

Functional Properties, Proximate Composition, and Sensory Evaluation of Maize *Ogi* Enriched with African Yam Bean (*sphenostylis stenocarpa*), Soybean Flours (*Glycine max*), and Their Protein Isolates

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ABSTRACT

Background: *Ogi*, a traditional Nigeria fermented cereal gruel, is widely consumed but limited by low protein content. Enrichment with African Yam bean, soy flours, and their protein isolates has been shown to enhanced their quality attributes.

Aim: This study evaluated the effect of African yam bean, soy flours, and their protein isolates addition on the functional properties, proximate composition, and sensory evaluation of maize *ogi*. **Methods:** *Ogi* was formulated to achieve 16% protein (dry weight) using material balance. The control (A) consisted of 100% maize flour, sample B (53.40% maize *ogi*: 46.60% African yam bean flour, sample C (76.40% maize *ogi*: 23.40% soy flour), sample D (89.40% maize *ogi*:10.60% African yam bean protein isolate), and Sample E (90.20% maize *ogi*: 9.80% soy protein isolate). Standard laboratory methods were used for analyses. Sensory evaluation employed a modified hedonic test (Ochelle, 2025) with 30 panellists. **Results:** Enrichment significantly ($p<0.05$) altered the functional and proximate properties of *ogi*. Protein isolates had higher foaming capacity (D: 16.01%; E: 21.02%) and oil absorption capacity (D: 1.51 ml/g; E: 1.71 ml/g) as compared to flour-enriched samples (B: 9.87%; C: 14.31% and 1.01, 1.22 ml/g, respectively). Protein content was highest in protein isolates enriched with *ogi* (D: 22.66%; E: 24.10%) relative to flour-enriched samples (B: 16.04 %; C: 19.65%). Sensory scores showed the control (A: 8.71) was most preferred, and all other samples were within an acceptable range of 6-9. **Conclusion:** Enrichment of maize *ogi* with African yam bean, soy flours, and their protein isolates significantly enhanced protein and functional properties while maintaining consumer acceptability.

Keywords: Malnutrition, African Yam Bean, Soybean, Functional Properties, Proximate Composition, Sensory Evaluation

INTRODUCTION

Ogi or pap is a local generic name for a fermented gruel or porridge made from cereals (commonly maize, sorghum, or millet). It is a staple food in most African countries [1]. It is also known as akamu and koko in eastern and northern Nigeria, respectively. It is commonly used as a complementary food for babies and young children and as a standard breakfast cereal for many homes. It is a smooth, free-flowing thin porridge obtained from wet-milled, fermented cereal grains, popularly served as a breakfast cereal and infant complementary food in Nigeria [2]. *Ogi* is produced from cereals such as sorghum, maize, and millet or their combinations [3]. A major disadvantage of cereal-based gruel, such as maize *ogi*, is its starchy nature, which causes it to absorb excessive water, resulting in a bulky gruel with decreased nutrient density [4]. Maize is a popular cereal that could be processed into starch and used as soup thickeners, pap (*ogi*), solid gel (*eko*), and mashed maize (*egbo*). It could also be processed into snacks like donkwa, popcorn, aadun, kokoro, and elebute [5]. It is a common food product that is eaten in the family of carbohydrates after rice and wheat; it can be eaten roasted or boiled [5,6]. Soybean, a legume, is one of the nutritious and affordable sources of plant protein that has been employed to improve the diets of millions of people, especially low-income earners in developing countries, owing partly to its functional properties [7]. Soybeans contain proteins (40%), lipids (20%), minerals (5%), and B vitamins for human nutrition [8]. Processing is necessary to destroy or remove some of the undesirable constituents of legumes, such as to improve their palatability [9]. Compared to soybean, African yam bean is an underutilized legume indigenous to West and East Africa with nutritional content comparable to other commonly consumed legumes. The nutrient density of the crop makes it a viable food crop for ameliorating the challenges of malnutrition faced in many developing countries, via direct consumption or fortification and enrichment of less nutritious staples. African yam bean is a hard-to-cook underexploited leguminous plant grown extensively in Western Africa [10], Eastern and Central Africa [11]. Protein isolates are the most refined form of protein products containing the greatest concentration of protein (90 %) on a dry weight basis [12]. Its 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's 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]. A combination of flours and protein isolates from African yam bean and soybean with maize in *ogi* preparations led to nutritional enhancement of maize *ogi*. Malnutrition remains a critical issue in many developing countries, especially among children and low-income communities, where diets are often deficient in essential nutrients. *Ogi*, a popular cereal-based gruel in Nigeria, is commonly made from maize and other cereals, but its high starch content and low protein levels make it nutritionally inadequate [3]. Regular consumption of *ogi* as a staple food can lead to protein-energy malnutrition and deficiencies in essential amino acids, vitamins, and minerals [15]. Despite various efforts to fortify cereal-based foods, the lack of affordable, nutrient-dense options persists. Furthermore, while legumes like African yam bean and soybean, rich in bioactive peptides, are known for their high protein and nutrient content [16,17], they remain underutilized in traditional diets. There is a critical need to enhance the nutritional profile of *ogi* by incorporating these nutrient-rich ingredients. This research seeks to address the problem of malnutrition by developing and evaluating *ogi* enriched with flours from African yam bean and soy flours and their protein isolates, and to assess the potential of this enriched product to provide a nutritionally balanced food source that can improve the dietary intake of vulnerable populations. *Ogi*, when prepared from maize and other cereal grains alone, is deficient in protein and could predispose high patronage communities (especially under-five children) to protein energy malnutrition. Processing of *ogi* (porridge) enriched with protein-rich legumes such as African yam bean, soybean, alongside their flours and protein isolates could combat malnutrition deficiency, while addressing significant health concerns. The broad objective of this work is the functional, proximate, and sensory evaluation of maize *ogi* enriched with flours and protein isolates from African yam bean and soybean.

MATERIALS AND METHODS

Materials

Maize (*Zea mays*), African yam bean (*Sphenostylis stenocarpa*), and soybean (*Glycine max*) were obtained from Wednesday Market, Dutsin-Ma, Katsina State. All equipment used was obtained from the Department of Food Science and Technology, Faculty of Renewable Natural Resources, Federal University, Dutsin-Ma, Katsina State.

Methods

Preparation of maize Ogi

ogi was processed according to the modified method of Chike and Onuoha [18] as shown in Figure 2. Maize grains were obtained, sorted to eliminate the bad grains, cleaned to remove debris and foreign materials, 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 commercial maize mill, and wet-sieved using a 250 µm sieve. The husks were disposed of while the filtrate (slurry) was allowed to ferment for 48 h. At the end of the fermentation period, the *ogi* was recovered by using a cheese cloth to squeeze out the water. The wet *ogi* sample was then dried in an oven (60 °C, 12 h). The dried starchy cake obtained was milled and sieved to obtain *ogi* flour.

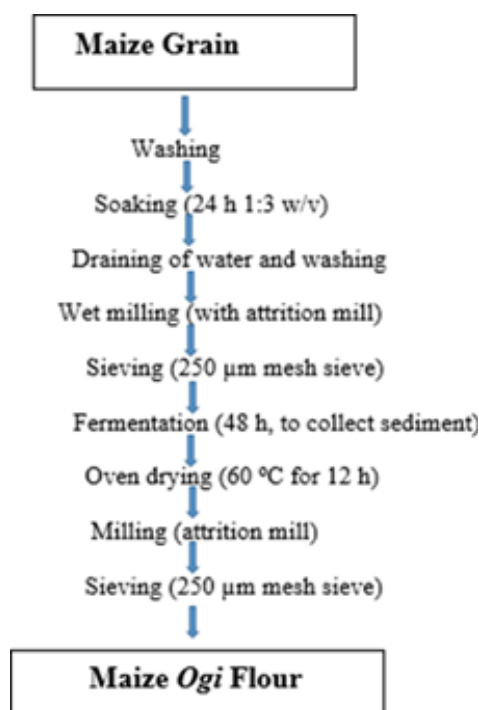


Figure 1. Flow Diagram for the Processing of Maize Ogi.

Source: [18] modified.

Production of African Yam Bean Flour

African yam bean flour was prepared according to the modified method described by [19] as shown in (Figure 3). African yam bean was sorted to remove extraneous materials and damaged seeds. Soaked (10 h at 1:2 w/v), boiled for 30 min, dehulled manually (by rubbing in between the palms),

and oven dried in the Gallenkamp (United Kingdom) moisture extraction oven at 60 °C for 12 h. The dried African yam bean was milled in a disc attrition mill into fine flour, followed by sieving through a 250µm mesh and packaging in airtight plastic containers, which were placed on shelves at room temperature until used.

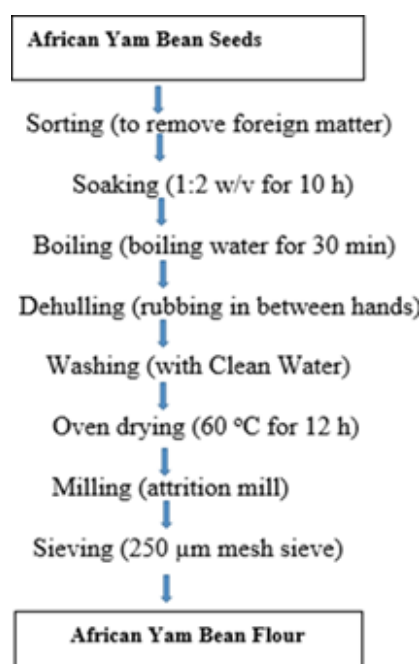


Figure 2. Flow Chart for the Processing of African Yam Bean Flour.

Source: Igboke et al. [19].

Production of Soybean Flour

Soybean flour was processed according to the modified method described by Bolarinwa et al. [20]. 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 a 250 µm mesh sieve to obtain smooth flour, as shown in Figure 3. The flour was defatted using n-hexane (flour to solvent ratio 1:5 w/v) as shown in Figure 5, 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.

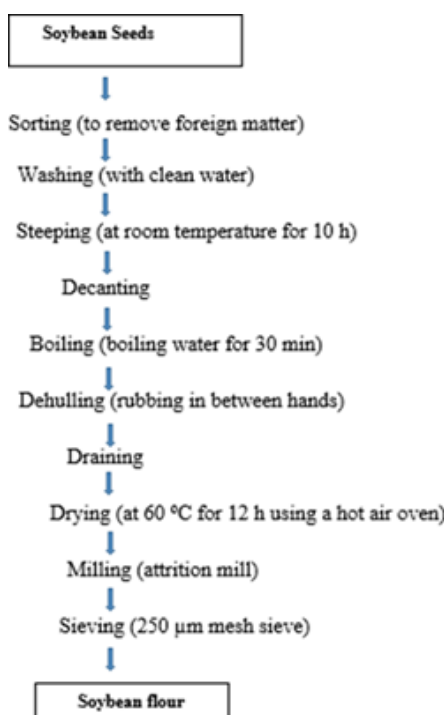


Figure 3. Flow Chart for the Processing of Soybean Flour.

Source: Bolarinwa et al. [20].

Processing of African Yam Bean Protein Isolate

African yam bean protein isolates were extracted from defatted African yam bean flour using a modified isoelectric precipitation procedure as described by Gbadamosi et al. [21]. The defatted flour was dispersed in distilled water at a 1:10 (w:v) ratio. This was followed by an 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. The residue was discarded, and the supernatant was 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 redispersed in 25 ml of distilled water, frozen at 0 °C, and then freeze-dried at -52 °C to yield a free-flowing powder. The African yam bean protein isolates were stored in a sealed tube at 4 °C until analyzed. The flow chart for the processing of African yam bean protein isolates is shown in Figure 4.



Figure 4. Flow chart for the processing of African Yam Bean Protein Isolates.

Source: Gbadamosi et al. [21] modified.

Processing of Soy Protein Isolate

Protein was extracted from defatted soy flour using a modified isoelectric precipitation procedure as described by Gbadamosi et al. [21]. The defatted flour was dispersed in distilled water at a 1:10 (w:v) ratio. This was followed by an 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 was 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 of 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. The flow chart for the processing of soy protein isolates is shown in Figure 5. The blend formulation is presented in Table 1.

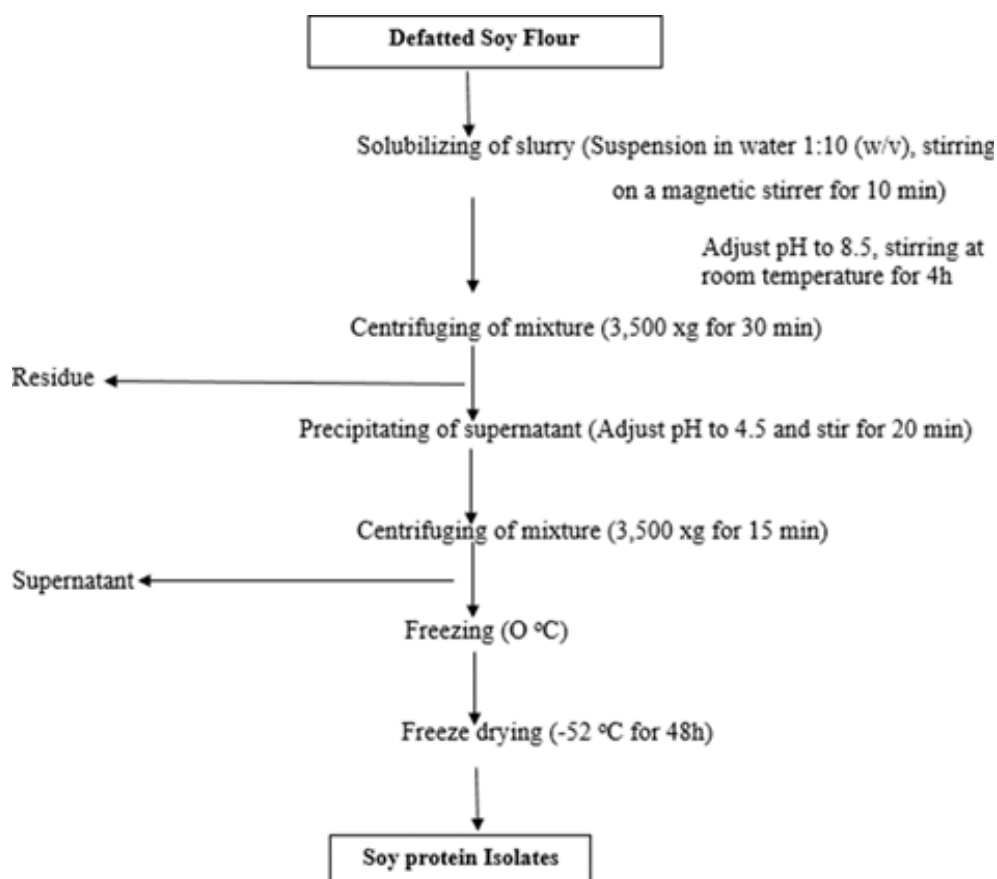


Figure 5. Flow Chart for the Processing of Soy Protein Isolates.

Source: Gbadamosi et al. [21] modified.

Table 1. Blend Formulation to Achieve (16 %) Protein Content

Samples	Maize Flour (MF)	African Yam Bean (AYBF)	Soybean Flour (SF)	African Yam Bean Protein Isolate (AYBPI)	Soy Protein Isolate (SPI)	Total
A	100	-	-	-	-	100
B	53.40	46.60	-	-	-	100
C	76.40	-	23.60	-	-	100
D	89.40	-	-	10.60	-	100
E	90.20	-	-	-	9.80	100

Functional Properties of Maize-Based *Ogi* Enriched with Flours and Protein Isolates from African Yam Bean and Soybean

Bulk density (BD)

This was determined according to the method of Onwuka [22]. A ten millilitres capacity graduated cylinder was weighed on a digital balance. The cylinder was gently filled with the sample. The bottom of the cylinder was tapped on the laboratory bench several times until no further diminution of the sample level occurred after filling to the 10 ml mark.

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

Oil absorption capacity (OAC)

One gram of the sample was weighed into a 20 ml conical graduated centrifuge tube. Ten millilitres of vegetable oil of a known density (0.99 mg/ml) was added to the sample, and the mixture was stirred on a magnetic stirrer at 1000 rpm for 5 min. The mixture was centrifuged at 3500 rpm for 30 min, and the supernatant was removed and measured with a 10

ml measuring cylinder [22]. The OAC was calculated thus, Oil absorption capacity = volume of oil absorbed $\times$ density $\times$ 100/ weight of sample used.

Water absorption capacity (WAC)

The water absorption capacity of the flour blends was determined as described by Onwuka [22]. One gram of the sample was weighed into a 20 ml conical graduated centrifuge tube. Using a warring whirl mixer, the sample was mixed thoroughly with 10ml of distilled water in a centrifuge tube for 30 minutes. The sample was allowed to stand for 30 minutes at room temperature and centrifuged at 500 rpm for 30 minutes. The volume of free water (the supernatant) was read directly from the graduated centrifuge tube.

$$\% \text{ WAC} = \frac{\text{Weight of water bound}}{\text{Weight of sample (dry basis)}} \times 100 \quad (2)$$

Swelling index

The swelling index was determined using the method of Onwuka [22]. Five grams' portion (dry basis) of each sample was transferred into clean, dried graduated (50ml) cylinders. The samples were gently levelled and the volumes noted. Fifty millilitres of distilled water was added to each sample. The cylinder was swirled and allowed to stand for 60 minutes while the volume change (swelling) was recorded every 15 minutes. The ratio of the initial volume to the final volume gave the swelling index.

$$\% \text{ Swelling index} = \frac{\text{Change in volume of sample (ml)}}{\text{Original volume of sample (g)}} \quad (3)$$

Foaming capacity

Foaming capacity was determined by the method of Onwuka [22]. One gram of each sample was blended with 50 mL of distilled water and whipped for 5 minutes at 1600 rpm. The whipped mixture was transferred into a 250ml measuring cylinder, and the volume was recorded after 30 seconds. Foam capacity was expressed as a percentage increase in volume using the formula below.

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

Gelatinization temperature

The gelatinization temperature was determined according to the method described by [22]. A suspension of 10 % of the sample in a test tube was prepared, and the aqueous suspension was heated in a boiling water bath with continuous stirring and was heated. The temperature 30 seconds after gelatinization was visually noticed as the gelatinization temperature and recorded.

Proximate Composition (%) of Maize Ogi Enriched with Flours and Protein Isolates from African Yam Bean and Soybean

Determination of moisture content

The moisture content was determined by the hot air oven method as described by AOAC [24]. An empty crucible was weighed, and 2 g of the sample was transferred into the crucible. This was taken into the hot air oven and dried for 24 h at 100 °C. The loss in weight was regarded as the moisture content and expressed as:

$$\% \text{Moisture} = \frac{W_2 - W_1}{W} \times 100 \quad (5)$$

Where:

W₂=Weight of the crucible and dry Sample

W₁=Weight of empty crucible

Weight of the Sample

Determination of Crude Protein Content

The microkjeldahl method, as described by AOAC [24], was used to determine the crude protein content of the maize *ogi*. Two grams of the sample were put into the digestion flask. The gramme of copper sulphate and sodium sulphate (catalyst) in the ratio 5:1, respectively, and 25ml concentrated sulphuric acid was added to the digestion flask. The flask was placed into the digestion block in the fume cupboard and heated until frothing ceased, giving a clear and light green colouration. The mixture was allowed to cool and diluted with distilled water until it reached 250 ml in a volumetric flask. The distillation apparatus was connected, and 10ml of the mixture was poured into the receiver of the distillation apparatus. Also, 10ml of 40% sodium hydroxide was added. The released

ammonia by boric acid was treated with 0.2 M of hydrochloric acid until the green colour changed to purple. The percentage of nitrogen in the sample was calculated using the formula:

Crude protein = % Total Nitrogen = (Titre blank) x Normality x N₂. Nitrogen factor = 6.25.

Crude protein% % total Nitrogen X 6.25

Determination of crude fat content

The Soxhlet extraction method described by AOAC [24] was used in determining the crude fat content of the samples. Two grams of the sample were weighed, and the weight of the flat-bottom flask was taken with the extractor. Mounted on it, the thimble was held halfway into the extractor, and the weight of the sample was applied. Extraction was carried out using a boiling point of 60 oC. The thimble was plugged with cotton wool. At completion of the extraction, which lasted for 8 hours, the solvent was removed by evaporation on a water bath, and the remaining part in the flask was dried at 80 oC for 30 minutes in the air oven to dry the fat, then cooled in a desiccator. The flask was reweighed and the percentage fat calculated thus:

$$\% \text{ fat} = \frac{\text{Weight of extracted fat}}{\text{Weight of sample}} \times 100 \quad (7)$$

Determination of ash contents

The AOAC [24] method for determining ash content was used. Two grams of the sample were weighed into an ashing dish, which had been pre-heated, cooled in a desiccator, and weighed after reaching room temperature. The crucible and content were then heated in a muffle furnace at 550 °C for 6-7 h. The dish was cooled in a desiccator and weighed after reaching room temperature. The total ash was calculated as a percentage of the original sample weight.

$$\% \text{ Ash} = \frac{(W_3 - W_1)}{(W_2 - W_1)} \times 100 \quad (8)$$

Where:

W₁ = Weight of empty crucible,

W₂ = Weight of crucible + sample before ashing,

W₃ = Weight of crucible + content after ashing.

Determination of Crude Fiber Content

The method described by AOAC [24] was used for fibre determination. Two (2) grams of the sample were extracted using diethyl ether. This was digested and filtered through the California Buchner system. The resulting residue was dried at 130 ± 2 °C for 2h, cooled in a desiccator, and weighed. The residue was then transferred into a muffle furnace (Shanghai box type resistance furnace, No.: SX2-4-10N) and ignited at 550 °C for 30 min, cooled, and weighed. The percentage crude fibre content was calculated as:

$$\% \text{ Crude fibre} = \frac{\text{Loss in weight after incineration}}{\text{Weight of original food}} \quad (9)$$

Determination of Carbohydrate Content

Carbohydrate content was determined by difference as follows:

$$\% \text{ Carbohydrate} = 100 - (\% \text{moisture} + \% \text{Protein} + \% \text{Fat} + \% \text{Ash} + \% \text{Fibre})$$

Energy value (Kcal)

The caloric value (Kcal) was calculated by multiplying the mean of crude protein and total carbohydrate by the Atwater factor by 4 each, and that of crude fat multiplied by 9, and summing up the products as the energy value.

Sensory Properties of Maize *Ogi* Enriched with Flours and Protein Isolates from African Yam Bean and Soybean.

Sensory evaluation was conducted using the 9-point hedonic scale as described by Iwe [25], with modifications in the number of panellists. Unlike earlier works that employed 20 - 25 panellists, this study engaged thirty (30) panellists to improve precision and reliability. Maize *ogi*, which was neither too thin nor too thick, was prepared by mixing 40 g of each flour sample in 80 ml of hot water using a graduated plastic cup. Hot water was boiled using a cordless electric kettle (Sayona, model no. SCK-25). Maize *ogi* from the various flour blends was presented to a panel of 30 judges, including both students and members of staff of the Department of Food Science and Technology, Federal University, Dutsin-Ma, Katsina, Nigeria, to obtain a triad for sensory quality evaluation, chosen based on their familiarity and experience with maize *ogi*. *ogi* produced from each flour blend, along with the reference sample, was presented in various coded forms and was randomly presented to the panellists. The panellists were provided with portable water to rinse their mouths between

evaluations. However, a questionnaire describing the quality attributes (aroma, mouthfeel, taste, consistency, and overall acceptability) of the *ogi* samples was given to each panellist. A nine (9) point Hedonic scale as described by [25] was used with 1 and 9 representing dislike extremely and like extremely, respectively. 9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like nor dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much and 1 = dislike extremely.

Statistical Analysis of Samples

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

RESULTS

Functional Properties of the Individual Flours and Their Protein Isolates

The flours and protein isolates used in the formulation of maize-enriched *ogi* were characterized separately for their functional properties, as shown in Table 2. The bulk density, oil absorption capacity, water absorption capacity, and swelling index differed significantly ($P < 0.05$). The bulk density ranged between 0.45 to 0.76 g/ml, the oil absorption capacity ranged from 1.00 to 1.43 ml/g, the water absorption capacity ranged between 1.00 and 1.59 ml/g, and the swelling index 1.01 and 1.75, respectively. The foaming capacity and gelatinization temperature ranged between 5.17 to 14.10 (%) and 49.99 to 70.50 °C, respectively.

Table 2. Characterization of Functional Properties of Maize Ogi, African yam bean flour, Soy flours, and Their Protein Isolates

Sample	BD (g/ml)	OAC (ml/g)	WAC (ml/g)	SI	FC (%)	GT (°C)
Maize ogi	0.76 ^a ±0.01	1.00 ^a ±0.03	1.59 ^a ±0.02	1.75 ^a ±0.02	5.17 ^a ±0.02	49.99 ^a ±0.02
African yam bean flour	0.69 ^b ±0.02	1.06 ^d ±0.02	1.46 ^b ±0.02	1.33 ^b ±0.02	7.60 ^d ±0.02	56.39 ^d ±0.02
Soyflour	0.57 ^c ±0.03	1.18 ^c ±0.02	1.30 ^c ±0.02	1.19 ^c ±0.02	8.88 ^c ±0.02	60.59 ^c ±0.02
African yam bean protein isolates (AYBPI)	0.49 ^d ±0.02	1.31 ^b ±0.02	1.15 ^d ±0.02	1.10 ^d ±0.03	10.05 ^b ±0.02	68.04 ^b ±0.03
Soy Protein Isolates (SPI)	0.45 ^e ±0.02	1.43 ^a ±0.02	1.00 ^e ±0.02	1.01 ^e ±0.02	14.10 ^a ±0.03	70.50 ^a ±0.02

Values are means ± standard deviations of triplicate determinations.

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

BD Bulk Density, OAC Oil Absorption Capacity, WAC= Water Absorption Capacity, SI= Swelling Index, FC= Foaming Capacity, and GT= Gelatinization Temperature.

Proximate Composition of the Individual Flours and Their Protein Isolates

The flours and protein isolates used in the formulation of maize-enriched *ogi* were characterized separately for their proximate composition, as shown in Table 3. There were significant differences ($P < 0.05$) in the moisture, crude protein, crude fat, crude ash, crude fiber, carbohydrate, and energy contents of the samples. The moisture content of maize *ogi*, African yam

bean flour, soyflour, and their protein isolates were 10.20 %, 9.00%, 8.50%, 5.10% and 4.50 %, respectively. The crude protein content of maize *ogi*, African yam bean flour, soyflour, and their protein isolates were 9.00%, 24.00%, 38.65%, 74.70% and 80.10%, respectively. The crude fat content of maize *ogi*, African yam bean flour, soyflour, and their protein isolates were 4.50%, 2.80%, 19.00 %, 1.20 %, and 0.80 %, respectively. The ash contents were: 1.30 %, 3.33 %, 4.50%, 3.00 % and 2.90 %, respectively. The crude fiber content of maize *ogi*, African yam bean flour, soyflour, and their protein isolates was 2.20 %, 3.82 %, 3.03 %, 0.87 %, and 0.50 %, respectively. The carbohydrate content of maize *ogi*, African yam bean, soyflour, and their protein isolates were 72.80 %, 57.90%, 26.35%, 14.81 %, and 11.20%, respectively. Also, the energy value (Kcal) for the various flours: maize *ogi*, African yam bean flour, soyflour, and their protein isolates were; 367.70kcal, 352.80 kcal, 336.00 kcal, 370.03 kcal, and 372.40 kcal, respectively.

Table 3. Characterization of Proximate Composition of Maize Ogi, African yam bean, Soybean Flours, and their Protein Isolates

Samples	Moisture content	Protein	Fat	Fibre	Ash	CHO	Energy
Maize Ogi	10.20 ^a ±0.02	9.00 ^e ±0.03	4.50 ^b ±0.8	2.20 ^c ±0.02	1.30 ^d ±0.01	72.80 ^a ±0.02	367.70 ^c ±0.10
African yam bean flour	9.00 ^b ±0.40	24.00 ^d ±0.51	2.80 ^c ±0.05	3.80 ^a ±0.05	3.22 ^b ±0.16	57.90 ^b ±0.04	352.80 ^d ±0.04
Soyflou R	8.50 ^c ±0.03	38.65 ^c ±0.03	19.00 ^a ±0.02	3.00 ^b ±0.12	4.50 ^a ±0.02	26.35 ^c ±0.02	336.00 ^e ±1.00
yam bean protein isolates	5.10 ^d ±0.02	74.70 ^b ±0.49	1.20 ^d ±0.02	0.87 ^d ±0.06	3.03 ^c ±0.16	14.81 ^d ±0.02	370.03 ^b ±0.07
Soy protein isolates	4.50 ^e ±0.02	80.10 ^a ±0.03	0.80 ^e ±0.02	0.50 ^e ±0.03	2.90 ^c ±0.02	11.20 ^e ±0.02	372.40 ^a ±0.02

Values are means ± standard deviations of triplicate determinations.

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

Functional, Proximate, and Sensory Evaluation of Maize Ogi Enriched with African yam bean Flour, Soyflour, and their Protein Isolates

Functional properties of maize *ogi* enriched with African yam

bean flour, soyflours, and their protein isolates are presented in Table 4. The bulk density for the unfortified sample (100% maize *ogi*) and fortified samples were: 0.76, 0.69, 0.57, 0.49, and 0.45 (g/ml), respectively. Results were significantly influenced (P<0.05) by various substitution levels of flours and protein isolates from African yam bean flour and soyflour. Also, OAC, WAC, SI, FC, and GT were found to range significantly (P<0.05) between 1.01 to 1.71 (ml/g), 1.18 to 1.61 (ml/g), 1.28 to 1.78, 5.19 to 21.02 (%) and 50.01 to 80.01 (°C), respectively.

Table 4. Functional Properties of Maize Ogi Enriched with African yam bean, Soy Flours, and their Protein Isolates

Sample	BD (g/ml)	OAC (ml/g)	WAC (ml/g)	SI	FC (%)	GT (°C)
A	0.81 ^a ±0.02	1.01 ^e ±0.03	1.61 ^a ±0.02	1.78 ^a ±0.03	5.19 ^e ±0.02	50.01 ^e ±0.02
B	0.74 ^b ±0.01	1.22 ^d ±0.03	1.49 ^b ±0.01	1.57 ^b ±0.02	9.87 ^d ±0.02	60.00 ^d ±0.02
C	0.66 ^c ±0.02	1.41 ^c ±0.02	1.37 ^c ±0.02	1.49 ^c ±0.02	14.31 ^c ±0.03	65.69 ^c ±0.50
D	0.63 ^c ±0.02	1.51 ^b ±0.02	1.29 ^d ±0.03	1.33 ^d ±0.03	16.01 ^b ±0.03	72.55 ^b ±0.02
E	0.59 ^d ±0.02	1.71 ^a ±0.02	1.18 ^e ±0.02	1.28 ^e ±0.03	21.02 ^a ±0.02	80.01 ^a ±0.03

Values are means ± standard deviations of triplicate determinations.

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

Key: Sample A (100 % maize *ogi*), Sample B (53:40 maize *ogi* and 46.60 African yam bean flour), Sample C (76.40 maize *ogi* and 23.40 soy flour), Sample D (89.40 maize *ogi* and 10.60 African yam protein isolate), and Sample E (90.20 maize *ogi* and 9.80 soybean protein isolates).

The proximate composition (% dry weight) of maize *ogi*

enriched with African yam bean flour, soyflours, and their protein isolates is depicted in Table 5. The moisture content, crude protein, and crude fat content of the composite flour ranged between 4.50 to 10.20 %, 9.17 to 24.10 %, and 0.80 to 4.50 % respectively. The ash, crude fiber, carbohydrate, and energy content of the samples ranged between 1.30 to 4.50 %, 0.50 to 3.82 %, 59.40 to 72.63 % and 350.62 to 372.64 kcal, respectively. Sensory properties of maize *ogi* enriched with African yam bean flour, soyflour, and their protein isolates are presented in Table 6. Sensory scores for aroma, appearance, taste, and consistency ranged between 7.30 and 8.44, 7.60 to 8.40, 7.78 to 8.81, and 7.50 to 8.15, respectively.

Table 5. Proximate Composition (% dry weight) of Maize Ogi Enriched with African yam bean, Soy Flours, and their Protein Isolates

Sample	Moisture content	Protein	Fat	Fibre	Ash	CHO	Energy
A	10.20 ^a ±0.02	9.17 ^e ±0.07	4.50 ^b ±0.02	2.20 ^c ±0.02	1.30 ^d ±0.02	72.63 ^a ±0.08	367.70 ^c ±0.02
B	9.04 ^b ±0.16	16.04 ^d ±0.03	2.81 ^c ±0.01	3.82 ^a ±0.06	3.33 ^b ±0.33	65.30 ^c ±0.01	350.62 ^a ±0.23
C	8.50 ^c ±0.02	19.65 ^c ±0.03	4.92 ^a ±0.02	3.03 ^b ±0.07	4.50 ^a ±0.02	59.40 ^d ±0.07	360.47 ^d ±0.12
D	5.10 ^d ±0.02	22.66 ^b ±0.57	1.20 ^d ±0.03	0.90 ^d ±0.03	3.00 ^c ±0.02	67.14 ^b ±0.52	370.12 ^b ±0.24
E	4.50 ^e ±0.03	24.10 ^a ±0.03	0.80 ^e ±0.03	0.50 ^e ±0.03	2.90 ^c ±0.03	67.20 ^b ±0.15	372.64 ^a ±0.47

Values are means ± standard deviations of triplicate determinations.

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

Key: Sample A (100 % maize *ogi*), Sample B (53:40 maize *ogi* and 46.60 African yam bean flour), Sample C (76.40 maize *ogi* and 23.40 soy flour) Sample D (89.40 maize *ogi* and 10.60 African yam protein isolate) and Sample E (90.20 maize *ogi* and 9.80 soybean protein isolates)

Sensory Scores of Maize Ogi Enriched with African yam bean flour, Soy flour, and their Protein Isolates

Sensory properties of maize *ogi* enriched with African yam bean flour, soy flour, and their protein isolates are presented in Table 6. Sensory scores for aroma, mouthfeel, taste, consistency, and overall acceptability ranged between 6.79 and 8.04, 7.55 to 8.20, 7.78 to 8.81, 7.50 to 8.15, 8.33 to 8.71, respectively.

Table 6. Sensory Evaluation of Maize Ogi Enriched with African yam bean, Soy Flours, and their Protein Isolates

Sample	Aroma	Mouth feel	Taste	Consistency	Overall Acceptability
A	8.04 ^a ±0.01	8.20 ^a ±0.01	8.81 ^a ±0.01	7.50 ^e ±0.02	8.71 ^a ±0.02
B	7.39 ^b ±0.02	8.00 ^b ±0.01	8.10 ^b ±0.02	7.71 ^d ±0.02	8.40 ^b ±0.02
C	7.30 ^c ±0.02	7.85 ^c ±0.02	8.09 ^b ±0.02	7.91 ^c ±0.02	8.60 ^c ±0.02
D	6.90 ^d ±0.02	7.70 ^d ±0.02	7.82 ^c ±0.02	8.10 ^b ±0.02	8.12 ^d ±0.02
E	6.79 ^e ±0.02	7.55 ^e ±0.02	7.78 ^d ±0.02	8.15 ^a ±0.02	8.33 ^a ±0.02

Values are means ± standard deviations of triplicate determinations.

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

Key: Sample A (100 % maize *ogi*), Sample B (53:40 maize *ogi* and 46.60 African yam bean flour), Sample C (76.40 maize *ogi* and 23.40 soy flour) Sample D (89.40 maize *ogi* and 10.60 African yam protein isolate) and Sample E (90.20 maize *ogi* and 9.80 soybean protein isolates).

DISCUSSION

Functional and Proximate Properties of the Individual Flours and Protein Isolates

Proximate assay is an important criterion used to assess the overall composition and nutritional status of any ingredient intended for food [26]. The proximate composition of maize *ogi*, and flours and protein isolates from African yam bean and soyflour showed a moisture content range of maize *ogi* (4.50 to 10.20 %) observed to be significantly lower (p<0.05)

than the (7.85 to 14.91 %) reported by [27] who worked on the chemical composition, functional, and sensory properties of maize *ogi* fortified with periwinkle meat flour. Soy protein isolate had the highest crude protein content of 80.10% similar to (89.31 %) for soy protein isolates reported by [28], who work on the quality and sensory properties of maize flour cookies enriched with soy protein isolate. The difference in value could be attributed to a varietal difference. Flours from African yam bean and soybean were found to be richer in fat, ash, and fiber when compared to their corresponding protein isolates. This could be as a result of the defatting process embarked upon isolation of protein. Also, the African yam bean and soy protein isolates had higher energy value when compared to their flour samples. The high energy value is of the essence since growing children need a lot of energy to support their growth. The values as well as extents of changes in functional properties of maize flour and flours from African yam bean and soybean were lower in most cases than in the protein isolates (Table 2). Adeyeye SAO, et al. [28] reported superior functionality for protein isolates compared to their respective flours. This might have been due to the concentration effects in moving from the multi-component flours to the isolated protein.

Functional Properties of Maize *Ogi* Enriched with African, Soy flours and their Protein Isolates

Bulk density results are used to evaluate the flour heaviness, handling requirement, and the type of packaging materials suitable for storage and transportation of food materials [29]. It indicates different packaging spaces and materials required for various food samples. Bulk density is a reflection of the load the samples can carry if allowed to rest directly on one another [3]. The bulk density of the maize *ogi* decreased with different incorporation levels of different levels of flours and protein isolates from African yam bean and soy flours. The bulk density of the 100 % maize *ogi* (0.81 g/ml) was higher than (0.60 g/ml) for maize *ogi* reported by Inyang and Effiong [27] but lower than (0.98) for maize *ogi* reported by [30]. It has been reported that bulk density is influenced by the structure of the starch polymers, and a loose structure of the starch polymers could result in low bulk density [31]. The observed decrease in bulk density with the addition of protein isolates, as observed in the protein isolates-enriched *ogi* (D and E) compared to those of flour-enriched *ogi* (B and C), could be a result of a reduction in carbohydrate content, which is known to influence bulk density [32]. The low bulk density observed

in the flour and protein isolates enriched *ogi* is a good physical attribute in terms of transportation and storability [3]. Low bulk density is also important in infant feeding, where less bulk is desirable for their small stomach as it engenders consumption of more quantity of the lighter food items and consequently, more nutrients for the infants. In this study, the values for oil absorption capacity of the 100 % maize *ogi* increased with the enrichment of flours and protein isolates from African yam bean and soybean. This is in line with Inyang and Effiong [27], who recorded 0.75 ml/g for maize *ogi* increment with different incorporation levels of periwinkle meat flour. The higher oil absorption capacity recorded with *ogi* enriched with protein isolates in samples D and E over the control and flour samples could be attributed to the higher protein content and their hydrophobicity. Oil absorption capacity is a measure of the flavor-retaining capacity of flour, which is very important in food formulations [33]. Oil absorption capacity also measures the ability of food materials to absorb oil [34]. Nonpolar amino acids are known to enhance hydrophobicity, causing flours to absorb more oil [35]. Consequently, *ogi* enriched with protein isolates has the potential to result in enhancement of flavor, improvement of palatability, and extension of shelf life of bakery or meat products, doughnuts, baked goods, porridges, pancakes, and soup mixes where fat absorption is desired. Oil absorption capacity is of great importance since fat acts as a flavor retainer and increases the mouth feel of foods [36]. The water absorption capacity of the samples decreased significantly ($p < 0.05$), with the addition of flours and protein isolates from African yam bean and soy flour. The water absorption capacity ranged from 1.18 to 1.61 ml/g. The water absorption capacity was highest for the control (sample A) and lowest for the maize *ogi* enriched with soy protein isolates (D and E). These results of these values are in agreement with the findings of Abioye et al. [37] and Ochelle et al. [38]. The higher water absorption capacity in the control sample could be attributed to its higher starch content. Jude-Ojei et al. [39] reported that flours with higher starch contents absorb a lot of water and swell rapidly as compared to food materials with less starch content. Water absorption capacity is the ability of a product to incorporate water, and water inhibition is an important functional trait in food such as sausages, custard, and dough [40]. It also refers to water retained by a food product following filtration and application of mild pressure of centrifugation [41]. Water absorption of flours is dependent mainly on the amount and nature of the hydrophilic constituents and, to some extent, on pH and the

nature of the protein. It has been suggested that flours with high water absorption capacity, as seen in the control sample, could prevent staling by reducing moisture loss [38]. Result of the swelling capacity showed that all the samples differed significantly ($p < 0.05$) with the addition of flours and protein isolates from African yam bean and soybean. The value of the swelling capacity ranged from 1.02 to 1.75. The swelling capacity was highest for sample A (100% wheat flour) and lowest for sample E. This result agrees with [3]. A decrease in the swelling index could be due to weak bond forces with the addition of African yam bean and soybean flours and their isolates. The swelling capacity of flour granules indicates the extent of associative forces within the granule. Addition of flours and protein isolates to the maize *ogi* significantly ($p < 0.05$) improved the foaming capacity of the blends, ranging from 5.19 % in 100% maize *ogi* (A) to 21.02 % (E) for soy protein isolate-enriched *ogi*, owing to the higher protein content in the enriched blends. Brou et al. (2013) reported that foaming capacity is positively correlated with protein contents of food substances. Inyang and Effiong [27] opined that the ability of flours to generate foams depends on the presence of flexible protein molecules, which tend to decrease the surface tension of water. Foaming capacity is used to determine the ability of flour to foam, which is dependent on the presence of the flexible protein molecules that decrease the surface tension of water [42]. The higher foaming capacity of African yam bean and soy flour blends samples suggests that they may be good forming agents where forming is essential, such as in the beverage industries. Good foaming capacity is also desirable in the food system, where conferment of porosity is essential. The gelation temperature decreased significantly ($p < 0.05$) down the column with the addition of African yam bean and soybean flour; the value of the gelation temperature ranged from 49.99 to 70.50°C. Sample E had the lowest gelation temperature, while sample A had the highest gelation temperature. The results of these values are not in agreement with [43] who worked on the effect of acha and sprouted soybean flour addition on the quality of wheat based cookies but within the range of results of (50.63 -79.01) reported by [3], who worked on the quality evaluation maize based *ogi* enriched with flours and protein isolates from bambaranut and soybean flours with their isolates. Increasing fiber content appears to delay gelation and subsequently its temperature. Thus, higher heat energy is required to attain significant gelation. Gelling temperature might be associated with the relative ratio of amylase and amylopectin [44] in the composite flour.

Proximate Composition of Maize *Ogi* (% dry weight) Enriched with African yam bean, Soy Flour, and their Protein Isolates

The proximate composition of maize *ogi* enriched with flours from African yam bean, soybean, and their protein isolates is presented in Table 6. The moisture content of the maize *ogi* (control sample) and the fortified samples (B-D) differed significantly ($p < 0.05$). Moisture content of control sample (10.20 %) was significantly ($p < 0.05$) higher when compared with that of the composite samples. The moisture results of this study (4.50 to 10.20) are in agreement with the work of Ameh et al. [3] who reported a moisture content of (8.63-9.41 %) for maize *ogi* produced from bambaranut, soy flours, and their isolates but contrary to the moisture results of (18.56 to 30.11 %) of wheat bread supplemented with water yam and soyflour reported by [38]. The value of the moisture content in this study is below the 14 % recommended by Amah et al. [45]. High moisture contents exceeding 14 % in flours encourage microbial activity and pose undesirable changes. The protein content of the maize *ogi* and fortified diets showed significant differences ($p < 0.05$) among all samples. The protein isolates enriched *ogi* (D and E) had the highest value of protein content (22.66 to 24.10 %), and the control sample had the lowest protein content of 11.23 %. The protein contents were comparable with the values of 8.06 -31.36 % reported by Adeyeye et al. [6] for maize flour cookies enriched with soy protein isolate. The higher protein contents in the protein isolates enriched *ogi* as compared to the flour and control samples may be attributed to the higher protein contents of the isolates from African yam bean and soybean. This is evidenced by the nutritional composition of their individual flours (Table 1). The lower protein content of the control sample may be because it was processed from 100 % maize *ogi*. Also, the protein contents of the fortified diets meet the specification of 16 % and above recommended by [46-48] for complementary foods. The variations in reported values of protein contents could be due to differences in the varieties of flours used, growing conditions, as well as fermentation conditions. The higher protein contents in the isolates and flour samples would be useful in eliminating the challenges of protein deficiencies, notably among children under five [49,50]. Proteins are essential for all body tissues, which help to produce new tissues. They are therefore extremely important for growth, pregnancy, and when recovering from wounds [51]. The fat content of the protein isolates and flour samples showed significant differences ($p < 0.05$). The flour-

enriched *ogi* had higher (2.81 and 4.91 %) fat contents, while the protein-isolate-enriched *ogi* had lower fat contents of (1.20 and 0.80 %), respectively. The fat contents of the fortified and unfortified *ogi* in this present study are lower than those of (10.37 to 18.01 %) reported by Akoja and Ogunsina [52] for composite of maize based snacks (kokoro) fortified with pigeon pea concentrate but higher than those of (0.59 and 1.58 %) reported by Adeyeye et al. [6] for composite cookies from maize and soy protein isolates. The high fat contents of the flour-enriched *ogi* (C) as compared to the control and protein isolates samples may be due to the addition of soybean flour to the flour-enriched *ogi* (C), soybean being an oilseed has more oil in it compared to the other flours used for supplementing the other samples. Soybeans have been reported to contain appreciable amounts of minerals and fat [3,53]. Also, the lower fat contents in the protein isolate-enriched *ogi* samples are not unexpected; this is due to the defatting and precipitation processes embarked upon in isolating proteins from African yam bean and soybean used in substituting maize *ogi* in those blends. However, the results of the fat contents in this study fall within the value of not more than 10 % crude fat recommended by the Protein Advisory Group [46], implying that complementary foods formulated from any of the fortified blends will be capable of meeting the fat needs of the consumers. 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 [54]. Hence, the samples with high percentage ash contents, as noticed in the flour-enriched *ogi* (B and C), are expected to have high concentrations of various mineral elements. The higher ash content of the flour-enriched *ogi* (C) observed could be attributed to the inclusion of soybean in the blends; this implied that the substituted soybean flour contained higher mineral elements than the flours used in substituting the other samples. Both the protein isolates and flour samples met the recommended dietary allowance (RDA) for ash in foods for children, ≤ 5.0 mg/100g, specified by [48,56]. The carbohydrate content of the samples decreased significantly ($p < 0.05$) with the addition of flours and protein isolates from African yam bean and soybean. The carbohydrate content of the maize *ogi* ranged from 59.40 to 72.63 %. The control sample (sample A) had the highest carbohydrate content of (72.63 %) while the maize *ogi* enriched with soy flour sample (sample C) had the least carbohydrate content of (59.40 %). The carbohydrate content of both the control and

fortified samples was greater than the minimum carbohydrate requirement 37% recommended by regulatory standards in Nigeria [57]. The lower carbohydrate contents in the fortified samples may be attributed to substitution effects. The calories of the fortified and control samples (350.62, 360.47, 370.12, 372.64, and 367.70Kcal) are within the specific minimum requirement of 380-425 kcal as recommended by FAO [58]. Tizazu et al. [59] also reported energy values of sorghum-based complementary food as 405.8 – 413.2 Kcal/100g, which is higher than the value obtained in this study. The calories in an infant's diet are provided by protein, fat, and carbohydrate, which are major components of complementary foods that help to meet the energy requirements of growing infants, and a lack of any of these leads to malnutrition [60]. Higher energy value of the protein isolate enriched *ogi* could find application in infant formula since growing children require high energy for growth. Ohizua et al. [34] pointed out that high energy content may be advantageous for the formulation of breakfast cereal and complementary foods. The human body requires energy for all bodily functions, including work and other activities, the maintenance of body temperature, and the continuous action of the heart and lungs. Energy is needed for the breakdown, repair, and building of tissues as well as essential for the growth of children [61].

Sensory Properties of Maize *Ogi* Enriched with African yam bean, Soy 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 in order to determine the acceptability of such a product. It is also an important criterion for assessing quality in the development of new products and for meeting consumer requirements [62]. The sensory characteristics of a food product are of paramount importance as they play an important role in determining the final product 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 sensory attributes evaluated in this research include aroma, mouthfeel, taste, consistency, and overall acceptability. For aroma, the control sample (100 %) maize *ogi* was rated highest followed (8.04 followed by the flour samples B and C (7.39 and 7.30), respectively. Significant differences existed among samples. The lower aroma value observed in the

protein isolates enriched *ogi* (D:6:90 and E: 6.79) as compared to the other samples may be attributed to the consumers' unfamiliarity with protein isolates. The panellist's preference for the control sample (A) over the other formulations may be due to their familiarity with maize *ogi*. Aroma is an important parameter of food [25]. 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 consumers, but could be further improved by adjusting processing conditions. The result of the mouth feel showed, the samples were significantly influenced ($p < 0.05$) among samples by the addition of flours and protein isolates from African yam bean and soybean. However, the Sample (A) control sample was rated highest among other samples by the panelists; this may be attributed to their familiarity with maize *ogi*. The taste of the maize *ogi* decreased with the addition of flours and protein isolates from African yam bean and soybean. The scores for taste ranged between 8.81 to 7.78. Taste is the sweet sensation caused in the mouth by contact with a sweetening agent, and it is an important sensory attribute of any food. *ogi* (porridge) of samples A (100 % maize *ogi*) and flour samples (B:8:10, C:8:09) had the highest taste. 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. The consistency results of *ogi* produced from (100 % maize flour), flours, and protein isolates from African yam bean and soybean revealed that the control sample A had the least rating of 7.50, followed by the flour sample of maize *ogi* and African yam bean flour (B: 7.71). 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 determines the amount of food an individual can swallow, because consumers prefer a smooth gruel and not a coarse product. However, consistency of both the control and composite diets was within acceptable limits. Water absorption capacity and swelling index are important parameters that 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 [63]. The sensory scores for overall acceptability of the porridge samples ranged between 8.12 and 8.71. There were significant ($p < 0.05$) differences among the samples. Sample C had the highest

mean score of 8.60, followed by the African yam bean flour enriched sample (B: 8:40), respectively. Also the appearance results showed significant ($p < 0.05$) difference among samples with sample A (control) having the highest score of (7.69) and the soy protein enriched protein isolates sample having the least appearance score of (7.00), the penallists preference for sample A (control) over the other samples maybe due to their familiarity with maize *ogi*. A good appearance makes a food product more appealing and attracts consumers to buy it. All the sensory scores evaluated were more than the minimum acceptable score of six (6) [64]. 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 African yam bean or soy flour, as well as their protein isolates.

CONCLUSION

The study investigated the effect of the addition of flours and protein isolates from African yam bean and Soyflour with maize *ogi* on the functional, proximate composition, and sensory attributes of five porridge formulations, and the following conclusions were drawn. Functional properties of the maize *ogi* flour were altered significantly by the addition of legume flours and protein isolates from African yam bean and soybean. The protein composition of the maize *ogi* was enriched significantly by the addition of the legume flours and protein isolates from both African yam bean and soybean. The higher protein following the enrichment of maize *ogi* with the legume flours and protein isolates will help in alleviating protein-energy malnutrition. The protein isolates enriched *ogi* conferred higher foaming capacity, oil absorption capacity. The maize *ogi* enriched with African yam bean and soyflour and their protein isolates did result in acceptable sensory scores. It is recommended that maize *ogi* be enriched with either flour or protein isolates from African yam bean or soyflour to help in improved protein delivery, particularly in a resource-constrained environment.

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None.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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