Mixing in hot water for sensory analysis

for each parameter. Results were considered statistically significant if $p < 0.05$. The values with different superscripts are significantly different from each other.

Color

The rating of color was in order $T_2 > T_1 > T_3$. T_1 has a rating of 6.5 ± 1.08, T_2 has a rating of 7.6 ± 1.35 and T_3 has a rating of 6.4 ± 1.17 on a hedonic scale. T_2 was significantly different from T_1 and T_3. The nutri-mix developed based on pearl millet malt was developed by Naveena *et al*. (2024) had a rating between 7 to 8, which is similar to our reading. Color is an important criterion for enhancing the aesthetic appeal of the product. Cocoa powder

Table 2: Determination of sensory attributes

	Sensory evaluation of nutri-mix					
	Color	*Taste*	*Flavor*	*Aroma*	*Texture*	*OAA*
T1 (Flaxseed)	6.5 ± 1.08a	5.9 ± 0.88a	6 ± 1.05a	5.5 ± 0.71a	5.9 ± 0.74a	5.96 ± 0.50a
T2 (Cocoa Powder)	7.6 ± 1.35b	7.6 ± 0.97b	7.7 ± 1.06b	7.3 ± 1.06b	6.1 ± 0.99a	7.26 ± 0.33b
T3 (Almond)	6.4 ± 1.17a	6.2 ± 0.92a	6 ± 0.82a	5.9 ± 0.88a	5.5 ± 0.71a	6 ± 0.40a
C.D.	0.767	0.713	0.931	0.859	NS	0.379
p-value (α = 0.05)	0.006	< 0.001	0.001	0.001	0.238	< 0.001

*The values are expressed as mean ± SD. The values with different superscripts are significantly different from each other. C.D. (Critical difference). NS (Not significant).

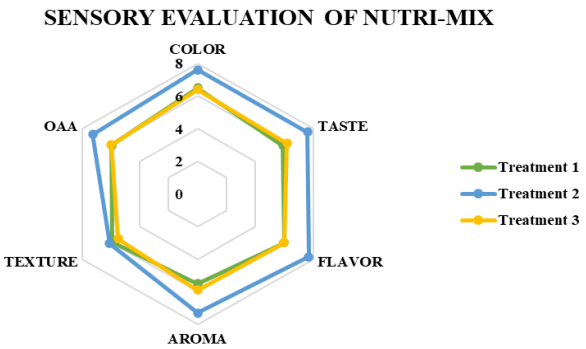

Fig. 7: Mixing in hot water for sensory analysis

gives an attractive appearance to the product, which appeals to all age groups. The color of cocoa powder is mainly due to its total polyphenol content and anthocyanin content. Alkalization also has a significant effect on the final color of cocoa powder (Li *et al*., 2013).

Taste

T_2 had the maximum score on taste (7.6 ± 0.97) and T_1 had the minimum score (5.9 ± 0.88). The addition of cocoa powder has the maximum effect on taste. Flaxseed had the minimum score in terms of taste. The rating order of taste was $T_2 > T_3 > T_1$. Taste is one of the most important parameters for the sensory acceptability of the product. It's critical to realize that taste is a mix of multiple sensory inputs rather than a single sense. The five primary taste qualities that our tongues can detect when we eat are sweet, sour, salty, bitter, and umami. Specific receptors on your tongue, known as taste buds, pick up these taste qualities and communicate them to the brain for processing (Helen V, 2023)

Flavor

Flavor is a combination of taste and aroma. Flavor in malt drinks can be due to the presence of various volatile substances. Aldehydes, ketones, alcohols, aromatic compounds, and furans are among the volatile substances that make up malt flavor (Chen *et al*., 2017). The highest score in flavor was achieved by T_2 (7.7 ± 1.06), while both T_1 and T_3 had a similar score, which was 6. The high score of T_2 may be due to the addition of cocoa powder. Beverages made with cocoa are quite popular with all age groups, but particularly with kids. The sensory qualities of cocoa-based beverages, along with their simplicity of preparation and consumption, contribute to their acceptance among consumers (Barisic *et al*., 2022).

Aroma

The aroma or odor of the product is one of the key indicators of food quality. Pleasant aroma attracts customers to the food. Aroma is released during eating, which is perceived by the nose (Hatakeyama & Taylor, 2016). The process of germination and kilning influences the production of aroma compounds. The enzymatic reduction during germination and the drying phase is responsible for the characteristic aroma of malt (Prado *et al*., 2021). In the present investigation, the highest score for aroma was in T_2 (7.3 ± 1.06) and T_1 had the lowest score (5.5 ± 0.71). Also, T_3 has an acceptance score of 5.9 ± 0.88.

Texture

In the present investigation, the Nutri-mix was scored on texture on the basis of a 9-point hedonic rating test. The texture was rated in order $T_2 > T_1 > T_3$. T_1 scored 5.9 ± 0.74, T_2 scored 6.1 ± 0.99 and T_3 scored 5.5 ± 0.71. There was no significant difference in the texture of all treatments. The sensory assessment of food's physical characteristics, mostly through touch and mouthfeel during consuming food, is known as "food texture". In order to regulate taste perception and the overall sensory pleasure of food, texture is essential. Research has indicated that textural characteristics like viscosity and tongue-coating qualities might affect how flavors are released and remain in the mouth (Baingana, 2024).

Overall acceptability (

The overall acceptability was calculated by taking the mean of 5 parameters (Table 2). Treatment 2 (7.26 ± 0.33) has the highest overall acceptability. The rating of OAA was in order $T_2 > T_3 > T1$. Similar health mixes with millets and conventional cereals were made before by P and Latha (2019), where OAA was 7.9 after 180 days of storage, which is similar to the present findings. This suggests that people have a good acceptance rate for malt-based drinks. Another malt-based probiotic drink was developed by Sharma and Sharma (2021), where the OAA observed was 7.97.

Conclusion and Future Aspects

The cocoa flavour was best suited to the sensory panel with an overall acceptability of 7.26 ± 0.33. It has the highest consumer

acceptance (Fig. 7). Malt beverages are widely accepted around the world because of their cultural significance, nutritional value, and adaptability. The rich flavor of cocoa and the health advantages of malt are combined in the well-liked category of beverages known as cocoa-based malt drinks. These beverages are popular among both adults and children because of their flavourful taste, ability to increase energy levels, and adaptability. So, manufacturers should concentrate on developing healthier versions, enhancing accessibility, and informing customers about their advantages in order to broaden their market. Malt beverages might continue to become a popular beverage choice around the world with advancements in flavor and composition.

To further enhance the nutritional value and consumer appeal of ready-to-eat food products, incorporating a variety of millets and exploring different taste profiles could be highly beneficial. Such innovations not only offer richer, more diverse food options but also contribute to promoting millet cultivation, a sustainable practice given millets' resilience to climate change compared to traditional grains. This approach holds strong potential for boosting both the health benefits and the commercial success of ready-to-eat products, aligning with growing consumer demand for nutritious, environmentally friendly food choices. In the future, researchers can also explore the shelf-life and nutritional assessment of malt-based products of millet. The commercialization of these products should be studied in detail to find consumers' needs and preferences. Also, diabetic free or protein-rich versions of this product can be explored in future studies.

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Authors Contribution

Kajal Srivastava-concept generation and the creation of the manuscript's initial draft. P. Vijayakumar- critical review and editing of the manuscript as well as supervision of the study.

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