

Effect of Sprouting Time on the Nutritional Quality, Functional Properties and Anti-nutrient composition of millet (*Pennisetum glaucum*)-African breadfruit (*Treculia Africana*) Composite Diets

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ABSTRACT

The influence of sprouting on the chemical composition and sensory attributes of millet (*Pennisetum glaucum*) and African breadfruit (*Treculia africana*) based composite diets was investigated. The formulated diets were evaluated for proximate composition, mineral and vitamin contents, anti-nutritional factors, and sensory acceptability. Sprouting increased moisture (6.09–6.97%), ash (1.19–1.59%), crude fibre (2.26–2.56%), carbohydrate (50.63–67.31%), energy (355.45–360.05 kcal/100 g), reducing sugars (2.40–5.17%), and dietary fibre (43.99–55.00%). Conversely, fat (11.62–7.30%), protein (28.20–16.45%), and starch (7.82–4.24%) contents declined with increasing sprouting duration. Despite this reduction, the protein content of the sprouted formulations remained comparable to that of the commercial reference product (16.45%). Sprouting significantly increased phosphorus (46.78–105.90 mg/100 g) and vitamins A, C, and E, while calcium (208.17–116.53 mg/100 g) and magnesium (158.36–76.82 mg/100 g) decreased. In addition, phytate, tannin, and oxalate contents were markedly reduced following sprouting. Sensory evaluation indicated improved organoleptic characteristics and good overall acceptability of the formulated diets. Although the commercial product (NUTREND) received the highest acceptability scores, likely due to consumer familiarity and widespread use, the sprouted composite diets demonstrated promising nutritional quality and sensory potential as complementary food formulations.

Keywords: Sprouting time; Millet; African breadfruit; Composite diets; Nutritional quality; Functional properties; Anti-nutritional factors

INTRODUCTION

Protein energy malnutrition (PEM) remains a major public health challenge in many low- and middle-income countries, particularly during the complementary feeding period. From six months of age, breast milk alone is insufficient to meet the increasing nutritional requirements of infants, making nutritionally adequate complementary foods essential. However, complementary foods consumed in many developing countries are predominantly cereal based and are often characterized by low protein quality, poor micronutrient density, and limited mineral bioavailability, increasing the risk of undernutrition and micronutrient deficiencies (UNICEF et al., 2023; FAO et al., 2024; WHO, 2023).

Although commercially produced complementary foods provide balanced nutrition, their high-cost limits accessibility for many low-income households. Consequently, increasing attention has been directed toward the development of affordable, nutrient dense complementary foods from locally available cereals and legumes. Cereal legume blends provide improved protein quality through amino acid complementation and represent a sustainable approach to enhancing the nutritional value of complementary foods (Nkhata et al., 2018; Ekong et al., 2022).

Sprouting is an economical bioprocessing technique that enhances the nutritional quality of cereals and legumes by improving nutrient digestibility, increasing vitamin content and mineral bioavailability, and reducing anti nutritional factors. It also improves functional and sensory characteristics, making sprouted ingredients suitable for complementary food production (Nkhata et al., 2018; Kurek & Wyrwisch, 2022).

Pearl millet (*Pennisetum glaucum*) is a climate resilient cereal recognized for its high energy value, dietary fibre, essential minerals, and diverse phytochemicals that contribute to both nutritional and health promoting properties (Samtiya et al., 2022). African breadfruit (*Treculia africana*) is an underutilized indigenous seed with high protein content, balanced essential amino acids, dietary fibre, minerals, and bioactive compounds. Recent studies have further demonstrated that appropriate processing methods, including sprouting and malting, improve its nutritional quality, protein digestibility, and reduce anti nutritional factors, thereby increasing its suitability for functional food and complementary food applications (Edima Nyah et al., 2023; Hill et al., 2025).

The complementary nutritional characteristics of pearl millet and African breadfruit provide a strong basis for developing affordable, nutrient dense complementary foods from indigenous raw materials. Therefore, this study evaluated the effect of sprouting on the nutritional quality, mineral composition, vitamin content, anti-nutritional factors, and sensory attributes of millet and African breadfruit based complementary diets.

MATERIALS AND METHODS

Sources of materials

The millet grains, African breadfruit, granulated sugar, crayfish, skim milk powder, salt and Nutrend (a commercial brand) were purchased from Eke-Ukwu market, Owerri in Imo State.

Processing of Sprouted Millet Flour

Millet grains (3 kg) were manually cleaned and sorted to remove stones, chaff, and other foreign materials. The cleaned grains were steeped in potable water at a grain to water ratio

of 1:3 (w/v) for 3 h at ambient temperature to facilitate water absorption prior to germination. The soaked grains were drained and spread uniformly on a moistened jute sack, covered with a muslin cloth, and overlaid with another moist jute sack to maintain adequate humidity during germination. Sprouting was carried out for 48, 72, and 96 h at $28 \pm 2^\circ\text{C}$. During germination, the grains were sprinkled with potable water at 12 h intervals and turned periodically to ensure adequate aeration and minimize mould growth.

At the end of each sprouting period, the rootlets were removed manually, and the sprouted grains were dehulled, washed, and sorted. The sprouted grains were oven dried in a Gallenkamp hot air oven at 55°C for 8 h prior to milling. The dried grains were milled separately using a disc attrition mill and sieved through a 1 mm mesh sieve to obtain flour of uniform particle size. The sprouted millet flours were packaged in labelled airtight polyethylene bags and stored at room temperature until further analysis.

Processing of sprouted African Breadfruit flour

African breadfruit seeds (3 kg) were manually cleaned and sorted to remove stones, dirt, and other foreign materials. The cleaned seeds were steeped in potable water at a seed to water ratio of 1:3 (w/v) for 6 h in covered plastic containers to facilitate water absorption prior to germination. The soaked seeds were drained and spread uniformly on a moistened jute sack, covered with a muslin cloth, and overlaid with another moist jute sack to maintain adequate humidity during sprouting. Germination was carried out for 96, 120, and 144 h at $28 \pm 2^\circ\text{C}$. During the sprouting period, the seeds were sprinkled with potable water at 12 h intervals and turned periodically to ensure adequate aeration and minimize mould growth.

At the end of each sprouting period, the rootlets were removed manually, and the sprouted seeds were dehulled, washed, and sorted. The sprouted seeds were oven dried in a Gallenkamp hot air oven at 55°C for 8 h prior to milling. The dried sprouted breadfruit seeds were milled separately using a disc attrition mill and sieved through a 1 mm mesh sieve to obtain flour of uniform particle size. The sprouted breadfruit flours were packaged in labelled airtight polyethylene bags and stored at room temperature until further analysis.

Processing of Crayfish Flour

Crayfish samples were cleaned, sorted, and winnowed to remove extraneous materials. The cleaned samples were dry milled using an electric blender (National, Model MK 308, Japan) and sieved through a 1 mm mesh sieve to obtain flour of uniform particle size. The resulting crayfish flour was packaged in labelled airtight polyethylene bags and stored at room temperature until further analysis.

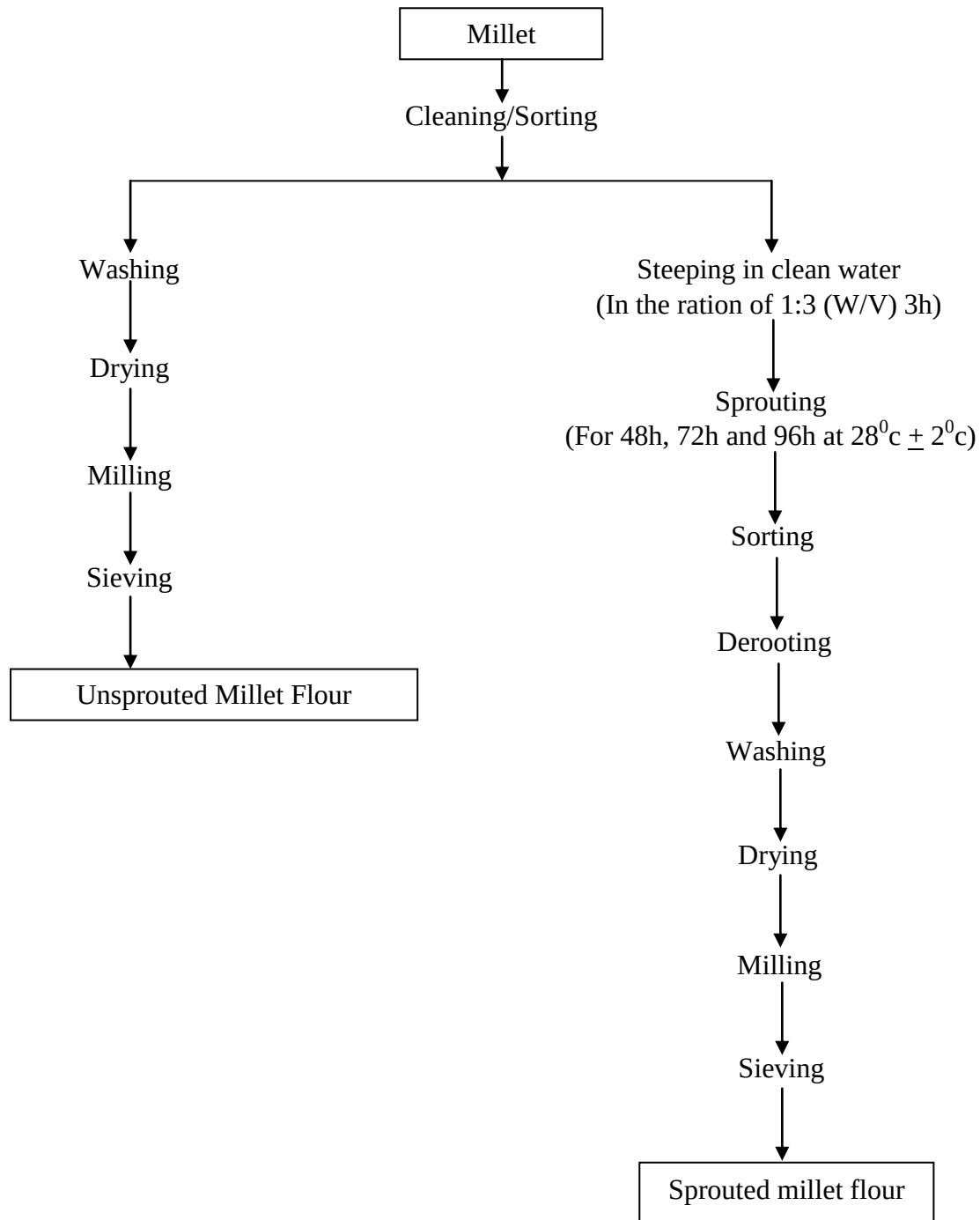


Fig 1. Flow chart of unsprouted and sprouted millet flour processing

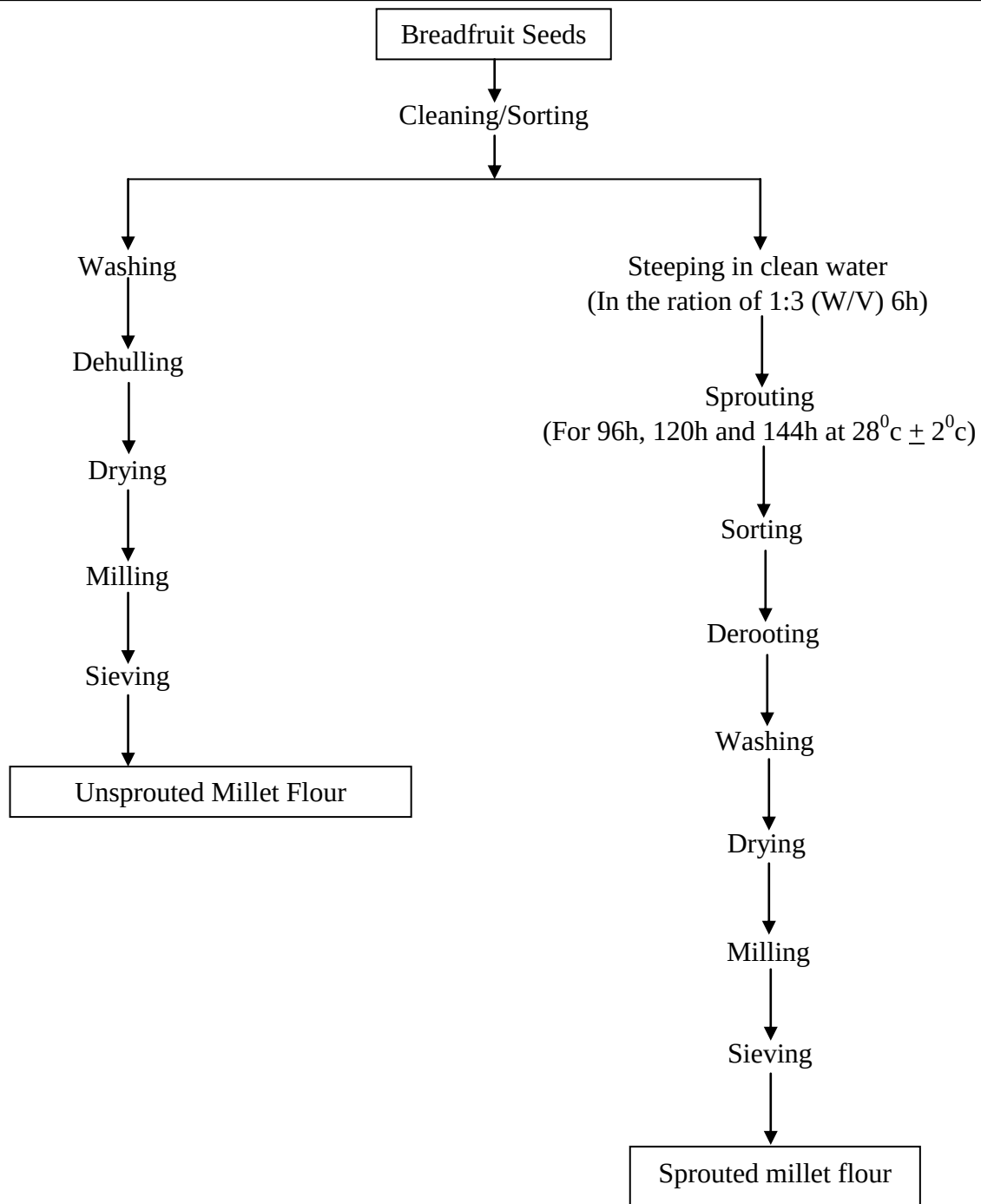


Fig 2: Flow chart of unsprouted and sprouted breadfruit seed flour processing

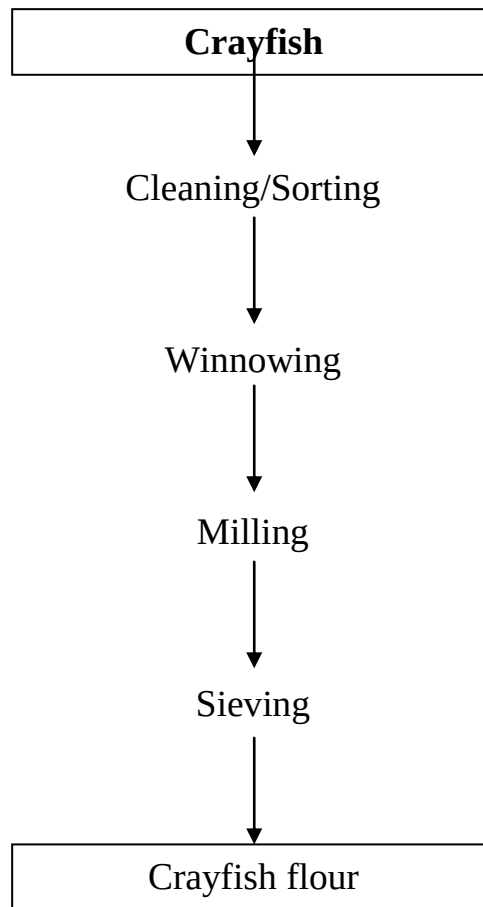


Fig 3: Flow chart of crayfish flour processing

Preparation of Composite Diets

The processed millet, African breadfruit, and crayfish flours were used for the formulation of composite diets. The composite flour blends were prepared using a millet to African breadfruit ratio of 70:30, with millet flour constituting 70% and African breadfruit flour constituting 30% of the cereal legume base. The formulated diets contained fixed proportions of millet flour, African breadfruit flour, crayfish flour, skimmed milk powder, sugar, and salt as shown in Table 1. The ingredients were thoroughly mixed to obtain homogeneous composite diets prior to subsequent analyses.

Table 1: Preparation of Composite Diets

Samples	Millet (g)	Breadfruit (g)	Crayfish (g)	Skimmed milk Powder (g)	Sugar (g)	Salt (g)
A NUTREND	(Commercial Product)					
B SMSB (48h/96h)	70.00	30.00	5.00	5.00	2.00	1.00
C SMSB (72h/120h)	70.00	30.00	5.00	5.00	2.00	1.00
D SMSB (96h/144h)	70.00	30.00	5.00	5.00	2.00	1.00
E MB	70.00	30.00	5.00	5.00	2.00	1.00

A Nutrend	-Commercial product
B SMSB-	Sprouted millet at 48h + sprouted breadfruit at 96h
C SMSB-	Sprouted millet at 72h + sprouted breadfruit at 120h
D SMSB	-Sprouted millet at 96h + sprouted breadfruit at 144h
E MB	-Unsprouted millet + breadfruit

Preparation of Porridges/Gruels

Porridges were prepared by dispersing 100 g of each composite flour blend in 200 mL of potable water. The mixture was heated with continuous stirring using a wooden spoon and cooked for 10–15 min until a smooth and desirable consistency was achieved. After cooking, 10 g of sugar and 20 g of milk were incorporated to enhance palatability. The prepared porridges were allowed to cool slightly before sensory evaluation and other analyses

Proximate Analysis

The proximate composition of the samples was evaluated according to the standard procedures of the *Official Methods of Analysis of AOAC International* (AOAC, 2019). Moisture, ash, crude protein, crude fat, and crude fibre contents were determined using the recommended AOAC protocols, while carbohydrate content was calculated by difference. The energy value was estimated from the proximate composition using the Atwater conversion factors (FAO, 2003). Starch content was determined using the enzymatic method based on α amylase and amyloglucosidase hydrolysis (Megazyme, 2017). Reducing sugar content was quantified using a validated spectrophotometric Benedict based method as described by Avila Alejandre et al. (2020). Total dietary fibre was determined using the enzymatic gravimetric procedure described in AOAC (2019).

Mineral Analysis

The mineral composition of the samples was determined following standard analytical procedures. Calcium and magnesium contents were quantified by atomic absorption spectrophotometry after appropriate sample digestion according to AOAC (2019) procedures.

Vitamin Analysis

The vitamin profile of the samples was evaluated using standard analytical methods. Vitamin C (ascorbic acid) content was determined according to the AOAC (2019) procedure, while vitamin A content was quantified based on spectrophotometric determination following appropriate extraction protocols.

Anti Nutritional Factor Analysis

The anti-nutritional factors of the samples were determined using standard analytical procedures. Phytate content was quantified using a colorimetric assay, tannin content was determined using the Folin Denis method, and oxalate content was evaluated by titrimetric analysis according to AOAC (2019) procedures.

Sensory Evaluation

The sensory acceptability of the formulated composite diets and the commercial reference product (Nutrend) was evaluated by a 30 member semi trained panel comprising nursing mothers from Imo State University, Owerri. Prior to evaluation, samples were coded and randomly presented to panelists under controlled conditions to minimize bias. Potable water was provided for palate cleansing between sample evaluations. Panelists assessed the sensory attributes, including taste, appearance, aroma, texture, colour, and overall acceptability, using a nine-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). The sensory evaluation data were subjected to statistical analysis to determine significant differences in the acceptability of the formulated diets.

Experimental Design and Statistical Analysis

A Completely Randomized Design (CRD) was used for laboratory analyses, while sensory evaluation was conducted using a Randomized Complete Block Design (RCBD), with panelists considered as blocks and food formulations as treatments. Data were analyzed using IBM SPSS Statistics version 30.0 and Microsoft Excel, and results were expressed as mean $\pm$ standard deviation. One way analysis of variance (ANOVA) was applied to assess significant differences among treatments, followed by Duncan's Multiple Range Test (DMRT) for mean separation at $p < 0.05$ (Montgomery, 2017).

RESULTS AND DISCUSSION

Proximate Composition of Sprouted Millet African Breadfruit Composite Diets

The proximate composition of millet (*Pennisetum glaucum*) and African breadfruit (*Treculia africana*) composite diets subjected to different sprouting durations is presented in Table 2. Sprouting significantly influenced ($p < 0.05$) the moisture, ash, crude fat, crude protein, carbohydrate, starch, reducing sugar, and dietary fibre contents of the formulated diets.

Moisture Content

The moisture content of the composite diets ranged from 6.09 to 6.97%. Sprouted samples exhibited slightly higher moisture values compared with the unsprouted control, with sample C (70:30 millet African breadfruit blend sprouted for 72 and 120 h) recording the highest value (6.97%). The increase in moisture content following sprouting may be associated with increased hydration and structural modification of seed components during germination. Germination conditions, particularly duration and moisture availability, are known to influence the physicochemical characteristics and storage stability of cereal and pulse-based ingredients (Kurek & Wyrwicz, 2022; Gunathunga et al., 2024). Although the observed moisture levels were relatively low, differences among formulations may influence storage

behaviour because moisture availability is a critical factor affecting microbial growth and shelf stability.

Ash Content

Sprouting significantly increased the ash content of the composite diets, with values ranging from 1.19 to 1.59%. Sample C recorded the highest ash content (1.59%), followed by samples B (1.48%) and D (1.35%), while the unsprouted sample E exhibited the lowest value (1.19%). The increase in ash content may be attributed to biochemical transformations during germination, including degradation of organic matter and improved retention or extractability of mineral constituents. Similar improvements in mineral related nutritional attributes following germination have been reported in cereal and legume grains, where sprouting enhances nutrient accessibility through enzymatic activation and reduction of mineral binding compounds (Gunathunga et al., 2024). African breadfruit seeds have also been reported as important sources of minerals including calcium, magnesium, iron, and zinc, contributing to their potential application in nutrient dense food formulations (Oni et al., 2020).

Crude Fibre Content

The crude fibre content ranged from 2.26 to 2.35%, with sprouted diets showing slightly increased values compared with the unsprouted control. The increase may be related to structural changes in cell wall polysaccharides during germination. Germination has been reported to modify dietary fibre fractions through enzymatic restructuring of cell wall components, although the magnitude of change depends on crop type and processing conditions (Gunathunga et al., 2024). The relatively low crude fibre values observed may also be associated with dehulling, which removes fibre rich outer layers of cereal grains and seeds.

Fat Content

Sprouting significantly reduced the fat content of the composite diets. The lowest fat value was recorded in sample C (5.11%), whereas sample D (9.11%) was comparable with the commercial product (9.17%). The reduction in lipid content during germination may be attributed to increased lipase activity and utilization of stored lipids as an energy source for embryonic growth. Germination activates metabolic pathways responsible for mobilizing storage reserves, resulting in reductions in lipid concentration and alterations in fatty acid composition (Gunathunga et al., 2024). Reduced fat levels may also improve storage stability by decreasing susceptibility to oxidative deterioration.

Protein Content

Protein content ranged from 16.15 to 28.20%, with the unsprouted sample E recording the highest value (28.20%) and the commercial product showing the lowest value (16.15%). The observed reduction following sprouting may be associated with proteolysis and utilization of amino acids during germination to support seedling development. Similar reductions in measured protein content after germination have been reported in cereals and legumes due to enzymatic hydrolysis and metabolic utilization of nitrogenous compounds (Gunathunga et al., 2024). Despite this reduction, all formulated diets contained protein levels above the minimum requirements recommended for complementary foods, indicating their nutritional potential.

Carbohydrate Content

Sprouting increased carbohydrate content compared with the unsprouted sample. The carbohydrate values ranged from 50.63 to 62.79%, with sample B recording the highest value (62.79%), which was comparable with the commercial product (62.46%). The observed increase may partly reflect the calculation of carbohydrate by difference, resulting from reductions in other proximate components. African breadfruit seeds naturally contain substantial carbohydrate reserves, while millet contributes considerable starch and energy density, supporting their suitability for complementary food development (Oni et al., 2020).

Energy Content

The energy values of the composite diets ranged from 355.45 to 361.25 kcal/100 g. These values were slightly higher than that of the commercial product (350.96 kcal/100 g). The high energy density observed may be attributed primarily to carbohydrate contribution, indicating that the formulated diets could provide adequate energy required during complementary feeding.

Starch Content

Sprouting significantly reduced starch content, with values decreasing from 7.82% in the unsprouted sample to 4.24% in sample D. The reduction became more pronounced with increasing sprouting duration, which may be attributed to increased amylolytic activity during germination. Activation of hydrolytic enzymes during sprouting converts stored starch into simpler sugars required for seed metabolism and growth. Similar reductions in starch content following germination have been reported in cereals and pulses (Gunathunga et al., 2024).

Reducing Sugar Content

The reducing sugar content increased following sprouting, ranging from 2.40 to 5.15%. Sprouted samples exhibited higher reducing sugar levels than the unsprouted control, reflecting enhanced hydrolysis of starch reserves during germination. Increased reducing sugars during sprouting result from the enzymatic conversion of complex carbohydrates into readily available sugars required for metabolic activities during seed development (Gunathunga et al., 2024).

Dietary Fibre Content

Sprouting increased dietary fibre content, with values ranging from 43.99 to 55.00%. Samples B and C recorded higher dietary fibre values than the commercial product, while sample D (46.76%) exceeded the unsprouted control (43.99%). Germination has been reported to influence dietary fibre composition by modifying soluble and insoluble fibre fractions and improving the functional properties of cereal and legume-based ingredients (Kurek & Wyrwicz, 2022; Gunathunga et al., 2024). These findings suggest that sprouting enhanced the functional fibre characteristics of the millet African breadfruit composite diets.

Mineral and Vitamin Composition of Millet African Breadfruit Composite Diets

The mineral and vitamin composition of the millet (*Pennisetum glaucum*) and African breadfruit (*Treculia africana*) composite diets subjected to different sprouting durations is

presented in Table 3. Sprouting significantly ($p < 0.05$) influenced the calcium, phosphorus, magnesium, vitamin A, and vitamin E contents of the formulated diets.

Calcium Content

The calcium content of the composite diets ranged from 116.53 to 208.17 mg/100 g. Sprouting resulted in a reduction in calcium concentration, with the unsprouted sample E recording the highest value (208.17 mg/100 g), while sample C exhibited the lowest value (116.53 mg/100 g). Nevertheless, the calcium contents of the sprouted diets remained higher than that of the commercial product. The observed reduction may be attributed to mineral diffusion into the soaking medium during the steeping stage of germination. Mineral losses during soaking have been reported in cereals and legumes due to leaching of soluble mineral fractions, although the extent of loss depends on crop type and processing conditions (Gan et al., 2023).

Phosphorus Content

Sprouting significantly increased phosphorus content from 46.78 mg/100 g in the unsprouted sample E to 104.90 mg/100 g in the sprouted diets. However, the commercial product recorded a higher phosphorus concentration (255.59 mg/100 g) compared with the formulated diets. The increase following sprouting may be associated with enhanced hydrolysis of phytate phosphorus through activation of endogenous phytase enzymes during germination, resulting in improved mineral release and bioavailability (Kurek & Wyrwicz, 2022). Germination induced phytate degradation has been widely reported as an important mechanism for improving mineral accessibility in cereal and legume-based foods.

Magnesium Content

The magnesium content decreased following sprouting, with values reducing from 158.36 mg/100 g in sample E to 76.82 mg/100 g in sample C. Similar to calcium, the reduction may be related to mineral migration during soaking and subsequent washing steps. The magnitude of mineral changes during germination depends on the balance between leaching losses and improved extractability caused by phytate degradation.

Vitamin A Content

Sprouting significantly increased vitamin A content, with values increasing from 4.12 µg/100 g in the unsprouted sample E to 11.63 µg/100 g in sample D. The enhancement may be attributed to increased synthesis and accumulation of carotenoid compounds, particularly β carotene, which serves as a precursor of vitamin A during germination. Germination has been reported to enhance bioactive compounds and antioxidant vitamins in cereal and legume grains through activation of metabolic pathways during seed development (Gan et al., 2023).

Vitamin E Content

Vitamin E content increased following sprouting, ranging from 5.13 mg/100 g in the unsprouted sample E to 8.23 mg/100 g in the sprouted diets. The increase may be associated with enhanced synthesis and accumulation of tocopherols during germination, which function as protective antioxidants in developing plant tissues. Increased tocopherol concentration

following germination has been reported in several cereal and legume grains (Gan et al., 2023).

Anti Nutritional Factor Composition of Millet African Breadfruit Composite Diets

The effects of sprouting on the anti-nutritional factors of the composite diets are presented in Table 4. Sprouting significantly ($p < 0.05$) reduced phytate, tannin, and oxalate contents compared with the unsprouted control.

Phytate Content

Phytate concentration decreased from 0.24 mg/100 g in the unsprouted sample E to 0.11 mg/100 g in sample D following sprouting. The reduction may be attributed to activation of endogenous phytase enzymes during germination, resulting in hydrolysis of phytic acid and release of bound minerals. Reduction of phytate levels through sprouting has been widely documented as an effective strategy for improving mineral bioavailability in cereal and legume-based foods (Kurek & Wyrwisch, 2022).

Tannin Content

Sprouting reduced tannin content from 0.37 mg/100 g in sample E to 0.16 mg/100 g in sample D. The decline may be associated with enzymatic degradation, oxidation, and diffusion of soluble tannin compounds during soaking and germination. Reduction of phenolic based anti-nutritional compounds following germination contributes to improved nutritional quality and digestibility of plant-based foods (Gan et al., 2023).

Oxalate Content

Oxalate content decreased from 0.19 mg/100 g in the unsprouted sample E to 0.10 mg/100 g in sample D. The reduction may be related to leaching during soaking and metabolic degradation during germination. Lower oxalate levels may contribute to improved mineral availability by reducing the formation of insoluble mineral oxalate complexes.

Sensory Attributes of Sprouted Millet African Breadfruit Composite Diets

The sensory attributes of the composite diets compared with the commercial product are presented in Table 5. Significant differences ($p < 0.05$) were observed among the samples for colour, taste, texture, and overall acceptability.

Colour

The commercial product (sample A) recorded the highest colour score (8.47), while the formulated diets showed acceptable scores ranging from 5.70 to 6.87. The lower colour preference of some sprouted samples may be associated with biochemical changes during germination, including pigment transformation and increased phenolic compounds. However, samples B, C, and E showed comparable colour acceptability, indicating that sprouting did not adversely affect visual quality.

Taste

The commercial product obtained the highest taste score (8.23), followed by sample B (6.27). The higher preference for the commercial product may be related to consumer familiarity, optimized formulation, and added flavour components. Among the formulated diets, sample B demonstrated the highest taste acceptability, suggesting that moderate sprouting duration may provide desirable flavour characteristics while limiting the development of undesirable germination associated flavours.

Aroma

Aroma scores varied among the samples, with the commercial product recording the highest value (7.60), followed by sample B (6.10). The formulated diets showed comparable aroma scores ranging from 5.30 to 5.73. Changes in aroma following sprouting may result from the formation of volatile compounds generated through metabolic activity during germination.

Texture

The commercial product recorded the highest texture score (7.83), while sample B showed the highest acceptability among the formulated diets (6.23). The lower texture scores observed in some sprouted diets may be associated with changes in starch structure, fibre characteristics, and water absorption properties following germination.

Overall Acceptability

The commercial product recorded the highest overall acceptability score (8.23), followed by sample B (6.67), sample C (6.17), and the unsprouted sample E (6.10). Sample D recorded the lowest acceptability score (5.63). Despite lower scores compared with the commercial product, all formulated diets achieved acceptable ratings above the neutral point of the hedonic scale, indicating their potential suitability as complementary food products.

Table 2: Proximate composition and energy values of sprouted and unsprouted millet and breadfruit composite diets

Parameters/Samples	A	B	C	D	E	LSD
Moisture (%)	4.90 ^e ± 0.54	6.34 ^b ± 0.10	5.97 ^a ± 0.38	6.25 ^{cb} ± 0.06	6.09 ^d ± 0.09	0.15
Ash (%)	2.5 ^a ± 0.39	1.48 ^a ± 0.06	1.59 ^b ± 0.01	1.35 ^d ± 0.12	1.19 ^e ± 0.19	0.05
Fat (%)	9.19 ^b ± 0.32	7.30 ^d ± 0.52	5.11 ^e ± 1.50	9.11 ^{cb} ± 0.29	11.62 ^a ± 1.41	0.10
Crude fibre (%)	4.70 ^a ± 0.85	2.46 ^{cb} ± 0.19	2.56 ^b ± 0.14	2.35 ^{cb} ± 0.24	2.26 ^d ± 0.28	0.15
Protein (%)	16.15 ^e ± 2.10	19.66 ^c ± 0.53	16.45 ^d ± 1.97	23.80 ^b ± 1.32	28.20 ^a ± 3.29	0.15
Carbohydrate (%)	62.46 ^c ± 1.07	62.79 ^b ± 1.22	67.31 ^a ± 3.24	57.10 ^b ± 1.32	50.65 ^e ± 4.22	0.29
Energy (Kcal)	350.96 ^e ± 2.85	359.01 ^{cb} ± 0.75	355.42 ^d ± 0.86	360.05 ^{ba} ± 1.21	361.25 ^a ± 1.75	1.42
Starch (%)	5.93 ^d ± 0.18	7.14 ^b ± 0.36	6.53 ^c ± 0.09	4.24 ^e ± 0.93	7.82 ^a ± 0.67	0.10
Reducing sugar (%)	8.24 ^a ± 1.51	4.69 ^c ± 0.08	5.17 ^b ± 0.14	3.81 ^d ± 0.47	2.40 ^e ± 1.10	0.10
Dietary fibre (%)	48.29 ^c ± 0.25	50.28 ^b ± 0.64	55 ^a ± 2.75	46.76 ^d ± 0.94	43.99 ^e ± 2.18	0.34

Note: Means in the same row with the same superscript are not significant different at (P<0.05). The means were separated using significant difference finisher's test.

A – Commercial product (NUTREND)

B – 70% millet flour + 30% breadfruit flour at 48h/96h sprouting time for millet & breadfruit respectively.

C – 70% millet flour + 30% breadfruit flour at 72h/128h sprouting time for millet and breadfruit respectively.

D – 70% millet four + 30% breadfruit flour at 96%/144h sprouting time for millet and breadfruit respectively.

E – 70% millet flour + 30% breadfruit flour (unsprouted).

Table 3: Mineral and Vitamin Contents of sprouted and unsprouted millet and breadfruit composite diets

Parameters/Samples	A	B	C	D	E	LSD
Calcium (mg/100g)	31.82 ^e ± 44.65	136.16 ^c ± 2.02	116.53 ^d ± 6.76	165.56 ^b ± 15.16	208.17 ^a ± 34.22	0.15
Phosphorus (mg/100g)	255.95 ^a ± 58.77	104.9 ^c ± 8.62	132.42 ^b ± 3.69	81.22 ^d ± 19.21	46.78 ^e ± 34.61	0.15
Magnesium (mg/100g)	68.21 ^a ± 17.65	106.67 ^c ± 0.45	76.82 ^d ± 13.80	128.31 ^b ± 9.23	158.36 ^e ± 22.67	0.15
Vitamin						
Vitamin C (mg/100g)	2.52 ^e ± 5.35	14.7 ^c ± 0.12	20.21 ^b ± 2.56	26.54 ^a ± 5.39	8.40 ^d ± 2.72	0.20
Vitamin A (µg)	4.5 ^d ± 1.13	6.73 ^c ± 0.13	8.16 ^b ± 0.51	11.63 ^a ± 2.06	4.12 ^e ± 1.30	0.15
Vitamin E (mg/100g)	4.62 ^e ± 0.68	5.96 ^c ± 0.08	6.75 ^b ± 0.27	8.23 ^a ± 0.93	5.13 ^d ± 0.45	0.29

Note: Means in the same row with the same superscript are not significant different at (P<0.05). The means were separated using significant difference finisher's test.

A – Commercial product (NUTREND)

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D – 70% millet four + 30% breadfruit flour at 96%/144h sprouting time for millet and breadfruit respectively.

E – 70% millet flour + 30% breadfruit flour (unsprouted).

Table 4: Anti-Nutrient Composition of sprouted and unsprouted millet and breadfruit composite diets

Parameters/Samples	A	B	C	D	E	LSD
Phytate (g/100g)	0.00 ^e ± 0.06	0.18 ^b ± 0.02	0.14 ^c ± 0.04	0.11 ^{dc} ± 0.09	0.24 ^a ± 0.05	0.03
Tannins (g/100g)	0.03 ^e ± 0.07	0.23 ^b ± 0.02	0.18 ^c ± 0.04	0.16 ^{dc} ± 0.01	0.37 ^a ± 0.08	0.04
Oxalate (g/100g)	0.04 ^e ± 0.04	0.14 ^b ± 0.09	0.12 ^{cb} ± 0.00	0.10 ^c ± 0.09	0.19 ^a ± 0.03	0.02

Note: Means in the same row with the same superscript are not significant different at (P<0.05). The means were separated using significant difference finisher's test.

A – Commercial product (NUTREND)

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C – 70% millet flour + 30% breadfruit flour at 72h/128h sprouting time for millet and breadfruit respectively.

D – 70% millet four + 30% breadfruit flour at 96%/144h sprouting time for millet and breadfruit respectively.

E – 70% millet flour + 30% breadfruit flour (unsprouted).

Table 5: Organoleptic Properties of sprouted and unsprouted millet and breadfruit composite diets

Parameters/Samples	A	B	C	D	E	LSD
Colour	3.47 ^a ± 0.80	6.87 ^b ± 0.08	6.10 ^{bc} ± 0.26	5.70 ^c ± 0.44	6.30 ^{bc} ± 0.17	0.78
Taste	8.23 ^a ± 0.86	6.27 ^b ± 0.02	5.60 ^b ± 0.32	5.33 ^b ± 0.44	6.13 ^b ± 0.08	1.06
Aroma	7.6 ^a ± 0.68	6.10 ^{ab} ± 0.04	5.70 ^{cb} ± 0.17	5.30 ^{db} ± 0.35	5.73 ^b ± 0.16	1.84
Texture	7.83 ^a ± 0.74	6.23 ^b ± 0.02	5.87 ^b ± 0.14	5.53 ^b ± 0.29	5.43 ^b ± 0.34	1.02
Acceptability	8.63 ^a ± 0.89	6.67 ^b ± 0.01	6.17 ^b ± 0.21	5.63 ^{cb} ± 0.45	6.10 ^{bc} ± 0.24	0.86

Note: Means in the same row with the same superscript are not significant different at (P<0.05). The means were separated using significant difference finisher's test.

A – Commercial product (NUTREND)

B – 70% millet flour + 30% breadfruit flour at 48h/96h sprouting time for millet & breadfruit respectively.

C – 70% millet flour + 30% breadfruit flour at 72h/128h sprouting time for millet and breadfruit respectively.

D – 70% millet four + 30% breadfruit flour at 96%/144h sprouting time for millet and breadfruit respectively.

E – 70% millet flour + 30% breadfruit flour (unsprouted).

CONCLUSION AND RECOMMENDATIONS

Conclusion

Sprouting significantly enhanced the nutritional quality of millet and African breadfruit based composite diets by reducing anti nutritional factors, improving nutrient availability, and maintaining acceptable sensory characteristics. The process improved the functional potential of the flours, demonstrating that sprouted millet and African breadfruit blends can serve as suitable ingredients for the development of affordable and nutritionally improved complementary foods. These findings highlight the potential of indigenous cereal and legume resources as alternatives or supplements to conventional maize based complementary foods in Nigeria.

Recommendations

This study provides baseline information on the processing, nutritional improvement, and utilization potential of sprouted millet and African breadfruit flour blends for complementary food development. The findings support the promotion of locally available cereal legume combinations as cost effective and nutrient dense alternatives to expensive commercial complementary foods. Further research should focus on optimizing processing conditions, evaluating long term storage stability, and assessing the nutritional performance of these formulations through appropriate biological models and community-based feeding studies.

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