



EVALUATION OF THE RECURRENCE OF CHILDHOOD FRACTURE TRAUMA IN THE ELDERLY, USING NATIONAL ORTHOPEDIC HOSPITAL, ENUGU

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Abstract

Background: Fractures are common during childhood and constitute 10 – 25 % of pediatric injuries. Fracture rate appears to be increasing over time and is commonly caused by osteoporosis, overuse and trauma from a fall, motor vehicle accident or tackle during sports. Materials and Methods: The research investigates prevalence, etiology and factors associated with recurrent fracture in this specific population. The study utilizes a purposive sampling technique to select individuals aged 50 and above with a documented history of childhood fracture trauma. Data is collected from medical records. Variables include demographic characteristics, medical history. Statistical analysis was used to explore relationships and identify factors influencing recurrent fracture. Results: Preliminary findings reveal a nuanced understanding of factors contributing to recurrent fracture, the analysis showed that 46.7% of the respondents had two recurrent fractures after their first fracture and were aged 60-69years. 53.3% of the respondents were female. The results showed that the most commonly fractured bones were bones of the upper and lower limb with equal percentage 40%. Major etiology of fracture in both initial fracture and final fracture is trauma with 53.3% and 76.7% respectively. This research contributes to the limited literature on the recurrence of childhood fracture trauma in the elderly. The findings aim to guild health care professionals in fracture management.

Key words: Bones, recurrent fracture, Trauma, osteoporosis

INTRODUCTION

Recurrent fractures in adults remain a major clinical challenge, particularly in aging populations. Individuals aged 60 years and above have been shown to exhibit the highest recurrence rates of fractures, likely due to age-related bone loss and comorbidities (Kanis et al., 2020). Fracture history is a strong predictor of subsequent fractures, and studies have confirmed that adults with prior fractures are significantly more likely to sustain future breaks, especially within 1 to 2 years after the first event (Johansson et al., 2022). Moreover, the burden of fracture recurrence increases healthcare costs and contributes to reduced quality of life in this age group (Curtis et al., 2023).

Interestingly, many individuals with recurrent fractures sustained their initial fracture before the age of 25, emphasizing the long-term implications of early skeletal trauma (Jones et al., 2005). A previous study reported that children and

adolescents who experienced one fracture had nearly twice the risk of subsequent fractures, and the risk tripled after a second fracture (Jones et al., 2005). This cumulative fracture risk continues into adulthood, suggesting that early bone injuries may impair future bone integrity or reflect underlying skeletal fragility (Cooper et al., 2021). These findings underscore the need to consider fracture history even from childhood in fracture prevention strategies across the lifespan (Cooper et al., 2021).

The anatomical site and initial management of the fracture are also crucial determinants of recurrence. Fractures involving the upper and lower limbs, especially the forearm, femur, and tibia, have shown higher recurrence rates (Curtis et al., 2023). A study evaluating treatment patterns found that suboptimal or delayed care particularly lack of anti-osteoporotic therapy or rehabilitation significantly increased the likelihood of refracture (Chen et al., 2015). Furthermore, inadequate stabilization or misalignment during initial treatment has been linked to persistent

biomechanical weaknesses and higher risk of refraction at the same site (Chen et al., 2015). These observations highlight the critical role of timely and appropriate fracture management in preventing recurrence.

MATERIAL AND METHODS

The study was carried out at the National Orthopaedic Hospital, Enugu, and involved a total number of 30 patients, comprising of 14 (46.7%) males and 16 (53.3%) females, aged 50 years and above with a documented history of childhood fracture trauma in. The sample population of this study were patients with recurrent fracture from physiotherapy and orthopedic department in National Orthopedic Hospital. The patients were interviewed and their data retrieved from their hospital folders. Data analysis was done using the Statistical Package for the social Sciences (SPSS) (International Business Machines (IBM), United States) Statistics v.23 package, means and *P value* < 0.05 was taken to be significant.

Enugu Metropolis is characterized by a diverse population with varying socioeconomic backgrounds. It is an urban center with access to advanced medical facilities, including National Orthopaedic Hospital, Enugu.

The study population were fracture patients from physiotherapy and orthopedic department in National Orthopedic Hospital Enugu.

The inclusion criteria for participants were as follows

- Must be aged 50 and above
- Diagnosed with bone refracture
- A past or present patient from National Orthopedic Hospital Enugu
- Must have accessible medical records

Participants were excluded from the study if they met any of the following criteria;

- Patients aged below 50
- Unavailability of complete medical records
- Patients that are not from the selected medial institute

RESULTS

Table 1 Demographic characteristics of the respondents n= 30

Variables	Parameter	Frequency%	Mean (Sd)
Age	50-59	6(20.7%)	2.2 (0.846)
	60-69	14 (46.7%)	
	70-79	8 (26.7%)	
	80 & above	2 (6.7%)	
Sex	Male	14 (46.7%)	1.53(0.507)
	Female	16 (53.3)	
Tribe	Igbo	19(63.3%)	1.76(1.165)
	Yoruba	4(13.3%)	
	Hausa	2(6.7%)	
	Others	5(16.7%)	
Age of first fracture	<25	20(66.7%)	1.33(0.479)
	<50	10(33.3%)	

A total number of 30 questionnaires were used. Results showed that majority (46.7%) of the respondents were aged from 60-69years while

53.3% of the respondents were female. Also, majority (63.3%) of the respondents were Igbos and 66.7% of the respondents age of first fracture were < 25years.

Table 2: To determine the prevalence of recurrent childhood fracture trauma in the elderly.

Variables	Parameter	Frequency%	Mean (Sd)
Number of times of refracture	Once	10(33.3%)	1.867(0.73)
	Twice	14(46.7%)	
	More than twice	6(20%)	

From the Table above, majority (46.7%) of the respondents had two recurrent of fracture prior to their first fracture.

Table 3: To identify factors influencing the recurrence childhood fracture in elderly

Variables	Number of Time of Refracture			
	B	S. E	T	P
Age	0.148	0.223	0.662	0.759
Sex	0.224	0.411	0.546	0.516
Tribe	0.101	0.192	0.527	0.592
Age of First Fracture	0.383	0.428	0.895	0.605
Type of Fracture	0.361	0.268	1.348	0.189
Fractured Bone	0.016	0.225	0.071	0.042
Initial Treatment	0.082	0.341	0.057	0.026
Treatment and Other Times	0.200	0.352	0.569	0.576
Last Treatment	0.718	0.419	1.715	0.103
Initial Etiology	0.134	0.172	0.779	0.445
Final Etiology	0.101	0.217	0.463	0.649

The dependent variable (number of times of re fracture was regressed on predicting variables of age, sex, tribe, age of first fracture, type of fracture, fractured bone, initial treatment, treatment at other times, initial and final etiology. The table shows

various independent variable influences the number of times of re fracture. Among them, only fractured bone and initial treatment were of significant influence.

Table 4: To assess the prevalence of etiology of bone fracture

Variables	Parameter	Frequency%	Mean (Sd)
Initial Etiology	Trauma	16(53.3%)	1.86(1.07)
	Osteoporosis	5(16.7%)	
	Overuse	6(20%)	
	Others	3(10%)	
Final Etiology	Trauma	23(76.7%)	1.86(1.07)
	Osteoporosis	4(13.3%)	
	Overuse	1(3.3%)	
	Others	2(6.7%)	

From the table above, majority (53.3 % and 76.7%) of the respondent etiology of fracture is trauma in both initial and final etiology of fracture.

Table 5: To assess the most commonly fractured bone

Variables	Parameter	Frequency%	Mean (Sd)
Fractured Bones	Bones of the upper limb	12 (40%)	2.0 (0.9097)
	Bones of the lower limb	6 (20%)	
	Hip Bone	12 (40%)	

The result showed the most common fractured bone were bones of the upper limb and lower limb with equal percentage (40%).

DISCUSSION

The findings of this study underscore the multifactorial nature of recurrent fractures in adults. The highest recurrence rate among individuals aged 60–69 aligns with existing literature, which associates increased age with reduced bone density, increased fall risk, and comorbidities (Kanis et al., 2020). The observation that most participants had their first fracture before the age of 25 suggests that early-life skeletal trauma is a significant predictor of later-life fracture recurrence (Jones et al., 2005). Prior studies have shown that childhood and adolescent fractures can double or triple the risk of future fractures, reflecting potential underlying skeletal fragility or insufficient bone recovery (Jones et al., 2005; Cooper et al., 2021). The upper

and lower limbs were the most commonly fractured and refractured regions, consistent with previous research identifying these locations as bearing the brunt of mechanical stress and falls (Curtis et al., 2023). The predominance of recurrence occurring twice is indicative of a progressive vulnerability, as each fracture increases the likelihood of subsequent injury (Johansson et al., 2022). Furthermore, both the site of the initial fracture and the nature of its treatment significantly influenced the likelihood of recurrence, with inadequate management contributing to biomechanical instability and prolonged healing (Chen et al., 2015).

CONCLUSION

This study concludes that recurrent fractures in adults are most prevalent among individuals aged

60–69 and are influenced by a history of early fractures, the anatomical site involved, and the adequacy of initial treatment. The long-term implications of early fractures emphasize the importance of monitoring bone health from a young age (Jones et al., 2005). The fact that upper and lower limb fractures are most commonly recurrent aligns with their susceptibility to mechanical loads and trauma (Curtis et al., 2023). Poor or delayed initial treatment remains a significant risk factor for refracture, further underscoring the importance of early clinical intervention (Chen et al., 2015). These findings highlight a need for improved strategies to predict, prevent, and manage fractures across the lifespan.

RECOMMENDATION

It is recommended that healthcare systems implement targeted screening for individuals with a history of childhood or adolescent fractures to enable early intervention and reduce long-term fracture risk (Cooper et al., 2021). Preventive measures, such as bone mineral density assessments, fall prevention programs, and lifestyle interventions that promote bone health, should be prioritized, especially for those entering their sixth decade of life (Kanis et al., 2020). Clinical protocols should ensure optimal management of the initial fracture through proper stabilization, timely surgery if indicated, and long-term follow-up with bone-strengthening therapies (Chen et al., 2015; Curtis et al., 2023). Policy makers should also consider expanding access to osteoporosis medications and post-fracture rehabilitation services to mitigate recurrence and improve quality of life (Johansson et al., 2022).

REFERENCES

- Chen, Y. C., Lin, F. H., Ko, C. L., Li, C. Y., & Hsu, Y. H. (2015). Risk factors and incidence of repeat osteoporotic fractures among the elderly in Taiwan: A population-based cohort study. *Medicine*, 94(36), e1520. <https://doi.org/10.1097/MD.0000000000001520>
- Cooper, C., Ferrari, S., & Kanis, J. A. (2021). Treatment of osteoporosis in the oldest old. *Osteoporosis International*, 32(4), 621–629. <https://doi.org/10.1007/s00198-020-05721-7>
- Curtis, J. R., Saag, K. G., Arora, T., Becker, D. J., & O'Malley, C. D. (2023). An evaluation of treatment patterns for patients with fragility fractures. *Journal of Orthopaedic Trauma*, 37(4), 212–219. <https://doi.org/10.1097/BOT.0000000000002634>
- Johansson, H., Kanis, J. A., Odén, A., McCloskey, E. V., & Harvey, N. C. (2022). A meta-analysis of previous fracture and subsequent fracture risk. *Osteoporosis International*, 33(1), 1–12. <https://doi.org/10.1007/s00198-021-06160-w>
- Jones, G., Nguyen, T., Sambrook, P. N., Kelly, P. J., & Eisman, J. A. (2005). Symptomatic fracture incidence in adolescent boys and girls: Evidence for gender differences in bone health. *Osteoporosis International*, 16(3), 325–331. <https://doi.org/10.1007/s00198-004-1689-7>
- Kanis, J. A., Johansson, H., Odén, A., Harvey, N. C., & McCloskey, E. V. (2020). Characteristics of recurrent fractures: Meta-analysis of evidence from cohort studies. *Osteoporosis International*, 31(1), 23–31. <https://doi.org/10.1007/s00198-019-05176-3>



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 (*Sesamum 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 Bui 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 Abasiokong 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 °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 °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 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 mililiters of distilled water, ensuring all lumps are to broken 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 mililiters 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;

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

$$\begin{aligned} \text{Where Au} &= \text{Absorbance of unknown} \\ \text{AStd} &= \text{Absorbance of standard} \\ \text{Cu} &= \text{Concentration of unknown} \\ \text{CStd} &= \text{Concentration of standard} \end{aligned}$$

Phytate

Four grams (4g) of the sample was soaked in 100 cm³ of 2% HCl for 3hrs and then filtered through two layers of filter paper. Twenty-five-centimeter cube (25cm³) of the filtrate was placed in 250cm³ conical flask and 5cm³ of 0.3 % NH₄SCN solution was added as an indicator. Fifty-three-centimeter cube (53.0cm³) of distilled water was added to reach the proper acidity. This mixture was titrated against FeCl₃ solution, which contains about 0.00195 g of Fe per cm³ of FeCl₃ 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 Phytate (Francis, 2007).

Table 1. Grains Size of Maize and Sesame

Sieve Sizes (mm)	Samples	
	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 ^c	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 ^c
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±0.00 ^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
Glutamic 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

significantly different (P<0.05).

Values with different superscript along the row under are

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 ^c	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
Glutamic 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

significantly different (P<0.05)

Values with different superscript along the row are

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 friscocream 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 friscocream, the lower value in SP was due to size of particle of the flour and the processing method used as described by (Henry 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. (2021). 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.

REFERENCES

- Abasiokong, S. O., Udoh, B. E., & Okon, E. E. (2010). Effect of germination on the nutritional composition of maize. *Journal of Food Science and Technology*, 47(2), 223–227. <https://doi.org/10.1007/s13197-010-0032-1>
- Adegbehingbe, K. T., Adetunji, C. O., & Olayemi, F. F. (2013). Functional properties of composite flour blends of wheat and plantain flours. *International Journal of Food Science and Nutrition Engineering*, 3(2), 45–49.
- Aggarwal, B., Vats, S., Kaushal, L., Singh, A., Padalkar, G., Yadav, H., & Umate, S. M. (2023). Biofortification of maize (*Zea mays*). *Biofortification in Cereals*, 2(1), 209–233.
- Audur, R., Sigurdsson, H., & Olafsdottir, G. (2017). Protein denaturation and functional properties during roasting of cereals. *Food Chemistry*, 221, 140–147. <https://doi.org/10.1016/j.foodchem.2016.10.048>
- Awuchi, C. G., Igwe, V. S., & Amagwula, I. O. (2019). Nutritional value of maize and its role in human diet. *International Journal of Advanced Academic Research*, 5(11), 1–17.
- Burns, R. E. (1963). Methods of tannin analysis for forage crop evaluation. *Agronomy Journal*, 55(5), 481–485. <https://doi.org/10.2134/agronj1963.00021962005500050026x>
- Chamba, M. V., Chivandi, E., & Mupangwa, J. F. (2021). Germination effects on nutritional composition of cereals and legumes. *African Journal of Food Science*, 15(3), 89–97. <https://doi.org/10.5897/AJFS2020.2023>
- Dapkunas, J. (2001). Particle size distribution and its importance in food processing. *Food Engineering Reviews*, 3(1), 15–22.
- Dhilwayo, P., Moyo, H. N., & Sibanda, T. (2023). Reduction of phytate and tannin content in cereals through germination. *Journal of Food Biochemistry*, 47(2), e14567. <https://doi.org/10.1111/jfbc.14567>
- Falmata, A. M., Zannah, I., & Babagana, M. (2014). Functional properties of maize-based complementary foods. *Nigerian Journal of Nutritional Sciences*, 35(1), 12–19.
- Francis, G. (2007). Phytate determination in cereals and legumes. *Journal of Agricultural and Food Chemistry*,

- 55(3), 1020–1024. <https://doi.org/10.1021/jf062913o>
- Goredema-Matongera, N., Ndhlela, T., Magorokosho, C., Kamutando, C. N., Van Biljon, A., & Labuschagne, M. (2021). Multinutrient biofortification of maize (*Zea mays* L.) in Africa: Current status, opportunities, and limitations. *Nutrients*, 13(3), 1039.
- Gunaratna, N. S., De Groote, H., Nestel, P., Pixley, K. V., & McCabe, G. P. (2010). A meta-analysis of community-based studies on quality protein maize. *Food Policy*, 35(3), 202–210.
- Harry, O. J., Adepoju, O. T., & Olayemi, F. F. (2018). Functional properties of germinated cereal flours. *Journal of Food Processing and Preservation*, 42(6), e13678. <https://doi.org/10.1111/jfpp.13678>
- Healthline Nutrition. (2025). Health and nutrition benefits of sesame seeds. Retrieved from <https://www.healthline.com>
- Heny, A. M., Singh, R., & Kumar, V. (2014). Particle size and swelling capacity of cereal flours. *Food Hydrocolloids*, 36, 85–92. <https://doi.org/10.1016/j.foodhyd.2013.09.012>
- Laminu, A., Modu, S., & Bintu, B. P. (2014). Effect of roasting on protein denaturation in legumes. *International Journal of Food Science and Nutrition*, 3(4), 55–62.
- Laxmikant, K., Kumar, K., Khuleshwar, K., Sahu, K. P., & Chandravanshi, N. K. (2025). Fish-based fortification: A promising approach to reduce nutritional deficiencies. *Fish World Journal*, 2(12), 1122–1130.
- Leach, H. W., McCowen, L. D., & Schoch, T. J. (1959). Structure of starch granules. *Cereal Chemistry*, 36(6), 534–544.
- Macheal, O. A., Adepoju, O. T., & Olayemi, F. F. (2018). Antinutritional factors in maize pericarp. *Journal of Food Science and Technology*, 55(12), 4950–4957. <https://doi.org/10.1007/s13197-018-3456-2>
- Moorthy, S. N. (2002). Physicochemical and functional properties of starch. *Starch/Stärke*, 54(12), 559–592. [https://doi.org/10.1002/1521-379X\(200212\)54:12<559::AID-STAR559>3.0.CO;2-9](https://doi.org/10.1002/1521-379X(200212)54:12<559::AID-STAR559>3.0.CO;2-9)
- Moyo, H. N. (2023). The impact of food processing techniques on nutrient retention and bioavailability. *Journal of Food Science and Nutrition*, 11(2), 145–160.
- Narayana, K., & Narsinga Rao, M. S. (1982). Functional properties of raw and heat processed winged bean flour. *Journal of Food Science*, 47(5), 1534–1538. <https://doi.org/10.1111/j.1365-2621.1982.tb04976.x>
- Natalie. (2025). Proven 10 health benefits of sesame seeds (science-based). *Nutrition Science Journal*. Retrieved from <https://www.nutrition.org>
- Noreen, S., Hashmi, B., Aja, P. M., & Atoki, A. V. (2025). Health benefits of fish and fish by-products: A nutritional and functional perspective. *Frontiers in Nutrition*, 12, 1–10.
- Okaka, J. C., & Potter, N. N. (1977). Functional properties of cowpea-wheat flour blends in breadmaking. *Journal of Food Science*, 42(3), 828–833. <https://doi.org/10.1111/j.1365-2621.1977.tb12504.x>
- Oladele, A. K., & Aina, J. O. (2009). Nutritional quality of roasted sesame seeds. *African Journal of Food Science*, 3(6), 147–150.
- Onabanjo, O. O., Akinyemi, A. F., & Afolabi, W. A. (2009). Nutritional composition of crayfish and its use in food fortification. *Nigerian Food Journal*, 27(2), 45–52.
- Popova, A., & Mihaylova, D. (2019). Antinutrients in plant-based foods: A review. *Open Biotechnology Journal*, 13, 68–76.
- Rachel, T., Singh, R., & Kumar, V. (2023). Processing methods and reduction of antinutrients in legumes. *Food Science and Nutrition*, 11(4), 210–220. <https://doi.org/10.1002/fsn3.3456>
- Singh, R., Sharma, P., & Kumar, V. (2023). The impact of germination and thermal treatments on quinoa nutrients and bioactive compounds. *Springer Food Science Series*, 1(2), 11–17.
- Singh, S., Habib, M., Mondal, D., Thakur, M., Kumar, Y., Bashir, K., & Jan, K. (2024). Effects of germination on physicochemical, thermal, protein digestibility, antinutrients, and antioxidant properties of sorghum flour. *International Journal of Food Science and Technology*, 59(9), 6513–6521.
- Soni, K., Samtiya, M., Krishnan, V., & Dhewa, T. (2022). Antinutritional factors: Nutrient bioavailability and health beneficial effects. In R. S. V. & S. Praveen (Eds.), *Conceptualizing plant-based nutrition* (pp. 157–179). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-4590-8_8