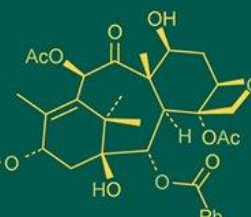
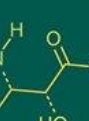
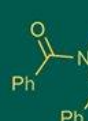


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Development of finger and banyard millet based fortified nutri-mix powder: A sensory acceptability, nutritional value and microbial load (shelf-life)

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Abstract

The formulation and development of multidimensional food Finger millet (*Eleusine coracana*) and Barnyard millet (*Echinochloa* spp) based incorporated product Nutri-mix powder. Products were developed by incorporating with Beetroot Powder, Carrot Powder, Moringa Powder, and Sprouted Grain Powder (Gram, Soybean, and Mung), jaggery powder to promote multidimensional and nutrient-rich. Value addition in food products refers to the process of improving quality, nutritional content, sensory attributes, and overall consumer appeal through the incorporation of functional ingredients. Nutri-mix powder formulations were developed. The products prepared as control and incorporated treatments with codes. Both value-added (incorporated) and control products were evaluated for sensory characteristics and proximate nutritional composition. The findings demonstrated that proximate composition analysis showed notable increases in crude protein (4.8-10.4 g/100 g), crude fat (21.7-32.3%), crude fiber (1.2-2.4%), and caloric value (476.1-544.0 kcal/100 g), while vitamin estimation revealed substantial increases in folic acid, cyanocobalamin and retinol contents, especially in T₄. Results confirm that the value-added Nutri-mix powder variants, particularly codes T₃ and T₄, exhibit enhanced nutritional and functional quality compared to the traditional formulation, supporting their potential as a nutritionally superior instant healthy drink mix powder option for contemporary consumers. Microbial analysis (shelf-life) of different incorporated product was safe initial to 45 days of storage. After 75 days microbial population was found increasing from lowest TFC was recorded in T₀ (2.00×10²cfu/g) and highest in T₁ (3.33×10²cfu/g). The TBC lowest in T₀ (3.67×10²cfu/g) and highest in T₄ (8.33×10²cfu/g) were found from shelf-life experiment.

Keywords: Barnyard millet, finger millet, sprouted grains, moringa, microbial load (self-life)

1. Introduction

Millet's grain plays a major role in alleviation and malnutrition among the children and adult. Barnyard (*Echinochloa* spp.) is oldest domesticated minor millet; it's also called *Sanwa* (Hindi), *Kuthiravaal* (Tamil), *Oodalu* (Kannada), *Udalu/Kodisama* (Telugu) and *Kuthiravaali* (Malayalam) in India (Harinarayanan *et al.*, 2023) [5]. Among many cultivated and wild species of barnyard millet grow in the world, most popular species are *Echinochloa frumentacea* (India) and *Echinochloa esculenta* (Japan) (Sood *et al.*, 2015) [23]. Barnyard millet grains are a rich source of dietary nutritional fiber, iron, zinc, calcium, protein, magnesium, fat, vitamins, and some essential amino acids (Singh *et al.*, 2010; Saleh *et al.*, 2013) [17, 19]. The approximate composition of barnyard millet in 100 gm grain is 10.5% protein, 3.6-3.8% fat, 51.5-62 g/100gm carbohydrate, 398 kcal/100 g energy, 5.41-6.8% crude fiber and total dietary fibre content is 12.6% including soluble (4.2%) and insoluble (8.4%) dietary fibre (Ugare *et al.* 2014; Singh *et al.* 2022) [20, 27]. This composition contributes to improved digestive health by preventing constipation, reducing blood cholesterol levels, and enabling a slow, sustained release of glucose during digestion. Barnyard millet grains are gluten-free, offering significant potential for use in health foods (Hoshino *et al.*, 2010) [6]. Finger millet (*Eleusine coracana*) is recognized as one of the most nutrient-dense minor cereals. In India, it is known by different names like *Mandua* (Hindi), *Ragi* (Kannada), *Kelvaragu* (Tamil), *Ragulu* (Telugu), *Moothari* (Malayalam) (Harinarayanan *et al.*, 2023) [5]. Its 100g grain is contain carbohydrates 66.82%, Protein 7.16%, Fat 1.92%, rich in dietary fibre 11.18% with insoluble 9.51% and soluble 1.67% (Rishitha, P. & Soni, D. 2024) [14].

Finger millet is providing essential amino acids such as isoleucine, phenylalanine, leucine, and methionine, also with key minerals including calcium, phosphorus, and iron. Finger millet is a good source of vitamins, particularly B-group vitamins (1.71 mg) and vitamin E (22 mg). Due to its rich nutritional profile, finger millet offers a wide range of health and medicinal benefits (Chandra *et al.*, 2016) ^[1].

Millet, known as "Nutri-Cereals," has improving nutrition, supporting environmental sustainability, and enhancing food security. Health benefits associated with millet consumption, emphasizing their role in addressing hidden hunger and malnutrition. Despite these benefits, millets face barriers in cultural acceptance and require improved processing techniques. Indian government is declared year 2023 are 'International Year of Millets'. The main purpose was to launch innovative schemes that promote millet cultivation and production as well as health benefits. Recommendations for these future policies aimed at ongoing millet promotion include advocating for millets as climate-resilient crops, enhancing farmers' access to better millet varieties and technologies, creating a conducive environment for millet processing and marketing, and encouraging international cooperation for millet research and development.

Millets such as Finger millet and Barnyard millet are rich in minerals, fiber and calcium, while pulses and legumes play significant protein content for health benefits. Incorporation of oilseed such as flaxseed and sesame enhance the content of essential fatty acids and micronutrients. The use of functional and test improvement ingredients such as moringa, carrot, and beet root powder due to their high level of bioactive compounds, vitamins and antioxidants. These ingredients not improved only nutritional profile but also add value in health benefits, enhance the immunity and prevents of chronic diseases. Additionally, the use of Jaggery, a traditional sweetener produced from sugarcane juice, forms an important dietary component of health benefits. It is considered a natural nutraceutical due to its content of essential amino acids, minerals, vitamins, and antioxidant compounds. As a functional food, jaggery provides substantial amounts of carbohydrates (sucrose, fructose, and glucose), minerals (such as calcium, potassium, sodium, iron, zinc, and magnesium), and vitamins (B, C, D, and E), all of which support normal growth and physiological functioning (Sharifi-Rad *et al.*, 2023; Anwar *et al.*, 2011; Rao & Singh, 2022; Singh, 2013) ^[13, 18, 19, 22].

The poor health outcomes among the tribe and village population in India, particularly women's and children's, are attributed to the lack of dietary diversity. Financial circumstances, shifts to lucrative crops, dependency on a Public Distribution System (PDS) that failed to incorporate traditional food patterns. A community feeding pilot study conducted among school-going children in India proved that millet-based food formulations are not only acceptable, but also help to improve the growth of children compared to regularly consumed rice-wheat based diets (Saikat *et al.*, 2024) ^[16]. Value addition in millet- based food products has emerged as a promising approach to enhance the nutritional quality, diversity, and marketability of these traditional grains. Millets, such as sorghum, pearl millet, finger millet,

foxtail millet, kodo millet and proso millet, have been staple foods for millions of people worldwide for centuries. Value addition in food products refers to the process of enhancing the quality, nutritional value, shelf-life, and overall appeal of raw or minimally processed foods through various techniques and interventions. Value addition plays a crucial role in improving food security and nutrition outcomes by enhancing the availability, accessibility, and affordability of nutrient-rich foods (Smith & Johnson, 2021) ^[22]. This will be assessed through a variety of indicators, including anthropometric measurements, body composition analysis and biochemical parameters. Early initiation of a safe, reliable, and sustainable nutrient-rich diet, especially from plant-based traditional food, represents a promising approach to treating malnutrition. Both Finger millet and Barnyard millet-based value-added products powder are micronutrient rich which can further address hidden hunger among children. This research will serve as a proof of concept for a larger randomized nutrition trial that includes the use of millets, grain and incorporated products to address undernutrition in village school children and health improvement.

2. Material and Methods

The study on developing finger millet and barnyard millet-based value-added product Nutri-mix powder was carried out in the Food Laboratory of the Department of Food Science and Nutrition, CSA University of Agriculture and Technology, Kanpur.

2.1 Procurement of raw ingredients

The raw ingredients required for product development: finger millet (ragi), barnyard millet (sanwa), beetroot, carrot, pulse grains (gram, mung and soybean), refined oil, flax seeds, sesame seeds, and jaggery powder-were procured in bulk from the local market of Rawatpur, Kanpur and moringa fresh leaf from research farm of CSA university.

2.2 Product development

The value-added product, nutri-mix powder was formulated using multigrain flour comprising finger millet flour & barnyard millet flour, sprouted grain powder, beetroot, carrot & moringa powder, jaggery, dry fruits and peanut seed were incorporated as respectively. The formulations were standardized by incorporating ingredients in different proportions across with product codes. The composition ratios for the Nutri Mix Powder variants (T₀-T₄) were as follows:

- T₀: 50:40:10
- T₁: 30:03:04: 40:01:10: 10:10
- T₂: 30:06:06: 40:02:10: 10:10
- T₃: 30:09:08: 40:03:10: 10:10
- T₄: 30:12:10: 40:04:10: 10:10

Where each treatment (T₁-T₄) ratio represents the proportion of millets flour, sprouted grains powder, beetroot powder, carrot powder, moringa powder, and jaggery respectively. Their control treatment (T₀) ratio represents wheat flour, sugar, and oil respectively.

Table 1: Formulations of nutri-mix powder with incorporation product codes

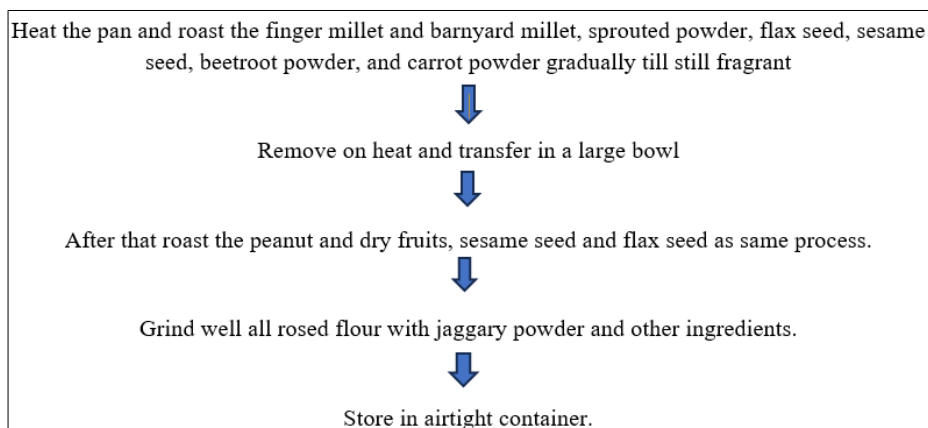
S.N.	Ingredients	Levels of incorporation (Product codes) in grams				
		T ₀ (control)	T ₁	T ₂	T ₃	T ₄
1.	Wheat flour	50	-	-	-	-
2.	Ragi flour	-	10	15	20	25
3.	Sanwa flour	-	20	15	10	05
4.	Sprouted Gram flour	-	01	02	03	04
5.	Sprouted Mung flour	-	01	02	03	04
6.	Sprouted Soyabean	-	01	02	03	04
7.	Carrot powder	-	01	02	03	04
8.	Beetroot powder	-	01	02	03	04
9.	Moringa powder	-	02	02	02	02
10.	Sugar	40	-	-	-	-
11.	Jagary	-	40	40	40	40
13.	Flax seed	-	0.5	01	1.5	02
14.	Sesame seed	-	0.5	01	1.5	02
15.	Dry fruits powder	-	10	10	10	10
16.	Peanut powder	-	10	10	10	10
17.	Refined Oil	10	10	10	10	10

The formulation of Nutri-mix powder prepared with different combinations of cereal, millet, pulses, vegetables, seeds and sweeteners. Five product codes with T₀ (control), T₁, T₂, T₃, and T₄ represent increasing levels of nutrient-rich ingredients (Table 1). The control sample (T₀) contains only wheat flour (50%) as the main base and sugar (30%) as the sweetener, without any millet, pulse, vegetable or seed incorporation, from T₁ to T₄ wheat flour is completely replaced with a combination of ragi (finger millet) flour, sanwa (barnyard millet) flour, and small quantities of pulse flours such as roasted gram, green gram, and soybean. As the formulation progresses from T₁ to T₄, the level of ragi flour increases from 10% to 25%, enhancing the calcium, fiber, and iron content. Conversely, sanwa millet flour decreases from 20% in T₁ to 5% in T₄, balancing texture and nutrient density. The addition of pulse flours (1-4%) contributes plant-based protein and improves amino acid balance. Carrot powder, beetroot powder, and moringa leaf

powder are incorporated in small but nutritionally significant amounts (1-4%), enriching the mix with natural vitamins, minerals, antioxidants, and colouring pigments. The sweetener in T₁ to T₄ is jaggery, replacing refined sugar to increase iron content and provide a natural caramelized flavour. Its concentration rises from 30% in T₁ to 45% in T₄, improving sweetness and binding properties. Nutrient-dense seeds such as flaxseed and sesame are added in increasing amounts (0.5-2%), enhancing omega-3 fatty acids, lignans, protein, and healthy fats. Dry fruit powder and peanut powder are kept constant at 10% each across all enriched formulations, supplying energy, essential fatty acids, micronutrients, and improving the taste profile.

Overall, as the mixture progresses from T₁ to T₄, the nutritional value significantly increases due to higher levels of millets, pulses, vegetables, and seeds. T₄ becomes the most nutrient-dense formulation, while T₀ remains the least enriched control sample.

2.2 Recipe of incorporated powder (Nutri-mix powder)



2.4 Sensory evaluation

Sensory evaluation was performed a nine-point hedonic scale in which 9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like nor dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much and 1 = Dislike extremely, which showed the degree of likeness (Kortei *et al.*, 2020) [7]. In the evaluation to assess taste, colour, aroma, texture, after-taste and overall acceptability. Sensory tests were carried out

under laboratory conditions with white-light illumination, neutral odour environment and controlled serving temperature. Panellists were instructed to cleanse the palate with water between samples.

2.5 Proximate analysis

The proximate analysis of Nutri mix powder was estimated following the method recommended by NIN (2003), Moisture content, Ash content, Protein content, Fat content, Carbohydrate content, Energy value and Fiber content.

• Moisture content

Moisture was estimated following the method recommended by NIN (2003). The moisture content was calculated from the loss in weight during drying and expressed as a (%) age:

$$\text{Moisture } \left(\frac{\text{g}}{100\text{g}} \right) = \frac{\text{Initial weight} - \text{Final weight}}{\text{Weight of the sample (g)}} \times 100$$

• Ash content

Samples were charred on a hot plate and incinerated in a muffle furnace at 600°C for 3-4 hours. The crucible was cooled in a desiccator and weighed repeatedly until a constant weight was achieved. Ash content was calculated using the formula:

$$\text{Ash } \left(\frac{\text{g}}{100\text{g}} \right) = \frac{\text{Weight of the ash (g)}}{\text{Weight of sample taken (g)}} \times 100$$

• Protein content

Protein was estimated by determining nitrogen content using the Micro-Kjeldahl method (NIN, 2003). A Kel Plus nitrogen estimation system was used. Nitrogen content was calculated using:

$$\text{Nitrogen } \left(\frac{\text{g}}{100\text{g}} \right) = \frac{(\text{Sample reading} - \text{Blank Reading}) \times \text{Normality of Hcl} \times 14}{\text{Weight of sample taken (g)}} \times 100$$

• Fat content

Fat content was analyzed using the Soxhlet extraction method as described by NIN (2003) on a Sox Plus system:

$$\text{Fat } \left(\frac{\text{g}}{100\text{g}} \right) = \frac{\text{Weight of flask with extracted fat (g)} - \text{Weight of empty flask (g)}}{\text{Weight of sample taken (g)}} \times 100$$

• Carbohydrate content

Carbohydrate content was determined using the differential method (NIN, 2003)

$$\text{Carbohydrate } \left(\frac{\text{g}}{100\text{g}} \right) = 100 - (\text{Moisture} + \text{Protein} + \text{Crude fiber} + \text{Fat} + \text{Ash})$$

• Energy value

The energy value of sample was calculated by using physiological fuel value per gram of protein, fat and carbohydrate NIN (2003):

$$\text{Energy } \left(\frac{\text{kcal}}{100\text{g}} \right) = (\% \text{Protein} \times 4) + (\% \text{Carbohydrate} \times 4) + (\% \text{Fat} \times 9)$$

Fiber content

Crude fiber was estimated using the acid-alkali digestion method as per NIN (2003) and AOAC guidelines. The fiber content was calculated from the loss in weight after ignition:

$$\text{Crude Fiber } \left(\frac{\text{g}}{100\text{g}} \right) = \text{Weight of residue (g)} - \text{Weight of ash (g)}$$

2.6 Shelf-life assessment

It is critically important to estimate the microbiological safety of food products. Thus, in the present experiment, the total plate count of bacteria and fungi of the produced products was assessed storage in at 0 to 75 days, used serial dilution poured plate method (Chaudhary *et al.*, 2020) [2]. The value-added millets-based product (packed in polyethnec begs) was kept at 100 g of each sample and grind with the help of pestle mortar for the homogenization. The homogenized each sample were taken 1g and put in the test tube with 9 ml of distilled water (10:1) mixed gently. There suspension was transferring next 9 ml distilled water test tube were using the serial dilution method @10⁻¹, 10⁻², 10⁻³, 10⁻⁴, ...10⁻⁹. The fungal and bacterial colony count in food product sample was used 10⁻² dilution and kept 1ml of suspension were transfer in culture plate medium (Potato dextrose agar medium, and nutrient agar medium) and spread with the help of glass spreader. This inoculated culture plate was covered with parafilm and pleased in the BOD incubator 2 to 5 days at 30 °C ±1 for bacterial count and 25 °C ±1 for fungal count.

2.7 Statistical analysis

Data collected from sensory and nutritional assessments were analyzed using one-way analysis of variance (ANOVA). When significance was observed, mean separation was performed based on Critical Difference (CD) values at a 0.5% probability level. Results marked with (S) indicate significant differences, whereas (NS) denotes non-significant variation. Total microbial count data analyzed by OPSTAT, PAU software.

3. Results and discussion

3.1 Sensory evaluation

The sensory evaluation of control product and value-added Nutri-mix powder presents the mean sensory scores (± standard deviation) for six key sensory attributes- taste, color, aroma, texture, mouthfeel and overall acceptability- across five formulations coded as T₀ to T₄. Also includes the Critical Difference (CD) at 0.5%, Standard Error of mean (S.Em), and F-value, all marked as Significant (S), indicating that the differences among the treatments were statistically meaningful (Table: 2).

Table 2: Sensory evaluation of value-added nutri mix powder with control product

Parameter	Levels of incorporation (Product code)					CD (0.5%)	S. Em	F Vlaue
	T ₀ (Control)	T ₁	T ₂	T ₃	T ₄			
Taste	6.50±0.66	7.40±0.61	9.45±0.55	6.70±0.75	6.30±0.78	0.77	0.26	S
color	6.65±0.62	7.55±0.49	9.50±0.97	6.80±0.91	6.05±0.64	0.66	0.23	S
Aroma	6.35±0.74	7.65±0.52	9.25±0.67	6.60±0.69	6.30±0.63	0.84	0.28	S
Texture	6.65±0.41	7.40±0.69	9.55±0.55	6.65±0.70	6.20±0.58	0.80	0.26	S
Mouth feel	6.70±0.53	7.15±0.69	9.45±0.55	6.80±0.71	6.30±0.71	0.69	0.24	S
Overall acceptability	6.20±0.71	7.80±0.58	9.70±0.34	6.45±0.83	7.10±1.14	0.72	0.26	S

*The values are expressed as mean ± SD. The values are significantly different from each other. C.D. (Critical difference), S= Significant at p < 0.05

Test

The evaluation of test was control sample (T_0) scored 6.50 ± 0.66 , while the highest score (9.45 ± 0.55) was recorded from product code T_2 . This clearly shows that the value-added formulation T_2 was most preferred by the sensory panel for its flavor balance and palatability. The other samples (T_1 , T_3 , and T_4) received moderate taste scores, with T_1 (7.40 ± 0.61) being slightly more acceptable than T_3 and T_4 , indicating that certain ingredient combinations in T_2 provided a more desirable taste profile.

Color

In the terms of color scoring, which reflects visual appeal, T_2 again achieved the highest rating score (9.50 ± 0.97), while the control and other formulations had less score in rating. The control (T_0) scored 6.65 ± 0.62 , and T_1

(7.55 ± 0.49) also performed well, but T_3 (6.80 ± 0.91) and T_4 (6.05 ± 0.64) were less appealing. This suggests that the incorporation of natural ingredients in T_2 possibly enhanced the appearance and brightness of the nutri-mix powder, making it more visually attractive.

Aroma

The aroma scores best rating with product code T_2 again leading (9.25 ± 0.67) compared to the control T_0 (6.35 ± 0.74). Product code T_1 (7.65 ± 0.52) is slightly more acceptable compare to T_3 (6.60 ± 0.69) and T_4 (6.30 ± 0.63). Aroma plays a crucial role in overall liking, and the results suggest that value-added ingredients contributed pleasant and distinctive aromas, likely from roasted grains, pulses, or nuts, which elevated the sensory experience.

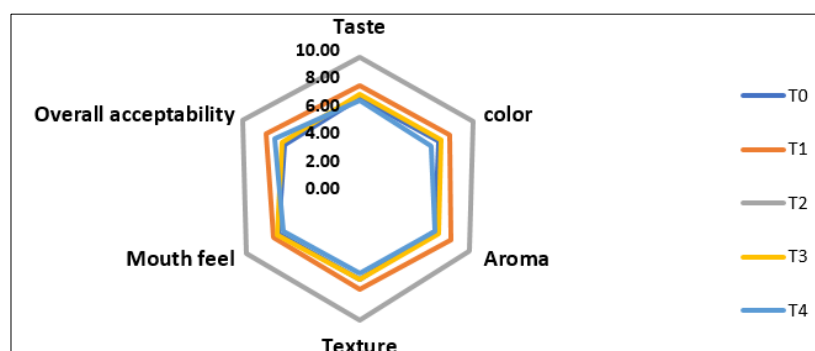


Fig 1: Sensory evaluation of incorporated nutri-mix powder

Texture

For texture, product code T_2 scored (9.5 ± 0.55) the highest among all formulations, while the control (T_0) had (6.6 ± 0.41). Other product code less sensory scored was T_1 (6.30 ± 0.63), T_3 (6.65 ± 0.70) and T_4 (6.65 ± 0.70). Texture is an important factor in dry mixes like nutri-mix powder, influencing how easily it blends with milk or water and its mouthfeel when consumed. The higher texture rating of T_2 suggests that it had an ideal fineness and smoothness, enhancing ease of mixing and overall product quality.

Mouth feel

Regarding mouthfeel aftertaste, which reflects the flavor left in the mouth after consumption, T_2 again stood out with a score of 9.45 ± 0.55 , while the control (T_0) recorded 6.7 ± 0.53 . Where T_1 also performed well (7.15 ± 0.69), suggesting that the value-added formulations improved flavor persistence and pleasantness after ingestion.

Overall acceptability

Finally, the overall acceptability—a combined measure of all sensory parameters clearly indicates that T_2 was the most favored formulation, receiving sensory score 9.70 ± 0.34 , compared to 6.20 ± 0.71 for the control (T_0). T_1 also had good acceptance (7.80 ± 0.58), but T_3 and T_4 were less preferred, with scores of 6.45 ± 0.83 and 7.10 ± 1.14 , respectively. Similarly, Nutri mix was prepared by Srivastava, K., & Vijayakumar, P. (2025) [24], Sensory evaluation was conducted a 9-point hedonic scale by a panel of 10 semi-trained members. Treatments T_1 and T_3 received overall acceptability scores of 5.96 ± 0.50 and 6.00 ± 0.40 , respectively, while T_2 (cocoa) achieved the highest score of 7.26 ± 0.33 . These findings (T_2) were the most preferred among consumers, highlighting its potential as an appetizing and nutritionally augmented health beverage.

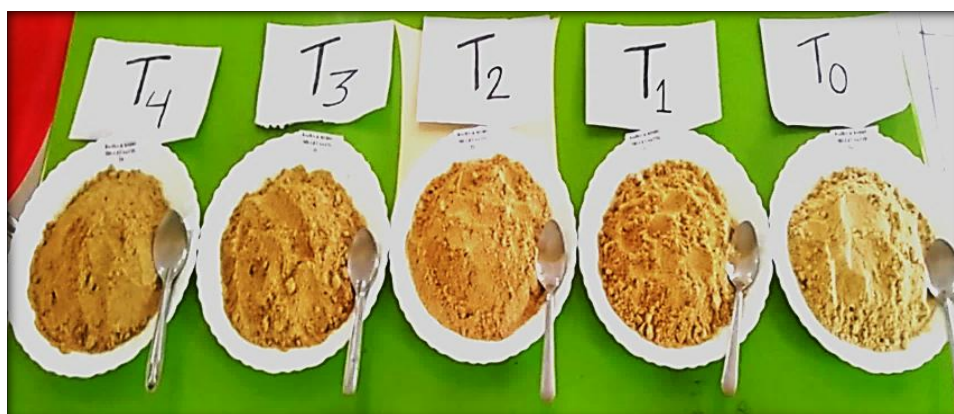


Fig 2: Nutri-mix powder with different incorporation (product codes viz. T_0 , T_1 , T_2 , T_3 and T_4)

3.2 Proximate analysis

The proximate composition (table:3.) of the control and value-added nutri-mix powder provides detailed information on its basic nutritional constituents- moisture, ash, crude protein, crude fat, carbohydrate, energy, and crude fiber for

different incorporation coded as T₀ to T₄. The table also includes the Critical Difference (CD) at 0.5%, Standard Error of Mean (S.E.m), and F-value, all marked as significant (S), confirming that the variations observed among samples were statistically meaningful.

Table 3: Proximate content of nutri-mix powder

Parameter (in 100g)	Levels of incorporation (Product)					CD (0.5%)	S.E.m	F Value
	T ₀ (Control)	T ₁	T ₂	T ₃	T ₄			
Moisture%	4.22±0.00	3.27±0.01	3.28±0.00	3.29±0.00	3.29±0.00	0.02	0.01	S
Ash%	3.42±0.15	4.32±0.10	4.64±0.08	4.40±0.04	4.40±0.04	0.44	0.14	S
Crude protein%	5.55±0.04	10.10±0.04	10.62±0.04	11.90±0.06	12.42±0.01	0.06	0.02	S
Crude Fat%	7.61±0.05	14.43±0.04	14.93±0.03	14.45±0.03	14.60±0.03	0.06	0.02	S
Crude Fiber%	1.23±0.01	2.43±0.03	2.35±0.01	2.45±0.02	2.50±0.02	0.29	0.23	S
Carbohydrate%	70.06±0.01	64.55±0.10	63.63±0.20	64.72±0.11	63.74±0.10	0.07	0.45	S
Energy (kcal.)	371.14±0.80	432.32±0.90	431.43±0.05	433.48±1.00	435.48±0.60	1.42	0.09	S

Note: S=significance

Table 3. Showed the proximate content of the developed control and value-added nutri-mix powder. The moisture content was 4.22 (%) in T₀ and it decreased to 3.27 (%) in T₁, 3.28 (%) in T₂, 3.29 (%) in T₃ and T₄. The ash content was 3.42 (%) in T₀ and it increased to 4.32 (%) in T₁, 4.64 (%) in T₂, 4.40 (%) in T₃, and 4.40 (%) in T₄. The crude protein content of value-added Nutri-mix powder was lowest 5.55 gm in T₀ and it increased to 10.10 gm in T₁, 10.62 gm in T₂, 11.90 gm in T₃, and 12.42 gm in T₄. The crude fat content of value-added powder was contained 7.61 (%) in T₀ and it increased to 14.43 (%) in T₁, 14.93 (%) in T₂, 14.45 (%) in T₃, and 14.60 (%) in T₄. The crude fiber content 1.23 (%) in T₀ and it increased to 2.43 (%) in T₁, 2.35 (%) in T₂, 2.45 (%) in T₃, and 2.50 (%) in T₄. The carbohydrate content was 70.06 (%) in T₀ and it decreased to 64.55 (%) in T₁, 63.63 (%) in T₂, 64.72(%) in T₃, and 63.74(%) in T₄. The energy content of value-added nutri-

mix powder was 371.14 kcal in T₀ and it increased to 432.32 (%) in T₁, 431.43 kcal in T₂, 433.48 kcal in T₃, and 435.48 kcal (%) in T₄.

3.3 Microbial analysis (self-life)

Microbial load in different product code is Total Bacterial Colony (TBC) and Total Fungal Colony (TFC) present in table: 4, microbial population is increase progressively in all product during storage period of 0 to 75 days. The bacterial count is very low in initial day is 0.00×10^2 cfu/g in all product (T₀ to T₄), after 15 days slightly increase bacterial population 0.33 to 1.00×10^2 cfu/g. at the storage of 75 days TBC is ranging from 3.67 to 8.33 the lowest TBC was recorded in T₀(3.67×10^2 cfu/g) followed by T₁ (5.00×10^2 cfu/g) and highest TBC was observed in T₄(8.33×10^2 cfu/g) followed by T₂(7.66×10^2 cfu/g) and T₃ (6.67×10^2 cfu/g).

Table 4: Effect of storage on microbial population of nutri-mix powder with different product code

Product Code	Total Bacterial colony (cfu/g × 10 ²)						Initial days	Total Fungal colony (cfu/g × 10 ²)				
	Initial	15 days	30 days	45 days	60 days	75 days		15 days	30 days	45 days	60 days	75 days
T ₀	0.33	0.33	0.66	2.00	3.33	3.67	0.00	0.00	0.00	0.00	0.67	2.00
T ₁	0.33	1.00	1.00	2.33	2.66	5.00	0.00	0.00	0.00	0.00	1.67	3.33
T ₂	0.00	0.67	2.00	4.33	5.67	7.66	0.00	0.00	0.00	0.00	1.33	2.67
T ₃	0.33	0.67	1.67	2.33	2.66	6.67	0.00	0.00	0.00	0.00	2.00	3.00
T ₄	0.33	0.33	1.00	3.33	4.00	8.33	0.00	0.00	0.00	0.00	1.33	2.33
CD	N/A	N/A	N/A	0.952	1.716	1.716	-	-	-	-	N/A	1.064
SE (m)	0.298	0.258	0.558	0.298	0.537	0.537	-	-	-	-	0.394	0.333

Note: N/A= not applicable (non-significant), cfu= colony forming unit

The TFC in all product code were not recorded population of fungi with initial to 45 days of storage, fungal colony was initial appears on after 60 days of storage. After 75 days Total Fungal Colony (TFC) was lowest recorded in T₀ (2.00×10^2 cfu/g) followed by T₄ (2.33×10^2 cfu/g) and the highest fungal count was recorded in T₁ (3.33×10^2 cfu/g) followed by T₃ (3.00×10^2 cfu/g). similarly, Tangariya, *et al.* (2018) [25], formulated composite flour and reported, bacterial count of 2.2×10^2 cfu/g at one month storage which increased to 5.5×10^2 cfu/g after two months of storage period Geetha, *et al.* (2019) [3] developed millet-based fiber mix food recorded increasing trend in total bacterial count as the storage period increased (0 to 90 days). The initiation of fungi was noticed at the storage period of 75 and 90 days. The Geetha, *et al.*, (2023) [4] was developed millet composite mix noticed TBC and TFC during storage period 90 days.

Initial load TBC was 4.5×10^2 cfu/g which increased to 8.1×10^3 at storage period. Mould count was less than 10 throughout the storage period whereas *E-coli* was not detected.

Conclusion

The present study demonstrated that the incorporation of finger millet, barnyard millet, sprouted grain flours, vegetable powders and oil-rich seeds effectively enhanced the nutritional, sensory and functional qualities of nutri-mix powder. Significant improvements were recorded in crude protein, crude fat, dietary fibre, caloric value and antioxidants content in the value-added formulations compared to the control sample. Sensory evaluation indicated that formulation T₂ was the most acceptable in terms of taste, texture, aroma, after-taste and overall

acceptability, while T₄ exhibited the highest levels of nutrients enrichment. Therefore, T₃ and T₄ have strong potential for large-scale production and commercialization as healthier alternatives to conventional wheat-based products. The self-life of nutri-mix powder was good quality and acceptable at the 45 days of storage.

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