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Chemical and Sensory Properties of Maize Ogi Enriched with Flours and Protein Isolates from Bambaranut and Soybean

Ameh, C.O., Abu, J.O and Bundle-Tsegba C. M

1. Department of Food Science and Technology, Joseph Sarwuan Tarka University, Makurdi, Benue State, P.M.B 2373

Abstract:
Background: Ogi is an infant complementary food in Nigeria that is starchy in nature, a bulky gruel with decreased nutrient density like protein and essential amino acids. Flours and protein isolates from bambaranut and soybean were prepared to enrich maize ogi. Objective: The objective of this study was to evaluate the chemical and sensory quality of maize ogi enriched with flours and protein isolates from bambaranut and soybean. Methods: Standard procedures were used for the processing of flours and protein isolates. Ogi made from 100 % maize flour served as control. The other samples include; maize ogi /soybean isolate (B), maize ogi /bambaranut isolate (C), maize ogi/soy flour (D) and maize ogi/bambaranut flour (E) in different blend ratio which were assessed for pasting analysis, amino acid, micronutrient, antinutrient and sensory evaluation. Result: Pasting properties of the maize-based ogi flour was altered significantly ($p<0.05$), the protein isolates enriched ogi had higher (79.22, 74.97 oC) pasting temperature over the flour enriched ogi (71.86, 66.31 oC). The micronutrients were greatly improved by the addition of flours from bambaranut and soybean while the anti-nutritional contents were minimal. In general, the ogi samples scored above 6 on a 9-point hedonic scale, suggesting that acceptable protein enriched ogi could be made from maize flours and either bambaranut or soy flour as well as their protein isolates. Conclusion: The protein, amino acids, micronutrient, composition of the maize-based ogi were enhanced significantly following the addition of flours and protein isolates from bambaranut and soybean with decreased antinutritional contents which could help in alleviating protein energy malnutrition among under five children.

Keywords: Maize ogi, bambaranut, soybean, bambaranut and soybean protein isolates.

INTRODUCTION

Ogi is a smooth, free flowing thin porridge obtained from wet-milled, fermented cereal grain popularly served as breakfast cereal and infant complementary food in Nigeria (1). *Ogi* is produced from cereals such as sorghum, maize and millet or their combinations (2). A major disadvantage with cereal-based gruel such as maize *ogi* is its starchy nature which makes them bind so much water, thus yielding a bulky gruel with decreased nutrient density (3).

Maize *ogi*, like most cereal products is low in protein as well as in essential amino acids such as lysine, tryptophan and threonine (4). Therefore, solitary and consistent consumption of maize *ogi* could predispose individuals to protein energy malnutrition which essentially is a state of inadequate dietary protein and energy (5).

Soybean (*Glycine max*), a legume, is one of the nutritious and affordable sources of plant protein that have been employed to improve the diets of millions of people, especially low-income

earners in developing countries owing partly to its functional properties (6). Soybean contains; proteins (40%), lipids (20%), minerals (5%), and B vitamins for human nutrition (7). Processing is necessary to destroy or remove some of the undesirable constituents of legumes such as soybean and bambaranut and to improve their palatability ((8)

Compared to soybean, Bambaranut (*Vigna subterranea L. Verdc*) is an under-utilized legume of the African origin and it is the third most important legume after groundnut (*Arachis hypogeal*) and cowpea (*Vigna unguiculata*) in Africa (9). Bambaranut contains about 24 % protein with a good balance of the essential amino acids and relatively high proportions of lysine (6-8%) and methionine (1-3%) (10). Bambaranut minor constituents include minerals, vitamins as well as anti-nutritional factors such as trypsin inhibitors and polyphenols (11).

Protein isolates are the most refined form of protein products containing the greatest concentration of protein (90 %) on a dry weight basis (12). It's high concentration of protein with the advantages of colour, flavour and functional properties makes it an ideal raw ingredient for use in beverages, infant and children milk food and certain types of specialty foods (12, 13). Protein isolates have been developed from a variety of legumes such as soybean, bambaranut, cowpea, peanut, canola, cashew nut, almonds, sesame, pinto and navy beans (14, 15). By combining legumes and their protein isolates with maize in *ogi* preparations, the protein value of maize *ogi* could be enhanced. The study was to evaluate the chemical and Sensory quality of maize *ogi* enriched with flours and protein isolates from bambaranut (*Vigna suberranea L*) and soybean (*Glycine max*).

MATERIALS AND METHODS

Maize, bambaranut and soybean, were obtained from Benue State Agricultural and Rural Development Authority (BNARDA), Makurdi, Nigeria. All equipment used were obtained from the Department of Food Science and Technology, Joseph Sarwuan Tarka University, Makurdi, Benue State and Kogi State University, Anyigba.

Preparation of Maize *Ogi*

Ogi was processed according to the modified method of (16). Maize grains were obtained, sorted to eliminate the bad grains, cleaned to remove debris and foreign bodies and steeped in clean tap water for 24 h at room temperature. The steeped grains were then washed with clean water, wet milled using a M6FY commercial flour milling machine and wet sieved using a 250 µm sieve. The husks were disposed while the filtrate (slurry) was allowed to ferment for 24 h to collect sediment. At the end of the fermentation period, *ogi* was recovered by using a cheese cloth to squeeze out the water. The wet *ogi* sample was then dried in the Gallenkamp (United Kingdom) moisture extraction oven (60 °C, 12 h). The dried starchy cake obtained was milled and sieved using (250 µm mesh sieve) to obtain *ogi* flour.

Processing of Defatted Bambaranut Flour

Bambaranut flour was prepared according to the method described by (17). The Bambaranut was sorted to remove extraneous materials and damaged seeds. Soaked (10 h at 1:2 w/v), boiled for 20 min, manually dehulled (by rubbing in between the palms) and oven dried in the Gallenkamp (United Kingdom) moisture extraction oven at 60 °C for 24 h. The dried bambaranut was milled in a M6FY commercial flour milling machine, followed by sieving through a 250 µm mesh and packaging in airtight plastic containers which were placed in shelves at room temperature until used. The flour was defatted using a modified method of (18). The flours were defatted using n-

hexane (flour to solvent ratio 1:5 w/v) with constant magnetic stirring provided for 4 hours. The trace of residual hexane was removed by placing the defatted flours inside a fume cupboard for 6 h to dry. Flours obtained were packed in plastic tubes until further use.

Processing of Defatted Soybean Flour

Soybean flour was processed according to the modified method described by (19). The soybean seeds were sorted to remove pebbles, stones and other extraneous materials. They were wetted, cleaned and steeped for 10 h. The steeped soybean seeds were drained and precooked for 15 min followed by dehulling (by rubbing in between the palms) and the hulls were removed by rinsing with clean water. The dehulled soybean seeds were oven dried at 60 °C for 12 h and dry milled into fine flour. The soybean flour was sieved using 250 µm mesh sieve to obtain smooth flour. The flour was defatted using a modified method of (18). The flours were defatted using n-hexane (flour to solvent ratio 1:5 w/v) with constant magnetic stirring provided for 4 hours. The trace of residual hexane was removed by placing the defatted flours inside a fume cupboard for 6 hours to dry. Flours obtained were packed in plastic tubes until further use.

Processing of Bambaranut Protein Isolate

Protein was extracted from defatted bambaranut flour using a modified isoelectric precipitation procedure (19). The defatted flour was dispersed in distilled water at 1:10 (w: v) ratio. This was followed by adjustment to pH 7.5 with 1.0 M NaOH to solubilize the protein. The resulting mixture was stirred using a magnetic stirrer for 4 h and centrifuged at 3,500 xg for 30 min using the labnet spectrafuge 6C low speed centrifuge. The residue was discarded and the supernatant filtered with cheesecloth and adjusted to pH 4.5 using 1.0 M HCl to precipitate most of the proteins. Thereafter, the mixture was centrifuged (3500 x g, 30 min). The resultant precipitate was re-dispersed in 25 ml distilled water, frozen at 0 °C and then freeze dried at -52 °C to yield a free-flowing powder. The bambaranut protein isolates was stored in a sealed tube at 4°C until analyzed.

Processing of Soy Protein Isolate

Protein was extracted from defatted soy flour using a modified isoelectric precipitation procedure (20). The defatted flour was dispersed in distilled water at 1:10 (w:v) ratio. This was followed by adjustment to pH 8.5 with 1.0 M NaOH to solubilize the protein. The resulting mixture was stirred using a magnetic stirrer for 4 h and centrifuged at 3,500 xg for 30 min. The residue was discarded and the supernatant filtered with cheesecloth and adjusted to pH 4.5 using 1.0 M HCl to precipitate most of the proteins. Thereafter, the mixture was centrifuged (3500 x g, 30 min). The resultant precipitate was re-dispersed in 25 ml distilled water, frozen at 0 °C and then freeze dried at -52 °C to yield a free-flowing powder. The soy protein isolate was stored in a sealed tube at 4 °C until analyzed.

Product Formulation

Five products were formulated as shown in Table 1. The products comprised A (100 % maize ogi), B (90.65 % maize flour + 9.35 % soy protein isolates), C (89.81 % maize flour + 10.19 % bambaranut protein isolates), D (75.07 % maize flour + 24.93 % soybean flour) and E (70.03 % maize flour + 29.97 % bambaranut flour). Each product was formulated to give 16g protein/100 g. The amounts of the materials required to meet the protein target were achieved through material balance from their respective protein contents using the procedure outlined by (21).

Table 1: Flour Blends Formulation to Achieve 16 % Protein

Samples	Maize Flour (MF)	Bambaranut Flour (BF)	Soybean Flour (SF)	Bambaranut Protein Isolate (BI)	Soy Protein Isolate (SPI)	Total
A	100	-	-	-	-	100
B	90.65	-	-	-	9.35	100
C	89.81	-	-	10.19	-	100
D	75.07	-	24.93	-	-	100
E	70.03	29.97	-	-	-	100

Pasting Properties of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Isolates

The Rapid Visco Analyser (RVA model 3D, Newport Scientific, Sydney, Australia) was used to determine the pasting properties of the samples. Exactly 2.5 g sample was weighed into a dried empty canister and 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 50 to 95 °C with a holding time of 2 min followed by cooling to 50 °C with 2 min holding time. Peak, trough, breakdown, final and set back viscosities as well as peak time and pasting temperature was read from the pasting profile with the aid of thermocline for windows software connected to a computer.

Determination of Micronutrients Composition of Maize-Based *Ogi* Enriched with Bambaranut, Soybean flours and their Protein Isolates

Determination of Potassium Content:

The method of (22) was used in determining the potassium content of samples. One gram of the sample was dissolved in 20 ml of acid mixture (650ml of concentrated HNO_3; 80ml PCA; 20ml conc H_2SO_4) and aliquots of the diluted clear digest were taken for photometry using Flame analyser (Sherwood Flame Photometer 410, Sherwood Scientific Ltd. Cambridge, UK).

Determination of Phosphorus Content:

The method of (22) was used in determining the potassium content of the samples. Two gram of food samples was ashed for 4h at 60 °C and five millilitres of 6N HCl and several drops of nitric acid was added. It was then heated to dissolve the ash completely, cooled and transferred to a 100 ml volume flask and diluted to volume with the volume flask. An aliquot was pipetted which contained five milligrams of phosphorus into a 100ml volume flask. The sample was added to molydovanadate reagent to 100 ml and the colour was allowed to develop for 10 minutes. The absorbance was read at 400nm against a phosphorus standard curve.

Determination of Sodium Content:

The method of (22) was used. Weight of 0.2542 g of NaCl was dissolved in 1 litre of distilled water to give 100ppm sodium. This working standard solution was diluted to produce a range containing 0 – 10ppm sodium and made up to 100 ml mark and 2 ml sample aliquot (sample stock solution) was read using a JENWAY PFP7 flame photometer. The concentration of the test mineral in the sample was calculated with reference to the graph (standard curve) and obtained as follows:

$$Na\ (mg/100g) = 100 \times Xx\ VF \times D\ \text{W} \times 100 \times \text{Va}$$

W = Weight of the sample analysed
X = Concentration of Na obtained from the standard curve

VF = Total volume of digest/extract (100ml)
Va = Volume of extract used
D = Dilution factor

Determination of Calcium Content:
Calcium was determined using the atomic absorption spectrophotometer described by (22). Calcium carbonate (2.495 g) was dissolved and diluted to 100ml with de-ionized water. This solution contained 1000 mg Ca^{2+} ions and from this stock solution, calcium standard of the following concentration levels 0.0, 3.0, 6.0, 9.0 were prepared. The absorbance of both the sample and the standard working aliquot were determined in the AGILENT (Model 5805, Agilent Spec England) atomic absorption spectrophotometer at 239.9 nm.

The concentration of the test mineral in the sample was calculated with reference to the graph (standard curve) and obtained as follows:

$$Ca\ (mg/100g) = 100 \times XxVf \times D\ W \times 100 \times Va$$

W = Weight of the sample analyzed
X = Concentration of Ca obtained from the standard curve
Vf = Total volume of extract
Va = Volume of extract used
D = Dilution factor

Determination of Thiamine Content:
The method of (22) was used. Five gram of homogenized sample was poured into 100 ml volumetric flasks and 0.1 N HCI was added and mixed. It was autoclaved for 30 minutes at 121 °C. The samples were allowed to cool and interfering substances was precipitated by adjusting the pH to 6.0 followed immediately by readjusting the pH to 4.5. This was then diluted to volume with water and filtered. Five millilitres of 6% enzyme (mylase) were added and incubated for 3 hours at 45-50 °C. This was then cooled and pH adjusted to 3.5 and diluted with water to volume, mixed and filtered. Ten millilitres of the diluted extract were oxidized by passing it through a SepPak C_{18} cartridge followed by 5ml 0.01 M phosphate buffer at pH 7.0. The Vitamin was separated by HPLC using a 4.6 mm X 25 cm ultraphere ODS, 5 columns and detected by fluorescence at 360 nm/415 nmex/em. The thiamine content was measured by the calculation below:

$$\mu g/g = CX\ VX\ (DF/WT)$$

Where,
C= Concentration of vitamin in µg/ml obtained from peak height or area of sample and standard
V= Sample Volume, ml
DF= Dilution factor
WT= Sample weight, g.

Determination of Riboflavin Content:
The method of (22) was used to determine the riboflavin content. Riboflavin was extracted with dilute acids and after removing the interfering substances by treatment with $KMno_4$, it was determined in a fluorimeter at 450-500 mm wavelength. Two grams of the sample and 10 mg of riboflavin were poured into conical flask, 50 ml of 0.2 NHCI was boiled on a water bath for an hour,

allowed to cool and the pH adjusted to 6.0 using NaOH, also 1N HCl was added to lower the pH to 4.5, it was filtered in a 100 ml measuring flask and volume was made up to the mark. Two test tubes were marked as 1 and 2 to remove interference. 1 ml of acetic acid (glacial) was added to each test tube, it was mix and 0.5ml of 3% $KMno_4$ was added. The fluorimeter was adjusted to zero deflection against $0.1NH_2SO_4$ and 100 against tube no 2. 20mg of sodium hydrogen sulphate was added to test tubes and fluorescence was measured within 10 seconds and was recorded as blank.

The riboflavin content was measured by the calculation below:
W=Weight of sample.
X= (reading of sample 1) - (reading of sample blank)
Y= (reading of sample + standard tube 2)- (reading of sample + standard blank)

$$\text{Riboflavin (mg per g of sample)} = \frac{x}{Y - X} = \frac{1}{w} \quad (10)$$

Determination of Niacin Content:
The method described by (22) using High performance liquid Chromatography was used in determining the niacin content. The first step was the use of alkaline digestion on food sample. Niacin derivatives such as coenzymes and niacinamide was converted into total niacin by alkaline digestion with aqueous calcium hydroxide.

Following alkaline extraction of food, niacin was purified and concentrated using C18 and cation exchange cartridge (SCX). The purified extract was determined by HPLC at a detection wavelength of 254 nm using C8 column and PIC A reagent in 15 % methanol. Food samples was finely grounded and mixed well before taking sample aliquot, an analytical balance was used to weigh accurately 1 g of sample and put into a 50 ml PP centrifuge tube, Alkaline Extraction was by weighing 0.75 g $Ca(OH)_2$ and added into the centrifuge tubes which contained the 1.0 g sample. Including a 'duplicate' sample, a 'control' sample, a 'recovery' sample, a 'niacin standard' and a 'blank'. and to the 'recovery' sample, 1.0 g of food sample was added in 1.0 ml niacin stock standard of 100 ug/ml and then 0.75 g $Ca(OH)_2$. To the 'niacin standard' tube was added 1 ml stock standard (100 ug/ml) and then 0.75 g of Ca (OH). The 'blank' sample which contained only water and Ca (OH). 25 ml measuring cylinder was used to add 10 ml UHQ water into all tubes and finally, a glass rod to mix each tube well, and then 10 ml of UHQ water was added. The glass rod was rinsed as well.

Determination of Selected Antinutritional Composition of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Determination of Phytate:
Phytic acid content was determined as described by (23). The test sample was extracted with 0.2N hydrochloric acid. The extract (0.5 ml) was transferred into a test tube fitted with a ground glass stopper. Ferric solution (1 ml) was added, the tube was covered and heated in a boiling water bath for 30 minutes. After cooling, the content of the tube was centrifuged (3000 xg) for 30 min. The supernatant (1 ml) was transferred to another test tube and 1.5 ml of 2, 2-bipyridine solution was added. Absorbance of the solution was measured at 519 nm against distilled water and the concentration was obtained from a calibration curve.

Determination of Tannins:

Tannins were determined as described by (23). Each sample (1g) was dispersed in distilled water (10ml) and agitated. This was left to stand for 30 minutes at room temperature and centrifuged. The supernatant (2.5 ml) was dispersed into a 50 ml volumetric flask. Standard tannic acid solution (2.5 ml) was transferred into a separate 50ml flask. Folin-Denis's reagent (1 ml) was measured into each flask, followed by 2.5 ml of saturated sodium carbonate (Na_2CO_3) solution. The mixture was diluted to the 50 ml mark and left for 90 min at room temperature. The absorbance was measured at 250 nm and readings were taken with the reagent blank at zero. The tannin content was derived from an (absorbance of test sample), As (absorbance of standard solution), C (concentration of standard solution), W (weight of sample used), Vf (total volume of extract) and Va (volume of extract analyzed), as shown below

$$\%\,Tannin = \frac{An}{As} X C X \frac{100}{w} X \frac{Vf}{VaA} \quad (11)$$

Trypsin Inhibitor Assay:

Trypsin inhibitory activity (TIA) was determined as described by (24). This was measured in terms of the extent to which an extract of the test sample inhibited the action of bovine trypsin on the substrate benzoyl-DL-arginine-p-nitrianilide (BAPNA). Each sample (1 g) was continuously extracted at room temperature for 3 h with 50ml of 10 mmol/L NaOH using a mechanical shaker (GallenKamp orbital shaker, Surrey, UK). The pH of the resulting slurry was adjusted from 9.4 to 9.6 with 1mol/L sodium hydroxide. After extraction, the suspension was shaken and diluted with distilled water so that 1 cm^3 of the extract produced trypsin inhibition of 40-60% at 37 °C. The respective dilutions were noted and TIA calculated in terms of milligrams of pure trypsin/g sample, using equation 2:

$$TIA = \frac{(2.632\ DA)}{S}$$

Where:
D=dilution factor,
A =change in absorbance at 410nm due to trypsin inhibition per cm^3 of diluted sample extract, and S=weight of the sample.

Determination of oxalates:

Oxalates were determined using the method of (22). Each sample (1 g) was weighed into 100ml conical flasks, 75 ml of 3 mol/L H_2SO_4 was added and the solution stirred intermittently with a magnetic stirrer for about 1hour and then filtered using Whatman No. 1 filter paper. The sample filtrate (extract, 25 ml) was collected and titrated against hot (80-90 °C) 0.1 N potassium permanganate ($KMnO_4$) until a faint pink colour which persisted for at least 30 seconds appeared. The concentration of oxalate in each sample was obtained from the conversion: 1 ml 0.1 permanganate = 0.006303 g oxalate.

Determination of Amino Acid Profile of Maize *Ogi* Enriched with Bambaranut, Soybean Flours and Their Protein Isolates (g/100 g protein)

Qualitative assessment of the essential and non-essential amino acid (profile) composition of the formulation was carried out using the method as reported by (25). The estimation of the amino acids was by the use of the guide strip technique where developed thin-layer chromatography

plates was used in locating the positions of amino acids in unsprayed plates. The squares containing amino acids was cut-out and eluted with 5 ml distilled water at 70 °C for 2 hours; the cellulose powder was removed by centrifugation at 5,000rpm for 5 min. The supernatant was decanted and kept for colorimetric analysis of amino acid profiles against FOA reference values of the essential amino acid

Sensory Properties of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Gruels which were neither too thin nor too thick were prepared by mixing 40 g of each flour sample in 80ml hot water using a graduated plastic cup. Hot water used was boiled using a cordless electric kettle (Sayona, model no. SCK-25). A semi-trained panel, consisting of 20 nursing mothers/caregivers selected from the Jos North Clinic, Plateau State, Nigerian were used. The nursing mothers/caregivers were women who had children within the ages of 6 months to 5 years. They were screened to ensure that they were familiar with the traditionally-prepared fermented maize *ogi* which is commonly used for complementary feeding. A 9-point hedonic scale (1- dislike extremely, 5- neither like nor dislike, 9- like extremely) as described by (26) was used to assess the sensory attributes of taste, aroma, appearance, mouthfeel, consistency and overall acceptability. The five coded samples were labelled as sample A-E, cooled to a lukewarm temperature, and served all together in disposable transparent plastic cups. Each panelist was provided with clean water which served as a palate cleanser in between evaluations.

Statistical Analysis of Samples

Data were subjected to Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test to compare treatment means; differences was considered significant at 95% ($p<0.05$) (SPSS V21 software).

RESULTS

Pasting Properties of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Pasting properties of maize-based *ogi* enriched with bambaranut, soybean flours and their protein isolates is presented in Table 2**.** There was a significant decrease ($p<0.05$) in the peak, trough, breakdown, final and setback viscosities and a significant increase ($p<0.05$) in the peak time and pasting temperature with the addition of flours and protein isolates from bambaranut and soybean to the 100 % maize *ogi*. The peak viscosity of the flour blends ranged from 190.80 to 294.00 RVU. The trough, breakdown and final viscosities of the unfortified and fortified samples ranged between 142.00 to 207.00 RVU, 48.86 RVU to 88.02 RVU and 200.00 to 300.00 RVU respectively. The setback viscosity, peak time and pasting temperature ranged between 115.20-200.50 RVU, 5.38-6.91 min and 60.40-79.22 °C, respectively.

Table 2: Pasting Properties of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Samples	PV(RVU)	TV(RVU)	BV(RVU)	FV(RVU)	SV(RVU)	PT (min)	PT (°C)
A	$294.00^{a}\pm0.01$	$207.00^{a}\pm0.02$	$88.02^{a}\pm0.02$	$300.20^{a}\pm0.04$	$200.50^{a}\pm0.02$	$5.38^{e}\pm0.01$	$60.40^{e}\pm0.01$
B	$190.80^{e}\pm0.05$	$142.00^{e}\pm0.02$	$48.86^{e}\pm0.06$	$200.00^{e}\pm0.01$	$115.20^{e}\pm0.01$	$6.91^{a}\pm0.01$	$79.22^{a}\pm0.02$
C	$220.90^{d}\pm0.95$	$165.00^{d}\pm0.01$	$55.87^{d}\pm0.96$	$236.00^{d}\pm0.08$	$122.30^{d}\pm0.02$	$6.32^{b}\pm0.01$	$74.97^{b}\pm0.02$
D	$244.40^{c}\pm0.42$	$179.60^{c}\pm0.03$	$64.69^{c}\pm0.43$	$250.50^{c}\pm0.01$	$130.00^{c}\pm0.02$	$5.89^{c}\pm0.01$	$71.86^{c}\pm0.02$
E	$262.00^{b}\pm0.02$	$188.60^{b}\pm0.51$	$73.40^{b}\pm0.53$	$273.20^{b}\pm0.01$	$155.50^{b}\pm0.02$	$5.65^{d}\pm0.02$	$66.31^{d}\pm0.01$

Values are means ± standard deviations of triplicate determinations.

Means within same column with different superscripts differed significantly ($p<0.05$)

Sample A (100 % maize *ogi*), Sample B (90.65 maize *ogi* and 9.35 soybean protein isolates), Sample C (89.81 maize *ogi* and 10.19 bambaranut protein isolate), Sample D (75.07 maize *ogi* and 24.93 soy flour) and Sample E (70.03 maize *ogi* and 29.97 bambaranut flour)
PV= Peak Viscosity, TV= Trough Viscosity, BV= Breakdown Viscosity, FV= Final Viscosity, SV= Setback Viscosity, PT (min)= Peak Time and PT(0C) =PastingTemperature

Amino Acid Composition of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates (g/100 g protein)

The amino acid composition of maize-based *ogi* enriched with bambaranut, soybean flours and their protein isolates (g/100 g protein) are shown in Table 3.

The results showed significant difference in all the samples analyzed. The leucine, lysine, tryptophan, glutamate and aspartate contents ranged between 6.36 to 7.67, 2.87 to 6.01, 0.97 to 1.37, 5.83 to 7.21 and 6.02 to 6.99 g/100 g protein respectively.

Table 3: Amino Acid Composition of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates (g/100 g protein)

Amino Acids	A	B	C	D	E	FAO/WHO, 1985
Valine	3.33^{e}±0.03	4.98^{a}±0.02	4.77^{b}±0.01	4.36^{c}±0.02	3.98^{d}±0.01	3.50
Threonine	2.78^{e}±0.01	4.00^{a}±0.02	3.67^{b}±0.01	3.21^{c}±0.01	2.94^{d}±0.01	3.40
Isoleucine	3.87^{e}±0.02	4.86^{a}±0.01	4.66^{b}±0.01	4.46^{c}±0.01	4.21^{d}±0.01	2.80
Leucine	6.36^{e}±0.01	7.67^{a}±0.01	7.22^{b}±0.02	6.88^{c}±0.01	6.56^{d}±0.01	6.61
Methionine	0.79^{d}±0.00	1.01^{a}±0.01	0.85^{b}±0.01	0.83^{c}±0.01	0.82^{c}±0.01	-
Phenylalanine	4.00^{e}±0.01	6.01^{a}±0.03	5.67^{b}±0.01	4.85^{c}±0.01	4.55^{d}±0.01	-
Lysine	2.87^{e}±0.01	6.01^{a}±0.02	5.89^{b}±0.12	5.68^{c}±0.01	5.44^{d}±0.02	5.80
Histidine	2.31^{e}±0.01	3.78^{a}±0.02	3.47^{b}±0.01	3.23^{c}±0.02	2.98^{d}±0.01	-
Tryptophan	0.97^{e}±0.02	1.37^{a}±0.01	1.29^{b}±0.01	1.19^{c}±0.01	1.15^{d}±0.01	1.10
Alanine	2.37^{e}±0.01	4.23^{a}±0.01	3.66^{b}±0.01	3.27^{c}±0.01	3.12^{d}±0.01	-
Aspartate	6.02^{e}±0.01	6.99^{a}±0.01	6.73^{b}±0.01	6.57^{c}±0.05	6.13^{d}±0.01	-
Glutamate	5.83^{e}±0.01	7.21^{a}±0.01	6.81^{b}±0.01	6.52^{c}±0.01	6.03^{d}±0.01	-
Serine	2.24^{e}±0.01	3.64^{a}±0.02	3.21^{b}±0.01	3.00^{c}±0.02	2.39^{d}±0.01	-
Glycine	2.52^{e}±0.02	3.69^{a}±0.00	3.50^{b}±0.02	3.24^{c}±0.01	2.90^{d}±0.01	-
Proline	4.76^{e}±0.01	6.00^{a}±0.01	5.64^{b}±0.01	5.22^{c}±0.02	4.90^{d}±0.01	-
Arginine	4.37^{e}±0.01	5.42^{a}±0.01	5.18^{b}±0.01	5.01^{c}±0.01	4.88^{d}±0.01	-
Tyrosine	1.46^{e}±0.01	1.95^{a}±0.01	1.72^{b}±0.01	1.67^{c}±0.01	1.57^{d}±0.01	-
Cysteine	1.00^{e}±0.01	1.87^{a}±0.01	1.61^{b}±0.01	1.49^{c}±0.01	1.26^{d}±0.05	-

Values are means ± standard deviations of triplicate determinations. Means within same column with different superscripts differed significantly ($p<0.05$). Sample A (100 % maize ogi), Sample B (90.65 maize ogi and 9.35 soybean protein isolates), Sample C (89.81 maize ogi and 10.19 bambaranut protein isolate), Sample D (75.07 maize ogi and 24.93 soy flour) and Sample E (70.03 maize ogi and 29.97) bambaranut flour

Micronutrient Composition of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates (mg/100g)

Table 4 shows the micronutrients composition of maize-based *ogi* enriched with bambaranut, soybean flours and their protein isolates (mg/100g). The sodium, calcium, phosphorus and potassium content ranged from, 8.02-43.76, 56.10-171.65, 155.90-272.00 and 178.70-644.20, respectively. Also, the thiamine, riboflavin and niacin ranged between; 0.53-0.98, 0.29-0.54 and 1.99-1.28, respectively.

Table 4: Micronutrient of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates (mg/100g)

Samples	Sodium	Calcium	Phosphorus	Potassium	Thiamine	Riboflavin	Niacin
A	8.02^{e}±0.01	56.10^{e}±0.01	155.90^{e}±0.01	178.70^{e}±0.01	0.53^{c}±0.01	0.29^{c}±0.01	1.99^{c}±0.01
B	10.08^{c}±0.01	61.55^{c}±0.01	196.80^{c}±0.01	212.00^{c}±0.01	0.37^{d}±0.01	0.19^{d}±0.01	1.28^{d}±0.01
C	8.98^{d}±0.01	58.21^{d}±0.01	180.30^{d}±0.01	182.60^{d}±0.01	0.25^{e}±0.01	0.14^{e}±0.01	1.23^{e}±0.01
D	43.76^{a}±0.01	171.65^{a}±0.01	272.00^{a}±0.01	644.20^{a}±0.01	0.98^{a}±0.01	0.59^{a}±0.01	2.73^{a}±0.01
E	31.52^{b}±0.01	82.23^{b}±0.01	201.50^{b}±0.01	284.90^{b}±0.01	0.66^{b}±0.01	0.34^{b}±0.01	2.22^{b}±0.01

Values are means ± standard deviations of triplicate determinations. Means within same column with different superscripts differed significantly (p<0.05) Sample A (100 % maize ogi), Sample B (90.65 maize ogi and 9.35 soybean protein isolates), Sample C (89.81 maize ogi and 10.19 bambaranut protein isolate), Sample D (75.07 maize ogi and 24.93 soy flour) and Sample E (70.03 maize ogi and 29.97 bambaranut flour)

Antinutritional Composition of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

The antinutritional composition of maize-based *ogi* enriched with bambaranut, soybean flours and their protein isolates are presented in Table 5. The oxalate content for unsubstituted sample (100 % maize *ogi*) and substituted samples ranged from 0.11 to 6.14 (mg/100g), respectively. The antinutrients were significantly decreased (p<0.05) by various substitution levels of protein isolates from bambaranut and soybean while there was a significant increase (p<0.05) with the addition of flours from bambaranut and soybean. Also, phytate, tannins and trypsin inhibitors (TIA) were found to range between 1.87 to 9.50 (mg/100g), 0.22 to 7.81(mg/100g) and 0.10 to 10.77 %, respectively.

Table 5: Antinutritional Contents of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Samples	Oxalate (mg/100g)	Phytate (mg/100g)	Tannins (mg/100g)	TIA (%)
A	0.25^{c}±0.01	2.60^{c}±0.01	0.35^{c}±0.01	0.48^{c}±0.57
B	0.11^{e}±0.01	1.87^{e}±0.01	0.22^{e}±0.01	0.10^{c}±0.01
C	0.15^{d}±0.01	1.91^{d}±0.01	0.26^{d}±0.01	0.12^{c}±0.01
D	4.04^{b}±0.01	8.94^{b}±0.01	5.21^{b}±0.01	6.96^{b}±0.01
E	6.14^{a}±0.01	9.50^{a}±0.01	7.81^{a}±0.01	10.77^{a}±0.05

Values are means ± standard deviations of triplicate determinations. Means within same column with different superscripts differed significantly (p<0.05) Sample A (100 % maize *ogi*), Sample B (90.65 maize *ogi* and 9.35 soybean protein isolates), Sample C (89.81 maize *ogi* and 10.19 bambaranut protein isolate), Sample D (75.07 maize *ogi* and 24.93 soy flour) and Sample E (70.03 maize *ogi* and 29.97 bambaranut flour)
TIA (Trypsin Inhibitory Activity)

Sensory Scores of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Sensory properties of maize-based *ogi* enriched with bambaranut, soybean flours and their protein isolates are shown in Table 6. Sensory scores for aroma, mouthfeel, appearance, taste, consistency and overall acceptability ranged between 7.35 and 8.40, 6.25 to 8.40, 6.50 to 8.20, 6.00 to 8.55, 6.20 to 8.70 and 7.00 to 8.65, respectively.

Table 6: Sensory Scores of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Sample	Aroma	Mouthfeel	Appearance	Taste	Consistency	Overall acceptability
A	8.40^{a}±0.50	8.40^{a}±0.75	8.20^{a}±0.83	8.55^{a}±0.60	8.70^{a}±0.47	8.65^{a}±0.59
B	7.35^{b}±0.59	7.15^{bc}±1.57	7.30^{b}±0.66	7.80^{b}±0.70	7.85^{b}±0.59	8.00^{b}±0.79

C	7.30^{b}±1.17	7.50^{b}±1.32	7.25^{b}±0.97	7.75^{b}±0.97	7.20^{c}±0.52	7.95^{b}±0.89
D	6.40^{c}±1.14	6.50^{cd}±1.19	6.80^{bc}±0.95	6.45^{c}±0.89	6.85^{c}±0.75	7.15^{c}±0.88
E	6.10^{c}±1.55	6.25^{d}±1.29	6.50^{c}±1.36	6.00^{c}±1.08	6.20^{d}±0.89	7.00^{c}±1.08

DISCUSSION

Pasting Properties of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Pasting is the result of a combination of processes that follows gelatinization from granule rupture to subsequent polymer alignment due to mechanical shear stress during the heating and cooling of starches (27). The pasting properties of maize-based *ogi* enriched with bambaranut, soybean flours and their protein isolates showed peak viscosity were between 190.80 and 294.00 RVU which are higher than the 67.50- 86.00 reported by (28) when they substituted yellow maize flour with composites of soybean and pumpkin flour. Peak viscosity is often correlated with the final product quality; it provides an indication of the viscous load likely to be encountered during mixing (29). Peak viscosity is also an index of the ability of starch to swell freely before their physical break down (30, 31). High peak viscosity is an indication of high starch content (32). The relatively lower peak viscosities of the protein isolates samples; B and C as compared to the flour samples; D and E indicates that the protein isolates flours will not form a very thick paste, hence, maybe suitable for product requiring low gel strength and elasticity such as infants weaning foods (28, 33). The lower peak viscosity content of the isolates samples as compared to the flour samples may also be attributed to the reduction in carbohydrate content of the protein isolates compared with the flour samples since peak viscosity is an indication of higher starch content. Differences observed in the peak viscosities of the protein isolates and flour samples also indicates that they were differences in the rate of water absorption and starch granule swelling during heating (28).

Trough, is the minimum viscosity value in the constant temperature phase of the RVA pasting profile and it measures the ability of the paste to withstand break down during cooling (30, 34). Trough, sometimes called hold period, hot paste viscosity, shear thinning, holding strength due to the accompanied breakdown in viscosity is when the samples were subjected to a period of constant temperature (usually 95 ^{o}C) and mechanical shear stress (35). There were significant ($p<0.05$) decrease with the addition of flours and protein isolates to the maize *ogi*. Trough viscosities were between 142.00 and 207.00 RVU, which are similar to the value of 177.48 - 196.26 RVU reported by (36) and higher than the value of 61.50 – 79.00 RVU reported for composites of yellow maize, soybean and pumpkin flours reported by (28). The protein isolates enriched *ogi* were found to have lower trough viscosities compared with the flour samples. Higher holding periods exhibited by the control and flour samples indicated that these formulations will withstand high heat treatments during processing than the protein isolates samples which have lower trough viscosities. High trough viscosities represent low cooking losses and superior eating quality (28). Decrease in trough viscosity is an indication of breakdown or stability of the starch gel during cooking (37, 38). The lower the trough viscosity, the more stable is the starch gel. Therefore, the lower trough values observed in the *ogi* enriched with protein isolates indicates the stability of the paste as compared to the flour samples during cooling.

Final viscosity gives a measure of the resistance of paste to shear force during stirring (31, 35, 39). The final viscosity of the maize-based *ogi* were between (200.00 and 300.20 RVU) and were lower as compared to (1895 and 1801.82 RVU) reported by (40) for kokoro from composites of maize and pigeon pea protein concentrate flours. The control and flour samples had higher final viscosities while the protein isolates enriched *ogi* had lower final viscosity values. The high value

of final viscosity observed in the control sample could be attributed to the aggregation of amylose. Final viscosity is commonly used to define the quality of particular starch-based flour, since it indicates the ability of the flour to form a viscous paste after cooking and cooling. Thus, the lower final viscosities recorded in the protein isolates samples implied that, the flours will form a low viscous paste rather than a thick gel on cooking and cooling and this is advantageous in complementary food since infants can easily swallow a low viscous paste rather than a thick gel that will require excessive dilution with water leading to nutrients and energy thinning.

Peak time is a measure of cooking time (31). The peak time also gives an indication of the ease of cooling. The shorter the peak time the higher the ease of cooling (41). The peak time showed significant ($p<0.05$) increase among the samples with the control sample having the lowest peak time (5.38 and the protein isolates enriched *ogi* (B), the highest (6.91). The peak time in this study is similar with (6.15 to 6.25 min) reported by (40) when they produced kokoro, a traditional maize-based snacks from composites of maize and pigeon pea protein concentrate. The higher peak time observed in the protein isolates enriched *ogi* as compared to the control and flour samples implied that the cooking time for the flour will also increase. Thus, *ogi* from (100 %) maize flour will cool easily as compared to other samples with higher peak time.

Pasting temperature is the temperature at which initial rise in viscosity occurs when starch granules and proteins begin to absorb water and swells as the temperature increases (42). This occurs when starch or starch-based foods are heated in water beyond a critical temperature, the granules absorb a large amount of water and swell to many times their original size, over a critical temperature, which is characteristics of a particular starch, the starch undergoes an irreversible process known as gelatinization (31). The pasting temperature is also a measure of the minimum temperature required to cook a given food sample (43) and affects the stability of other components in the food formula and also affects energy costs (44). The pasting temperature showed significant ($p<0.05$) increase among all the sample. The pasting temperature observed in this study is lower than the value of (80.20 – 82. 25 ^{o}C) reported by (40) for maize-based snack fortified with pigeon pea protein concentrate. Since, pasting temperature is a measure of the minimum temperature required to cook a given food sample, protein isolates enriched *ogi* with higher pasting temperature as compared to the flour samples may not be recommended for certain products due to high cost of energy. The lower pasting temperature noted in the control sample may be due to the higher carbohydrate content in the sample as compared to the flours and isolates samples. However, since the pasting temperatures in all the samples were found to be lower than the boiling point of water; it therefore means, it can form a paste in hot water below boiling point. Also, the variation in pasting temperatures among the flours and protein isolates enriched *ogi* showed, the formulations will not have the same cooking time since pasting temperature depicts onset of rise and gelatinization temperature of the sample (27).

Amino Acid Composition of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates (g/100 g protein)

Amino acids are the chemical building blocks that make up proteins and provide the structure for all living things as proteins participate in the vital chemical processes that sustain life. All amino acids in food have different roles that helps the body to grow and function optimally. However, essential amino acids are of main concern as they are not synthesized in the body and must be supplied in adequate amount through diets. The amino acid compositions (Table 3) showed that Leucine is the most abundant essential amino acid and it is more dominant in the protein isolates enriched *ogi* (B). The leucine content of the maize *ogi* increased significantly ($p<0.05$) with the

addition of flours and protein isolates from bambaranut and soybean. This increase could be as result of increase in the concentration of protein in the blends. This finding is in line with (45) who reported a progressive increase in the leucine contents of nixtamilized maize flour supplemented with sprouted soybean flour. (46) gave the reference standard for leucine to be (6.61 g/100 g protein). since the flours and isolates enriched *ogi* were higher than the reference standard, it means *ogi* made from these combinations ought to meet the leucine needs of the infants.

Lysine is a major limiting amino acid in cereal grain, this explains why the lysine content was lowest (2.87 g/100 g protein) in the control sample (100 % maize *ogi*) but was improved upon the addition of flours and isolates from bambaranut and soybean. The high protein in bambaranut and soy protein isolates could be responsible for the high increase in lysine content of the protein isolates enriched *ogi.* The low level of lysine in the control sample is not unexpected as lysine has been reported to be the major limiting amino acid in maize, (47). Although, there was a significant increase in lysine contents with increasing concentration of protein in the blends, it is noteworthy to say that only the protein isolates enriched *ogi* met the reference standard of (5.8 g/100 g protein reported by (46) implying that the protein isolates enriched *ogi* stand a better chance of meeting the lysine need of an infant when compared to the flour enriched *ogi*. (45) also reported increase in lysine content when he supplemented nixtamalized maize flour with sprouted soybean flour. The main role of lysine is to participate in protein synthesis; hence, it is important for growth and maintenance of the body.

Glutamate and aspartate were the most abundant none essential amino acids found in all the samples and ranged between (5.83 to 7.21) and (6.02 to 6.99) g/100 g protein, respectively. However, there was a significant increase with different incorporation levels of flours and protein isolates from bambaranut and soybean. The 100 % maize *ogi* had the least values but was improved upon the addition of flours and protein isolates from bambaranut and soybean. The increase in glutamate and aspartate content of the fortified samples could be likened to the addition effect of legumes from bambaranut and soy flour in the blends. Several researchers have documented increase in glutamic and aspartic acid as a result of the effects of legumes in the blends, (45, 48, 49).

Generally, the protein isolates enriched *ogi*, (B) was the highest in all the amino acids analysed. This could be as a result of soy protein influence on the composites. Soy isolates had the highest protein contents. In all, the protein isolates enriched *ogi* and the flour enriched *ogi* (D) met the reference standard for all essential amino acids. Therefore, infant foods formulated from such blends ought to meet the essential amino acid needs of the infants.

Micronutrient Composition of Maize-Based Ogi Enriched with Bambaranut, Soybean and Protein Isolates (mg/100 g)

The sodium content of the protein isolates enriched *ogi* (D) (43.76 mg/100g) was found to be higher in value than the control and the flour samples. The unfortified *ogi* (A) had the least content of sodium. There was a significant ($p<0.05$) increase with the fortified samples. The sodium content was found to be between (8.02 and 43.76 mg/100g) which was higher than (7.12 to 8.56 mg/100g) reported by (50) who worked on the nutritional evaluation of maize-millet based complementary foods Fortified with Soybean but lower than (58.60 to 67.99 mg/100g) reported by (51) who studied the nutritional characteristics of maize-based complementary food enriched with fermented and germinated *Moringa oleifera* seed flour. Sodium is normally consumed in the form of salt; it is essential in the regulation of water content and in the maintenance of osmotic

pressure of the body fluid. It also aids in the transport of CO_2 in the blood. However, sodium is one of the minerals whose intake is considered a factor in the ethology of hypertension, hence its low intake is encouraged (52).

The phosphorus content of the fortified *ogi* showed significant increase ($p<0.05$) among the samples. there was an increment in the phosphorus content upon the addition of flours and protein isolates from bambaranut and soybean implying that both bambaranut and soybean are rich in phosphorus. Comparing the flour enriched *ogi* with the protein isolates enriched *ogi* showed that those of the flour enriched *ogi* were more abundant in phosphorus than the protein isolates enriched *ogi.* This can be attributed to the presence of ash in the flours as compared to the protein isolates fours. The ash content of food material could be used as an index of mineral constituents of the food because ash is the inorganic residue remaining after water and organic matter have been removed by heating in the presence of an oxidizing agent (53, 54). The phosphorus contents in this study were higher than (159.30-182.00 mg/100 g). The physico-chemical and sensory properties of complementary foods from blends of malted and non-malted sorghum, soybean and *moringa oleifera* seed flours. The recommended dietary allowance (RDA) for phosphorus in infants' food is ≥180 mg/100 g (55, 56) and all the fortified *ogi* had phosphorus contents above this value meaning that both the flours and protein isolates enriched *ogi* are adequate in phosphorus which is fundamental to growth, maintenance, and repair of all body tissues, and is necessary, along with calcium and magnesium, for proper growth and formation of bones in infants and children (57, 58).

The thiamine contents (0.25 to 0.98 mg/100 g) were lower in the protein isolate enriched *ogi* (C) and higher in the flour enriched *ogi* (D). The thiamine content was higher than (0.20 to 0.33 mg/100 g) but lower than (2.3 to 3.0 mg/100 g) reported by (58). The fortified and unfortified *ogi* met the Adequate Intake (AI) of infants 0-1 year (0.2 to 0.3 mg/day) reported by the (59) suggesting that *ogi* can be made from any of the combinations with the assurance that the niacin need of the infants will be taken care of. The lower contents of thiamine in the protein isolates enriched *ogi* (B and C) could be attributed to the processing techniques employed right from the raw materials to the isolation of bambaranut and soybean which were used in the blends. Thiamine serves as a cofactor for key enzymes involved in carbohydrate metabolism. Mild thiamine deficiency is a significant public health problem across the world (60). Severe deficiency causes beriberi, a disease that has been associated with high consumption of refined rice and cereals and low intakes of animal and dairy products (61).

The riboflavin contents (0.14 to 0.59 mg/100 g) are within (0.29 to 0.64) reported by (62) for nutrient composition and suitability of four commonly used local complementary foods in Akwa Ibom state, Nigeria. Addition of flours from bambaranut and soybean to maize *ogi* lead to a corresponding increase in their riboflavin contents while the addition of isolates from bambaranut and soybean lead to decrease in their riboflavin contents. This could be attributed to the fact that legume flours have appreciable level of vitamins in them. According to the Institute of Medicine, Food and Nutrition Board, the Adequate Intake (AI) for infants 0-1 years is (0.3 to 0.4 mg/day) and the flour enriched *ogi* (D and E) met this standard. Riboflavin plays a central role in the catabolism of carbohydrates. It provides the reactive moieties of the flavin coenzymes (FMN and FAD) which serve as electron carriers in redox reactions (63). Deficiency causes impaired growth, impaired vision, dermatitis, cracked and red lips and Inflammation of the lining of mouth and tongue (64).

Antinutritional Composition of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Cereals and legumes are rich in nutrients but the bioavailability of these nutrients is usually low due to the presence of antinutritional factors such as phytate, oxalate, tannin and trypsin inhibitor (65). Soaking, boiling, fermentation and sprouting are among the traditional processing methods usually employed to reduce or eliminate these anti-nutritional factors in foods (66). The total oxalate content of this study showed that the protein isolates enriched *ogi* (B) had the lowest content of total oxalate while the flour enriched *ogi* (E) had the highest value. The relatively high amount of oxalate in the flour samples could be attributed to the presence of bambaranut and soybean in the blends. The oxalate contents in this study values are within (0.20-7.10mg/100g) reported by (67) who worked on the production and quality evaluation of *ogi* from fermented maize and horse eye bean. Oxalates affects calcium and magnesium metabolism and react with proteins to form complexes which have an inhibitory effect in peptic digestion (68). Kidney stone patients who form calcium oxalate-containing stones are advised to limit their intake of foods which contain 410 mg oxalate per serving, with total oxalate intake not exceeding (50–60 mg/day) (69). since none of the *ogi* samples have oxalate content up to 50 mg/g, it can be inferred that both the fortified and unfortified *ogi* in this present study when consumed is safe and will not pose any adverse effect on the bioavailability of nutrients. Phytate as a very stable and potent chelating food component is considered to be an anti-nutrient by virtue of its ability to chelate divalent minerals and prevent their absorption (70). The Phytate contents (1.87 to 9.50 mg/100 g) are lower than (2.54 to 13.36) reported by (71) who worked on the nutritional composition and antinutritional properties of maize *ogi* cofermented with pigeon pea but higher than (2.16 to 2.45 mg/g) presented by (72) who worked on the anti-nutrient and mineral properties of complementary food from malted red sorghum and defatted soybean flour blend. The low Phytate content of the unfortified *ogi* (100% maize flour) as compared to the flour enriched *ogi* could be attributed to the leaching effect of the soaking and dehulling employed on maize grain before milling. The reduction in the phytate content of the 100 % maize *ogi* may be due to hydrolysis of phytate by the enzyme phytase into lower inositol phosphates which are believed to be activated during the fermentation process by organisms (yeasts) whose hydrolysing ability is enhanced by fermentation (73). Phytates are known to form complexes with iron, zinc, calcium, and magnesium making them less available and thus inadequate in food samples especially for children, (71). It is known that (10–50 mg) phytate per 100 g will not cause a negative effect on the absorption of zinc and iron (74). Hence, the Phytate contents of the various *ogi* obtained from this study showed the porridges are within the safe limit and will not cause health hazards.

Tannins are naturally occurring plant polyphenols. Their main characteristic is to bind and precipitate protein thereby interfering with its digestion and absorption (74). The tannin contents (0.22 to 7.81 mg/100g) are lower than (0.92 to 8.70 mg/100g) reported by (67) for *ogi* from fermented and unfermented horse eye bean. (75) reported lethal dose of tannins to be 90 mg/100g, the tannin contents in this present study are by far, lower than the lethal dose. therefore, the fortified and unfortified *ogi* can be said to be within safe limits. The low level of tannins recorded in the protein isolates enriched *ogi* (B and C) as against the flour enriched *ogi* could be due in part to the protein isolates inclusion in those blends. (76) reported antinutrients to be higher in flours but, were significantly reduced on isolation as a result of the processes involved in the isolation of protein. Also, the low content of tannin in the 100% maize flour (A) could be attributed to fermentation. Food processing like fermentation, sprouting, decanting etc. reduces the anti-nutritional content of food thereby activating the hydrolytic enzyme (α and β

amalyses) and proteolytic enzyme (69). The presence of tannins can cause browning or other pigmentation problems in both fresh foods and processed products, (72).

Generally, the anti-nutritional contents were seen to be higher in the flours when compared to the protein isolates samples. This may be due to the processes involved in the isolation of protein. The nutritional effect of these anti-nutrients is related to their interaction with protein and minerals, (76). It is of essence to note that, despite the increase in the anti-nutritional contents in the flour enriched *ogi* (D and E), their values are within the recommended safe limits. All the samples were low and may not pose any adverse effect on bioavailability of the nutrients.

Sensory Properties of Maize-Based *Ogi* Enriched with Bambaranut, Soybean Flours and their Protein Isolates

Sensory evaluation is usually carried out towards the end of product development or formulation cycle and this is done to assess the reactions of Consumers about the product to determine the acceptability of such product. It is also an important criterion for assessing quality in the development of new products and for meeting consumer requirements (77). The sensory characteristics of food products is important as it plays an important role in determining the final acceptability by consumers. Industries and food developers have embraced sensory evaluation as an invaluable tool for creating successful products and understanding the sensory properties of materials. The attributes evaluated in this research includes aroma, mouthfeel, appearance, taste, consistency and overall acceptability.

In terms of aroma, the control sample (100 %) maize *ogi* was rated highest followed by the protein isolates enriched *ogi* (B), 8.40 and 7.35, respectively. Significant differences existed among all the samples. The lower aroma value observed in the flour enriched *ogi* (E) as compared to the rest samples maybe attributed to the higher proportion of bambaranut flour that was used in substituting the blend. The panellist preference for the control sample (A) over the other formulations maybe due to their familiarity with the smell of maize *ogi*. Aroma is an important parameter of food (6). Good aroma from food excites the taste buds, making the system ready to accept the product. Poor aroma may cause outright rejection of food before they are tasted. The aroma ratings of the evaluated samples are within acceptable limits and therefore would not be objectionable to the infants, but could be further improved by adjusting processing conditions.

The result of the mouthfeel showed, the samples were significantly reduced ($p<0.05$) by the addition of flours and protein isolates from bambaranut and soybean. However, the protein isolates enriched *ogi* (B) had the highest mean score of (8.40) whereas the flour enriched *ogi* (E) had the lowest mean value of (6.25), implying that the protein isolates enriched *ogi* was most preferred in terms of mouthfeel. This could be attributed to the soft texture of soy protein isolates used in the blend. The observed differences in mouth feel in the protein isolates sample B as compared to the other samples could be attributed to the higher proportions of maize *ogi* used in the blend or simply due to the coarseness of maize *ogi* in the protein isolates blend.

The taste of the maize-based *ogi* decreased with the addition of flours and protein isolates. there was however, no significant difference between the flour samples (D and E) as well as the protein isolates samples (B and C). The scores for taste ranged between 8.55 to 6.00. Taste is the sweet sensation caused in the mouth by contact with sweetening agent and it is an important sensory attribute of any food. Porridges of samples A (100% maize ogi) and B of 90.65:9.35 of maize *ogi* blended with soy protein isolate had the highest taste scores. Differences in taste could be

attributed to molecular changes in the flour due to different processing conditions (soaking, Dehulling, drying and defatting) that the raw materials were subjected to (28).

The consistency results of *ogi* produced from (100 % maize flour), flours and protein isolates from bambaranut and soybean revealed that, the control sample A had the best rating of 8.70 followed by the protein isolates sample B 7.85. The differences in the consistency rating of sample A as compared to others may be due to constitutional variations. This consistency is very important, as it would determine the amount of food an infant can swallow, because infants can swallow a smooth gruel and not a coarse product. However, consistency of the composite diets was within acceptable limits. Water absorption capacity and swelling index are important parameters which determine the consistency of the flour. A very thick consistency would need increased efforts to swallow and therefore may limit the food intake in young children who have not fully developed their swallow ability (78).

The sensory scores for overall acceptability of the porridge samples ranged between 7.00 and 8.65. There were significant ($p<0.05$) differences among the samples. Sample A had the highest mean score of 8.65 followed by the protein isolates sample E 8.00, respectively. All the sensory scores evaluated were more than the minimum acceptable score of six (6) (79). The results revealed high mean scores in all the sensory attributes evaluated as all the samples maintained a high level of acceptability by the panelists suggesting that acceptable protein enriched *ogi* could be made from maize flour and either bambaranut or soy flours as well as their protein isolates.

CONCLUSION

The protein, amino acids, micronutrient, composition of the maize-based *ogi* were enhanced significantly following the addition of legume flours and protein isolates from bambaranut and soybean with decreased in antinutritional content which could help in alleviating protein energy malnutrition among under five children.

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