

SENSORY AND NUTRITIONAL EVALUATION OF FONIO-MUNG BEAN FOOD PRODUCTS

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Abstract

This study evaluated the nutritional and sensory properties of a fonio-mung bean products developed by enriching white fonio (*Digitaria exilis*) with mungbean (*Vigna radiata*) flours. Seven blends were formulated by varying ratios of fonio and mungbean flours. The products were assessed for proximate composition, selected mineral and vitamin contents, as well as sensory attributes, following standard methods. Data were analyzed using descriptive statistics and one-way ANOVA at $p \leq 0.05$. Significant difference in energy, proximate, mineral and vitamin contents were observed in the fonio-mung bean blends. Blend FM1 had the highest energy content while A2 exhibited the highest proximate composition. Also, highest mineral and vitamin contents were recorded in blend A2 and FM1/FM4 respectively. However, blend A2 recorded the highest levels of antinutrients (phytate and tannin). Sensory evaluation results indicated that FM2 was the most preferred blend, whereas FM1 had the lowest acceptability. The incorporation of mung bean flour into fonio flour significantly enhanced its nutritional profile and sensory appeal. These findings highlight the potential of fonio-mung bean food products as a nutritious alternative to conventional breakfast cereals, with promising benefits for improving dietary protein and micronutrient intake. Further research is recommended to assess the shelf life of the product.

Keywords: Fonio-mung bean; Sensory evaluation; Food product; Nutrient evaluation

Introduction

White fonio (*Digitaria exilis*) is rapidly gaining international recognition for its excellent nutritional features particularly its rich methionine and cysteine content (Yilmaz, 2023). Fonio only lacks adequate protein to meet daily dietary needs, as a result necessitating the formation of enriched

breakfast cereals. To promote nutritional adequacy, mung beans (*Vigna radiata*) which are abundant in protein and essential vitamins and minerals, are integrated. This complementary combination enhances fonio's unique amino acid profile and mung bean's robust protein and micronutrient

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contribution, resulting in a nutritionally adequate breakfast cereal (Diatta *et al.*, 2024). Mung beans are well-known for easy digestibility and diverse health-promoting properties, match fonio's energy-providing ability and low glycemic index, making it suitable for blood sugar control. The resulting fonio-mung bean breakfast cereal is designed to overcome the nutritional deficiencies of conventional cereals, which are often characterized by high carbohydrate content and low protein and vitamin levels. By merging these two nutrient-dense plants-based ingredients, the cereal offers a convenient, wholesome, and immediate breakfast resolution, supporting dietary diversification and addressing widespread nutritional gaps. The resulting blend will support the growing global trend towards plant-based diets, which are increasingly championed for their positive impact on overall health and well-being. Furthermore, the incorporation of mung beans enhances the cereal's fiber content, promoting digestive health and satiety (Dimopoulou *et al.*, 2024). This enriched cereal provides an essential source of plant-based protein, crucial for muscle maintenance and repair, especially beneficial for individuals with active lifestyles (Singh *et al.*, 2025). The cereal's balanced nutrient profile supports sustained energy release, preventing energy collapse and promoting protracted vitality throughout the day. Additionally, the fonio-mung bean breakfast cereal formulation aims to empower individuals to make healthier dietary choices, contributing to improved public health outcomes. This study is set to evaluate the nutritional value of white fonio (*Digitaria exilis*) enriched with mung beans (*Vigna radiata*) breakfast cereal.

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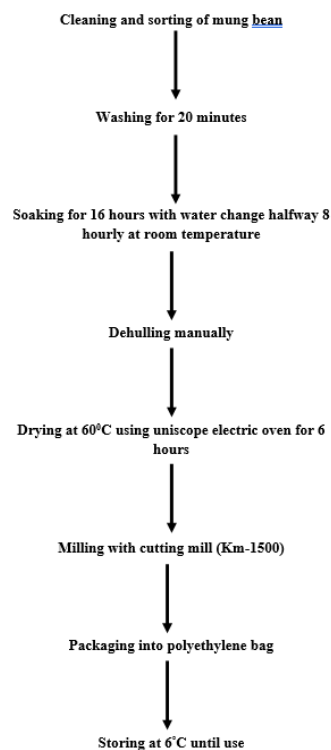


Figure 1. Production of mung bean flour

Materials and Methods

Sample collection

Mung beans and white fonio seeds (Figure 3 and Figure 4) were purchased from TRS Organics in Ajah, and BaglaAgro in Maryland in Lagos State, Nigeria.

Production of white fonio and mung bean flours

The production of white fonio and mung bean flours were shown below in Figure 1 and Figure 2.

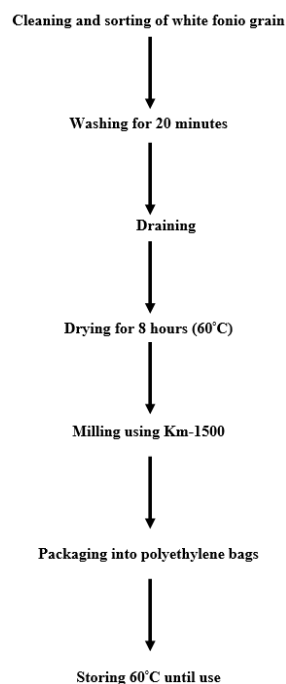


Figure 2. Production of white fonio flour (Agu *et al.*, 2015)



Figure 3. Image of White Fonio Grain



Figure 4. Image of White Fonio Grain

Formulation of Fonio - Mung Bean Composite Flour

To create the composite flour, whole meal fonio and mung bean flours were blended in different ratios. Each blend was thoroughly mixed to ensure uniformity and seven (7) blend samples were produced as shown in Table 1 below:

Table 1. Formulation of Fonio- Mung Bean Composite Flour

Samples	Fonio Flour (g)	Mung Bean Flour (g)
A1	100	0
A2	0	100
FM1	50	50
FM2	60	40
FM3	70	30
FM4	80	20
FM5	90	10

Production of the Whole Meal FonioMung Bean Gruel/ Breakfast Product

After fonio and mungbeans were milled into fine flours, seven breakfast fonio-mung bean products were prepared using the sample blends above. For added flavour and nutritional benefits, finely grinded dates (1g), salt (1g) and some water were incorporated into each of the fonio-mung bean composite flour table above. The dates not only add natural sweetness but also provide additional fiber and essential nutrients. The mixed ingredients were then transferred to a baking sheet, ensuring an even layer for uniform baking. The mixture was baked at a temperature of 60°C for 1hour. This developed a toasted flavor and a crunchy texture in the cereal and, the mixture was allowed to cool. The cooled product was then broken into smaller pieces or flakes for desired final texture of the breakfast

cereal. These pieces were further dried in the oven at a low (40°C) temperature to remove any residual moisture, ensuring a longer shelf life. Finally, the dried cereal pieces were packaged in airtight containers to preserve freshness and prevent contamination. It was further taken to Precision Food and Feed Laboratory located in Ibadan for laboratory analysis.

Energy and Nutrient Analysis

The energy contents of the blends were determined using Atwater general factors (Protein: 4 kcal/g, Fat: 9 kcal/g and Carbohydrate: 4 kcal/g) (AOAC, 2005). Moisture, fat, crude protein, crude fibre and ash contents of the breakfast cereals were determined in triplicates according to the approved procedures of the Association of Official Analytical Chemists (AOAC, 2005). The iron, magnesium, calcium and zinc contents were determined using the atomic absorption spectrophotometer (Buck 200, Buck Scientific, USA), while sodium and potassium were determined using flame Jenway Digital Flame Photometer (PFP7, Bibby Scientific Limited, United Kingdom) (Olutayo *et al.*, 2018). Folic acid (vit B9) concentration was determined by preparing standard and working solutions in an alkaline medium, analyzing the sample with added reagents NQS (1, 2 - naphthoquin-4-sulfonate) and buffer solution), and measuring the absorbance at 436nm. The determination of ascorbic acid involves reagent preparation, sample extraction with metaphosphoric acid-acetic acid solution, oxidation using bromine water, reaction with 2, 4-dinitrophenyl hydrazine, and spectrophotometric measurement at 521 nm to calculate concentration using a standard calibration curve (AOAC, 2005). Vitamin E content was determined by preparing extraction and colorimetric reagents, extracting the sample with ethanol and hexane, measuring absorbance at 520 nm, and using a calibration curve to calculate the concentration. Vitamin A was determined by saponifying the sample with ethanol and potassium hydroxide, extracting with petroleum ether, measuring absorbance at 325 nm, and calculating concentration using a calibration curve. Phytic acid is determined by extracting with hydrochloric acid, titrating with iron (III) chloride using ammonium thiocyanate as an indicator, and calculating content based on titrant volume and dilution factor. The Folin-Ciocalteu method determines phenolic content by homogenizing the sample, extracting phenolic compounds, reacting with Folin-Ciocalteu reagent and sodium carbonate, and measuring absorbance at 725 nm to calculate concentration using a calibration curve (AOAC, 2005; Adepoju & Etukumoh, 2014).

Sensory Evaluation of the Whole Meal Fonio-Mung Bean Breakfast Products

The sensory evaluation of the seven (7) breakfast cereals produced was assessed by fifty-member panelists. The panelists were selected randomly from the Department of Food Science and Technology, College of Food and Agricultural Sciences, Bells University of Technology, Ota, Ogun State. Panelists had to commit to participation throughout the evaluation period. The products were evaluated for colour, texture, flavour, aroma and overall acceptability according to the procedure of Ayo *et al.*, (2014). A nine-point Hedonic scale from 9 (like extremely) to 1 (dislike extremely) was used. The scores were statistically analyzed using analysis of variance. The products, appropriately coded and of the same quantity (10 ml) and temperature ($29 \pm 3^\circ\text{C}$) were placed in clean plastic plates. The panelists rinsed their mouths with bottled water after tasting each sample. Test samples were served randomly to panelists in different cubicles to ensure deserved privacy under bright light.

Ethical Consideration

Ethical approval is not required by the national law but an exemption from ethics committee approval was obtained with no formal documentation but the appropriate protocols for protecting the rights and privacy of all participants were utilized during the execution of the research. There was no coercion to participate, full disclosure of study requirements and risks, written consent of the participants was sought after, no release of participant data without their knowledge and they were permitted to withdraw from the study at any time.

Results and Discussion

Results

Table 2 presents the energy and proximate content of the breakfast cereals. There was a significant difference in the energy and proximate contents of the breakfast cereals at $p < 0.05$. Energy content varied from 404.23 kcal/100g in FM1 to 304.51 kcal/100g in A2. The moisture content ranged from 4.42% in FM1 to 11.51% in FM3. Protein content ranged from 11.08% in A2 to 27.46% in F5. The fat content varied from 1.7% in A1 to 9.20% in FM5. The fiber content ranged from 0.09% in A1 and A2 to 0.50% in FM5. Ash content ranged from 0.86% in A1 to 3.27% in A2. The Nitrogen Free Extract (NFE) values represented the carbohydrate content of the food product which

ranged from 58.78% in A2 to 75.76% in A1. In overall, the breakfast cereal (A2 and FM5) had the highest proximate content, followed by A1 and FM3, and others.

Table 3 presents a detailed analysis of micro-nutrients (minerals) in various food samples. These samples include pure and blended flakes of Fonio and Mungbean in different ratios. There was a significant difference in mineral contents (g/100g) at $p < 0.05$. Calcium content ranged from 23.72g in A1 to 60.87g in A2. The magnesium content ranged from 66.01g in FM5 to 138.42g in A2. Iron content ranged from 3.20g in FM3 to 5.45g in A2. Zinc content ranged from 1.54g in FM5 to 2.60g in A2.

Sodium content ranged from 70.95g in A1 to 196.24g in FM2. Potassium content ranged from 102.09g in A1 to 692.07g in A2. Sample A2 had significantly higher mineral content followed by FM2 and others.

Table 4 indicates significant difference in vitamin content at $p < 0.05$. Vitamin B₉ ranged from 0.0305 in FM4/FM2/FM1 to 0.0470 in A1. Vitamin C ranged from 1.3005 in A1 to 15.14 in FM4. Vitamin E ranged from 0.0855 in A1 to 0.7395 in FM5. Vitamin A ranged from 0.0113 in A1 to 0.0245 in FM2. FMI, FM2 and FM4 were significantly higher in vitamin content, followed by FM5 and others.

Table 2. Formulation of Fonio- Mung Bean Composite Flour

Samples	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fibre (%)	Total Ash (%)	NFE (%)	Energy (kcal/100g)
A1	10.30±0.028 ^d	11.70±0.021 ^f	1.70±0.028 ^g	0.09±0.007 ^f	0.86±0.014 ^g	75.76 ± 0.530 ^a	365.14±0.02 ^e
A2	7.90±0.198 ^e	27.46±0.035 ^a	2.51±0.042 ^f	0.09±0.014 ^f	3.27±0.021 ^a	58.78 ± 0.226 ^e	304.51±0.14 ^f
FM1	4.42±0.007 ^g	17.48±0.035 ^b	6.15±0.021 ^c	0.15±0.014 ^e	2.08±0.042 ^b	69.74 ± 0.007 ^c	404.23±0.22 ^a
FM2	11.17±0.028 ^b	15.89±0.170 ^c	5.60±0.028 ^d	0.20±0.014 ^d	1.49 ± 0.028 ^d	65.65 ± 0.156 ^d	376.56±0.15 ^d
FM3	11.51±0.028 ^a	14.91±0.021 ^d	5.61±0.035 ^d	0.31±0.035 ^c	1.62 ± 0.035 ^c	66.06 ± 0.014 ^d	374.37±1.02 ^d
FM4	6.62±0.035 ^f	13.28±0.028 ^e	3.11±0.007 ^e	0.40±0.021 ^b	1.55 ± 0.007 ^d	75.06 ± 0.042 ^b	381.35±0.11 ^c
FM5	10.94±0.071 ^c	11.08±0.120 ^g	9.20±0.028 ^a	0.50±0.021 ^a	1.21 ± 0.021 ^c	67.09 ± 0.120 ^d	395.48±0.23 ^b

^{A1}fonio flour, ^{A2} mungbean flour, ^{FM1} 50% fonio+50% mungbean, ^{FM2}60% fonio + 40% mungbean, ^{FM3} 70% fonio + 30% mungbean, ^{FM4} 80% fonio + 20 % mungbean, ^{FM5} 90% fonio + 10% mungbean. Values with the same superscripts are not significantly different by column and vice versa at $p < 0.05$.

Table 3. Mineral Content of the Fonio-Mung Bean Breakfast Products

Samples	Calcium	Magnesium	Iron g/100g	Zinc	Sodium	Potassium
A1	23.72 ± 0.151 ^e	78.51 ± 0.029 ^c	3.68 ± 0.097 ^d	1.87 ± 0.022 ^d	70.95 ± 0.115 ^g	102.09 ± 0.454 ^g
A2	60.87 ± 0.238 ^a	138.42 ± 0.208 ^a	5.45 ± 0.078 ^a	2.60 ± 0.031 ^a	172.86 ± 0.313 ^c	692.07 ± 0.081 ^a
FM1	47.72 ± 0.436 ^b	99.43 ± 0.286 ^b	3.95 ± 0.025 ^c	2.24 ± 0.002 ^b	187.00 ± 0.374 ^b	373.05 ± 0.351 ^b
FM2	37.20 ± 0.041 ^c	80.30 ± 0.070 ^d	3.20 ± 0.014 ^f	1.84 ± 0.000 ^e	196.24 ± 0.460 ^a	237.92 ± 7.220 ^e
FM3	36.40 ± 0.058 ^d	74.70 ± 0.033 ^f	3.06 ± 0.004 ^g	1.71 ± 0.018 ^f	131.92 ± 0.195 ^e	297.76 ± 0.351 ^c
FM4	47.00 ± 0.00 ^b	81.07 ± 0.253 ^c	4.40 ± 0.008 ^b	1.93 ± 0.054 ^c	125.05 ± 0.267 ^f	289.94 ± 0.296 ^d
FM5	37.80 ± 0.026 ^c	66.01 ± 0.032 ^g	3.42 ± 0.042 ^e	1.54 ± 0.006 ^g	168.80 ± 0.117 ^d	130.09 ± 0.037 ^f

^{A1}fonio flour, ^{A2} mungbean flour, ^{FM1} 50% fonio+50% mungbean, ^{FM2}60% fonio + 40% mungbean, ^{FM3} 70% fonio + 30% mungbean, ^{FM4} 80% fonio + 20 % mungbean, ^{FM5} 90% fonio + 10% mungbean. Values with the same superscripts are not significantly different by column and vice versa at $p < 0.05$.

Table 4. Mineral Content of the Fonio-Mung Bean Breakfast Products

Samples	Vitamin B ₉ (%)	Vitamin C (%)	Vitamin E (%)	Vitamin A (%)
A1	0.0305 ± 0.00212 ^c	1.3005 ± 0.02051 ^g	0.0855 ± 0.00071 ^g	0.0113 ± 0.00014 ^c
A2	0.0385 ± 0.00212 ^b	8.3985 ± 0.00495 ^f	0.1710 ± 0.00283 ^f	0.0139 ± 0.00035 ^d
FM1	0.0455 ± 0.00212 ^a	12.0575 ± 0.06435 ^e	0.3115 ± 0.00495 ^e	0.0245 ± 0.00085 ^a
FM2	0.0455 ± 0.00071 ^a	14.2930 ± 0.01273 ^b	0.3565 ± 0.00212 ^d	0.0251 ± 0.00028 ^a
FM3	0.0350 ± 0.00283 ^{bc}	14.1005 ± 0.00495 ^c	0.5195 ± 0.00354 ^c	0.0229 ± 0.00035 ^b
FM4	0.0470 ± 0.00141 ^a	15.1400 ± 0.00566 ^a	0.5515 ± 0.00212 ^b	0.0212 ± 0.00035 ^c
FM5	0.0340 ± 0.00283 ^{bc}	13.6545 ± 0.00778 ^d	0.7395 ± 0.00354 ^a	0.0204 ± 0.00064 ^c

^{A1}fonio flour, ^{A2} mungbean flour, ^{FM1} 50% fonio+50% mungbean, ^{FM2}60% fonio + 40% mungbean, ^{FM3} 70% fonio + 30% mungbean, ^{FM4} 80% fonio + 20 % mungbean, ^{FM5} 90% fonio + 10% mungbean. Values with the same superscripts are not significantly different by column and vice versa at $p < 0.05$.

Table 5. Antinutrient Content of the Fonio-Mung Bean Breakfast Products

Samples	Phytate (%)	Tannin (%)
A1	2.39 ± 0.369 ^d	26.56 ± 0.060 ^s
A2	2.68 ± 0.052 ^a	123.80 ± 0.385 ^a
FM1	2.30 ± 0.013 ^e	115.49 ± 0.192 ^b
FM2	2.60 ± 0.004 ^b	78.87 ± 0.052 ^c
FM3	2.41 ± 0.019 ^c	96.17 ± 0.010 ^e
FM4	2.38 ± 0.011 ^d	79.39 ± 0.029 ^d
FM5	2.36 ± 0.014 ^d	57.11 ± 0.296 ^f

^{A1}fonio flour, ^{A2} mungbean flour, ^{FM1} 50% fonio+50% mungbean, ^{FM2}60% fonio + 40% mungbean, ^{FM3} 70% fonio + 30% mungbean, ^{FM4} 80% fonio + 20 % mungbean, ^{FM5} 90% fonio + 10% mungbean. Values with the same superscripts are not significantly different by column and vice versa at p<0.05.

Table 6. Sensory Evaluation of the Fonio-Mung Bean Breakfast Products

Samples	Aroma	Flavour	Texture	Colour	Overall
A1	5.19 ^f	6.35 ^b	5.95 ^f	6.85 ^c	4.9 ^f
A2	5.18	5.99	5.87	6.78	5.0
FM1	6.48 ^c	5.7 ^e	8.05 ^a	7.2 ^b	7.75 ^b
FM2	7.00 ^a	7.9 ^a	7.15 ^c	8.00 ^a	8.75 ^a
FM3	5.71 ^e	6.25 ^c	7.00 ^d	6.05 ^c	6.55 ^d
FM4	6.57 ^b	5.75 ^e	6.75 ^c	6.55 ^d	6.45 ^e
FM5	5.90 ^d	5.95 ^d	7.70 ^b	6.55 ^d	6.75 ^c

^{A1}fonio flour, ^{A2} mungbean flour, ^{FM1} 50% fonio+50% mungbean, ^{FM2}60% fonio + 40% mungbean, ^{FM3} 70% fonio + 30% mungbean, ^{FM4} 80% fonio + 20 % mungbean, ^{FM5} 90% fonio + 10% mungbean. Values with the same superscripts are not significantly different by column and vice versa at p<0.05.

Table 5 shows the phytate and tannin content of the breakfast cereals. There was a significant difference in the antinutrient contents at p< 0.05. Phytate content ranged from 2.30 % in FM1 to 2.62% in A2. Tannin ranged from 26.56 % in A1 to 23.80 % in A2. Sample A2 had significantly higher antinutrient content.

Table 6 shows the sensory evaluation ratings. The Aroma rating ranged from 5.19 in F1 to 7.0 in FM2. The Flavor rating ranged from 5.70 in FM1 to 7.90 in FM2. The texture rating ranged from 7.0 in FM3 to 8.05 in FM1. Colour ratings ranged from 6.05 in FM3 to 8.00 in FM2. FM2 recorded the highest overall acceptability with a score of 8.75, indicating it is the most preferred blend among the sensory panel. F1 had the lowest overall acceptability score of 4.90, suggesting it is the least preferred.

Discussion

The energy contents of the breakfast cereal products fell within the range of the most commercial ready-to-eat breakfast cereal. This finding is in agreement with the report of Tacer-Caba *et al.*, (2015) and Rehal *et al.*, (2022). In addition to this, These products can furnish the daily energy requirement of an adult which is supported by the work of van den Boom *et al.*, (2006) who reported that breakfast cereal product consumption provide an adequate

energy for Spanish children, adolescents and young adults. Also, the shelf life and stability of a food product is heavily influenced by its moisture content. Sample FM1, which exhibited lower moisture levels, demonstrated a prolonged shelf life due to reduced microbial activity. In contrast, FM3 had elevated moisture content, indicating a need for additional preservation methods to maintain stability. These findings align with observations by Awulachew, (2021), which explored the relationship between moisture, microbial growth, and shelf stability.

Mungbean flour (A2) contained a high level of protein, highlighting its potential as a protein-rich ingredient. Fonio-based products, which are naturally lower in protein, benefit from the addition of mungbean, resulting in a product with an improved protein profile (Diatla *et al.*, 2024; Sibanda *et al.*, 2024). Blend A1, characterized by the highest Nitrogen Free Extract (NFE) value (75.76%), is a substantial source of carbohydrates, suitable for providing quick energy, especially when energy-dense foods are needed. A2, with a lower NFE (58.78%), provides a more balanced nutrient composition, offering benefits beyond carbohydrates. The increased fat content in FM5 contributes to higher energy density, improved texture, and enhanced creaminess, making it suitable for products like complementary flours and processed snacks (Palzer, 2009; Bourouis *et al.*,

2023). Blend A1 may be preferred for low-fat diets due to its low fat content and ability to improve metabolic health and reduce cardiovascular risks (Fleming, 2002; Nordmann *et al.*, 2006; Thom & Lean, 2017).

Several studies revealed that higher fat levels increase smoothness and reduce hardness, contributing to a desirable mouth feel (Stubbs *et al.*, 2000; Bell & Rolls, 2001; Forde & Bolhuis, 2022). Additionally, reduction in fat content of food makes food firmer and less cohesive, positioning them for specific dietary products. Dietary fiber, both soluble and insoluble, is vital for digestive health and satiety, influencing gut motility, microbiota, and blood glucose levels (Kumar *et al.*, 2020). FM5's high fiber content offers benefits such as improved bowel regularity and appetite control (Akhlaghi, 2024) while A1 and A2, with lower fiber content, may require supplementation. Research by Guan *et al.* (2021) supports the role of fiber in digestive health and metabolic regulation. Ash content, indicating total mineral content, is high in A2 (mungbean flour), signifying a rich source of minerals essential for various physiological functions (Nwajagu *et al.*, 2021). Mungbeans contain iron, zinc, magnesium, and potassium, which are crucial for health (Gunathilake *et al.*, 2016). Ampah (2020) highlighted the importance of legumes as mineral sources and the impact of processing on bioavailability. A2, despite its mineral richness, has the lowest NFE, making it a less effective energy source.

The micronutrient analysis depicted a clear trend, with mungbean breakfast cereals A2 having the highest levels of most of the analyzed minerals (calcium, magnesium, iron, zinc, potassium, and phosphorus). This highlights mungbean flour as an excellent source of essential minerals and a valuable addition to a healthy diet. On the other hand, fonio breakfast cereals A1 consistently exhibited the lowest levels of several minerals (calcium, sodium, potassium, and phosphorus). While the fonio blend was well-suited for low-sodium diets, it may need to be supplemented or paired with other foods to ensure sufficient intake of essential minerals. Additionally, the results revealed that FM2 has the highest sodium content, a factor to consider in dietary planning, especially for individuals managing high blood pressure or following sodium-restricted diets. These findings are in line with prior studies by Jukanti *et al.* (2016) and Diatta *et al.* (2024).

Vitamin content varied significantly across samples, influenced by ingredients and processing. Folate, vitamin C, vitamin E, and vitamin A levels were examined (Awuchi, 2020; Garg *et al.*, 2021). FM4 contained a high level of vitamin C, FM5 was

rich in high vitamin E, and FM2 had high level of vitamin A. Formulations like FM1, FM2, and FM4 showed optimized vitamin profiles, which are important for addressing nutritional deficiencies (Ramashia, 2018; Chepkoech, 2024).

Fonio Flake (F1) contained the highest phytate levels, potentially reducing mineral absorption, while FM1 had the lowest phytate content (Onyenweaku *et al.*, 2021). A2 had the highest tannin content, affecting protein and mineral absorption, whereas F1 had the lowest. Tannin levels varied in blends, decreasing with increasing Fonio content (Deraz & Khalil, 2008; Pokharel, 2022; Balaso, 2024). Sensory evaluation favored FM2 for aroma, flavor, color, and overall acceptability, while F1 was the least preferred. FM1 had good texture but poor flavor. FM3's texture scores were inconsistent. Balanced blends like FM2 performed best. Lawless and Heymann (2010) noted the complexity of sensory testing due to human variability.

Conclusions

This study provides evidence that mung bean-enriched fonio cereals represent a nutritionally superior and sensorially acceptable food product. Given the observed enhancements in protein and micronutrient content, these breakfast products offer a promising dietary intervention. To ensure long-term viability, shelf life studies are essential to establish optimal storage conditions and inform product development as recommendation.

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