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EFFECTS OF GERMINATION AND THERMAL PROCESSING ON THE PHYSICOCHEMICAL PROPERTIES AND ANTINUTRIENT CONTENTS OF MAIZE SESAME AND FISH FORTIFIED BLENDS.

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ABSTRACT

Functional properties of food describe the physical and chemical characteristics that influence how components behave during food processing, storage, and consumption. Attributes such as water absorption capacity, solubility, foaming ability, and viscosity are critical in determining texture, stability, and overall product quality beyond nutritional value, these properties shape consumer acceptability and industrial applications by mediating interactions among proteins, carbohydrates, and lipids. This study developed complementary food blends from locally available maize (M), sesame (S), and fish (F), with Frisocream (FC) as the control. Processing methods included sprouting, dehulling, and roasting. Sprouted maize flour was blended with varying proportions of sesame and fish to produce three formulations: Blend A (60% M: 16% S: 24% F), Blend B (60% M: 24% S: 16% F), and Blend C (70% M: 15% S: 15% F). The blends were analyzed for amino acid profile, functional properties, and antinutritional factors using standard methods. Results revealed significant improvements ($p>0.05$) in some essential amino acids such as lysine (7.11 g/100 g), methionine (2.55 g/100 g), phenylalanine (3.95 g/100 g), and tryptophan (5.78 g/100 g) compared to the control. Functional properties including bulk density, solubility index, and swelling power were enhanced in the formulated blends. Processing also reduced antinutritional factors, with tannins decreasing by up to 75.56% in fish and phytates by 54.79% in maize. In conclusion, maize, sesame and fish blends demonstrated improved nutritional and functional qualities, offering strong potential as complementary foods for infants and children. Among the formulations, Blend A was superior in essential amino acid content, highlighting its promise for managing protein-energy malnutrition in resource-limited settings.

Keywords: Antinutrients, Physicochemical, Nutrition, Maize, Sesame, Fortified nutrients

INTRODUCTION

Maize remains one of the most important staple cereals in sub-Saharan Africa, consumed daily by millions as a primary source of calories, (Health and Nutrition, 2025). Despite its widespread use, maize is nutritionally limited, particularly in its protein quality, as it lacks sufficient levels of essential amino acids such as lysine and tryptophan (Vita Library, 2025). This deficiency contributes to protein-energy malnutrition, especially in populations that rely heavily on maize-based diets Gunaratna et al, 2010. Sesame, a nutrient-rich oilseed, offers complementary benefits through its high-quality protein, minerals, and healthy fats while fish provides easily digestible animal protein and bioavailable micronutrients such as calcium, iron, and zinc (Noreen et al, 2025). The fortification of maize–sesame blends with fish therefore presents a strategic approach to improving dietary quality and addressing nutritional deficiencies in vulnerable populations (Goredema et al, 2021; Natalie, 2025). The full nutritional potential of these composite blends is often constrained by the presence of antinutritional factors such as phytates, tannins, and oxalates. These compounds interfere with mineral absorption and protein digestibility, thereby reducing the bioavailability of critical nutrients (Popova et al, 2019). Processing techniques such as germination and thermal treatment have been widely studied as effective methods to reduce antinutrient levels and enhance the functional properties of food (Soni et al, 2022). Germination activates endogenous enzymes that break down complex macromolecules, improving digestibility and increasing the concentration of bioactive compounds (Singh et al, 2019). Thermal processing methods such as boiling, roasting, and extrusion—can denature proteins, gelatinize starch, and inactivate heat-labile Antinutrient, though excessive heat exposure may also degrade sensitive nutrients (Laxmikant et al., 2025). The relevance of this study is particularly significant to the catchment area, where maize is a dietary cornerstone and protein deficiency remains a pressing public health challenge Aggarwal et al, (2023). In many rural and peri-urban communities, limited access to diverse food sources exacerbates malnutrition, stunting, and poor health outcomes, especially among children and women of reproductive age (Singh, et al, 2023). Developing fortified blends that are affordable, culturally acceptable, and nutritionally enhanced offers a practical solution to bridge dietary gaps and improve food security (Moyo et al, 2023). By investigating the effects of germination and thermal processing on the physicochemical properties and antinutrient contents of maize–sesame–fish blends, this research provides critical evidence to guide food product development, community nutrition interventions, and policy initiatives. Ultimately, the findings have the potential to support sustainable nutrition strategies that reduce malnutrition and improve health outcomes in the catchment area, contributing to broader goals of food security and public health advancement.

Sample Collection

Maize *(Zea mays),* Sesame *(Sesanum indicum),* Fish *(Euastacus spp*) were purchased from Yunusari Local Government area of Yobe State.

Sample Identification

The samples were identified in the Faculty of Agriculture University of Maiduguri, Borno State, Nigeria. Maize (HB: NO MZ 3 Biu red), Sesame (HB: NO SS 1 Yobe local,) and Fish (HB: NO CF Dubu amiya).

Preparation Germinated Maize

The maize was sprouted according to the method described by Abasiekong et al. (2010), Slightly modified, one kilogram (1 kg) of maize sample was soaked in a plastic bucket containing 1 litre of tap water and steeped for twelve hours (12 hours) at room temperature (36 -37 °C). The steep water was discarded by decantation and the steeped grains were placed in a container and covered with a jute bag for forty-eight hours (48hrs) for germination to occur. The germinated grains were then spreaded on a clean tray pan and sundried for two days by putting it in a sterilized tray pan. The maize grains then milled using attrition miller to an average particle size of less than 0.3 mm. The milled grains were then sieved through a fine mesh (0.5 mm) to obtain the maize flour.

Preparation of Sesame

The sesame was prepared according to Oladele et al. (2009) with slight modification. Exactly 500 g of sesame was sorted to remove dirt and other contaminants and steeped in water for 20 minutes to wash clean and dry, then roasted for about 10 to 15 minutes and finally ground in to fine powder.

Preparation of Fish

The fish was prepared according to the method of Onabanjo et al*.,* (2009). Five hundred grams (500g) of crayfish was weighed and cleaned of dirt, dried thoroughly, soaked in warm water for 5 minutes to prevent bad smell and spread on a tray and dried in an oven for 1 hours at 50 ^{0}C to ensure uniform drying. The crayfish was milled and sieved with a 500-micron mesh sieve. The flour was kept in an airtight container for further formulation.

Determination of Functional Properties

pH

The pH of sample solution was measured by reconstituting a volume of 10% (w/v) of the flour suspension in a distilled water. The sample was mixed in a plastic beaker thoroughly, then, the value was recorded using the electronic pH meter.

Water Absorption Capacities (WAC)

Water absorption capacity (WAC) was determined by the method of Sosulski (1976). Two grams (2 g) of the sample was mixed with 20 ml distilled water and then allowed for 30 minutes at an ambient temperature of 32°C. Lastly centrifuged for 30 minutes at 2000 × g. Then, the water absorption capacity (WAC) was calculated as a % of water retained per gram the formulation flour.

$$\text{Water absorption capacity (WAC)} = \frac{\text{Weight of absorbed water}}{\text{Weight of sample}}$$

Bulk Density (BD)

The bulk density BD was determined using the methods of Okaka and potter (1977). Fifty grams (50g) of the sample material was placed in a 100ml graduated cylinder and packed by gently tapping of the cylinder on a bench top 40 to 50 times. The final volume of the material was recorded and expressed as g/ml.

$$\text{Bulk Density (BD)} = \frac{\text{Weight of flour}}{\text{Volume of bulk flour}}$$

Foam Capacity (FC)

The FC was determined as described by Narayana and Narsinga (1982) with slight modifications. Two grams (2g) of flour sample was placed into 100 milliliters measuring cylinder containing 50 milliliters distilled water at 30 ^{0}C. The mixture was shaken vigorously to become uniform for 5 minutes and then observed the volume of the foam immediately at 30s, after whipping was calculated as form capacity (FC) using the expression below.

$$\text{Form Capacity (FC)} = \frac{\text{Difference in Volume}}{\text{Volume before blending}}$$

Swelling Power (SP)

Swelling power was determined through the method described by Leach et al. (1959). With slight modifications. Using centrifuge tube, one gram of the formulated sample was collected and mixed with 10 ml distilled water and heated at 80°C for 30 minutes. With continuous shaking during the heating period. After heating, and the suspension was centrifuged at 1000rm for 15 minutes. The supernatant was then decanted and the paste weighted. The swelling power was expressed as

$$\text{Swelling Power (SP)} = \frac{\text{Weight of the paste}}{\text{Weight of dry flour}}$$

Water Solubility Index (WSI)

Water solubility index (WSI) was measured according to the method of Anderson et al. (1996). Two point five (2.5 grams) of the sample was dissolved in 25 militers of distilled water, ensuring all lumps are to breaken up with aid of a glass rod. Stirring for 30 minutes, the mixture was rinsed into centrifuge tubes and then made up to 32.5 militers and set to centrifuge at 3000rm for 10 min. The supernatant was decanted; the weight of the solid content was recorded after it has evaporated to constant weight. The water solubility index was then expressed as:

$$\text{Water solubility index (WSI)} = \frac{\text{Weight of dissolved supernatant solid}}{\text{Weight of dry sample}}$$

Determination of Antinutrient

Tannin Content Determination

Vanillin Hydrochloric Acid quantitative method was used as described by Burns (1963). Zero point two five (0.25g) of sample was weighed into Erlenmeyer flask and was pipette into 10ml of 4% HCl in methanol, the flask was closed with paraffin wax. The flask was shaken for twenty min (20 min) on a wrist action shaker and was centrifuged for ten min at 4500 rev/min. One millilitre of the extract was pipetted and one ml of one % vannillin was added. Zero-point five ml concentrated HCl phenol standard was prepared and five different test tubes were labelled as 1, 2, 3, 4 and 5; 0.1, 0.3, 0.5, 0.7 and 1.0 ml were pipetted respectively of phenol reagent into the tubes. The volume of the test tubes was made up to one ml with eight % HCl in methanol, 0.1ml of 1% vanillin and 0.5ml of concentrate and made up to volume to 5.5ml alongside with 4% Hydrochloric acid in methanol. The blank sample was made using five mills of 4% Hydrochloric acid in methanol instead of the extract. The absorbance of the sample solution and the standard sample blank was taken in the spectrophotometer at five hundred (500 nm) exactly for twenty minutes into incubation.

Calculations;

$$AU/CU = AStd/CStd$$

$$Cu = \frac{Au \times CStd}{AStd} = Mg/g$$

Where Au = Absorbance of unknown
AStd = Absorbance of standard
Cu = Concentration of unknown
CStd = Concentration of standard

Phytate

Four grams (4g) of the sample was soaked in 100 cm^3 of 2% HCl for 3hrs and then filtered through two layers of filter paper. Twenty-five-centimeter cube ($25cm^3$) of the filtrate was placed in $250cm^3$ conical flask and $5cm^3$ of 0.3 % NH_4SCN solution was added as an indicator. Fifty-three-centimeter cube ($53.0cm^3$) of distilled water was added to reach the proper acidity. This mixture was titrated against $FeCl_3$ solution, which contains about 0.00195 g of Fe per cm^3 of $FeCl_3$ solution. The result was multiplied by factor 1.95 to obtain Phytate P. Phytate P result was multiplied by factor 3.55 to convert to Phyatate (Francis, 2007).

Table 1. Grains Size of Maize and Sesame

	Samples	
Sieve Sizes (mm)	**Maize**	**Sesame**
4.0	1.38	0.00
3.35	88.23	0.00
2.80	8.39	1.23
2.36	1.21	83.20
2.00	0.00	9.12
1.0	0.00	5.20
Pan	0.00	1.20
TOTAL	99.21	99.75

Table 2: Hardness of Grains Maize and Sesame

Samples	Grains hardness
Maize	5- Apolite
Sesame	6- Quartz

Table 3: Functional Properties of Maize, Sesame and Fish

Parameters (%)	Red maize		Sesame		Fish
	Raw	Processed	Raw	Processed	Raw
WAC	85.52±1.38[b]	88.00±0.12[a]	38.18±0.18[a]	34.18±0.17[b]	132.18±0.10[b]
SP	389.01±0.06[b]	413.00±0.08[a]	120.01±0.09[b]	141.00±0.13[a]	196.00±0.08[b]
BD	63.07±0.34[b]	74.10±0.07[a]	76.32±0.48[a]	74.71±0.29[b]	51.01±0.06[b]
WSI	186.00±0.14[a]	185.00±0.01[b]	120.10±0.03[b]	125.07±0.07[a]	242.00±0.12[b]
pH	6.47±0.03[a]	6.33±0.03[a]	6.43±0.03[a]	6.20±0.06[b]	6.73±0.07[a]
FC	16.00±0.05[a]	10.73±.2.66[b]	4.00±0.10[a]	6.00±0.15[a]	8.00±0.11[a]

Value is mean ± SEM, n=3
Values with different superscript along the row are significantly different (P<0.05) Key: **WAC=** Water absorption Capacity **SP=** Swelling power **BD=** Bulk density **WSI** = water solubility index **FC=** foaming Capacity

Table 4: Functional Properties of Complementary Food Blends

Parameters (%)	Blend A	Blend B	Blend C	Frisocream (F®)
WAC	94.45±0.18[a]	80.00±0.12[d]	85.67±0.34[c]	90.32±0.30[b]
SP	263.03±0.22[d]	206.67±0.24[e]	314.27±0.33[b]	346.67±0.33[a]
BD	62.17±0.02[c]	60.24±0.15[d]	64.03±0.01[b]	57.17±0.02[e]
WSI	195.20±0.01[a]	190.30±0.01[b]	187.33±0.04[c]	176.52±0.18[d]
Ph	5.17±.03[c]	5.47±0.09[b]	6.00±0.06[a]	6.07±0.06[a]
FC	12.11±0.08[a]	12.03±0.18[a]	8.03±0.11[b]	6.40±0.13[c]

Value are mean ± SEM, n=3
Values with different superscript along the row are significantly different (P<0.05)
WAC= Water absorption Capacity **SP=** Swelling power **BD**= Bulk density **WSI** = water solubility index
FC= foaming Capacity

Table 5: Anti-nutrient Composition of Raw and Processed Maize, Sesame and Fish Blends

Samples	Anti-nutrient (Tannin mg/g)		Residual Tannins (%)	Anti-nutrient (phytate mg/g)		Residual Phytate (%)
	Raw	Processed		Raw	Processed	
Red maize	1.82±0.01[a]	0.62±0.01[b]	65.93	0.50±0.06[a]	0.27±0.03[b]	46.0
Sesame	1.03±0.02[a]	0.60±0.01[b]	41.75	0.73±0.07[a]	0.33±0.03[b]	54.79
Fish	0.90±0.01[a]	0.22±0.01[a]	75.56	0.17±0.06[a]	0.13±0.03[b]	23.53

Value are mean ± SEM, n=3
Values with different superscript along the row are significantly different (P<0.05)

Table 6: Amino Acid Composition of Raw and Processed Maize, Sesame and Fish

Parameters(ug/100g)	Maize		Sesame		Fish	
	Raw	Processed	Raw	Processed	Raw	Processed
Histidine	1.14±0.01^{b}	1.65±0,01^{a}	1.33±0.04^{a}	0.76±0.38^{b}	2.12±0.02^{b}	2.82±0.01^{a}
Isoleucine	1.21±0.01^{b}	1.51±0.00^{a}	1.62±0.01^{b}	1.82±0.01^{a}	2.15±0.02^{b}	2.52±0.01^{a}
Leucine	5.10±0.00^{b}	5.21±0.01^{a}	5.66±0.00^{b}	5.71±0.00^{a}	6.71±0.01^{b}	6.92±0.01^{a}
Lysine	3.81±0.00^{b}	3.91±o.00^{a}	5.61±0.00^{b}	5.71±0.01^{a}	6.57±0.00^{b}	7.35±0.01^{a}
Methionine	2.59±0.34^{a}	2.82±0.01^{a}	1.77±0.02^{a}	1.79±0.00^{a}	3.27±0.01^{a}	3.29±0.01^{a}
Phenylalanine	2.96±0.01^{b}	3.15±0.00^{a}	2.21±0.01^{b}	2.44±0.18^{a}	3.12±0.01^{b}	3.19±0.19^{a}
Threonine	2.62±0.01^{b}	2.82±0.01^{a}	5.19±0.01^{b}	5.53±0.01^{a}	9.25±0.01^{b}	9.48±0.08^{a}
Tryptophan	1.24±0.00^{b}	1.27±0.01^{a}	4.21±0.00^{b}	4.29±0.01^{a}	8.21±0.01^{b}	8.29±0.00^{a}
Valine	2.75±0.01^{a}	2.75±0.01^{a}	2.46±0.01^{b}	2.51±0.01^{a}	3.61±0.01^{b}	3.76±0.00^{a}
Arginine	4.63±0.00^{a}	4.94±0.01^{a}	7.17±0.00^{a}	7.22±0.01^{a}	7.88±0.33^{b}	8.53±0.34^{a}
Alanine	4.24±0.01^{b}	4.48±0.01^{a}	3.14±0.01^{b}	3.20±0.01^{a}	6.34±0.00^{b}	6.48±0.00^{a}
Aspartic acid	5.46±0.00^{a}	5.24±0.01^{b}	6.91±0.01^{a}	7.12±0.04^{b}	9.45±0.00^{b}	9.52±0.01^{a}
Cysteine	2.64±0.01^{a}	2.53±0.01^{b}	2.76±0.01^{b}	2.09±0.01^{a}	3.24±0.00^{b}	3.61±0.01^{a}
Glutamatic acid	7.27±0.01^{b}	7.46±0.01^{a}	7.41±0.01^{a}	7.71±0.01^{b}	10.13±0.01^{b}	10.54±0.01^{a}
Glycine	4.44±0.01^{b}	4.47±0.01^{a}	4.91±0.02^{b}	4.95±0.01^{a}	7.35±0.00^{b}	7.83±0.01^{a}
Proline	3.47±0.01^{b}	3.73±0.01^{a}	3.78±0.00^{b}	3.82±0.01^{a}	3.85±0.01^{b}	5.90±0.01^{a}
Serine	4.34±0.01^{a}	4.22±0.01^{a}	3.56±0.66^{a}	4.20±0.01^{a}	4.90±0.01^{b}	5.18±0.08^{a}
Tyrosine	3.63±0.01^{b}	3.87±0.01^{a}	3.12±0.01^{b}	3.17±0.01^{a}	4.66±0.01^{b}	5.88±0.01^{a}

Value are mean ± SEM, n=3
Values with different superscript along the row under are significantly different (P<0.05).

Table 7: Amino Acids Composition of Complementary Food Blends

Parameters (g/100g)	Blend A	Blend B	Blend C	Frisocream (F®)
Histidine	3.13±0.01^{a}	2.46±0.01^{c}	2.88.02^{b}	2.35±0.02^{d}
Isoleucine	2.73±0.02^{b}	1.81±0.01^{c}	1.71±0.00^{d}	3.15±0.03^{a}
Leucine	5.57±0.01^{a}	5.32±0.01^{c}	5.51±0.01^{d}	5.18±0.05^{b}
Lysine	7.11±0.01^{a}	7.26±1.34^{a}	6.26±0.02^{a}	5.62±0.01^{b}
Methionine	2.24±0.01^{b}	2.55±0.01^{a}	1.81±0.01^{a}	1.24±0.01^{e}
Phenylalanine	3.95±0.01^{a}	3.85±0.01^{a}	2.56±0.00^{b}	3.82±0.15^{a}
Threonine	8.82±0.01^{a}	7.25±0.00^{b}	6.28±0.00^{d}	3.26±0.02^{e}
Tryptophan	5.71±0.00^{b}	5.78±0.00^{a}	5.26±0.01^{d}	5.62±0.01^{c}
Valine	1.75±0.00^{c}	1.93±0.01^{c}	1.61±0.33^{c}	3.31±0.01^{a}
Arginine	3.45±0.00^{c}	3.17±0.02^{c}	4.52±0.34^{a,b}	4.97±0.07^{a}
Alanine	3.25±0.00^{e}	3.65±0.00^{d}	3.85±0.00^{b}	3.70±0.03^{c}
Aspartic acid	6.74±0.01^{b}	6.34±0.01^{d}	6.46±0.00^{c}	9.20±0.01^{a}
Cysteine	2.35±0.00^{b}	1.97±0.01^{c}	2.42±0.00^{a}	1.17±0.01^{d}
Glutamatic acid	9.64±0.01^{a}	8.66±0.01^{b}	8.20±0.01^{d}	8.420.01^{c}
Glycine	4.73±0.001^{a}	3.84±0.01^{d}	3.92±0.01^{b}	3.90±0.01^{c}
Proline	3.83±0.01^{a}	3.66±0.01^{b}	3.57±0.00^{c}	1.95±0.03^{e}
Serine	3.45±0.01^{a}	3.36±0.01^{b}	3.26±0.01^{c}	2.74±0.02^{e}
Tyrosine	3.84±0.01^{a}	3.47±0.01^{c}	3.76±0.01^{b}	3.12±0.01^{e}

Value are mean ± SEM, n=3
Values with different superscript along the row are significantly different (P<0.05)

DISCUSSION

The various percentage mesh sizes exhibited by maize and sesame retained, is to determine the gradation of an aggregate seeds size used for this analysis having uniform compliance of design control, requirements and production of quality seeds that are not damaged, which is similar to the work credited by (Dapkunas, 2001).

The higher grains hardness observed by maize when compared to sesame seed presented in Table 2. May be attributed to the fact that during processing local milling machine was able to crush maize and sesame within some seconds, however, the maize was found to be more harder, this may be attributed to presence of high content of tannin and other anti-nutrient present in the pericarp as credited by (Macheal et al*.,* 2018).

The ability of food material to absorb or retain more water when immersed completely in water represents the water absorption capacity (WAC). The formulation with a high WAC is attributed to the loss of starch crystalline structure and a rise in amylose leaching and solubility during processing technique of germinating as credited by (Suresh et al*.,* 2015). The increase in WAC could have been contributed by protein denaturation during roasting that breaks protein into individual polar amino acid to water (Audur et al*.,* 2017). Complementary flour with a high WAC indicates that they can be utilized to formulate certain items, including dough, sausage, processed cheese, and baked food (Adegbehingbe et al*.,* 2013). The reduction in the WAC proportion might be caused by polar amino acids being less readily available in some content of the formulation as observed by Harry et al. *(*2018). The results show that Blend A with higher water absorption capacity followed by the control commercially weaning frisocream and B had lowest followed by Blend C, as credited in the finding of Falmata et al. (2014).

The swelling power of the complementary foods blends was decrease when compared to the commercially weaning frisocream, the lower value in SP was due to size of particle of the flour and the processing method used as described by (Heny et al*.,* 2014). According to Awuchi et al. (2019), increase in the swelling power of Blend C is caused by increased in amylopectin content and favorably compared to the control. Additionally, Moorthy (2002) stated that the swelling power indicates the extent of association forces in the starch granules as well as the starch capacity to absorb water and swell while for some food items like bakery swelling capacity is regarded as a quality indicator.

The significant ($p<0.05$) reduction in bulk density by Blend B and Blend A compared to that of Blend C in the complementary food blends observed in this study was similar to the finding of Falmata et al. (2014). The reduction in the bulk density is usually due to germinating technique employed as a result of the absorption of water that tends the soften the grains, thus making milling easier with smaller particles sizes than that of raw grains, hence the reduction in bulk density. The significant of this is that the less bulk density flours have higher nutrient density (Adegbehingbe et al*.,* 2013).

A significant percentage (%) decrease in the level of anti-nutritional factors, the tannin and the phytate in the sprouted and roasted maize, sesame and fish observed might be due to increase in the activity of phytase during germinating which breaks the phytic acids into phosphate and myoinositol phosphate (Dhilwayo et al*.*, 2023). This hydrolysis of phytate during sprouting is as a result of increased in the activity endogenous phytase (enzyme activity). Since, phytic acid is a factor considered to be responsible for decrease mineral bioavailability, its decrease during sprouting might also enhance the nutrient density with respect to mineral and vitamins bioavailability as reported in study of Chamba et al. *(*2021). Processing method such as soaking, roasting, fermentation and germination of cereals and legumes seeds has been earlier observed to decrease phytate content (Rachel et al*.,* 2023). Maize, sesame and fish has shown significant reduction in percentage level of phytate, which is as a result of same enzymatic activities mobilized of phytase enzyme. In a similar reported pattern by Dhilwayo, et al. (2023), the processing method can significantly reduce the phytate and tannin content of cereals and legumes. The reduction in level of phytate in cereals and legumes signifies a better signal for nutritional bioavailability and encourage low pH medium during sprouting that would provide favorable conditions for phytase activity.

A significant reduction in the percentage level of tanin content of the cereal and the legumes, might be due to leaching out of tanin during sprouting as observed in the report of Dhilwayo, et al. (2023). In a related study by Abdulrahman *(*2007), during sprouting the activity of polyphenols, oxidase and other metabolic enzymes will have decreased. Tanins are also considered as an inhibiting factor for nutrient absorption, therefore, the decreased in tanin content is more advantageous in bioavailability of diets for plant-based foods.

The increase in amino acid composition of some essential amino acid of the complementary food blends of Blend A exhibited a higher value compared to the commercially weaning food in terms of leucine (5.57 g/100) phenylalanine (3.95g/100g) and threonine (8.82g/100). Similarly, the level of lysine, methionine and tryptophan of Blend B were also increase with respect to the commercial weaning frisocream, this variation could be due to the activities of microorganism that responsible to convert the nutrient in the cereals into amino acid for their consumption during sprouting period (Chamba et al*.,* 2021). In the same manner, the lost in isoleucine is due to sprouting medium need some amino acid to be utilized by the sprouting seed in the germinating medium, the observation was in line with the reports of Falmata et al. (2021) and Chamba et al. (*2*021). The decreases recorded in some of the essential amino acids might be due to denaturation of proteins by activities of roasting (Laminu et al. 2014).

CONCLUSION

Germination and thermal processing enhanced the nutritional and functional qualities of maize, sesame and fish blends by improving essential amino acids and reducing antinutritional factors. Functional properties such as water absorption, swelling power, and solubility were also strengthened. Among the formulations, Blend A showed the best nutritional profile, making it a promising option for addressing protein-energy malnutrition in resource-limited communities.

RECOMMENDATIONS

i. **Nutrition Programs:** Incorporate maize, sesame and fish blends into community feeding initiatives to combat malnutrition.
ii. **Food Industry:** Encourage local processors to adopt germination and roasting techniques for fortified complementary foods.
iii. **Policy:** Support the use of locally available crops in fortification strategies to improve food security.
iv. **Research:** Conduct further studies on sensory quality, shelf-life, and nutrient bioavailability of these blends.
v. **Awareness:** Promote education on the benefits of germination and thermal processing for better dietary outcomes.

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