

Effect of soybeans flour inclusion on the functional, nutritional characteristics and sensory quality attributes of malted maize based complementary food

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Abstract

The study evaluates the effect of soybeans flour inclusion on the functional, nutritional characteristics and sensory quality attributes of malted maize based complementary food. Standard processing and analytical methods were used in raw material preparation and analyses. The functional properties of the flour blends (100:0, 90:10, 80:20, 70:30, 60:40 and 50:50) values ranged from 0.59 to 0.70 g/mL, 1.18 to 1.57 g/g, 1.30 to 3.64 mL/g, 2.81 to 8.55% and 6.89 to 9.0% for bulk density, water absorption capacity, swelling capacity, swelling index and least gelation concentration respectively. The minerals (Zn, Mg, Fe, K and Ca) analysed ranged from 9.21 to 22.63 mg/100 g, 44.73 to 81.35 mg/100 g, 11.24 to 24.53 mg/100 g, 371.13 to 669.47 mg/100 g and 290.16 to 412.04 mg/100 g respectively. Range of values of 47.34 to 91.63 ($\mu\text{g}/100\text{g}$), 0.43 to 1.30 mg/100 g, 1.14 to 2.85 mg/100 g, 1.24 to 3.56 mg/100 g and 0.27 to 0.86 mg/100 g for vitamin A, B1, B2, B3 and B9 respectively for flour blends. Result showed negligible amounts of antinutritional factors ranging from 0.33 to 0.073 mg/100 g, 0.04 to 0.06 mg/100 g, 0.05 to 0.07 mg/100 g and 0.94 to 1.34 mg/100 g for phytate, oxalate, trypsin inhibitor and tannin respectively. The result of sensory attributes showed that the inclusion of soybeans flour had significant effect on sensory quality attributes with general acceptability range of 3.8 to 6.00 of flour blends. The study established that supplementation of maize flour with soybeans flour improves the nutritional profile of the complementary food.

Keywords: Malted maize, soybeans, complementary food, nutritional characteristics, sensory quality

Introduction

One of the main factors contributing to the high infant mortality rate in poor nations, particularly in sub-Saharan Africa, is malnutrition (Aboufazli *et al.*, 2015). After weaning, which often occurs in children under two years old, is the most challenging phase. Undernutrition can be caused by a variety of complex factors at the local level, such as improper or inadequate weaning diets, disease, or infection resulting from contaminated weaning foods. At six months of age, when the child's needs for energy, protein, and micronutrients cannot be satisfied exclusively from breast milk, the provision of appropriately nutritional weaning meals is essential to the child's healthy growth and development (Semba, 2016) [34]. It is essential that a complementary diet high in these nutrients be included. The type of food utilized for weaning in each location is therefore determined by the community's resources, culture, traditions, knowledge, and technical expertise (Animasahun and Itiola, 2021) [7]. In many villages and rural areas in Nigeria, weaning foods consists of starchy preparation mostly from cereals like sorghum, millet and maize which provide calories and inadequate protein and other nutrients leading to protein energy malnutrition (Tiencheu *et al.*, 2021).

Maize is a crop with a high yield that is rich in calories and some nutrients. Because of its adaptability, it is an important food source for communities and promotes food security. Maize is a rich source of fiber and carbohydrate, maize also contains important elements like potassium, magnesium, and vitamin C. Because of its nutritional makeup, it is a useful as diets. Maize can be consumed raw or processed in other forms like flours. The flour is used in the preparation

of *ogi* a population weaning food usually used for its functional and sensory attributes (Liomba *et al.*, 2018) [24]. However, the flour is reportedly deficient in protein (Tiencheu *et al.*, 2021) and major concern for malnutrition related problems. Processing technologies such as malting of cereal grains result to starch modification and improve functional, nutrients and texture characteristics of food and so add value to food (Liomba *et al.*, 2018) [24]. Due to nutrients deficiency of maize flour, legumes such as soybeans rich in proteins are used in production of composite flour or complementary flour for protein energy malnutrition prevention.

According to Chibarabada *et al.* (2017) [9] soybeans (*Glycine max*) belong to the family Leguminosae and sub-family *papilionnideae*. Soybeans are sometimes described as the next important food crop after cereals. Soybean plant are sources of low-cost dietary proteins and minerals as compared to animal products (Chibarabada *et al.* 2017) [9]. Locally produced legumes are therefore an important source of affordable alternative protein to poor resource people in many African countries. As an important component crop, soybean are richest in nutrients and the one from which the most dietary products are made is used in various traditional farming systems of various countries (Okwunodulu *et al.*, 2019) [30].

Several research studies have been carried out on maize-soybeans based complementary foods. For instance, Folorunso *et al.* (2018) [15] evaluated the effect spice and soybeans inclusion in maize-based complementary food; Ezeokeke and Onuoha (2016) [12], reported on the nutrient's composition of maize, soybeans and banana flour bends complementary food. In another study, the nutritional

quality of quality-protein supplemented maize-based complementary food was evaluated by Maseta, *et al.* (2017) [26]. However, there is scarce report on the effect of soybeans flour inclusion in malted maize-based complementary food. The study therefore seeks to fill the research gap by providing information on the effect of soybeans flour inclusion on the quality of malted maize-based complementary food.

Material and methods

Yellow maize (*zea mays*) variety and soybeans (*Glycine max*) were purchased from Wurukum Market Makurdi Benue. Standard chemicals and reagents used for analyses were sourced from Department of Chemistry, Benue State University Makurdi. Malted maize flour was prepared following the description of Olaoye *et al.* (2015) [1] method with modification. Clean water was used to wash the whole grains (3kg) of maize after sifting to remove dirt and other unwanted elements. After an hour, the grains were emptied from the water. Placed on jute bags, the grains were dampened and allowed to sprout for a duration 72 hours. The sprouted grains were oven dried at 50°C for 24 hours and Winnowing was used to remove radicles and plumules from the germinated grains. The dried grains were steeped in water for 48 hours, wet milled into slurry using hammer mill (Tigerextruda 6.5 hp, UK), sieved and pressed into cake. The cake was oven dried, milled into flour and stored polythene bag for further use.

The method of Ndife *et al.* (2011) [28] with slight modification was used in the production of soy flour. The soybean (1 kg) was thoroughly cleaned to remove dirt and other extraneous materials such as stones and sticks. It was then washed and boiled in water at 100°C for 60min. The cooked beans were dehulled and recooked for 3h. This was followed by oven drying at 60°C for 15h. The dried beans were allowed to cool, then dry – milled, sieved and stored in airtight containers for further use

Blend formulation

The prepared maize flours were measured into weights: 100g, 90g, 80g, 70g, 60g and 50g while soybeans flour will be measured weight of 10g, 20g, 30g, 40g and 50g. The samples will be mixed in the ratio of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50. The flours were blended, and each combination will represent A, B, C, D and E respectively as shown as in Table 1.

Table 1: Formulation of malted maize and soybeans flour blends for production of complementary foods

Sample code	Flour	
	Malted Maize	Soybeans
A	100	0
B	90	10
C	80	20
D	70	30
E	60	40
F	50	50

1. Determination of functional properties malted maize and soybeans flour blends

1.1. Determination of bulk density

The bulk density was determined using the method described by AOAC (2012) [1]. About 2.5 g of sample was filled in a 10 ml graduated cylinder and its bottom tapped on

the laboratory bench until there was no decrease in volume of the sample. The volume was recorded. The bulk density was calculated as:

$$\text{Bulk density} = \frac{\text{Weight of sample (g)}}{\text{Volume of sample (ml)}} \quad (1)$$

1.2. Determination of swelling capacity

Swelling capacity was determined according to the method of Onwuka (2005) [31]. About 100 mg of the sample was mixed with 10 ml of distilled water in a calibrated cylinder at room temperature. After equilibration for 18h, the bulk volume was recorded, and swelling capacity expressed as volume occupied by sample per gram of original sample dry weight.

$$\text{Swelling capacity (\%)} = \frac{\text{change in volume of sample}}{\text{original weight of sample}} \times 100 \quad (2)$$

1.3. Determination of water absorption capacity (WAC)

Water absorption capacity was determined following the methodology of Robertson *et al.* (2000) [32]. About 0.5g of sample was weighed in a test tube and an excess of water (10mL) will be added. The mixture was agitated and left to hydrate for 30min. After centrifugation at 1650 r/min for 10 minutes, the mixture was left to settle and to separate the supernatant. Finally, the sediment was weighed. The WAC was calculate as follows:

$$\text{WAC} = \frac{\text{Sediment weight (g)} - \text{Sample weight (g)}}{\text{Sample weight}} \quad (3)$$

1.4. Determination of gelation concentration

The method of AOAC (2012) [1] was used in gelation concentration determination. The flour blends sample suspensions of 2-20% was prepared in distilled water and vortexed for 5 minutes. About 10ml of prepared dispersions was transferred into a test tube. The tubes were heated at 90°C for 30 minutes in water bath and then placed in a cold room at 4°C for 30 minutes. The gelation concentration was determined as the lowest concentration at which the sample did not fall or slip from an inverted test tube.

1.5. Determination of foam capacity of flour blends

The foaming capacity and stability was determined using the method described by Onwuka (2005) [31]. Two grams (2 g) of the composite flour sample was added to 50 mL of distilled water at 30±2°C in a 100 ml graduated cylinder. The suspension was mixed and shaken manually for 5 minutes to foam. The volume of foam at 0 second after whipping was expressed as foaming capacity using the formula;

$$\text{Foam capacity} = \frac{\text{Volume after whipping}}{\text{Volume of mixture}} \times 100 \quad (4)$$

2. Mineral Analysis

The method of AOAC (2012) [1] with slight modification was used in to determine minerals contents. Mineral analysis of samples was determined in two phases: sample digestion, and atomic absorption spectrophotometer (AAS) analysis.

2.1. Sample digestion

Into a digestion tube, 1 g of the sample will be weighed; 15 ml of concentrated Nitric acid (HNO₃) added to each sample and digested for 30 min at 150°C in a digester inside a fume chamber. The sample will be digested until the solution turned pale yellow and allowed to cool. Ten millilitres of concentrated perchloric acid (70% HClO₃) will be added and the digestion continued at 200°C until the solution became colourless. After complete digestion, the solution will be cooled slightly, and 80 mL of distilled water will be added. The mixture will be boiled for about 10 min and filtered through whatman No. 42 filter paper into 250 mL volumetric flask. The solution will be made to the mark with distilled water.

2.2. Determination of the concentration of Ca, Mg, K, P, I.

The above mineral concentrations were determined using Atomic Absorption Spectrometer (Spectra AA220FS Model). The mineral contents in the samples was calculated and results expressed in mg/100 g.

3. Determination of vitamins composition

The methods of AOAC (2012) [1] was used in the determination of vitamins (A, B₁, B₂, and C)

1. Determination of vitamin A content

The method of AOAC (2012) [1] using the colorimeter was adopted. This measured the unstable colour at the absorbance of 620nm that resulted from the reaction between vitamin A and SbL₃.

Pyrogallol (antioxidant) will be added to 2g sample prior to saponification with 200ml alcoholic KOH. The saponification took place in water bath for 30 minutes. The solution was transferred to a separating funnel where water was added. The solution was extracted with 1–2.5ml of hexane. The extract was washed with equal volume of water. The extract was filtered through filter paper containing 5g anhydrous Na₂SO₄ into volumetric flask. The filter paper was rinsed with hexane and made up to volume. The hexane was evaporated from the solution and blank. About 1ml chloroform and SbL₃ solution was added to the extract and blank. The reading of the solution and blank was taken from the colorimeter adjusted to zero absorbance or 100%.

Calculation

$$\text{Vitamin A} = A_{620\text{nm}} \times \text{SL} \times (\text{V/Wt}) \text{ Mg} \quad (5)$$

Where: A_{620nm} = Absorbance at 620nm, SL = Slope of standard curve (Vit. A conc) + A₆₂₀ reading

V = Final volume in colorimeter tube, Wt = Weight of sample

2. Determination of vitamin B₁ (Thiamine) content

Thiamine content was determined using the scalar analyzer method of AOAC (2012) [1]. Five grams of each sample was homogenized in 5ml normal ethanoic sodium hydroxide solution. The homogenate was filtered and made up to 100ml with the extract solution. A 10ml aliquot of the extract was dispensed into a flask and 10ml of potassium dichromate solution added. The resultant solution was incubated for 15min at room temperature (25±1°C). The absorption was read from the spectrophotometer at 360nm

using a reagent blank to standardize the instrument at zero. The thiamine content was calculated as follows:

$$\text{Thiamine mg/100g} = \frac{100}{w} \times \frac{au}{as} \times cd \quad (6)$$

Where; W = Weight of sample analyzed, au = Absorbance of the sample solution, as = Concentration of standard solution, C = Concentration of standard solution, d = Dilution factor

3. Determination of Vitamin B₂ (Riboflavin) Content

Riboflavin was determined according to the method of AOAC (2012) [1]. Two grams of sample was placed in a conical flask and 50ml of 0.2N HCl was added to the sample, boiled for 1 hour, and then cooled. The pH was adjusted to 6.0 using sodium hydroxide. About 1N HCl was added to the sample solution to lower the pH to 4.5. The solution was filtered into 100ml measuring flask and made to volume with water. To remove interference, two tubes were taken, labelled 1 and 2. Ten millilitre of filtrate and 1ml of riboflavin standard was added to test tube 2. About 1ml of glacial acetic acid was added to each tube and mixed, and then 0.5ml of 3%KMnO solution added to each tube. They were allowed to stand for 2 minutes, after which 0.5ml of 3% H₂SO₄ was added and mixed well. The fluorimeter was adjusted to excitation wavelength of 470nm and emission wavelength of 525nm. The fluorimeter was adjusted to zero deflection against 0.1N H and 100 against tube 2 (standard). The fluorescence of tube 1 was read. Two millilitre of sodium hydrogen sulphate will be added to both tubes and the fluorescence measured within 10 seconds. This was recorded as blank reading.

Calculation:

$$\text{Riboflavin mg/g} = \frac{x}{y-x} \times \frac{1}{w} \quad (7)$$

Where

W = Weight of sample

X = Reading of sample – blank reading

Y = Reading of sample + standard tube (2) – reading of sample + standard blank.

4. Determination of vitamin B₃ content

A measured weight (5 g) of each sample was treated with 50 ml of 1N sulphuric acid (H₂SO₄ solution) and was shaken for 30 min. The mixture was treated further with 3 drops of aqueous ammonia and filtered. The filtrate (extract) was used for the analysis. Standard niacin (nicotinic acid) solution was prepared and diluted as desired. About 10 ml portion of the standard solution, sample extract and 10 ml of the acid solution (treated with a drop of ammonia) was dispensed into separate flasks to serve as standard, the sample and reagent blank respectively. Each of them was treated with 5 ml of normal potassium cyanide solution and acidified with 5 ml of 0.02N H₂SO₄ solution; its absorbance was read in a spectrophotometer at a wavelength of 470 nm. The reagent blank was used to calibrate the instrument at zero. Niacin content was calculated using the formula;

$$\text{Niacine} \frac{\text{mg}}{100} = \frac{100}{W} \times \frac{Au}{As} \times \frac{C}{1} \times \frac{Vf}{Va} \times D \quad (8)$$

Where

W - Weight of sample analyzed, Au= Absorbance of sample, As= Absorbance of standard solution

C = Concentration (mg/ml) of standard solution, Vf = Total volume of filtrate, Va = Volume of filtrate analyzed, D = Dilution factor where applicable, C =Concentration of standard solution, Vf =Total volume of filtrate, Va =Volume of filtrate analyzed, D =Dilution factor where applicable

5. Determination of Vitamin C (Ascorbic acid) content

The method described by AOAC (2012) [1] was used. Exactly 10g of the sample was extracted with 50ml EDTA/TCA (50 g in 50ml of water) extracting solution for 1 hour and filtered through a Whatman filter paper into a 50ml volumetric flask and made up to the mark with the extracting solution. Twenty (20ml) of the-extract was pipetted into a 250ml conical flask and 10ml of 30% K.I will be added and 50ml of distilled water added. This was followed by 2ml of 1% starch indicator. The solution will be titrated against 0.02ml CuSO₄ solution to a dark end point. The vitamin C content was calculated as:

$$\text{Vitamin C} \frac{\text{mg}}{100\text{g}} = 0.88 \times \frac{100}{5} \times \frac{V_f}{20} \times \frac{T}{1} \quad (9)$$

Where; Vf = Volume of extract, T = Sample titre – blank titre.

6. Determination of anti-nutrients Content of maize and soybeans flour blends

7. Determination of phytate Contents

Phytate determination in the samples was done according to method of AOAC (2012) [1]. Phytate was extracted with 0.5 mol/L (HNO₃) solution and digested with 0.5 ml of perchloric acid (HClO₄). The digested sample was made up to 25 ml volume with distilled water in a standard volumetric flask. From this extract, 2.5 ml of sample was taken and added to 2.5 ml of nitric acid, and the phytic phosphorus present in the extract react with 2.5 ml of vanadium molybdate (solution) reagent to produce a yellow-orange complex. The absorbance (OD) was measured at 460 nm wavelength using a spectrophotometer (P7 UV/Vis spectrophotometer). The phytate content was then be calculated from the 2 mg of phytic acid standard concentration with a reagent blank treated as sample above.

$$\text{Phytate (mg/100 g)} = \frac{\text{Sample absorbance} \times \text{Standard concentration}}{\text{Standard absorbance} \times \text{Weight of sample}} \times 100 \quad (10)$$

8. Determination of tannins content

Tannin content was determined according to AOAC (2012) [1] Method. Sample (5 g) was dispensed in 50 ml of distilled water and shaken. The mixture was allowed to stand for 30 min at 28°C before it was filtered through whatman no.4 grade of filter paper. The extract (2 ml) was dispensed into a 50 ml volumetric flask. Similarly, 2 ml standard tannic solution (0.1 mg/ml tannic acid) and 2 ml distilled water was put in a separate volumetric flask to serve as standard. 2.5 ml of saturated sodium carbonate (Na₂CO₃) solution and 1 ml of Folin-C reagent was added to each flask and volume made up to 50 ml and mixed well. After standing for 1½ h, the sample was filtered using whatman no.4 grade of filter paper and the absorbance measured at 760 nm against reagent blank.

$$\text{Tannin(mg/100 g)} = \frac{\text{standard concentration} \times \text{sample absorbance}}{\text{standard absorbance} \times \text{weight of sample}} \times 100 \quad (11)$$

9. ypsin inhibitor content

Trypsin inhibition activity was assayed by the procedure of AOAC (2012) [1]. Sample extract (0.1 ml) and 0.9 ml of 0.1 mol/L phosphate buffer pH 8.0 was mixed with the same volume of trypsin solution and preincubated at 37°C for 5 min; 1 ml of 0.03% (w/v) Bovine Serum Albumin (BSA) was added to the mixture and incubated for 30 min at 37°C after which the reaction will be stopped by the addition of 2 ml of 5% (w/v) Trichloroacetic acid (TCA) solution. The mixture was filtered to 1 ml of the filtrate, 5 ml of 0.55 mol/L Na₂CO₃ and 0.1 ml of Folin-C reagent. The resulting color absorbance will be determined at 660 nm wavelength. Standard sample will be prepared in the absence of inhibitor.

$$\% \text{ Trypsin activity} = \frac{T - T_0}{T} \times 100 \quad (12)$$

10. Sensory Quality Attributes Evaluation

The sensory evaluation of gruel from blends of maize and soybeans samples were carried out to determine the acceptability of the product as described by Choi *et al.* (2018) [10]. Twenty-member trained panellists comprising of nursing mothers, staff and students of the department of Food Science and Technology, University of Agriculture Makurdi, Benue state was used to evaluate the samples. Eighty grams (80g) of each sample were mixed with 140mL of cold water to produce slurry. Then, 100mL of boiling water was added to each of the slurry with continuous stirring to obtain homogenous gruel. Three grams (3g) of granulated sugar was added to each sample of the gruels. The gruels were evaluated in sensory evaluation booths for attributes of aroma, colour, taste, sourness and overall acceptability in 3-digit coded white plastic cups on a 9-point Hedonic Scale, where 9 represented “like extremely” and 1 represented “dislike extremely”. Clean water was provided to the judges to rinse their mouth in between testing of the gruels to avoid residual effect.

Results and discussion

1. Effect of soybeans flour inclusion on functional properties of malted maize-based complementary food

The functional properties of malted maize and soybeans flour is presented in Table 2. The bulk density, swelling capacity and swelling index decreased with level of soybeans flour inclusion in the blends while the water absorption capacity and least gelation capacity increased with level of soybeans flour inclusion in the blends. The bulk density ranged from 0.59 to 0.70 g/mL. The addition of soybeans flour to maize flour had significant (p<0.05) effect on the bulk density of maize and soybeans flour blends. The bulk density decreased with level of soybeans flour inclusion in the blends. The control sample and the sample with 10% had no significant (p>0.05) difference in bulk density. Also, the samples with 10, 20 and 30% had no significant (p>0.05) difference in bulk density of the flour blends. The sample with 50% soybeans flour had the least bulk density while the control sample (100% maize flour) had high bulk density. The finding of this study agreed with the report of Akubor *et al.* (2019) [5] who also reported

decrease in bulk density with inclusion of soybeans flour to wheat flour. According to Godswill (2019)^[17], bulk density of flour is influenced by the structural arrangement of the carbohydrates and other polymers present in the flour. Therefore, bulk density is useful in determining the packaging requirement of flour and material handling during processing. The low bulk densities reported by this study implies economical packaging.

The water absorption capacity increased with the inclusion of soybeans flour in the blends. Water absorption capacity is dependent on the hydrophilic constituents of the material such as polysaccharides and proteins, which are related with diffusion phenomena and affinity for water. The water absorption capacity increased with the inclusion of soybeans flour in the blends. The control sample had the least WAC while the sample with 50% soybeans flour inclusion had high WAC. There was no significant ($p < 0.05$) difference in the sample with 30, 40 and 50% soybeans flour inclusion. The finding of this study agreed with the report of Ukeyima *et al.* (2019)^[38] who also reported increase in WAC with level of garden pea flour addition to maize flour. Water retention capacity is important parameters which ultimately determine the sample consistency (that is solid, semi-solid, or liquid). Flours with both high-water retention capacity values hold large amounts of water during their preparation into gruels and thus, become voluminous with a low energy and nutrient density (Ukeyima *et al.*, 2019)^[38]. Thus, food sample with low water retention capacity will potentially provide more energy than food flours with high water retention capacity.

The inclusion of soybeans flour in maize flour had significant ($p < 0.05$) effect on the swelling capacity and swelling index of all the samples. The swelling capacity and swelling index decreased with increased level of soybeans flour inclusion in maize flour. The variation in the swelling capacity (SC) indicates degree of exposure of internal structure of starch present in the flour to action of water (Blessing, 2014)^[8]. The nature of the food materials used, and the starch content of the food materials could account for the trend in result. This result showed similarity with the report of Ocheme *et al.* (2017)^[29] who reported range of 9.91% to 12.71% for swelling capacity with increasing level of groundnut protein concentrate in complementary food.

The least gelation concentration of the flour blends increased with increasing level of soybeans flour inclusion in the blends. This could be linked to the relative ratio of different constituents such as protein, carbohydrates and lipids in the flours. The control sample (100% maize flour) had significantly ($p < 0.05$) low least gelation concentration. The least gelation concentration is the ability of flour to form gel, which provides structural matrix for holding water and other water-soluble materials like sugars and flavors. The gelation property of the flour provides consistency in food preparations especially the semi-solid products (Singh, 2021)^[35]. The lower the least gelation concentration (LGC), the better the gelation capacity of the protein ingredient (Singh, 2021)^[35].

2. Effect of soybeans flour inclusion on antinutritional content of malted maize-based complementary food

The result of antinutritional factors in maize-based complementary food (Table 3) revealed that the inclusion of soybeans flour in the blends resulted to significant ($p < 0.05$) increase in phytate content of blends. The increase in

phytate content can be attributed to high phytate content in soybeans. Olapado *et al.* (2017)^[1] reported phytate content of 0.85% in maize flour while David *et al.* (2022)^[1] reported phytate content of 1-3% in legumes depending on the type, cultivar and variety. The sample with 50% soybeans flour inclusion had significantly ($p < 0.05$) high phytate content while the least phytate content was reported in maize flour. The finding by this study showed consistency with the report of Inyang *et al.* (2019)^[19] who reported increase in phytate content (0.76 to 1.31) in nixtamalized maize flour supplemented with sprouted soybeans. Adeoti and Osundahunsi (2017)^[4] reported critical value of 5 to 6 mg/g for phytate. The phytate level reported by this study was below the critical value.

The oxalate content result showed low levels of oxalate across all the samples. The low oxalate level reported by this study could be due to processing methods which significantly reduced the oxalate level in food. Moriki *et al.* (2019)^[27] noted that processing methods such as soaking and natural lactic acid fermentation decreased tannin and phytate contents of pearl millet, sorghum and maize. The finding by this study showed consistency with the report of Samuel *et al.* (2019) whose phytate content in maize-mushroom flour ogi ranged from 0.02 to 0.03 mg/100 g. Adeoti and Osundahunsi (2017)^[4] reported critical value of 0.25 mg/g for Oxalate. The oxalate level reported by this study was below the critical value.

Dietary protease inhibitors, like trypsin inhibitor, cause the irreversible development of trypsin-enzyme inhibitor complexes. Children grow more slowly because of this reduced intestinal trypsin and subsequent indigestibility of food protein (Kurk, 2019)^[23]. The trypsin inhibitor content obtained were below the critical value of 0.25 mg/100 g reported by Adeoti and Osundahunsi (2017)^[4] suggesting that the formulated products pose no danger to health and nutrients bioavailability. Samuel *et al.* (2024)^[33] also reported low levels of trypsin inhibitor in maize-based complementary food.

The tannin content increase with inclusion of soybeans flour in maize flour. Inyang *et al.* (2019)^[19] also reported increase in phytate content (0.24 to 0.57 mg/100 g) in nixtamalized maize flour supplemented with sprouted soybeans. The increase in tannin content could be due to high tannin content in soybeans flour and this agreement with Inyang *et al.* (2019)^[19] who reported high tannin content in soybeans as compared to maize flour. Additionally, it has been observed by Fekadu *et al.* (2013)^[14] that 560 mg of tannic acid is the maximum amount that a man should consume each day. This suggests nutrients bioavailability of the formulated food products. It has been noted that tannins have an impact on how easily proteins are digested, which negatively affects the bioavailability of non-hem iron and results in poor absorption of iron and calcium. Tannins also have an impact on carbohydrates, which lowers the energy value of a diet high in tannins.

3. Effect of soybeans flour inclusion on mineral content of malted maize-based complementary food

It is believed that minerals are vital to human nutrition (Godswill *et al.*, 2020)^[18]. The mineral content of maize-based complementary food is presented in Table 4. Minerals are necessary components of bones, teeth, tissues, muscles, blood, and nerve cells. They are also essential for overall mental and physical health (Godswill *et al.*, 2020)^[18]. They

also support blood coagulation, neuron responsiveness to physiological stimulus, and the preservation of acid-base equilibrium. The result of mineral content of maize-based complementary food is presented in Table 4. A significant ($p < 0.05$) increase in magnesium content with level of soybeans flour inclusion was observed. The magnesium content ranged from 44.73 – 81.35 mg/100 g. The increase in magnesium content could probably be due to high magnesium content of soybeans. The finding by this study agrees with the report of Abraham *et al.* (2021) [3] who reported increase in magnesium content of sorghum- fluted pumpkin leaves based complementary food. Tiencheu *et al.* (2016) [36, 37] also reported increase in magnesium content in maize, Pawpaw and Mackerel Fish Meal complementary food. The magnesium content of was below the 130mg/day recommendation by institute of medicine (IOM) of the United state. However, the sample with 50% soybeans flour inclusion which was higher in magnesium content provided 62.57% as contribution to RDA.

The potassium content differed significantly ($p < 0.05$) among all the samples. Soybeans is reportedly high in potassium content. Ambawat and Khetarpaul (2018) [6] reported potassium content of 1489.67 mg/ 100 g on dry weight basis in soybeans. The increase in potassium content could be due addition of soybeans flour in the blends. The sample with 50% soybeans flour inclusion had higher potassium content while the control sample (100 % maize flour) the least potassium content. The finding by this study agrees with the report of Jaiyeoba *et al.* (2021) [21] who reported increase in potassium content (222.32g to 510.5mg/100g) with inclusion of mushroom flour in yellow-maize based *ogi*. The potassium content was below the 3800mg/ day recommendation by institute of medicine of the United state. However, the sample with 50% soybeans flour inclusion which was higher in potassium content provided 17.62% contribution to RDA.

The calcium content also increased with the inclusion of soybeans flour in maize flour. All the samples significantly ($p < 0.05$) differed in calcium content. The increase in calcium content is probably due to the inclusion of soybeans flour in the blends. Ambawat and Khetarpaul (2018) [6] reported calcium content of 500 mg/100 g in soybeans flour. Jaiyeoba *et al.* (2021) [21] also reported increase in calcium content with inclusion of mushroom flour in yellow maize *ogi*. However, the calcium content reported by this study was higher than the 68.02 to 119.2mg/100g reported by Jaiyeoba *et al.* (2021) [21] but lower than the 1000 mg/day RDA by IOM (2005) [1]. The sample with 50% soybeans flour inclusion provided 41.20% RDA. The main component of bone, calcium aids in the growth of teeth. Additionally, blood coagulation and the stability of intracellular cement components depend on calcium (Marcus and Anyadiegwu, 2016) [25].

High amounts of zinc are found in almost all body tissues, including the eyes, prostate gland, and sperm cells, where it is thought to have vital roles (Fallah *et al.*, 2018) [13]. Zinc contributes to night vision and dark adaption in addition to vitamin A (Fallah *et al.*, 2018) [13]. Zinc is a vital trace element that is involved in many different cell functions. The inclusion of soybeans flour in maize flour had significant ($p < 0.05$) effect on the zinc content of the flour blends. The zinc content increased with addition of soybeans flour in the blend. Similar trend was reported by Jaiyeoba *et al.* (2021) [21] whose zinc content in yellow maize-mushroom *ogi* ranged from 2.282 to 3.25mg/100g.

Iron is a necessary component of hemoglobin, the blood pigment that carries oxygen, and it participates in the electron-transferring events of the mitochondria (Keppner *et al.*, 2020) [22]. The iron content significantly ($p < 0.05$) increased with level of soybeans flour inclusion in the blends. The finding by this study agrees with the report of Abraham *et al.* (2021) [3] and Jaiyeoba *et al.* (2021) [21] who respectively reported increase in iron content with inclusion of fluted pumpkin leaves and mushroom flour in cereal-based complementary food. The result showed that all the sample could provide up to 100% of the 10mg/day recommendation by IOM (2005) [1].

4. Effect of soybeans flour inclusion on vitamin content of malted maize-based complementary food

The vitamin A content is presented in Table 5. The vitamin content increased with level of soybeans flour inclusion. In all the samples, the sample with 50% soybeans flour inclusion had higher vitamin content while the control sample (100% maize flour) had the least vitamin content.

The vitamin A content significantly ($p < 0.05$) differed among the samples. The finding by this study agrees with the report of Samuel *et al.* (2024) [33] whose vitamin A content ranged from 4.86 to 9.06 A (μ /100 g) and increase with inclusion of mushroom flour inclusion in maize based *ogi*. However, the vitamin A content obtained by this study was higher than the range of values reported by Samuel *et al.* (2024) [33]. The difference in raw materials in complementary food formulation could account for the variation in result. The vitamin A content did not meet the adequate intake of 300 μ g/day recommendation by IOM (2005) [1]. However, the sample with 50% soybeans flour inclusion could contribute 30.54% to adequate intake recommendation.

In the metabolism of carbohydrates and branched-chain amino acids, thiamine serves as the coenzyme thiamine pyrophosphate (TPP). The result showed that the formulation with 50% soybeans flour inclusion had higher vitamin B1 content while the control sample had the least vitamin B1 content. The vitamin B1 content of all the samples differed significantly ($P < 0.05$). Mariam (2005) [1] reported value ranges of 0.15 to 0.57 mg/100 g for Thiamine (Vitamin B1). Samuel *et al.* (2024) [33] also reported increase in vitamin B1 content in maize-based complementary food supplemented with mushroom flour. All the values obtained were within the WHO /FAO safe level recommendation of 0.2 - 0.9 mg/day for infants and children.

The riboflavin content result showed significant ($p < 0.05$) difference among the samples. The increasing trend with level of soybeans flour inclusion in maize-based complementary was also reported by Samuel *et al.* (2024) [33] who observed increase in vitamin B2 with level of mushroom flour inclusion in maize-based complementary food supplemented with mushroom flour. The nutrient intake requirement for infants and children given by WHO / FAO (2000) recommendation of Riboflavin is 0.3 – 0.9 mg. The result obtained in this study was in line with the recommendation stated above.

The niacin content result also showed significant ($p < 0.05$) difference among the samples. The increasing trend with level of soybeans flour inclusion in maize-based complementary was also reported by Samuel *et al.* (2024) [33] who observed increase in vitamin B3 with level of mushroom flour inclusion in maize-based complementary

food supplemented with mushroom flour. The inclusion of soybeans flour at up to 30% level could meet the 2 – 12 mg/day for infants and children recommendation by WHO / FAO (2000).

5. Effect of soybeans flour inclusion sensory quality malted maize-based complementary food

The result of sensory quality attributes of malted maize-soybeans flour blends gruel is presented in Table 6. The appearance rating decreased with inclusion of soybeans flour in the blends. This could probably be because of soybeans flour addition to maize flour which resulted to deviation to the normal appearance of *ogi*. The result agreed with the report of Samuel *et al.* (2024) [33] who reported decrease in appearance rating with mushroom flour inclusion in the maize-based *ogi*. Factors that can affect the appearance of the composite diets include the chemical composition of flours, the drying temperature and duration, and the proportions or ratio of ingredients: maize soybeans flours. Aroma is very important in food as it influences the acceptance of food before they are consumed.

The aroma result of the flour blends gruel at up to 30% soybeans flour inclusion were within the acceptable limit. Although the control sample had higher mean score for aroma, the result indicated no significant difference ($P>0.05$) with the sample with 10% soybeans flour inclusion. The least aroma score rating was observed in the gruel with 50% soybeans flour inclusion to maize flour. This could be attributed to aroma of soybeans flour which might have affect the aroma of maize flour *ogi*. Samuel *et al.* (2024) [33] also reported decrease in aroma of *ogi* with mushroom inclusion in maize *ogi*. Low flavour ratings could reduce the acceptability of the food by an infant; hence diet with 0% soybeans flour is the most suitable for a weaning food due to its high flavour rating.

Sourness is a characteristic or distinct mouth feel *ogi* sensory attribute. The result of sourness indicates higher sensory scores rating of control sample (100% maize flour) and the 10% soybeans inclusion gruel. The sourness decreased with increase in soybeans flour inclusion in the blends. This could be due to inclusion of soybeans flour in the blends. The result agrees with the report of Samuel *et al.* (2024) [33] whose general acceptability decreased with inclusion of mushroom flour in the blends.

Taste is one of the sensory attributes that involves the use of the taste buds to determine food preferences. The result indicates higher mean scores for the control sample. The taste of the control sample and the sample with 10% soybeans was not significantly ($p>0.05$) different. The taste rating decreased with inclusion of soybeans flour in the blends. The finding by this study agrees with the report of Samuel *et al.* (2024) [33] who reported decrease in taste with inclusion of mushroom flour in maize flour. Toddlers and pre-school children are likely to prefer flavoured foods therefore, to further improve the taste ratings; flavor or flavor enhancer might need to be incorporated into the formulated samples.

The control sample had the higher ratings for overall acceptability. The inclusion of soybeans flour in the blends at up to 20% showed no significant ($p>0.05$) difference in general acceptability of gruel from the flour blends. This implies consumer acceptable of the product at up to 20% level of soybeans flour inclusion. The least general acceptability was reported in the gruel with 50% soybeans flour inclusion. Samuel *et al.* (2024) [33] also reported decrease in general acceptability of *ogi* made from maize and mushroom flour blends. The high general acceptability ratings of the control may be attributed to additional flavourings, colourings and sophisticated processing of raw materials.

Table 2: Functional properties of malted maize and soybeans flour blends

Sample	B.D (g/mL)	WAC (mL/g)	SC%	SI (g/g)	LGC%
A (100:0)	0.70 ^d ±0.01	1.18 ^c ±0.01	3.64 ^f ±0.02	8.55 ^f ±0.01	6.09 ^a ±0.13
B (90:10)	0.68 ^{cd} ±0.01	1.34 ^b ±0.76	3.57 ^e ±0.01	8.40 ^e ±0.06e	6.89 ^b ±0.01
C (80:20)	0.67 ^c ±0.01	1.34 ^b ±0.01	3.35 ^d ±0.07	5.85 ^d ±0.05	7.81 ^c ±0.01
D (70:30)	0.67 ^c ±0.02	1.45 ^c ±0.01	3.06 ^c ±0.09	4.55 ^c ±0.01	7.93 ^{cd} ±0.07
E (60:40)	0.63 ^b ±0.01	1.49 ^c ±0.01	1.47 ^b ±0.02	3.06 ^b ±0.08	8.06 ^d ±0.08
F (50:50)	0.59 ^a ±0.01	1.57 ^c ±0.02	1.30 ^a ±0.03	2.81 ^a ±0.01	8.28 ^e ±0.08
LSD	0.03	0.13	0.12	0.11	0.18

Key: B.D = Bulk density, WAC = Water absorption Capacity, SC = swelling capacity, SI = swelling index.
LGC = Least gelation capacity

Table 3: Antinutritional factors of malted maize and soybeans flour blends

Sample	Phytate	Oxalate	Trypsin Inhibitors	Tannins
A(100:0)	0.33 ^a ±0.01	0.06 ^{bc} ±0.01	0.05 ^a ±0.01	0.94 ^a ±0.01
B(90:10)	0.35 ^a ±0.01	0.07 ^c ±0.01	0.06 ^a ±0.01	0.98 ^b ±0.01
C(80:20)	0.38 ^b ±0.01	0.06 ^{bc} ±0.01	0.07 ^a ±0.01	0.10 ^{ab} ±0.02
D(70:30)	0.48 ^c ±0.01	0.06 ^c ±0.01	0.07 ^a ±0.00	0.10 ^{ab} ±0.01
E(60:40)	0.52 ^d ±0.01	0.03 ^a ±0.01	0.11 ^a ±0.01	1.11 ^c ±0.02
F(50:50)	0.73 ^e ±0.02	0.04 ^{ab} ±0.01	0.07 ^a ±0.08	1.34 ^d ±0.01
LSD	0.032	0.02	0.08	0.03

Table 4: Mineral content (mg/100 g) of malted maize and soybeans flour blends

Sample	Mg	K	Ca	Zn	Fe
A(100:0)	44.73 ^a ±0.04	371.13 ^a ±0.01	290.16 ^a ±0.04	9.21 ^a ±0.03	11.24 ^a ±0.05
B(90:10)	48.55 ^b ±0.07	393.46 ^a ±0.02	318.67 ^b ±0.03	11.545 ^b ±0.06	12.53 ^b ±0.04
C(80:20)	56.63 ^c ±0.04	447.16 ^b ±35.5	356.37 ^c ±0.02	12.15 ^c ±0.06	14.83 ^c ±0.04
D(70:30)	59.52 ^d ±0.02	472.24 ^b ±0.04	382.44 ^d ±0.03	16.14 ^d ±0.06	16.12 ^d ±0.02
E(60:40)	61.34 ^e ±0.05	613.74 ^c ±4.26	399.37 ^e ±0.03	18.55 ^e ±0.06	19.835 ^e ±0.05
F(50:50)	81.35 ^f ±0.06	669.47 ^d ±0.02	412.04 ^f ±0.04	22.63 ^f ±0.04	24.53 ^f ±0.04
LSD	0.12	35.72	0.08	0.13	0.10

Table 5: Vitamin content of malted maize and soybeans flour blends

Sample	A (μ /100 g)	B1(mg/100 g)	B2(mg/100 g)	B3(mg/100 g)	B9(mg/100 g)
A(100:0)	47.34 ^a ±0.05	0.43 ^a ±0.02	1.14 ^a ±0.02	1.24 ^a ±0.03	0.27 ^a ±0.03
B(90:10)	56.34 ^b ±0.06	0.57 ^b ±0.04	1.87 ^c ±0.01	1.34 ^a ±0.01	0.33 ^a ±0.02
C(80:20)	64.16 ^c ±0.08	0.61 ^b ±0.02	1.95 ^d ±0.02	1.62 ^c ±0.00	0.41 ^b ±0.04
D(70:30)	68.52 ^d ±0.03	0.69 ^c ±0.03	1.75 ^b ±0.01	2.01 ^d ±0.01	0.46 ^b ±0.03
E(60:40)	87.25 ^e ±0.07	0.88 ^d ±0.02	2.16 ^e ±0.01	2.62 ^e ±0.01	0.63 ^c ±0.03
F(50:50)	91.63 ^f ±0.04	1.30 ^e ±0.02	2.85 ^f ±0.04	3.56 ^f ±0.01	0.86 ^d ±0.04
LSD	0.14	0.06	0.06	0.04	0.07

Table 6: Sensory quality attributes of gruel from blends of malted maize and soybeans flour blends

Sample Code	Taste	Sourness	Aroma	Appearance	General acceptability
A(100:0)	6.20 ^d ±1.55	6.50 ^b ±1.78	6.40 ^d ±1.71	6.00 ^d ±1.15	6.40 ^c ±0.97
B(90:10)	5.20 ^{cd} ±2.10	7.00 ^b ±0.94	5.80 ^{cd} ±1.23	5.20 ^{cd} ±1.03	6.00 ^c ±1.33
C(80:20)	4.70 ^{bc} ±2.00	5.40 ^a ±1.51	4.90 ^{bc} ±1.6	4.50 ^{bc} ±1.08	5.40 ^{bc} ±1.26
D(70:30)	4.30 ^{abc} ±1.25	4.90 ^a ±0.74	4.60 ^{ab} ±0.52	4.00 ^{ab} ±0.82	4.70 ^{ab} ±1.16
E(60:40)	3.30 ^{ab} ±0.95	4.40 ^a ±1.07	4.20 ^{ab} ±0.92	4.50 ^{bc} ±1.27	4.80 ^{ab} ±1.40
F(50:50)	3.20 ^a ±0.63	4.50 ^a ±0.71	3.60 ^a ±0.97	3.20 ^a ±1.03	3.80 ^a ±1.14
LSD	1.35	1.07	1.10	0.962	1.09

Conclusion

The inclusion of soybeans flour in malted maize-based flour had impact on the functional, nutritional and sensory properties of the maize-based complementary food. The increase in protein and micro-nutrients (minerals and vitamins) with inclusion of soybeans flour in the blends implies Protein and micronutrient malnutrition can be reduced through supplementation of malted maize-based complementary food with soybeans flour. The study concludes that soybeans inclusion in malted maize-based complementary food could be useful in improving the nutritional composition of *ogi* made from cereals.

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