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Acceptability and Nutritional Potential of Instant Pap (Ogi) Enriched with Landolphia togolana Stem Powder

Landolphia togolana Gövde Tozu ile Zenginleştirilmiş Hazır Mısır Lapası'ın (Ogi) Kabul Edilebilirliği ve Besin Potansiyeli

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Abstract

The study assessed the acceptability and nutritional potential of instant pap (*Ogi*) enriched with *L. togolana* stem powder (LTSP). Powdered *Sorghum* seed and *L. togolana* stem bark was used to create 4 formulas with different concentration combinations: IOF (100% *Ogi* flour); LIO1 (95% *Ogi* flour + 5% LTSP); LIO2 (90% *Ogi* flour + 10% LTSP) and LIO3 (85% *Ogi* flour + 15% LTSP). Proximate analysis was determined using the AOAC method, and the concentrations of vitamins and minerals were determined using AAS. The sensory attributes results suggested that LIO1 instant *Ogi* with 5% LTSP maintained acceptability (8.02±0.79). Additionally, enriching *Ogi* with LTSP significantly ($p < 0.05$) increased its fiber, ash, and carbohydrate contents (from 3.46% to 3.90%, 1.39% to 2.97%, and 70.03% to 73.55%, respectively), while decreasing its moisture, fat, and protein contents (from 9.07% to 7.00%, 3.42% to 2.06%, and 12.65% to 10.62%, respectively). The enriched pap (*Ogi)* has higher ($p<0.05$) vitamins (B1, B2, B3, B6, B9, C, and E), and minerals (Zn, Fe, Ca, P, and K) contents. The study concluded that *L. togolana* stem bark powder increases the nutritional content of the instant *Ogi* and its acceptability.

Özet

Bu çalışma, *L. togolana* gövde tozu (LTSP) ile zenginleştirilmiş hazır mısır lapasının (Ogi) kabul edilebilirliğini ve besin potansiyelini değerlendirmiştir. Toz halinde sorgum tohumu ve *L. togolana* gövde kabuğu kullanılarak farklı konsantrasyon kombinasyonlarına sahip 4 formül oluşturulmuştur: IOF (%100 Ogi unu); LIO1 (%95 Ogi unu + %5 LTSP); LIO2 (%90 Ogi unu + %10 LTSP); ve LIO3 (%85 Ogi unu + %15 LTSP). Yaklaşık besin analizleri AOAC yöntemi kullanılarak yapılmış; vitamin ve mineral konsantrasyonları ise AAS ile belirlenmiştir. Duyusal özellikler sonuçları, %5 LTSP içeren LIO1 numaralı hazır Ogi'nin kabul edilebilirliğini koruduğunu göstermiştir (8.02±0.79). Ayrıca, LTSP ile zenginleştirilen Ogi'nin lif, kül ve karbonhidrat içeriği anlamlı derecede artmıştır (sırasıyla %3.46'dan %3.90'a, %1.39'dan %2.97'ye ve %70.03'ten %73.55'e), buna karşılık nem, yağ ve protein içeriği azalmıştır (sırasıyla %9.07'den %7.00'ye, %3.42'den %2.06'ya ve %12.65'ten %10.62'ye). Zenginleştirilmiş lapa (Ogi), daha yüksek ($p<0.05$) vitamin (B1, B2, B3, B6, B9, C ve E) ve mineral (Zn, Fe, Ca, P ve K) içeriğine sahiptir. Çalışma, *L. togolana* gövde kabuğu tozunun hazır Ogi›nin besin içeriğini ve kabul edilebilirliğini artırdığını sonucuna varmıştır.

INTRODUCTION

Fermented maize product, commonly known as pap (*Ogi* in Yoruba), is a widely consumed weaning and breakfast cereal in sub-Saharan Africa. It is traditionally made using maize, sorghum, or millet (1). The preparation process involves soaking cleaned grains in water at ambient temperature (approximately 25±2°C) for two to three days. Afterward, the steeping water is drained, and the fermented grains are washed and wet-milled. The bran is separated through wet sieving, allowing the resulting slurry to settle and ferment naturally for another two to three days. The fermented wet slurry is then transformed into a ready-to-eat gruel by mixing it with hot water. Consumers often enhance its taste by adding sweeteners such as honey or sugar (2).

Ogi, also known as akamu or pap, holds significant cultural and nutritional importance in Nigeria (3). It is consumed by many households, particularly in the southwestern region (4). Sorghum is a nutritious grain that offers several health benefits. However, like other grains, Sorghum may lack certain essential nutrients compared to a well-rounded diet. Research has shown that Sorghum lacks lysine, vitamin B12, folate, and ascorbic acid (vitamin C), and it is relatively low in minerals such as calcium, iron, and zinc compared to some other grains. Several studies revealed that *Ogi* can be enriched with date palm fruits, acha-tamba, soy peptides, and other seeds and spices. Ilori *et al.* (5) investigated the nutritional composition and acceptability of powdered *Ogi* enriched with date palm fruits, revealing that samples with higher date inclusion were favored and considered nutrient-dense, suggesting their potential to alleviate hunger (5). Also, Ogori *et al.* (6) examined *Ogi* enriched with acha-tamba and hydrolyzed soy peptides. The finding showed that increased inclusion of these ingredients positively affected moisture content, protein, ash, and various functional properties, while sensory evaluation showed that panelists preferred moderate inclusions (6).

Landolphia togolana, a climbing plant belonging to the Apocynaceae family, is commonly referred to as vine rubber. The genus *Landolphia* comprises approximately 64 species distributed across Africa. In Nigeria, it is known by various local names, including "Eso/Utu" in Igbo, "Mba/Alakitipa" in Yoruba, "Jabajaba" in Akoko, and "Ciwa" in Hausa (7). Scientific research has demonstrated that different parts of *L. togolana* exhibit properties such as anti-inflammatory, anti-nociceptive, antioxidant, antimicrobial, and hepatoprotective effects (8, 9, 10). The stem of *L. togolana* also contains various secondary metabolites, such as alkaloids, flavonoids, and tannins, which have been shown to have potential medicinal properties (11). The production of instant '*Ogi*' has emerged due to the rising demand for fast foods among the urban population. It is popular due to its affordability, ease of preparation, and versatility as a meal option for children and adults (12). However, traditional *Ogi* has limitations in terms of its nutritional composition. It contains relatively

low levels of essential nutrients such as proteins, vitamins, and minerals, making it insufficient to fully meet the dietary needs for optimal health (13, 14). This poses a particular concern for vulnerable groups, including children, pregnant women, and lactating mothers, who have higher nutrient requirements (15). Ojo & Enujiugha (1) reported that *Ogi* can be found in different kinds of cereal, including Sorghum, maize, millet, etc. However, the nutritional composition of traditional *Ogi* is relatively low, and it may not adequately meet the nutrient requirements of individuals, especially those with specific dietary needs. As a result, there is a growing interest in developing enriched variants of *Ogi* to enhance its nutritional value. A promising option for enrichment is *Landolphia togolana* stem powder, known to be a rich source of essential nutrients, including vitamins, minerals, and dietary fiber. Consequently, this study seeks to evaluate the acceptability of instant *Ogi* enriched with *L. togolana* stem powder.

MATERIALS

Plants collection

The raw materials used in this study were red sorghum (*Sorghum bicolor*) and the stem of *Landolphia togolana*. The sorghum was sourced from the Oja-Oba market (coordinates: 8° 29′ 59.99″ N, 4° 32′ 59.99″ E) in Ilorin, Kwara State, while the *L. togolana* stem was procured from Adelabu Salami's farm located in Owo (coordinates: 7°11′46.32″ N, 5°35′12.52″ E), Ondo State, Nigeria. The plant samples were identified and authenticated at the Department of Plant Biology and Biotechnology, University of Benin, Nigeria, by Prof. Akinobosun, a taxonomist. Voucher numbers UBH-S289 for sorghum and UBH-L200 for *Landolphia* were assigned.

METHODS

Plant preparation

The stems were collected in a clean container. Impurities were removed by rinsing thoroughly with clean water. The stems were dried naturally under direct sunlight in a well-ventilated area until they became crispy and bristles. The stems were broken into small pieces using mortar and pestle, then ground to powder using a mechanical blender, and then it was sieved using a fine mesh (85 microns) to remove coarse particles or fiber. The powdered sample was stored in a closed container until further use.

Preparations of enriched instant *Ogi* with *L. togolana* stem powder

The sorghum grains were sorted, cleaned, and steeped for 48 hours at 25℃. It was wet-milled and left to ferment and settle for 72 hours. The fermented product was decanted to make *Ogi* cake. As previously reported, the Sorghum water extract (*Ogi* cake) was dewatered and dried for 11 hours at 50℃ (16). Dry-milling was done, and the Ògi flour was cooled. The powdered *Ogi* was enriched by adding different amounts of the powdered stem of *L. togolana* to prepare 4 formulas used for this study (Table 1).

Table 1. Composition Ratios of Four Potential Formulations

The proportion of blend ratio (%)		
Sample code	Instant *Ogi* flour (%)	*Landolphia togolana* stem powder (%)
IOF	100	-
LIO1	95	5
LIO2	90	10
LIO3	85	15

KEY:

IOF = 100% Instant *Ogi* flour

LIO1: 95% instant *Ogi* flour and 5% *Landolphia togolana* stem powder

LIO2: 90% instant *Ogi* flour and 10% *Landolphia togolana* stem powder

LIO3: 85% instant *Ogi* flour and 15% *Landolphia togolana* stem powder

Data in Table 1 show the amounts of *L. togolana* stem bark extract and *Ogi* (*S. bicolor* seed flour) used to formulate the four formulations evaluated.

Proximate Analysis

The samples were subjected to proximate analysis, where the ash, crude fiber, and moisture contents were measured according to the AOAC method (17). Crude protein was determined using the Kjeldahl method, fat was extracted using Soxhlet extraction, and carbohydrates were calculated by difference.

Moisture Content Determination

The Petri dishes were thoroughly washed and then dried in an oven. After drying, the dishes were cooled in a desiccator, and their weights, along with the lids, were measured on a balance. A 2.0 g sample of each test material was placed into the empty dishes and spread evenly. The weight of the samples and the dishes were recorded. The samples were then placed in the oven and dried at 105°C for 3 hours. After this period, the samples were cooled in a desiccator, weighed again, and returned to the oven for further drying until a constant weight was achieved.

The dried sample and Petri dishes were weighed again, and the weight was recorded. The percentage moisture content was calculated using the following formula:

$$\% \, \boldsymbol{Moisture} = \left(\frac{\boldsymbol{W2 - W3}}{\boldsymbol{W2 - W1}}\right) \times \boldsymbol{100}$$

Where:

- **W1**: Initial weight of the Petri dish
- **W2**: Weight of the sample and Petri dish before drying
- **W3**: Weight of the sample and Petri dish after drying

Crude Ash Content Determination

The crucibles and their lids were placed in the furnace and heated at 550°C for 2 to 3 hours to ensure the removal of impurities. After heating, the crucibles were allowed to cool in a desiccator for 30 minutes, and the weight of the crucible and lid was recorded. Then, 5 g of the sample was weighed into the crucibles, and a few drops of glycerol were added, mixed thoroughly, and then ashed in a muffle furnace at 550°C for 4 to 5 hours until a whitish-grey residue was formed. The crucibles were cooled in the desiccator and reweighed. The percentage of ash content was calculated using the formula:

$$\% \, \boldsymbol{Total \; Ash} = \left(\frac{\boldsymbol{W3 - W1}}{\boldsymbol{W2 - W1}}\right) \times \boldsymbol{100}$$

Where:

- **W1** = Weight of the dish
- **W2** = Weight of the dish + sample before ashing
- **W3** = Weight of the dish + sample after ashing

Lipid Content

The crude fat content of the sample was determined using a Soxhlet extractor, equipped with a reflux condenser and a distillation flask (17). All glassware was rinsed with petroleum spirit, drained, and dried in an oven at 102°C for 30 minutes before being cooled in a desiccator. A 2.0 g sample of each material was placed in the fat extractor thimble, which was plugged with cotton wool at the bottom, and positioned in the appropriate chamber of the extractor. The distillation flask was filled two-thirds full with n-hexane and heated using a heating mantle to initiate boiling. The distillate was collected until the extractor siphoned after 4 hours. Following this, the n-hexane was recovered into a clean container, and any remaining solvent was evaporated in the oven at 70°C. The distillation flask was then cooled in a desiccator, and its final weight was recorded. The amount of oil extracted was determined by calculating the difference between the initial and final weights of the sample (17).

It can be represented as:

$$\% \, \boldsymbol{Crude \; Fat} = \left(\frac{\boldsymbol{W2 - W1}}{\boldsymbol{Weight \; of \; sample}}\right) \times \boldsymbol{100}$$

Where:

- **W2** = Weight of the receiver flask and fat
- **W1** = Weight of the empty receiver flask

Crude Fiber

Two grams (2g) of each of the samples were defatted during fat analysis. The defatted samples were boiled in 200ml of 1.25% H_2SO_4 solution under reflux for 30 minutes. The samples were washed with several portions of hot (boiling) water using a two-fold muslin cloth to trap the particles (residue). The residues were carefully transferred back to the flask and 200ml of 1.25% NaOH solution was added to it. Again, the samples were boiled for 30 minutes and washed as before with hot water. Then they were transferred to a weighed porcelain crucible and dried in the oven at 105°C for 3 hours. After cooling in a desiccator, they were weighed and then put in a muffle furnace and burnt at 550°C for 4 hours until they became ash. Again, the samples were cooled in a desiccator and reweighed.

$$\%\ \boldsymbol{Crude\ Fibre\ Content}\ (\%) = \left(\frac{\boldsymbol{Weight\ of\ samples\ after\ ashing}}{\boldsymbol{Weight\ of\ sample}}\right) \times \mathbf{100}$$

Protein Content

Two grams of each sample were placed into a digestive flask, followed by the addition of 5 g of Kjeldahl catalyst and 20 mL of concentrated H_2SO_4. A blank sample, prepared with the same constituents, was also set up. The flask was positioned at an incline and gently heated until the solution became clear. This process was carried out in a fume cupboard. After digestion, the flask was removed from the heat, allowed to cool, and then diluted with 60 mL of distilled water. The flask was then transferred to a micro Kjeldahl analyzer (distillation unit), where 40% NaOH was introduced. The mixture was heated to release ammonia, which was distilled into a conical flask containing 25 mL of 4% boric acid for 15 minutes, forming an ammonium borate solution. This solution was titrated against 0.1M HCl until a purplish-grey endpoint was reached. The same procedure was followed for the blank solution. Protein content was calculated using the formula below:

The percentage of nitrogen is calculated using the formula:

$$\%\ \boldsymbol{Nitrogen} = \left(\frac{(\boldsymbol{A} - \boldsymbol{B}) \times \boldsymbol{N} \times \mathbf{14.007}}{\boldsymbol{W}}\right) \times \mathbf{100}$$

Where:

- **A** = Volume of 0.1M HCl (in mL) used for the sample
- **B** = Volume of 0.1M HCl (in mL) used for the blank titration
- **N** = Normality of HCl
- **W** = Weight of the sample (in grams)
- **14.007** = Atomic weight of nitrogen
- **6.25** = Protein nitrogen conversion factor

The percentage of crude protein is then calculated as:

$$\%\ \boldsymbol{Crude\ Protein} = \boldsymbol{Nitrogen} \times \boldsymbol{Conversion\ Factor}$$

Carbohydrate

Carbohydrate content was determined using the difference method, as outlined by (18). The moisture, fat, protein, and ash content percentages of each sample were summed up and subtracted from 100, as follows:

Carbohydrate content = 100 – [protein (%) + fat (%) + moisture (%) + ash (%)].

Determination of the vitamin content of the samples

Vitamin A content determination

The Vitamin A content in the sample was measured using Pearson's method (19). First, one gram of the ground sample was macerated with 20 mL of petroleum ether, then the mixture was decanted into test tubes and evaporated to dryness. The residue was treated with 0.2 mL of

a chloroform-acetic anhydride solution (1:1, v/v), followed by 2 mL of a TCA chloroform solution (1:1, v/v). The absorbance was then recorded at 620 nm. Vitamin A standards were prepared using the same method, and their absorbances were measured at the same wavelength. The Vitamin A concentration in the samples was calculated by extrapolating from the standard curves.

Vitamin C content determination

The Vitamin C content was analyzed using ultraviolet spectrophotometry as outlined by Rahman et al. (20). In this method, 1 gram of each sample, a 1 mM ascorbic acid stock solution (used as a standard), and a 1 mM trichloroacetic acid (TCA) solution (used as a blank) were placed into separate test tubes. Each tube then received 10 mL of TCA solution, followed by 1 mM of dinitrophenyl hydrazine-thiourea-copper sulfate reagent. The test tubes were capped and incubated in a water bath at 37°C for 3 hours. After incubation, the tubes were chilled in an ice bath with gentle shaking for 10 minutes. Subsequently, 2 mL of cold 12 M H_2SO_4 was added to each tube. The spectrophotometer was set to zero absorbance using the blank at 520 nm, and the absorbances of the standards and samples were measured at the same wavelength.

Vitamin D content determination

A 1 g sample of each was extracted using 5 mL of chloroform-methanol (1:9) and spun at 3500 rpm. The clear solutions were then pipetted into test tubes, and their absorbances were measured at 264 nm using a UV spectrophotometer. Blank and standard vitamin D solutions were also prepared for comparison. The vitamin D content was determined as follows:

Where A sample represents the absorbance of the test sample, A_standard refers to the absorbance of the standard solution, A_blank is the absorbance of the blank, and Conc_standard is the concentration of the standard in mg/100g.

Vitamin E (α-tocopherol) Determination:

A widely used colorimetric method for quantifying α-tocopherol is based on its reducing properties. In this procedure, α-tocopherol reduces ferric chloride (Fe^{3+}) to ferrous chloride (Fe^{2+}), which then reacts with 2,2′-bipyridyl to form a red complex. The intensity of this red color is proportional to the concentration of α-tocopherol in the sample and can be measured spectrophotometrically at 520 nm (21).

Vitamin K (Phylloquinone) Determination:

For vitamin K analysis, a colorimetric method involves the reaction of phylloquinone with 2,4-dinitrophenylhydrazine (DNPH) to form a hydrazone derivative. This derivative exhibits a characteristic color that can be quantified spectrophotometrically. The absorbance measured at a specific wavelength correlates with the vitamin K concentration in the sample (22).

Vitamin B-Complex content determination

The microbiol*ogi*cal assay method for determining vitamin B complex levels involves using *Lactobacillus casei* (ATCC 7469) as the test organism. This bacterium is cultivated in a nutrient broth medium enriched with a vitamin B complex-free soy hydrolysate. The sample is serially diluted and added to the nutrient broth in a sterile 96-well microplate. The microplate is then incubated for 18–24 hours at 37°C in a CO_2 incubator. After incubation, the growth of *L. casei* is measured using a spectrophotometer at a wavelength of 600 nm. The vitamin B complex content is determined by comparing the growth of the test organism with that of a known standard solution. This method is based on the work of (23), who developed a modified medium for *Lactobacillus casei* to assay B vitamins. Additionally, the microbiol*ogi*cal assay of folic acid derivatives using *Lactobacillus casei* has been documented in clinical chemistry studies (24).

Mineral Concentration Determination

Reagents: Analytical grade nitric acid (HNO_3) and 70% perchloric acid ($HClO_4$), both supplied by Fischer Scientific, were used for the wet digestion of the samples. All solutions were prepared with deionized water, and all glassware

was thoroughly cleaned and rinsed before use.

Standard Preparation: Stock standard solutions of 1000 ppm were diluted to prepare calibration standards at three to five different concentrations for each mineral to create a calibration curve.

Procedure: To start the mineral analysis, approximately 0.2 g of the sample was placed in a 100 mL volumetric flask. Four milliliters of HNO_3 were added, and the flask was left to stand for a few hours. The mixture was then heated in a water bath until the red fumes from the nitric acid dissipated. After cooling to room temperature, 4 mL of perchloric acid was added, and the flask was heated again to evaporate the contents. Once evaporation was complete, the sample was filtered using Whatman No. 42 filter paper, and the volume was adjusted to 100 mL with distilled water. Mineral concentrations were measured using atomic absorption spectroscopy (Shimadzu), with hollow cathode lamps for Zn, K, Mg, Ca, Mo, Na, Mn, Fe, Cu, and P as the radiation source. Air-acetylene was used as the fuel, and all samples and standards were analyzed in duplicate.

Sensory Analysis

The sensory evaluation of the enriched instant Ogi samples was conducted using a 9-point hedonic scale, where 1 = dislike extremely and 9 = like extremely. The evaluation was carried out in a well-lit and ventilated sensory laboratory under controlled conditions to minimize external influences on the panelists' perceptions. A total of 30 semi-trained panelists, consisting of students and staff members familiar with cereal-based foods, were recruited for the sensory evaluation. The panelists were selected based on their availability, willingness to participate, and their ability to distinguish basic sensory attributes. Before the evaluation, they were briefed on the purpose of the study and the evaluation procedures. Each Ogi sample was prepared following the same standardized cooking procedure to ensure consistency. The samples were cooked into a semi-solid gruel by mixing 50g of Ogi flour with 250mL of boiling water, stirring continuously until a smooth, homogenous texture was achieved. The gruel was allowed to cool to a comfortable tasting temperature (approximately 45°C). The samples were presented in coded white disposable cups to prevent bias, and the order of presentation was randomized to eliminate positional effects. Panelists were provided with clean drinking water and plain crackers to cleanse their palates between samples. The panelists assessed the samples based on colour, aroma, texture, taste and overall acceptability.

Method of Data Analysis

Panelists recorded their responses on structured sensory score sheets using the 9-point hedonic scale. The collected data were analyzed with Statistical Package for Social Sciences (SPSS) Software, version (25.0). The results were expressed in mean and standard deviation and Analysis of Variance (ANOVA) was used determine significant differences among the samples. Duncan's Multiple Range Test (DMRT) was used for mean separation at $p < 0.05$ significance level.

RESULTS AND DISCUSSION

Proximate Analysis Result

Most foods are supplemented to produce better acceptance and dietary enrichment with increased nutritional functionality, leading to better dietary benefits. In this study, dried and powdered extract of Sorghum was enriched with *Landolphia togolana*, a known medicinal with high amounts of minerals and vitamins. The data in Table 2 revealed the proximate parameters of the enriched instant *Ogi* with *L. togolana.* The results revealed that the moisture content of the samples varied between 7.00% and 9.07%. Interestingly, the IOF exhibited the highest moisture content ($p<0.05$) at 9.07 ± 0.08%, while the LIO samples showed lower moisture contents, ranging from 7.00 ± 0.01% to 7.20 ± 0.01%. The decrease in moisture content with the inclusion of *L. togolana* stem powder indicates that the powder may have functioned as a moisture barrier, thereby reducing the water absorption capacity of the *Ogi* flour, which is in line with (25).

Fat Content Results

The fat content of any food is critical as it contributes to the product's nutritional value and sensory attributes. In this study, the fat content of the samples ranged from 2.06% to 3.42%. The IOF had the highest (p<0.05) fat content (3.42 ± 0.16%), while the LIO3 sample had the lowest fat content (2.06 ± 0.01%). The gradual reduction in fat content with the incorporation of *L. togolana* stem powder might be a result of lower fat content of the stem powder itself, this is similar to the result obtained by (26).

Fiber Content Results

Fiber is an essential dietary component that aids digestion and improves overall gut health. The quality of crude fat in the samples was lower than the 10 g/100 g recommended by the Food and Agriculture Organization (FAO) (27). The fiber content of the samples ranged from approximately 3.46% to 3.90%. Interestingly, the LIO1 samples generally exhibited slightly higher fiber content than the IOF. Among the LIO1 samples, LIO2 and LIO3 showed the highest (p<0.05) fiber content (3.86 ± 0.01% and 3.90 ± 0.02%, respectively). This indicates that the stem powder might have contributed additional dietary fiber to the *Ogi* flour, making it a potentially healthier option; this was in agreement with (28) that enriched maize *Ogi* flour enriched with *Moringa oleifera (M. oleifera)* seed to improve the nutritional quality. All the formulations are considered beneficial products because fiber aids in promoting bowel movement, thereby helping to prevent gastrointestinal disorders (29, 30).

Protein Content Evaluation

Protein is a vital nutrient required to grow and repair body tissues. The protein content of the samples varied between approximately 10.57% and 12.65%. The protein content slightly decreased as the *L. togolana* stem powder percentage increased (p>0.05). This decrease in protein content might be due to the stem powder's relatively lower protein content than the *Ogi* flour. This is similar to the work of (5), who enriched powdered *Ogi* with date palm. The results indicated that the protein content of the samples decreased as the proportion of date fruit increased, which contrasts with the findings of (6).

Ash Content Result

Ash content measures the mineral content present in the sample and indicates the overall mineral composition. The ash content of the samples ranged from approximately 1.39% to 2.97%. The IOF had the lowest ash content (1.39 ± 0.19%), while the LIO3 sample had the highest (p<0.05) ash content (2.97 ± 0.03%). The increase in ash content with the addition of *L. togolana* stem powder suggests that the powder might be a source of minerals, contributing to the overall mineral content of the enriched *Ogi* sample. This aligns with the research carried out by (5), who enriched powdered *Ogi* with date palm fruits to improve its nutritional content. In other words, the substantial increase (p<0.05) in ash content can be attributed to the high mineral content of date palm fruits (29).

Table 2. Proximate analysis of enriched instant *Ogi* sample with *L. togolana* stem powder

Sample (%)	IOF	LIO1	LIO2	LIO3
Moisture	9.07±0.08^{a}	7.20±0.01^{b}	7.05±0.09^{c}	7.00±0.01^{c}
Fat	3.42±0.16^{a}	2.70±0.03^{b}	2.13±0.01^{c}	2.06±0.01^{c}
Fibre	3.46±0.11^{d}	3.52±0.08^{c}	3.86±0.01^{b}	3.90±0.02^{a}
Protein	12.65±0.04^{a}	10.57±0.02^{c}	10.61±0.03^{b}	10.62±0.01^{b}
Ash	1.39±0.19^{c}	2.87±0.05^{b}	2.87±0.02^{b}	2.97±0.03^{a}
Carbohydrate	70.03±0.03^{a}	73.15±0.06^{b}	73.50±0.02^{b}	73.55±0.02^{b}

Key: **IOF =** 100% Instant *Ogi* flour; **LIO1**: 95% instant *Ogi* flour and 5% *Landolphia togolana* stem powder; **LIO2**: 90% instant *Ogi* flour and 10% *Landolphia togolana* stem powder and **LIO3**: 85% instant *Ogi* flour and 15% *Landolphia togolana* stem powder.

Note: *Values are presented as Mean ± SD (Standard Deviation), n = 2. Values with different superscripts within the same row are significantly different at (p<0.05).*

Carbohydrate Content Result

Carbohydrates are the primary energy source in the human diet. The carbohydrate content of the samples ranged from approximately 70.03% to 73.55%. It was observed that the LIO1 samples generally had slightly higher ($p<0.05$) carbohydrate content compared to the IOF. This increase might be attributed to the dilution effect of the stem powder on the *Ogi* flour. This is similar to the reports from studies in which Sorghum-*Ogi* was enriched with plantain flour (31). *Sorghum-Ogi* has been fortified with several food materials to increase its nutritional value.

Vitamins Content Determination

The results presented in Table 3 highlight the impact of adding *L. togolana* stem powder on the levels of vitamins B1, B2, B3, B6, B9, C, and E in enriched instant *Ogi*. The concentration of vitamin B1 (thiamine) showed a slight increase with the inclusion of *L. togolana* stem powder. The highest concentration of 0.47 ± 0.01 mg/100g was observed in sample LIO3, representing a significant ($p<0.05$) increase when compared to the control sample, IOF (0.38 ± 0.00 mg/100g). This enrichment of vitamin B1 in LIO3 suggests that *L. togolana* stem powder could be a potential source of thiamine.

The results revealed a progressive increase in vitamin B2 (riboflavin) content with adding *L. togolana* stem powder. LIO3 demonstrated the highest concentration of 0.22 ± 0.01 mg/100g, which was significantly higher ($p<0.05$) compared to both the control (IOF) and the other enriched samples (LIO1 and LIO2). This suggests that *L. togolana* stem powder has a considerable impact on enhancing riboflavin levels in instant *Ogi*. This agrees with the work of (32), who fortified Sorghum flour with roasted Bambara groundnut. The study revealed a significant increase in the concentration of riboflavin.

All enriched samples (LIO1, LIO2, and LIO3) showed comparable vitamin B3 (niacin) concentrations, ranging from 2.70 ± 0.00 to 2.88 ± 0.00 mg/100g. These concentrations did not differ significantly ($p>0.05$) from the control (IOF) sample, which had a value of 2.69 ± 0.00 mg/100g. The study indicates that adding *L. togolana* stem powder did not significantly influence niacin concentrations in the instant *Ogi*. This differs from the findings of (33), who reported an increase in niacin content in cereal porridge fortified with mushroom flour. The addition of *L. togolana* stem powder led to an increase in the vitamin B6 (pyridoxine) content of the instant *Ogi*. Sample LIO3 had the highest concentration (0.41 ± 0.01 mg/100g), significantly higher than the control (IOF) sample, which contained 0.32 ± 0.00 mg/100g. This indicates that *L. togolana* stem powder enhances pyridoxine levels in the fortified *Ogi*.

The results demonstrated a notable increase

Table 3. Vitamins concentrations of enriched instant *Ogi* with *L. togolana* stem powder

Vitamin (mg/100g)	IOF	LIO1	LIO2	LIO3
B1	0.38 ± 0.00^{a}	0.39 ± 0.00^{a}	0.40 ± 0.00^{a}	0.47 ± 0.01^{ab}
B2	0.15 ± 0.00^{a}	0.15 ± 0.00^{a}	0.17 ± 0.00^{ab}	0.22 ± 0.01^{b}
B3	2.69 ± 0.00^{a}	2.70 ± 0.00^{a}	2.80 ± 0.00^{a}	2.88 ± 0.00^{a}
B6	0.32 ± 0.00^{a}	0.34 ± 0.00^{a}	0.37 ± 0.00^{ab}	0.41 ± 0.01^{b}
B9	8.22 ± 0.02^{a}	8.31 ± 0.00^{a}	8.90 ± 0.01^{b}	9.37 ± 0.06^{c}
C	0.83 ± 0.00^{a}	1.43 ± 0.00^{b}	1.83 ± 0.00^{c}	1.96 ± 0.05^{c}
E	1.54 ± 0.01^{a}	1.64 ± 0.01^{b}	1.67 ± 0.01^{c}	1.78 ± 0.01^{d}

Key: **IOF =** 100% Instant *Ogi* flour; **LIO1**: 95% instant *Ogi* flour and 5% *Landolphia togolana* stem powder; **LIO2**: 90% instant *Ogi* flour and 10% *Landolphia togolana* stem powder and **LIO3**: 85% instant *Ogi* flour and 15% *Landolphia togolana* stem powder.

Note: *Values are presented as Mean ± SD (Standard Deviation), n = 2. Values with different superscripts within the same row are significantly different at (p<0.05).*

in vitamin B9 (folate) concentration with the addition of *L. togolana* stem powder. Sample LIO3 exhibited the highest ($p<0.05$) concentration (9.37 ± 0.06 mg/100g), significantly surpassing the control (IOF) sample (8.22 ± 0.02 mg/100g). This indicates that *L. togolana* stem powder could serve as a potent source of folate in instant *Ogi*. Notably, vitamin C (ascorbic acid) concentrations in the enriched *Ogi* formulations (LIO1, LIO2, and LIO3) were substantially higher ($p<0.05$) compared to the control (IOF). LIO3 displayed the highest concentration of 1.96 ± 0.05 mg/100g, indicating that *L. togolana* stem powder significantly enhanced the vitamin C (ascorbic acid) content. This is also similar to the study of (32). The vitamin E (tocopherol) concentrations in the enriched *Ogi* formulations were consistently higher than in the control (IOF), with LIO3 showing the highest concentration of 1.78 ± 0.01 mg/100g. The results suggest that *L. togolana* stem powder positively influenced the vitamin E content in the instant *Ogi*.

Minerals Content Determination

Table 4 revealed the impact of incorporating different proportions of *L. togolana* stem powder on the mineral content of instant *Ogi*. As the percentage of the stem powder increases (from LIO1 to LIO3), there is a noticeable increase in the concentration of Zn, Fe, Ca, P, and K. This suggests that *L. togolana* stem powder is a valuable source of essential minerals that can significantly enhance the nutritional profile of instant *Ogi*. The results indicate a gradual increase in zinc concentration by incorporating *L. togolana* stem powder. IOF (100% Instant *Ogi* flour) exhibited the lowest zinc content at 2.84 mg/100g, while LIO3 (85% Instant *Ogi* flour and 15% *L. togolana* stem powder) showed the highest zinc concentration at 4.06 mg/100g. The differences in zinc levels are statistically significant ($p<0.05$), suggesting that *L. togolana* stem powder supplementation positively influences zinc content in instant *Ogi*. This is in agreement with the study of (34) that enriched Sorghum-*Ogi* with cocoa powder. Their results indicated a notable ($p<0.05$) increase in the formulations with cocoa powder. Like zinc, the iron content increased as *L. togolana* stem powder was added. IOF had the lowest iron concentration at 4.46 mg/100g, while LIO3 had the highest at 5.96 mg/100g. The differences observed are statistically significant ($p<0.05$), signifying the potential of *L. togolana* stem powder to enhance iron levels in instant *Ogi*. This is similar to the work of (5), who enriched powdered *Ogi* with date palm fruits to improve its nutritional composition of *Ogi*.

Calcium concentration showed slight variations across the different formulations of enriched instant *Ogi*. The calcium content ranged from 28.40 mg/100g in IOF to 30.92 mg/100g in LIO3. However, the differences were slightly significant ($p<0.05$), indicating that adding *L. togolana* stem powder barely affected the calcium levels in the final product. This is similar to the research carried out by (35) that enriched yellow maize *Ogi* porridge enriched with African Yellow Bean (AYF) flour which shows a significant ($p<0.05$) increase in the amount of calcium of the *Ogi*. Phosphorus content gradually increased with the addition of *Landolphia togolana* stem powder. IOF had the lowest phosphorus content at 286.50 mg/100g, whereas LIO3 showed the highest at 298.47 mg/100g. The observed differences in phosphorus levels were statistically significant ($p<0.05$), highlighting the positive impact of *Landolphia togolana* stem powder on phosphorus enrichment in instant *Ogi*. This is also similar to the work of (5), who enriched powdered *Ogi* with date palm fruits to improve its nutritional composition of *Ogi*. Potassium content also consistently increased as the proportion of *Landolphia togolana* stem powder increased. IOF had the lowest potassium concentration at 351.91 mg/100g, while LIO3 had the highest at 365.65 mg/100g. The differences in potassium levels were statistically significant ($p<0.05$), suggesting that adding *Landolphia togolana* stem powder positively influenced potassium levels in instant *Ogi*. This is also in line with the work of (5), who enriched powdered *Ogi* with date palm fruits to improve its nutritional composition of *Ogi*.

Sensory Analysis Result

The results presented in Table 5 show the mean scores and standard deviations for sensory evaluation attributes of instant *Ogi* enriched with different proportions of *L. togolana* stem

powder. The sensory evaluation assessed the *Ogi* samples' color, aroma, texture, taste, and overall acceptability. The color attribute received the highest mean score in all samples, ranging from 7.05 to 7.99. The mean score of IOF was significantly higher ($p < 0.05$) than that of LIO2 and LIO3, suggesting that the addition of *L. togolana* stem powder at higher proportions (10% and 15%) resulted in a slight reduction in the perceived color appeal compared to the control sample (IOF). However, all samples still received relatively high scores, indicating that adding *L. togolana* stem powder did not significantly affect the color perception of the *Ogi*.

The aroma attribute showed a variation in mean scores among the samples, ranging from 7.18 to 7.73. LIO1 obtained the highest mean score for aroma, significantly different ($p < 0.05$) from the aroma mean scores of LIO2 and LIO3. The aroma scores for IOF and LIO1 were relatively close, suggesting that adding a 5% proportion of *L. togolana* stem powder did not negatively impact the aroma perception of the *Ogi*. For the texture attribute, the mean scores ranged from 6.95 to 8.16. IOF received the highest mean score for texture, which was significantly different ($p < 0.05$) from the scores of LIO2 and LIO3. This indicates that the incorporation of 10% and 15% *L. togolana* stem powder negatively affected the texture perception of the *Ogi*. However, the difference between IOF and LIO1 was insignificant; suggesting that adding 5% *L. togolana* stem powder had a minor effect on the texture.

The taste attribute significantly varied among the samples, with mean scores ranging from 7.33 to 7.82. The taste mean score of IOF was lower ($p < 0.05$) than that of LIO1; indicating that adding 5% *L. togolana* stem powder improved the taste perception of the *Ogi*. However, the taste scores of IOF and LIO2 were not significantly different; suggesting that further increasing the proportion of *L. togolana* stem powder (10% and 15%) did not lead to further improvements in taste. The participants' overall acceptability scores of the *Ogi* samples ranged from 7.40 to 8.15. The control (IOF) obtained the highest mean overall acceptability score, which was significantly

Table 4. The mineral concentration of enriched instant *Ogi* with *L. togolana* stem powder

Minerals (mg/100g)	IOF	LIO1	LIO2	LIO3
Zn	2.84 ± 0.07^{a}	2.91 ± 0.03^{a}	3.13 ± 0.02^{ab}	4.06 ± 0.11^{b}
Fe	4.46 ± 0.00^{a}	4.57 ± 0.03^{a}	4.96 ± 0.04^{b}	5.96 ± 0.20^{c}
Ca	28.40 ± 0.58^{a}	29.80 ± 0.10^{a}	30.43 ± 0.79^{b}	30.92 ± 0.19^{b}
P	286.50 ± 0.88^{a}	290.52 ± 2.35^{b}	296.07 ± 1.12^{c}	298.47 ± 1.34^{d}
K	351.91 ± 1.56^{a}	357.22 ± 1.40^{b}	360.72 ± 0.69^{c}	365.65 ± 0.52^{d}

Key: **IOF =** 100% Instant *Ogi* flour; **LIO1**: 95% instant *Ogi* flour and 5% *Landolphia togolana* stem powder; **LIO2**: 90% instant *Ogi* flour and 10% *Landolphia togolana* stem powder and **LIO3**: 85% instant *Ogi* flour and 15% *Landolphia togolana* stem powder.

Note: *Values are presented as Mean ± SD (Standard Deviation), n = 2. Values with different superscripts within the same row are significantly different at (p<0.05).*

Table 5. Mean ($\bar{x}$) and Standard Deviation (SD) of Sensory Evaluation of Instant *Ogi* enriched with *L. togolana* Stem Powder

Sample	Color	Aroma	Texture	Taste	Overall Acceptability
IOF	7.99 ± 0.75^{a}	7.20 ± 1.08^{ab}	8.16 ± 1.09^{a}	7.58 ± 0.98^{b}	8.15 ± 0.79^{a}
LIO1	7.55 ± 0.98^{ab}	7.73 ± 1.17^{a}	7.91 ± 1.08^{ab}	7.82 ± 0.99^{a}	8.02 ± 0.82^{ab}
LIO2	7.15 ± 1.02^{abc}	7.18 ± 1.19^{b}	7.36 ± 1.45^{abc}	7.58 ± 1.22^{b}	7.63 ± 1.12^{abc}
LIO3	7.05 ± 1.08^{bc}	7.18 ± 1.38^{b}	6.95 ± 1.21^{bc}	7.33 ± 1.27^{c}	7.40 ± 1.21^{abc}

Key: **IOF =** 100% Instant *Ogi* flour; **LIO1**: 95% instant *Ogi* flour and 5% *Landolphia togolana* stem powder; **LIO2**: 90% instant *Ogi* flour and 10% *Landolphia togolana* stem powder and **LIO3**: 85% instant *Ogi* flour and 15% *Landolphia togolana* stem powder.

different ($p < 0.05$) from the scores of LIO2 and LIO3. This suggests that the incorporation of 10% and 15% *L. togolana* stem powder significantly influences the overall acceptability of the *Ogi*. This is consistent with the findings of (36), who supplemented *Ogi* with termite flour and revealed that the modified *Ogi* maintained higher overall acceptability compared to traditional *Ogi*. However, the overall acceptability score of LIO1 was not quite different ($p>0.05$) from that of IOF, indicating that adding 5% *L. togolana* stem powder maintained the overall acceptability of the *Ogi*.

CONCLUSIONS

In conclusion, the research highlights the significance of consuming enriched instant *Ogi* with *L. togolana* and its widespread popularity. The sensory evaluation suggests that incorporating 5% stem powder maintains acceptability. Low awareness about the product's benefits and nutritional advantages could hinder its adoption. Factors influencing acceptability and barriers to adoption should be considered when promoting this enriched *Ogi*. The study also provides valuable insights into the nutritional changes of adding *L. togolana* stem powder. It was highlighted that the higher the level of *L. togolana* in the *Ogi* sample, the higher the nutrient present. Further awareness campaigns and education programs are recommended to enhance acceptance and adoption. The nutritional values of enriched *Ogi* with *L. togolana* stem powder in this study could help meet the dietary needs of various groups, thus increasing the popularity and usage of the plant.

REFERENCES

1. Ojo, D. O., & Enujiugha, V. N. (2018). Comparative evaluation of ungerminated and germinated co-fermented instant 'OGI' from blends of maize (*Zea mays*) and ground bean (*Kerstingiella geocarpa*). *Journal of Nutrition, Health & Food Engineering, 8*(1), 68–73. https://doi.org/10.15406/jnhfe.2018.08.00258
2. Akintayo, O. A., Hashim, Y. O., Adereti, A. G., Balogun, M. A., Bolarinwa, I. F., Abiodun, O. A., Dauda, A. O., Solaja, A. A., & Alabi, O. F. (2020). Potentials of rice as a suitable alternative for the production of Ogi (a cereal-based starchy fermented gruel). *Journal of Food Science,* 1–9.
3. Olawoye, B. (2017). Nutritional evaluation of maize Ogi fortified with germinated African yam bean flour. *Food Science & Nutrition, 5*(6), 1197–1202. https://doi.org/10.1002/fsn3.500
4. Oluwamukomi, M. O., Akinoso, R., & Adebowale, A. A. (2017). Optimization of the process conditions for Ogi production from maize grits. *Food Science & Nutrition, 5*(4), 778–788. https://doi.org/10.1002/fsn3.467
5. Ilori, A. O., Ogungbemi, K., Balogun, B., Oke, O. A., Balogun, D. A., Odeniyi, T. A., Ajisafe, S. S., & Ogunremi, O. B. (2022). Evaluation of the nutritional composition and acceptability of powdered Ogi enriched with date palm fruits. *Research Journal of Food Science and Nutrition, 7*(1), 25–29.
6. Ogori, A. F., Uzor, O. A., Hleba, L., Císarová, M., Glinushkin, A., Laishevtcev, A., Derkanosova, A., Igor, P., Plygun, S., & Shariati, M. A. (2020). Physicochemical, functional, and sensory properties of acha-tamba-based Ogi enriched with hydrolyzed soy peptides. *Journal of Microbiology, Biotechnology and Food Sciences, 9*(4), 823–830.
7. Opaleke, D. O., Salami, L. I., Uko-Aviomoh, E. E., Nwabah, N. I., & Oluwadare, A. A. (2021). Influence of socio-economic status of women on awareness and utilization of *Landolphia togolana* root as a soup thickener in Ondo State, Nigeria. *Technical and Vocational Education Journal (TAVEJ, 7,* 114–123.
8. Away, E. S., Akan, N. P., Okokon, J. E., Umoh, U. J., Akpan, E. J., & Ekanem, E. B. (2012). Phytochemical and antimicrobial activities of different extracts of *Landolphia heudelotii* stem bark. *Asian Pacific Journal of Tropical Medicine, 5*(6), 447–450.
9. Nwaogu, L. A., Owoyele, B. V., & Soladoye, A. O.

(2010). Anti-inflammatory and analgesic activities of *Landolphia owariensis* in rodents. *African Journal of Traditional, Complementary and Alternative Medicines, 7*(1), 47–53. https://doi.org/10.4314/ajtcam.v7i1.56218

10. Owoyele, B. V., Olaleye, S. B., Oke, J. M., & Elegbe, R. A. (2001). Anti-inflammatory and analgesic activities of leaf extract of *Landolphia owariensis*. *African Journal of Biotechnology, 4,* 131–133. https://doi.org/10.4314/ajbr.v4i3.53896

11. Oladeji, O. S., Oluyori, A. P., & Dada, A. O. (2024). *Landolphia* (*P. Beauv.*) genus: Ethnobotanical, phytochemical, and pharmacological studies. *Saudi Journal of Biological Sciences, 31*(6), Article 103988. https://doi.org/10.1016/j.sjbs.2024.103988

12. Adegunwa, M. O., Adeniran, O. I., & Fasoyiro, S. B. (2020). Comparative study on the nutritional composition and acceptability of maize and sorghum Ogi produced from different starters. *Journal of Culinary Science & Technology, 18*(3), 223–231.

13. Ijarotimi, O. S., Oluwajuyitan, T. D., Olugbuyi, A. O., & Makanjuola, S. B. (2022). Comparative study on nutrient composition, functional property, and glycaemic index of "Ogi" prepared from selected cereal grains. *Journal of Future Foods, 2*(4), 380–387. https://doi.org/10.1016/j.jfutfo.2022.08.010

14. Ajala, A. S., & Taiwo, T. F. (2018). Study on supplementation of 'Ogi' with oyster mushroom flour (*Pleurotus ostreatus*). *Journal of Nutrition, Health & Food Engineering, 8*(3), 287–291. https://doi.org/10.15406/jnhfe.2018.08.00284

15. Makinde, O. A., Uthman, O. A., Mgbachi, I. C., Ichegbo, N. K., Sule, F. A., & Olamijuwon, E. O. (2022). Vulnerability in maternal, newborn, and child health in low- and middle-income countries: Findings from a scoping review. *PLOS ONE, 17*(11), e0276747. https://doi.org/10.1371/journal.pone.0276747

16. Akingbala, J. O., Onochie, E. U., Adeyemi, I. A., & Oguntimehin, G. B. (1987). Steeping of whole dry milled maize kernel in Ogi preparation. *Journal of Food Processing and Preservation, 11,* 1–11.

17. Association of Official Analytical Chemists (AOAC). (2012). *Official methods of analysis* (19th ed., pp. 121–130). Washington, DC.

18. Odoh, U. E., & Agbachi, B. C. (2020). Phytochemical, proximate, and nutritive composition analyses of the seed of *Landolphia owariensis P. Beauv.* (Apocynaceae). *World Journal of Innovative Research (WJIR, 8*(1), 104–109.

19. Pearson, D. (1976). *The chemical analysis of food* (17th ed., pp. 3–4). Churchill Livingstone.

20. Rahman, M. M., Khan, M. R., & Hosain, M. M. (2007). Analysis of vitamin C (ascorbic acid) contents in various fruits and vegetables by UV spectrophotometry. *Bangladesh Journal of Scientific and Industrial Research, 42,* 417–424.

21. Jargar, J. G., Hattiwale, S. H., Das, S., Dhundasi, S. A., & Das, K. K. (2012). A modified simple method for determination of serum α-tocopherol (vitamin E). *Journal of Basic and Clinical Physiology and Pharmacology, 23*(1), 45–48. https://doi.org/10.1515/jbcpp-2011-0033

22. Ere, D., & Sisein, E. A. (2018). Determination of vitamin K1 in *Aspilia africana, Vernonia amygdalina, Chromoleana odorata,* and *Alchornea cordifolia* extract. *Saudi Journal of Medical and Pharmaceutical Sciences, 4*(5), 527–529. https://doi.org/10.36348/sjmps.2018.v04i05.006

23. Clegg, K. M., Kodicek, E., & Mistry, S. P. (1952). A modified medium for *Lactobacillus casei* for the assay of B vitamins. *Biochemical Journal, 50*(3), 326–331. https://doi.org/10.1042/bj0500326

24. Ball, G. F. M. (1994). Microbiological methods for the determination of the B-group vitamins. In *Water-soluble vitamin assays in human nutrition* (pp. 117–140). Springer. https://doi.org/10.1007/978-1-4615-2061-0_7

25. Adeyeye, E., & Ayejuyo, O. (1994). Chemical composition of *Cola acuminata* and *Garcinia kola* seeds grown in Nigeria. *International Journal of Food Sciences and Nutrition, 45,* 223–230.

26. Choi, Y. S., Choi, J. H., Han, D. J., Kim, H. Y., Kim, H. W., Lee, M. A., Chung, H. J., & Kim, C. J. (2012). Effects of *Laminaria japonica* on the physico-chemical and sensory characteristics of reduced-fat pork patties. *Meat Science, 91*(1), 1–7. https://doi.org/10.1016/j.meatsci.2011.11.011

27. Food and Agriculture Organization (FAO). (1985). Guidelines for development of supplementary foods for older infants and young children. Report of the 14th Session of the Codex Committee on Foods for Special Dietary Uses, Appendix 12, Rome.

28. Oladeji, O. A., Taiwo, K. A., Ishola, M. M., & Oladeji, B. S. (2017). Nutritional and quality characteristics of white maize Ogi flour enriched with *Moringa oleifera* seed. *Biotechnology Journal International, 18*(1), 1–11.

29. Ashraf, Z., & Hamidi-Esfahani, Z. (2011). Date and date processing: A review. *Food Reviews*

International, 27(2), 101–133.

30. Sani, M. N., Abdulkadir, F., Salim, F. B., Abubakar, M. M., & Kutama, A. S. (2016). Date palm (*Phoenix dactylifera*) as a food supplement and antimicrobial agent in the 21st century: A review. *Journal of Pharmacy and Biological Sciences (IOSR-JPBS), 11*(4), 46–51.
31. Oluseyi, A. K., Theresa, A. O., Abisola, M., Oluwatoyin, A. C., Iyabo, O. G., Funmi, A. O., & Oluwakayode, A. S. (2019). Nutritive assessment of sorghum-Ogi plantain flour weaning food. *IOP Conference Series: Materials Science and Engineering, 509*(1).
32. Stella, M. A., & Olufemi, G. A. (2019). Assessment of the nutritional qualities of a locally produced weaning blend of sorghum Ogi flour fortified with Bambara groundnut flour. *The International Journal of Biotechnology, 8*(2), 115–124.
33. Samuel, A. M., Ikya, K. J., & Ahure, D. (2024). Nutritional characteristics and sensory properties of maize-based Ogi supplemented with mushroom (*Pleurotus ostreatus*) flour. *European Journal of Nutrition & Food Safety, 16*(6), 8–17. https://doi.org/10.9734/ejnfs/2024/v16i61435
34. Odunlade, T. V., Taiwo, K. A., & Adeniran, H. A. (2016). Functional and antioxidative properties of sorghum Ogi flour enriched with cocoa. *Annals. Food Science and Technology, 17*(2), 497–506.
35. Ukom, A. N., Adiegwu, E. C., Ojimelukwe, P. C., & Okwunodulu, I. N. (2019). Quality and sensory acceptability of yellow maize Ogi porridge enriched with orange-fleshed sweet potato and African yam bean seed flours for infants. *Scientific African, 6*, e00144.
36. Awoyale, W., Fadeni, F. R., & Maziya-Dixon, B. (2024). Influence of adding edible termite flour to Ogi powder: Its chemical and phytochemical composition. *Frontiers in Nutrition, 11,* Article 1403660.https://doi.org/10.3389/fnut.2024.1403660

ENDIX

Plate 1. *Sorghum* Flour

Plate 2. *L. togolana stem powder*

Plate 3. Packaged LTSP *Ogi (instant Ogi)*.