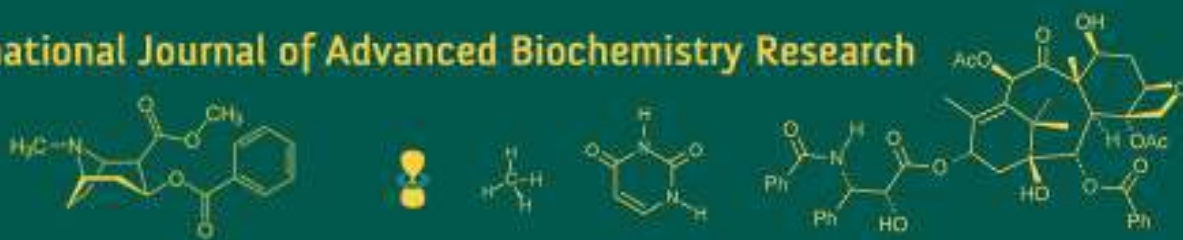


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Development, optimization and nutritional characterization of millet spread to combat hidden hunger

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Abstract

The present study was conducted to develop millet spread to mitigate hidden hunger (a person is suffering from micronutrient deficiencies). Total of five treatments were prepared at different level of proportions containing finger millet, barnyard millet, sweet potato, sesame seeds and anjeer respectively. The sensory characteristics and proximate composition, including mineral of millet spread were analyzed. The spread formulated (T₂) with barnyard millet (38g), finger millet (50g) and sweet potato (5g) along with other ingredients were found to be more acceptable in terms of overall acceptability (8.80) as compared to control (6.01), respectively. The research findings indicated that the incorporation of millets and sweet potato enhanced the nutritional value especially micronutrients (iron and zinc). The most acceptable millet spread treatment (code T₂) high in ash content (1.90%), protein (6.77%), dietary fibre (6.51%) and low in fat content (4.03%) furthermore regarding mineral content, highest iron (1.54) and zinc (2.01) was found in treatment T₂ respectively. The developed product is a healthy choice and help people for combating hidden hunger as well as lifestyle diseases.

Keywords: Barnyard millet, finger millet, hidden hunger, millet spread, sweet potato

Introduction

Hidden hunger refers to a form of micronutrient malnutrition that occurs when an individual's diet provides sufficient calories but lacks adequate vitamins and minerals necessary for proper growth, development, and physiological functioning. Unlike overt hunger, which is visible through undernutrition or emaciation, hidden hunger often goes unnoticed because affected individuals may appear to be consuming enough food and may not show immediate physical symptoms (Muthayya *et al.*, 2013) ^[11]. The primary cause of hidden hunger is poor dietary quality. Diets that rely heavily on staple cereals (such as rice, wheat, or maize) often lack diversity and fail to provide essential micronutrients like iron, zinc, iodine, vitamin A, and folate. Other contributing factors include: Poverty and limited access to nutrient-rich foods (e.g., fruits, vegetables, legumes, animal products) (FAO, 2013) ^[7]. Soil nutrient depletion, which affects the micronutrient content of crops (White & Broadley, 2009) ^[19]. Poor health and sanitation, which can impair nutrient absorption (Black *et al.*, 2008) ^[4]. Hidden hunger can have profound health, developmental, and economic impacts, especially on women and children. Deficiencies in micronutrients lead to: Impaired cognitive development and learning capacity in children (Grantham-McGregor *et al.*, 2007) ^[9]. Weakened immune systems, increasing susceptibility to infections (Bhutta *et al.*, 2013) ^[3]. Increased maternal and child mortality, particularly due to deficiencies in iron, vitamin A, and iodine (Black *et al.*, 2013) ^[11]. Reduced productivity and economic growth, as malnourished individuals are less able to work effectively, perpetuating cycles of poverty and malnutrition (Stein & Qaim, 2007) ^[15]. Globally, over 2 billion people suffer from hidden hunger, with the highest burden in low- and middle-income countries, particularly in South Asia and Sub-Saharan Africa (WHO, 2020) ^[20]. Women of reproductive age and children under five are the most vulnerable groups. Millets, being naturally rich in iron, calcium, fiber, and antioxidants, are increasingly being explored as sustainable options to combat hidden hunger through the development of value-added products such as spreads, snacks, and flours.

Finger millet (*Eleusine coracana* L. Gaertn.), also known as ragi in India, is a small-seeded cereal crop widely cultivated in Africa and South Asia. Finger millet is valued for its high nutritional content, climate resilience, and long shelf life, making it a promising crop to address food and nutritional security, especially in developing countries (Upadhyaya *et al.*, 2007) [18]. Finger millet is rich in carbohydrates, dietary fiber, calcium, iron, and essential amino acids, making it superior to many major cereals such as rice and wheat in several aspects (Antony *et al.*, 1997) [11]. Calcium levels in finger millet are 10 times higher than rice and 3-5 times higher than wheat, making it an excellent food for children, pregnant women, and the elderly (Rao *et al.*, 2017) [12]. Finger millet contains several bioactive compounds such as phenolic acids (e.g., ferulic acid, caffeic acid), flavonoids, tannins (in pigmented varieties), phytates and dietary fiber-associated compounds. These compounds exhibit antioxidant, anti-inflammatory, and antimicrobial activities, which may contribute to lower risks of chronic diseases (Devi *et al.*, 2014) [6].

Whereas, barnyard millet is a minor cereal often referred to as a “climate-resilient crop” because of its ability to grow under diverse and adverse agro-climatic conditions. Barnyard millet is gaining popularity as a nutri-cereal due to its high nutrient density, fast growth cycle, and suitability for sustainable farming systems (Saleh *et al.*, 2013) [13]. Barnyard millet offers several health-promoting benefits due to its unique nutrient and phytochemical profile (Ugare *et al.*, 2014) [17]. Barnyard millet is particularly valued for its high fiber content, low glycemic index, and a favorable macronutrient-to-micronutrient balance compared to polished rice and wheat (Gopalan *et al.*, 2011) [8]. Iron content in barnyard millet is often 2-5 times higher than that of rice, making it a valuable cereal in combating iron-deficiency anemia. Its polyphenols contribute to antioxidant activity, potentially reducing risk of chronic diseases such as diabetes and cardiovascular disorders (Shobana *et al.*, 2013) [14].

Sweet potato is a rich source of energy, carbohydrates, vitamins (especially vitamin A in orange-fleshed varieties), minerals, dietary fiber, and antioxidants. Its composition varies with variety, flesh color, and growing conditions (Bovell-Benjamin, 2007) [5]. Sweet potato is notable for its provitamin A carotenoids, particularly in orange-fleshed varieties (OFSP), which can significantly contribute to

vitamin A requirements, especially in children and women in developing countries (Hagenimana *et al.*, 1998) [10]. Sweet potato contains various bioactive compounds with health-promoting properties: Carotenoids (β -carotene, lutein, zeaxanthin): Especially abundant in orange- and yellow-fleshed varieties. Anthocyanins: Predominant in purple-fleshed varieties; act as potent antioxidants. Phenolic acids: Chlorogenic acid, caffeic acid, and others contribute to antioxidant capacity (Truong *et al.*, 2007) [16].

Materials and Methods

Selection of raw materials

Barnyard millet, finger millet and sweet potato were collected from local market of Kanpur, Uttar Pradesh, India. Other supporting ingredients like anjeer, sesame seeds, fresh milk etc. also collected from local market of Kanpur.

Processing of Finger and Barnyard millet

Firstly, millets were thoroughly cleaned to remove unwanted foreign materials. For the preparation of spread both the millets (finger and barnyard) were soaked whole night just double amount of water (w/v). Next day, water was drained and washed under tap water 2-3 times to remove dirt. After that, grind it by adding fresh and clear water; extract was collected through muslin cloth.

Processing of Sweet potato

Fresh purple skin sweet potato was purchased; wash it carefully to remove soil and dirt. After that peeled it with the help of peeler and sliced it very thin through slicer. Boil the water, add sweet potato slices and remain in water for 2-3 minutes, dried it under sun rays. The fully dried sweet potato slices were collected and grinded to make fine powder; put in air tight container till further use.

Preparation of other ingredients

Sesame seeds and anjeer were collected from local market, clean it properly to remove stones, duplicate materials etc. and put it in air tight container till further use.

Formulation of different proportions of millet spread

Total five treatments including control of millet spread were prepared at varying proportions of millets and sweet potato. The Table 1 illustrated below depicts different ratios of treatments for the preparation of millet spread.

Table 1: Different proportion of ingredients used for millet spread preparation

S. No.	Ingredients	Percent replacement				
		Control	T ₁	T ₂	T ₃	T ₄
1	Barnyard millet (g)	100	48	38	28	18
2.	Finger millet (g)	-	40	50	60	70
3.	Sweet potato (g)	-	05	05	05	05
4.	Sesame seeds (g)	-	02	02	02	02
5.	Fig (g)	-	05	05	05	05
6.	Water (ml)	85	85	85	85	85
7.	Total cooked weight (g)	263	273	278	266	281

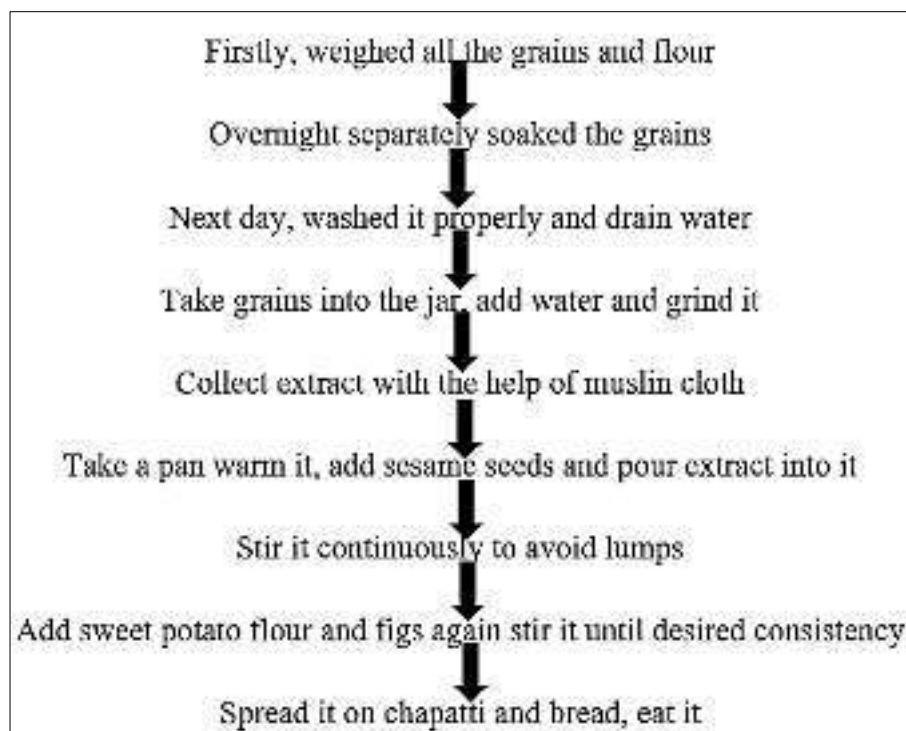


Fig 1: Flow diagram of preparation of different proportion of millet spread

Nutritional composition of millet spread

Proximate composition of millet spread

All the estimations were done in triplicates. Moisture, ash, crude protein, crude fat, crude dietary fibre were estimation by taking three replicates of each treatments by AOAC 2000 method. Physiological energy was calculated by formula: $[4 \times \text{protein}\% + 4 \times \text{carbohydrate}\% + 9 \times \text{fat}\%]$. Carbohydrate was calculated by formula: $[100 - (\text{Moisture} + \text{Protein} + \text{Crude Fibre} + \text{Fat} + \text{Ash})]$.

Minerals

Minerals viz. iron and zinc were estimated by AAS (Atomic Absorption Spectrophotometer). The desired samples in liquid form were sprayed into the flame of an AAS, whereas

absorption or emission of the minerals to be analyzed was measured at a specific wavelength.

Sensory evaluation

The sensory evaluation and organoleptic quality of millet spread was evaluated by nine point hedonic rating scale.

Statistical Analysis

All samples were taken in triplicates and presented as a mean $\pm$ SD. OPSTAT software was used to analyze the data of nutritional composition and sensory evaluation of millet spread. The one way ANOVA was used to measure the significant differences.

Results and Discussion

Table 2: Sensory characteristics of millet spread by nine point hedonic rating scale

Parameters given in (Mean $\pm$ SD)						
Treatment	Appearance	Color	Taste	Texture	Flavor	Overall Acceptability
To	6.01 $\pm$ 0.30	6.52 $\pm$ 0.60	6.22 $\pm$ 0.77	6.93 $\pm$ 1.23	6.10 $\pm$ 1.63	6.35 $\pm$ 1.48
T1	7.96 $\pm$ 0.70	8.29 $\pm$ 1.09	8.42 $\pm$ 0.75	8.03 $\pm$ 0.85	8.43 $\pm$ 0.90	8.18 $\pm$ 0.64
T2	8.83 $\pm$ 0.35	8.92 $\pm$ 0.53	8.88 $\pm$ 0.81	8.66 $\pm$ 0.80	8.72 $\pm$ 0.84	8.80 $\pm$ 0.72
T3	8.51 $\pm$ 1.01	8.42 $\pm$ 0.68	8.69 $\pm$ 0.50	8.53 $\pm$ 0.64	8.61 $\pm$ 0.76	8.55 $\pm$ 0.45
T4	7.50 $\pm$ 0.83	8.12 $\pm$ 0.71	8.33 $\pm$ 0.56	8.19 $\pm$ 0.95	8.36 $\pm$ 0.96	8.01 $\pm$ 0.74
Mean	7.74	8.74	7.87	7.97	7.77	8.33
Variance	1.54	1.50	1.49	1.59	1.74	1.08
SD	1.24	1.22	1.22	1.26	1.32	1.04
SE	0.02	0.01	0.01	0.02	0.02	0.01
CV	0.18	0.18	0.18	0.18	0.19	0.15
S/NS	S	S	S	S	S	S

All values are given in mean $\pm$ SD.

CD at 5% level of probability

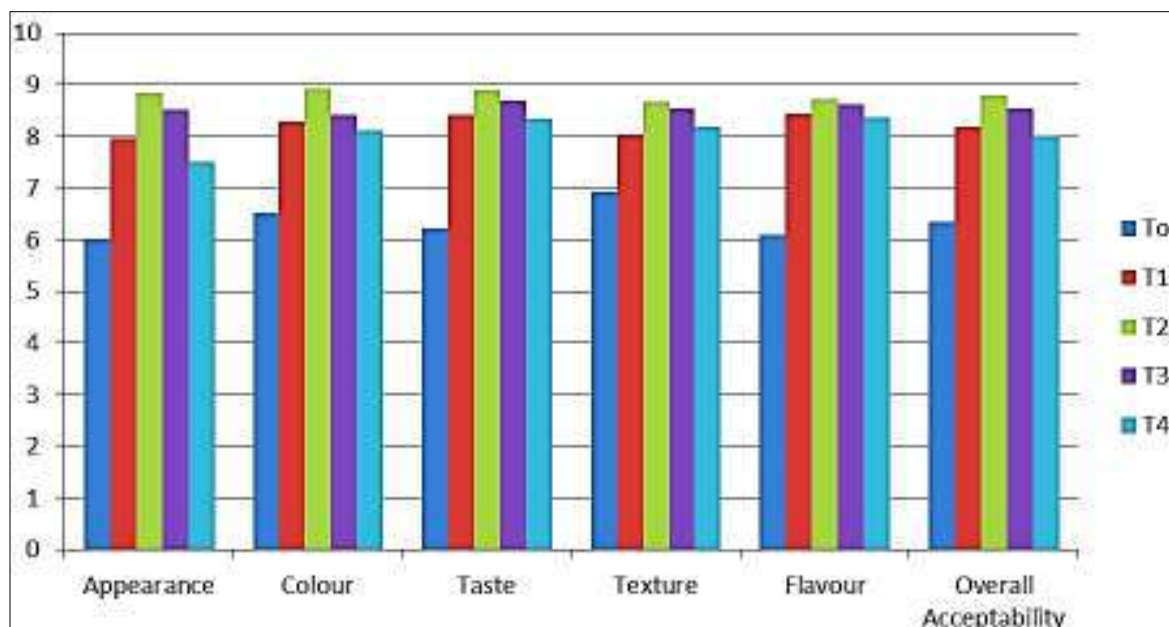


Fig 2: Sensory evaluation of millet based spread

The findings of sensory evaluation are given in Table 2 and Fig 2. Treatment T₂ scored highest in appearance i.e. 8.83 followed by T₃, T₁, T₄ and least by control (T₀) i.e. 6.01. Therefore, significant difference was found among each other when compared with control at 5% level of probability. Furthermore, regarding color treatment T₂ (8.92) scored well including T₃, T₁, T₄ and minimally by control (6.52) which is not good in color. Statistically, when compared with control all treatments of millet spread found significant each other having at 5% level of probability. Taste is one of the five basic human senses and refers specifically to the perception of flavor sensations detected by the taste buds on the tongue and other areas of the oral cavity. However, millet spread developed from treatment T₂ (8.88) first position in score in addition to T₃, T₁, T₄ and least by control (T₀) i.e. 6.22. Statistical analysis revealed that all millet spread treatments were significantly different from the control, with a nominal p-value of 0.00 at the 5% level of significance. On the other hand, treatment T₂ (8.66) was perfect in texture and rated highest than others; while, treatment T₃ was the next followed by T₄, T₁ and lastly T₀ (6.93). All treatments of millet spread showed statistically significant differences compared to the control, with a p-value of 0.01, indicating significance at the 5% probability level. While in case of flavor, millet spread prepared from treatment T₂ (8.72) found highest score along with T₃, T₁, T₄ and least by control (T₀) i.e. 6.10. However, statistical data depicts that all treatments were significantly differ with each other in contrast to control (P<0.05). Lastly, about overall acceptability of treatments prepared from millet spread elevated score seems to be in T₂ (8.80) thereafter T₃, T₁, T₄ and lowest in T₀ (6.35) among all. Analysis showed that all treatments were significantly different from one another, with a p-value of 0.00 at the 5% significance level.

Nutritional composition of millet spread

Proximate composition of millet spread

The proximate composition and physiological energy values of various treatments of millet spread are represented in Table 3.

Physiological Energy: In case of physiological energy content, highest mean score value seen in treatment T₄ (195.05±2.84) succeeded by T₂, T₃, T₁ and minimum energy content in control (T₀) i.e. 162.55±5.98. Therefore, statistically energy revealed a highly significant treatment effect when compared with control having p value = 0.01 at 5% level of probability.

Moisture content: However, moisture content (g/100g) showed an inverse trend, decreasing from 58.85% in T₀ to 47.01% in T₂, with a mean of 51.04%. While, from the Table 3 highest moisture content seen in control (58.85±0.54) followed by T₁, T₄, T₃ and lowest in T₂ (47.01±0.34). The ANOVA for moisture showed a highly significant treatment effect among each other at 5% level of probability.

Ash content: The ash content (g/100g) from Table 3 found highest in T₂ (1.90±0.25) subsequently, T₃, T₁, T₄ and lowest in T₀ (0.60±0.02). Ash increased markedly from 0.60% (T₀) to 1.90% (T₃), showing that treatments enhanced mineral composition compared to control. Statistically when compared all treatments with control then a highly significant effect was found in each other at 5% level of probability and demonstrating that mineral content was positively influenced by treatment application.

Crude Protein content: With regard to protein content (g/100g), its levels improved markedly with treatments, rising from 2.94% (T₀) to a maximum of 6.77% (T₂), yielding a mean of 5.06%. From Table 3 it was depicted that maximum protein found in treatment T₂ (6.77±0.23) including T₃, T₁, T₄ and minimum in T₀ (2.94±0.06) respectively. Statistically, data was showed a highly significant difference (p-value = 0.00) observed between one and other treatments at 5% level of probability (P<0.05).

Crude Fat content: In case of fat content (g/100g) which increased from 2.79% in T₀ to 4.57% in T₄, with a mean of 3.98%. The given Table 3 represents the highest amount of

fat seen in treatment T₄ (4.57±0.43) in addition to T₁, T₂, T₃ and lowest in T₀ (2.79±0.17). Statistical result indicated that the significant difference manifested between ($P<0.05$) all treatment compared to control.

Dietary Fibre content: Concerning to dietary fibre (g/100g) content which is presented in Table 3. Fibre

increased from 3.40% (T₀) to 6.51% (T₂), showing that enrichment substantially improved functional quality. The highest dietary fibre seen in treatment T₂ (6.51±0.62) followed by T₃, T₁, T₄ and minimal amount in T₀ (3.40±0.53). Statistically, results indicated a strong treatment effect among each treatment.

Table 3: Proximate composition and energy value of different treatments of millet based fortified millet spread

g/100g							
Treatment	Energy (Kcal)	Moisture	Ash	Protein	Fat	Dietary Fibre	Carbohydrate
T ₀	162.55±5.98	58.85±0.54	0.60±0.02	2.94±0.06	2.79±0.17	3.40±0.53	31.42±1.00
T ₁	195.14±3.97	49.00±0.74	1.74±0.34	5.88±0.39	4.34±0.49	5.97±0.24	33.14±1.55
T ₂	197.43±2.65	47.01±0.34	1.90±0.25	6.77±0.23	4.03±0.32	6.51±0.62	33.52±0.19
T ₃	197.00±4.62	47.27±0.96	1.82±0.16	6.54±0.33	4.21±0.08	6.25±0.34	32.67±1.19
T ₄	195.05±2.84	48.23±0.48	1.63±0.13	5.15±0.11	4.57±0.43	5.82±0.08	33.83±0.33
Mean	178.11	51.04	1.56	5.06	3.98	5.55	34.15
Variance	283.49	16.26	0.28	1.63	0.50	1.37	2.46
SD	16.84	4.03	0.53	1.28	0.70	1.17	1.57
SE	4.35	1.04	0.14	0.33	0.18	0.30	0.41
CV	0.09	0.08	0.34	0.25	0.18	0.21	0.05

All values are Mean ± SD

Note: The Atwater General Factor System (Protein: 4 kcal/g, Carbohydrate: 4g/100g, Fat: 9g/100g)

C.D. at 5%

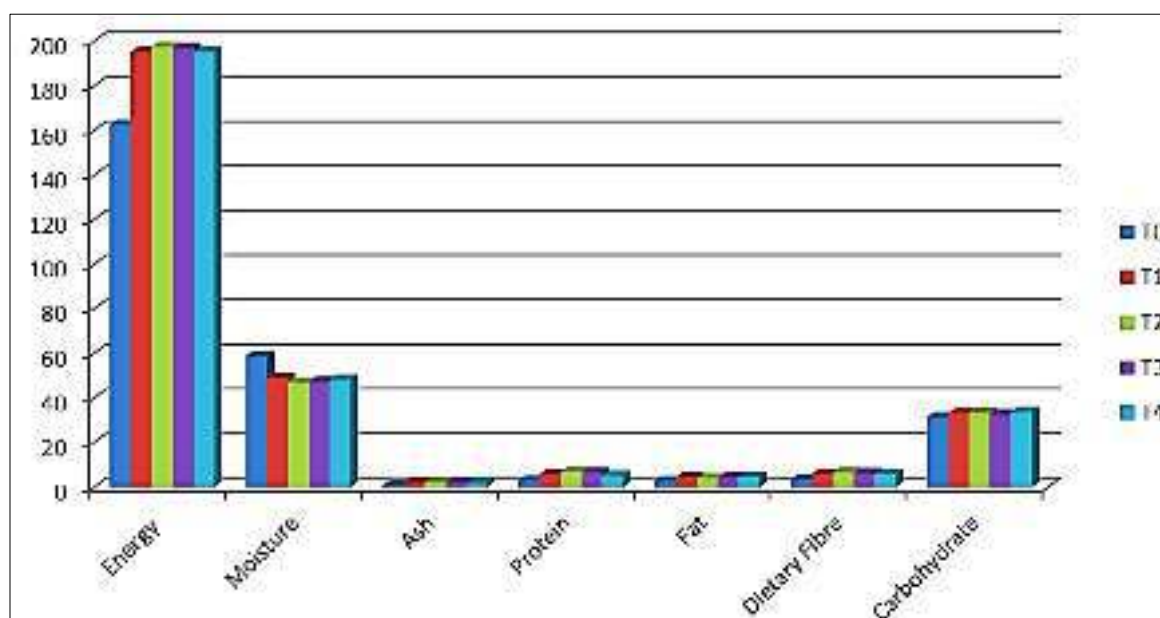


Fig 3: Proximate and energy value of millet based spread

Carbohydrate content

The carbohydrate content (g/100g), from Table 3 found maximum in treatment T₄ (33.83±0.33) after that T₂, T₁, T₃ and minimum in T₀ (31.42±1.00). Carbohydrate content remained relatively stable (32.66–35.72%). Statistically,

treatment effect was showed significant difference at 5% level of probability.

Minerals

The iron and zinc of millet spread presented in Table 4.

Table 4: Minerals composition (mg/100g) of formulated millet spread

Treatment	T ₀	T ₁	T ₂	T ₃	T ₄	Mean	CV	S/NS
Iron	0.03±0.00	1.28±0.02	1.54±0.00	1.47±0.01	1.15±0.01	0.95	0.51	S
Zinc	0.07±0.00	1.85±0.00	2.01±0.00	1.98±0.01	1.76±0.01	4.71	0.15	S

Iron content: The result showed in Table 4, iron (Fe) content expressed in mg/100g; it increased markedly from 0.03 mg in the control (T₀) to 1.54 mg in T₂. Though, highest mean score value found in treatment T₂ (1.54) in addition to T₃, T₁, T₄ and least in T₀ (0.03) among all. Statistically, significant difference (p -value = 0.01) found

among each other when compared to control ($P<0.0$).

Zinc content: In connection with zinc (Zn) content (mg/100g); zinc content improved significantly, ranging from 0.07 mg (T₀) to 2.01 mg (T₂). However, increased amount seen in treatment T₂ (2.01) subsequently, treatment

T₃, T₁, T₄ and lastly in control (T₀) i.e. 0.07. ANOVA findings represents p value negligible (0.00); means significant difference found ($P < 0.0$) each other in contrast with control.

Conclusion

From the above findings it was concluded that micronutrients rich spread was developed prepared from base ingredients viz. finger millet, barnyard millet and sweet potato as well as other supporting ingredients. Among five combinations at different level of proportions, treatment T₂ (38g barnyard, 50g finger millet and 5g sweet potato) found to be best in sensory evaluation and overall acceptability. The millet spread is nutritionally rich in terms of protein, dietary fibre, iron, zinc and low in crude fat which enhances nutritional health status of individuals. All treatments of millet spread good in nutritional value, promote healthier choice as well as mitigate micronutrient deficiencies and day-to-day lifestyle disorders.

References

1. Antony U, Chandra TS. Antinutrient reduction and enhancement in protein, starch, and mineral availability in fermented flour of finger millet (*Eleusine coracana*). Food Chem. 1997;58(4):337-340.
2. AOAC. Official methods of analysis. 17th ed. Washington (DC): Association of Official Analytical Chemists; 2000.
3. Bhutta ZA, Ahmed T, Black RE, Cousens S, Dewey K, Giugliani E, et al. What works? Interventions for maternal and child undernutrition and survival. Lancet. 2013;371(9610):417-440.
4. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet. 2008;371(9608):243-260.
5. Bovell-Benjamin AC. Sweet potato: a review of its past, present, and future role in human nutrition. Adv Food Nutr Res. 2007;52:1-59.
6. Devi PB, Vijayabharathi R, Sathyabama S, Malleshi NG, Priyadarisini VB. Health benefits of finger millet polyphenols and dietary fiber: a review. J Food Sci Technol. 2014;51(6):1021-1040.
7. FAO. The state of food and agriculture: food systems for better nutrition. Rome: Food and Agriculture Organization of the United Nations; 2013.
8. Gopalan C, Rama Sastri BV, Balasubramanian SC. Nutritive value of Indian foods. Hyderabad: National Institute of Nutrition, ICMR; 2011.
9. Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B, et al. Developmental potential in the first 5 years for children in developing countries. Lancet. 2007;369(9555):60-70.
10. Hagenimana V, Carey EE, Gichuki ST, Oyunga MA, Imungi JK. Carotenoid contents in fresh, dried and processed sweet potato products. Ecol Food Nutr. 1998;37(5):455-473.
11. Muthayya S, Rah JH, Sugimoto JD, Roos FF, Kraemer K, Black RE. The global hidden hunger indices and maps: an advocacy tool for action. PLoS One. 2013;8(6):e67860.
12. Rao BD, Devi SP, Rao MV. Nutritional importance and processing aspects of finger millet (*Eleusine coracana*). Food Sci Nutr. 2017;5(5):1-6.
13. Saleh ASM, Zhang Q, Chen J, Shen Q. Millet grains: nutritional quality, processing, and potential health benefits. Compr Rev Food Sci Food Saf. 2013;12(3):281-295.
14. Shobana S, Krishnaswamy K, Sudha V, Malleshi NG, Anjana RM, Palaniappan L, et al. Finger millet (*Ragi, Eleusine coracana* L.): a review of its nutritional properties, processing, and plausible health benefits. Adv Food Nutr Res. 2013;69:1-39.
15. Stein AJ, Qaim M. The human and economic cost of hidden hunger. Food Nutr Bull. 2007;28(2):125-134.
16. Truong VD, McFeeters RF, Thompson RT, Dean LL, Shofran B. Phenolic acid content and composition in leaves and roots of common commercial sweet potato (*Ipomoea batatas* L.) cultivars in the United States. J Food Sci. 2007;72(6):C343-C349.
17. Ugare R, Chimmad B, Naik R, Bharati P, Itagi S. Glycemic index and significance of barnyard millet (*Echinochloa frumentacea*) in type II diabetics. J Food Sci Technol. 2014;51(2):392-395.
18. Upadhyaya HD, Reddy VG, Gowda CLL. Characterization and genetic diversity of core collection of finger millet (*Eleusine coracana* (L.) Gaertn.) germplasm. Plant Genet Resour. 2007;5(3):129-139.
19. White PJ, Broadley MR. Biofortification of crops with seven mineral elements often lacking in human diets—iron, zinc, copper, calcium, magnesium, selenium and iodine. New Phytol. 2009;182(1):49-84.
20. World Health Organization (WHO). Micronutrient deficiencies. Geneva: World Health Organization; 2020.