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Proximate and Sensory Evaluation of the Composite of Finger, Foxtail and Little Millets

Samreen Fatima[1], Kahkashan Parvin[1], Arvind Kumar Srivastava[1], Farzana Mahdi[2]

[1]Department of Food and Nutrition, Era University, Lucknow, U.P., India

[2]Department of Personalized and Molecular Medicine, Era University, Lucknow, U.P., India

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KEYWORDS
Foxtail millet, Finger millet, Little millet, Sensory evaluation, Proximate analysis, Millet composite.

ABSTRACT:

Introduction: Millets are nutrient-dense grains, abundant in proteins, fiber, essential minerals, vitamins, and bioactive substances. They help lower the chance of lifestyle-associated conditions such as cardiovascular problems, diabetes and some chronic disorders due to their low glycemic response and health-promoting qualities. This study was undertaken to prepare a nutritionally balanced millet composite by mixing three millets, i.e. foxtail, finger and little.

Methods: The millet composite was prepared by mixing finger, foxtail, and little millets in a ratio of 1:1:1, and the mixture was soaked in water for 8 to 10 hours. The water was decanted and the residual material was termed as composite. The sensory analysis was done by 30 panelists using a 9-point hedonic scale. Proximate analysis of the composite was done by standardized methods.

Results: Proximate analysis of the composite revealed 67% carbohydrate, 9.16 % protein, 1.3 % fat, 13.4% moisture, 7.84 % fiber, 1.36 % ash, and an energy value of 316 Kcal. Sensory evaluation of the composite showed sensory score, i.e. 8.4±0.2 for color, 8.3±0.3 for texture, 8.5±0.3 for flavor, 8.5±0.2 for taste and 8.3±0.3 for overall acceptability.

Conclusions: Composite having three of the millets (foxtail, finger and little millets) was found to be superior not only in terms of enriching nutritional components but also for its taste, texture, color, flavor, and overall acceptability.

1. Introduction

Nowadays, people are more interested in foods because of their functional qualities as well as their nutritional value, particularly for their role in disease prevention rather than treatment. Cereal foods, which are abundant in essential macro and micronutrients as well as non-nutrient bioactives, secondary metabolites, and phytochemicals, are key contributors to the food system. Epidemiological findings have indicated a significant connection between millet intake and a lowered risk or occurrence of cardiac diseases, diabetes, specific forms of cancer and other related health problems [1].

Millets are members of the Poaceae family [2]. Millets are divided into two categories: major and minor. The major millets are sorghum, finger millet and pearl millet. On the other hand, minor millets comprise proso, kodo, little and foxtail millet [3]. Year 2023 was declared to be the "International Year of Millets" by the United Nations in honour of their benefits for health, nutrition, and climate resilience [4]. Typically, millets include 65–75% carbohydrates, 7–12% protein, 5% fat, and 8–15% dietary fiber. Protein digestion is improved by their prolamin content, and they contain more important amino acids than other cereals [5].

Because of the increase in health problems and lifestyle-related illnesses, there is a growing need for functional foods made from traditional and underutilized grains like millets. Creating value-added millet products is a workable approach to improve dietary diversity and nutritional intake in regions where metabolic illness and micronutrient deficits are common [6]. Including millet

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in baked goods or convenience foods can improve their nutritional content without sacrificing their flavor [7]. Nutritional analysis and organoleptic evaluation are essential steps in creating food products made from millet. In order to determine customer acceptance, sensory or organoleptic evaluation looks at characteristics that are critical to market viability, such as color, taste, texture and flavor [8]. By analyzing a product's moisture, protein, fat, ash, fiber and carbohydrate content, nutritional analysis evaluates its nutritional quality and makes sure it complies with dietary and health regulations [9]. These assessments together confirm that the created items are both organoleptically acceptable and sufficiently nutrient-dense.

The present study reports the preparation of millet composites, their sensory attributes and nutritional analysis of the most acceptable preparation.

2. Materials and Methods

2.1. Procurement of raw materials

Finger, foxtail and little millets were procured from Gramya Ventures Private Limited, Kadiri, Andhra Pradesh and authenticated at the Indian Institute of Millets Research (IIMR), Hyderabad.

2.2. Pre-treatment of millets

After procurement, each millet grain was subjected to the same pre-treatment process separately. These underwent cleaning to remove extraneous materials like dust, stones and broken grains. The cleaned grains were then soaked for 8-10 hours in water. After draining the extra water, millet was spread evenly on trays and shade-dried for 48 hours.

2.3. Preparation of composite of finger, foxtail and little millets

The composite of finger, little and foxtail millets was prepared by adding two in a fixed quantity and varying one. The other ingredients in the composite were added in a fixed quantity. Figure 1 shows different composite preparations. Tables 1 to 3 present the ingredients in various composites.

All these composite preparations were evaluated with the help of 9-point hedonic scale by 30 expert members for color, texture, taste, flavor and overall acceptability.

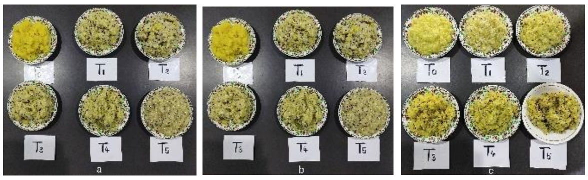

Figure 1: a) Composite with finger millet as variable, b) Composite with foxtail millet as variable, c) Composite with little millet as variable

Table 1. Ingredients of the composite with fixed amounts of little and foxtail and variable amounts of finger millet

Ingredients	T_0 (control)	T_1	T_2	T_3	T_4	T_5
Finger millet (g)	-	1	2	3	4	5
Foxtail millet (g)	-	5	5	5	5	5
Little millet (g)	-	5	5	5	5	5
Rice (g)	25	25	25	25	25	25
Dal (g)	25	14	13	12	11	10
Turmeric (pinch)	1	1	1	1	1	1
Salt (pinch)	2	2	2	2	2	2
Water (ml)	250	250	250	250	250	250

Table 2. Ingredients of the composite with fixed amounts of finger and little and variable amounts of foxtail millet

Ingredients	T_0 (control)	T_1	T_2	T_3	T_4	T_5
Finger millet (g)	-	5	5	5	5	5
Foxtail millet (g)	-	1	2	3	4	5
Little millet (g)	-	5	5	5	5	5
Rice (g)	25	25	25	25	25	25
Dal (g)	25	14	13	12	11	10
Turmeric (pinch)	1	1	1	1	1	1
Salt (pinch)	2	2	2	2	2	2
Water (ml)	250	250	250	250	250	250

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Table 3. Ingredients of the composite with fixed amounts of finger and foxtail and variable amounts of little millet

Ingredients	T_0 (control)	T_1	T_2	T_3	T_4	T_5
Finger millet (g)	-	5	5	5	5	5
Foxtail millet (g)	-	5	5	5	5	5
Little millet (g)	-	1	2	3	4	5
Rice (g)	25	25	25	25	25	25
Dal (g)	25	14	13	12	11	10
Turmeric (pinch)	1	1	1	1	1	1
Salt (pinch)	2	2	2	2	2	2
Water (ml)	250	250	250	250	250	

2.4. Proximate composition analysis

The nutrient profile of the composite was assessed to evaluate its nutritional quality. The analyses were carried out following the standard procedures prescribed by the FSSAI- Manual of methods of analysis of food. Carbohydrate, protein, fat, fiber, moisture and ash content were measured. All analyses were conducted in triplicate for reliability.

2.5. Statistical analysis

Sensory evaluation data were analyzed using linear mixed-effects models (LME), with treatment as a fixed effect and panelist, along with replicates nested within panelist as random effects, to account for repeated measurements by the same panelists. For all analyses, R software was used.

3. Results

3.1. Sensory evaluation of the composites with finger millet as variable

The sensory evaluation of the composite with varying quantities of finger millet revealed notable differences among the six formulations (T_0-T_5) across all assessed parameters, including color and appearance, flavor, texture, taste, and overall acceptability. The mean sensory evaluation scores and standard deviations are presented in Table 4, while comparative trends are shown in Figure 2 (boxplots).

Table 4. Sensory attributes of the composites with variable amount of finger millet

Attributes	T_0	T_1	T_2	T_3	T_4	T_5
Color and Appearance	7.6 ±0.8	6.7 ±0.3	6.7 ±0.3	6.9 ±0.4	7.1 ±0.2	7.9 ±0.7
Texture	7.3 ±0.9	6.3 ±0.4	6.5 ±0.5	6.8 ±0.5	7.1 ±0.3	7.9 ±0.7
Flavor	7.3 ±0.9	6.3 ±0.4	6.3 ±0.4	6.5 ±0.4	6.9 ±0.4	7.9 ±0.7
Taste	7.2 ±1.2	6.4 ±0.3	6.4 ±0.5	6.6 ±0.3	7.1 ±0.4	8.1 ±0.8
Overall Acceptability	7.3 ±0.9	6.4 ±0.3	6.4 ±0.4	6.7 ±0.4	7.1 ±0.3	7.9 ±0.7

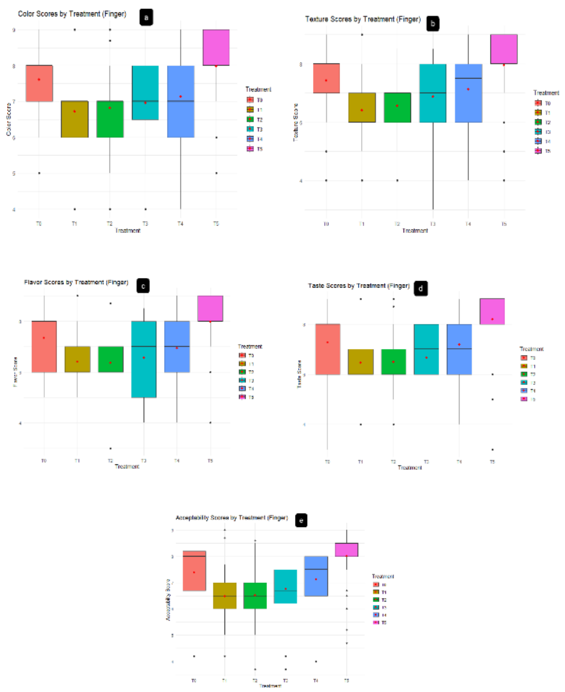

Figure 2. Distribution of sensory scores represented through boxplots for (a) Color and Appearance, (b) Texture, (c) Flavor, (d) Taste, (e) Overall Acceptability across different formulations (T_0-T_5) of the composite

Statistical analysis using linear mixed-effects models confirmed that treatment had a significant effect ($p < 0.05$) on each sensory attribute. For color and appearance, T_5 differed significantly from T_0 ($p = 0.0022$), while T_1 to T_4 showed lower estimated means.

For texture, T_5 again outperformed other samples with a significant positive estimate (p = 0.0010), while T_1 and T_2 had the lowest scores. In terms of flavor, T_5 was significantly superior to all other formulations ($p < 0.0001$), suggesting a more appealing profile. The same trend was observed for taste, where T_5 (mean = 8.19) showed significantly higher scores than all other treatments ($p < 0.0001$). For overall acceptability, T_5 significantly exceeded T_0 ($p < 0.0001$), as well as all test samples ($p < 0.001$), highlighting its strong potential as the preferred formulation. Treatments T_1 and T_2 consistently recorded the lowest scores across parameters, with no significant difference between them, indicating limited acceptability.

These results demonstrate that the formulation has a significant influence on sensory characteristics. The superior ratings of T_5 could be due to the optimized balance of finger millet and other ingredients, resulting in improved mouthfeel, flavor, and visual appeal. In contrast, the poorer performance of T_1 and T_2 may result from coarser texture, reduced flavor intensity, or less attractive appearance. While the control (T_0) received moderate scores, it was consistently outperformed by T_5 in flavor, taste, and overall acceptability, confirming the potential of millet-based product innovations to surpass traditional preparations. The inclusion of random effects for panelists and replicates in the statistical models enhanced reliability by accounting for individual variability and repeated measures. The findings support the selection of T_5 as the most promising formulation of composite, based on its superior sensory profile and statistically validated acceptability.

3.2. Sensory evaluation of the composites with foxtail millet as variable

The sensory evaluation of the composite with varying quantities of foxtail millet revealed marked differences among the six formulations (T_0-T_5) across all assessed parameters. The mean sensory scores and standard deviations are presented in Table 5, while comparative trends are shown in Figure 3 (boxplots).

Table 5. Sensory attributes of composites with variable amount of foxtail millet

Attributes	T_0	T_1	T_2	T_3	T_4	T_5
Color and Appearance	7.4 ±0.3	6.6 ±0.5	6.8 ±0.4	7.2 ±0.3	7.7 ±0.3	8.2 ±0.1
Texture	7.1 ±0.1	6.4 ±0.3	6.6 ±0.3	7.1 ±0.3	7.5 ±0.4	8.1 ±0.1
Flavor	7.4 ±0.2	6.6 ±0.4	6.7 ±0.8	6.8 ±0.7	7.5 ±0.4	8.4 ±0.1
Taste	7.3 ±0.2	6.6 ±0.4	6.6 ±0.8	6.8 ±1.1	7.5 ±0.4	8.4 ±0.1
Overall Acceptability	7.3 ±0.2	6.3 ±0.5	6.6 ±0.5	6.9 ±0.7	7.5 ±0.4	8.2 ±0.1

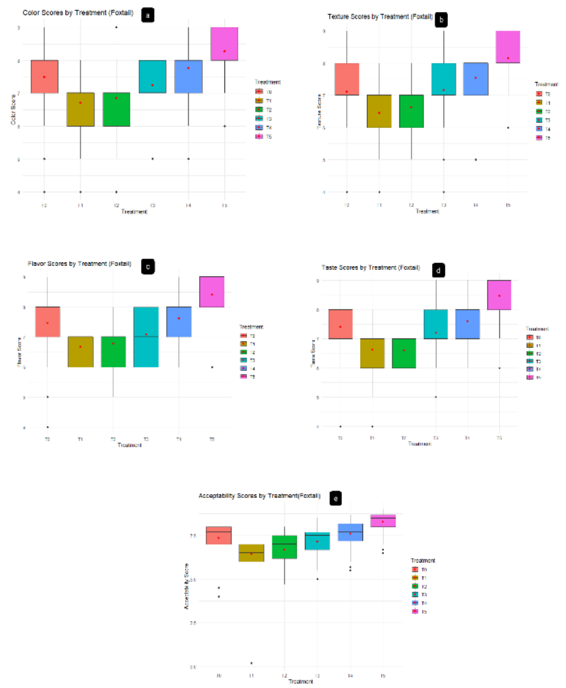

Figure 3. Distribution of sensory scores represented through boxplots for (a) Color and Appearance, (b) Texture, (c) Flavor, (d) Taste, (e) Overall Acceptability among different formulations (T_0-T_5) of the composite

Statistical analysis using linear mixed-effects models revealed that treatment had a significant effect ($p < 0.05$) on each sensory attribute. For color and appearance, T_5 differed significantly from the control T_0 ($p < 0.0001$), while T_1 to T_3 had significantly lower values. T_4 showed a modest but significant improvement over T_0 (p = 0.0074). In terms of texture, T_5 again outperformed all other samples ($p < 0.0001$), while T_1 and T_2 were significantly lower than the control. T_3 was comparable to T_0 (p = 0.9977), and T_4 showed moderate improvement (p = 0.0004). The flavor analysis showed a

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consistent increase from T_1 to T_5, with T_5 being significantly superior to all other samples ($p < 0.0001$). While T_4 did not significantly differ from T_0 ($p = 0.6368$), all other test samples had significantly lower flavor scores. Taste followed a similar trend. T_5 (mean = 8.47) recorded the highest score, showing a statistically strong deviation compared to other test groups ($p < 0.0001$). T_1 and T_2 scored significantly lower compared to the control ($p < 0.0001$), while T_3 and T_4 were statistically similar to T_0 ($p > 0.05$). For overall acceptability, T_5 again showed the highest score (8.31), which was significantly greater than all other treatments ($p < 0.0001$). T_4 and T_3 approached the acceptability level of T_0, but only T_3 was statistically comparable ($p = 0.3480$). T_1 and T_2 had significantly lower scores than T_0 ($p < 0.001$).

These results underscore that the formulation significantly influenced sensory properties. The superior ratings of T_5 may be attributed to the optimal proportion of foxtail millet and ingredient balance, enhancing color, flavor, and mouthfeel. Conversely, the lower scores for T_1 and T_2 may result from coarse texture, bland flavor or visual inconsistencies.

While the control (T_0) maintained moderate scores, it was consistently outperformed by T_5, affirming the potential of millet-based innovations to deliver improved consumer satisfaction. The use of mixed-effects modeling accounted for variability among panelists and replicates, ensuring statistical robustness. These findings highlight T_5 as the most promising composite formulation.

3.3. Sensory evaluation of the composites with little millet as variable

The sensory analysis of the composite with varying quantities of little millet (T_0–T_5) was conducted to evaluate consumer preferences across five sensory parameters. Table 6 displays the findings of the sensory evaluation and corresponding graphical representations are shown in Figure 4 (boxplots).

Table 6. Sensory attributes of the composites with variable amount of little millet

Attributes	T_0	T_1	T_2	T_3	T_4	T_5
Color and Appearance	8.2 ±0.05	7.3 ±0.5	7.6 ±0.4	7.7 ±0.3	8.1 ±0.3	8.4 ±0.2
Texture	8.1 ±0.2	7.1 ±0.4	7.4 ±0.4	7.6 ±0.3	7.9 ±0.3	8.3 ±0.3
Flavor	8.1 ±0.1	6.9 ±0.4	7.2 ±0.4	7.5 ±0.4	7.8 ±0.3	8.5 ±0.3
Taste	8.1 ±0.1	6.9 ±0.5	7.2 ±0.4	7.5 ±0.3	7.8 ±0.3	8.5 ±0.2
Overall Acceptability	8.1 ±0.1	7.0 ±0.4	7.3 ±0.3	7.5 ±0.3	7.9 ±0.3	8.3 ±0.3

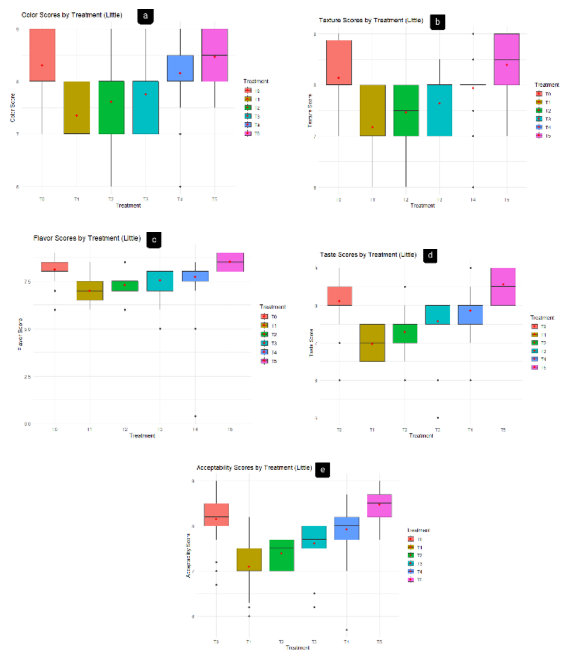

Figure 4. Distribution of sensory scores represented through boxplots for (a) Color and Appearance, (b) Texture, (c) Flavor, (d) Taste, (e) Overall Acceptability across different formulations (T_0-T_5) of the composite

Statistical analysis using linear mixed-effects models revealed that treatment had a significant effect ($p < 0.05$) on each sensory attribute. For color and appearance, T_5 differed significantly from the control T_0 ($p < 0.0001$), while T_1 to T_3 had significantly lower values. T_4 showed a modest but significant improvement over T_0 ($p = 0.0023$). In terms of texture, T_5 again outperformed all other samples ($p < 0.0001$), while T_1 and T_2 were significantly lower than the control. T_3 was comparable to T_0 ($p = 0.8194$), and T_4 showed moderate improvement ($p = 0.0009$). The flavor analysis showed a consistent increase from T_1 to T_5, with T_5 being significantly superior to all other samples ($p < 0.0001$). While T_4 did not significantly differ from T_0 ($p = 0.5589$), all other test samples had significantly lower flavor scores. Taste followed a similar trend. T_5 (mean = 8.56) recorded the highest score, showing a significant difference compared to other treatments ($p < 0.0001$). T_1 and T_2 scored significantly below the control ($p < 0.0001$), while T_3 and T_4 were statistically similar to T_0 ($p > 0.05$). For overall acceptability, T_5 again showed the highest score (8.47), which was significantly greater than all other treatments ($p < 0.0001$). T_4 and T_3 approached the acceptability level of T_0, but only T_3 was statistically comparable ($p = 0.4302$). T_1 and T_2 had significantly lower scores than T_0 ($p < 0.001$).

These results underscore that the formulation significantly influenced sensory properties. The superior ratings of T_5 may be attributed to the optimal proportion of little millet and ingredient balance, enhancing color, flavor, and mouthfeel. Conversely, the lower scores for T_1 and T_2 may result from coarse texture, bland flavor, or visual inconsistencies. While the control (T_0) maintained moderate scores, it was consistently outperformed by T_5, affirming the potential of millet-based innovations to deliver improved consumer satisfaction. The use of mixed-effects modeling accounted for variability among panelists and replicates, ensuring statistical robustness. Overall, these findings highlight T_5 as the most promising formulation of the composite.

3.4. Proximate analysis of the millet composite

Table 7 presents the content of major macromolecules, i.e., carbohydrate, protein, and fat. Table 7 also presents the moisture, fiber, ash and energy content of the most acceptable composite preparation.

The moisture content was found to be 13.4%, suggesting moderate shelf stability suitable for dry storage. The protein content of 9.16% highlights the composite's potential as a plant-based protein source, supporting its use in protein-enriched formulations. The fat content was relatively low at 1.3%, aligning with the naturally low-fat nature of millets.

Table 7: Proximate composition of the millet composite

S.no.	Content	g/100 g
1	Carbohydrate	67
2	Protein	9.16
3	Fat	1.3
4	Moisture	13.4
5	Fiber	7.84
6	Ash (%)	1.36
7	Energy (Kcal)	316

A high carbohydrate content (67%) makes the composite an energy-rich food, while the dietary fiber content of 7.84% enhances its functional value by aiding digestion and promoting satiety. The ash content, representing total mineral content, was 1.36%, indicating the presence of essential micronutrients. The calculated energy value of 316 Kcal per 100g suggests that the millet composite can contribute significantly to daily energy requirements, making it a suitable base for developing nutritionally dense food products.

4. Discussion

This study highlights the usefulness of finger, foxtail and little millets in formulating a composite that combines desirable organoleptic qualities with nutritional benefits. The sensory trials of composite showed that higher inclusion levels of millets (T_5 treatments) scored superiorly in terms of color, flavor, texture, taste, and overall acceptability when compared with the control and lower levels. These findings highlight the scope of utilizing underutilized millets in modern dietary innovations to develop food products that are healthy and attractive to customers. Analysis through linear mixed-effects models indicated that the treatment significantly influenced sensory attributes, with sample T_5 achieving the highest scores across all parameters ($p < 0.05$). Increased millet integration improved the appearance, mouth feel, and flavor balance, while the coarse texture and lack of visual homogeneity in T1 and T2 may have contributed to their comparatively low acceptability. These results demonstrate that to ensure consumer preference in millet-based formulations, proper standardization is crucial. A nutrient-rich profile was represented in the millet composite's proximate composition, which included low fat (1.3%), high carbs (66.95%), moderate protein (9.16%), and significant dietary fiber (7.84%). These findings are in line with previous analyses of millets' nutritional makeup, which emphasize the grain's capacity to supply vital minerals and energy.

Overall, the results confirm that millets have the potential to be good substitutes for polished grains because of their high nutritional constituents and biologically active components. Their resilience to severe weather conditions, along with their health benefits, makes them a more significant factor in the issue of food and nutrition security. In addition to meeting nutritional requirements, the composite developed in this study also satisfies the global demand for climate-smart and functional food options.

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