



Quality Assessment of Powdered Maize Ogi Fortified with African Walnut (*Tetracarpidium conophorum*) Flour

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Authors' contributions

This work was carried out in collaboration among all authors. Author IA designed the study. Author CVE managed the literature searches and analyses of the study under the supervision of author IA. Author NM performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/MRJI/2021/v31i430311

Editor(s):

(1) Dr. Marcin Lukaszewicz, University of Wroclaw, Poland.

Reviewers:

(1) Luis Jesús Galán Wong, Universidad Autónoma de Nuevo León, México.

(2) Javan Ominde Ogola, University of Eldoret, Kenya.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/69183>

Original Research Article

Received 15 April 2021

Accepted 22 June 2021

Published 25 June 2021

ABSTRACT

Protein deficiency of fermented cereal gruel popularly known as ogi (akamu) is a justification to fortify it with African walnut. In this study, powdered maize ogi and walnut flour in the ratio 100:0; 90:10; 80:20 and 70:30 labelled AZ, BY, CX and DW, respectively were formulated. Sample 'AZ' served as the control. Microbiological analysis, proximate composition, and functional properties of the composite flour samples were determined using Standard methods. Sensory evaluation of ogi porridge prepared using the flour samples were carried out using 9-point Hedonic scale. Total heterotrophic bacterial and fungal count of the flour samples were within the range of 7.01-7.41 and 4.23-4.45 log₁₀CFU/g, respectively. The frequency of occurrence of bacterial isolates from the flour samples include *Corynebacterium* spp. (27%), *Micrococcus* spp. (14%), *Lactobacillus* spp. (13%), *Citrobacter* spp. (13%), *Pseudomonas* spp. (13%), *Bacillus* spp. (13%) and *Streptococcus* spp. (7%) while the fungal isolates were *Aspergillus* spp. (45%), *Rhizopus* spp. (22%), *Geotrichum* spp. (22%) and *Mucor* spp. (11%). All the proximate parameters and functional properties of the flour samples

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showed significant differences ($p < 0.05$) with the exception of protein content and bulk density, respectively. Sample 'AZ', 'BY', 'CX' and 'DW's protein content is $0.88 \pm 0.08\%$, $1.14 \pm 0.20\%$, $1.23 \pm 0.27\%$ and $1.31 \pm 0.38\%$, respectively. The lipid content ($2.00 \pm 0.75 - 15.20 \pm 0.61\%$), ash content ($0.40 \pm 0.06 - 0.90 \pm 0.04\%$), emulsion capacity ($2.98 \pm 0.14 - 5.62 \pm 0.17\%$), bulk density ($0.56 \pm 0.06 - 0.61 \pm 0.06$ g/ml), and swelling index ($1.99 \pm 0.10 - 18.89 \pm 0.21\%$) of the flour samples increased as the level of walnut flour substitution increased with few exceptions. In contrast, other proximate parameters, gelatinization temperature ($75.6 \pm 0.48 - 82.4 \pm 0.58$ °C), water absorption ($2.60 \pm 0.11 - 3.35 \pm 0.35$ g/g) and oil absorption ($1.56 \pm 0.06 - 1.80 \pm 0.08$ g/g) capacity of the flour samples decreased with few exceptions. Although ogi porridge made from 'BY' is more desirable than using other fortified flour formulations, ogi porridge made from 'AZ' was assigned the highest score for all the sensory attributes except appearance. Interestingly, ogi porridge prepared using maize ogi flour fortified with walnut flour and 100% maize ogi flour were generally acceptable.

Keywords: Cereal gruel; African walnut; ogi flour; food fortification; protein deficiency; weaning food.

1. INTRODUCTION

Malnutrition is still posing a serious challenge in many developing countries despite intensive efforts made by some researchers and relevant authorities in fighting the menace. Majority of those suffering from malnutrition are children below the age of 5 years [1,2]. This ugly development has been linked to infant mortality, poor intellectual and physical development of children [3]. Data released by National Population Commission (NPC) in 2014 reported that prevalence of stunting, underweight and wasting in children less than 5 years old due to protein energy malnutrition in children fed with carbohydrate-dense ogi is 37%, 29%, and 18%, respectively [4].

Ogi porridge also known as pap (akamu) is prepared by pouring boiled water (100 °C) into ogi slurry and continuously stirring the mixture until a thick paste is formed. It is commonly used as a weaning food for toddlers. Pap (akamu) also serve as a breakfast meal for adults and children [5,6]. Sick people are usually fed with pap because it digests quickly [4,6]. In local markets, ogi is usually displayed as a wet cake covered with transparent polythene bags or leaves [7]. It has been reported that cereal gruel commonly used in developing countries to feed children does not contain high amount of protein, energy and essential vitamins much needed by a growing child [2]. Notwithstanding the nutritional deficiencies in ogi, many families in Nigeria are still relying heavily on complementary foods mainly cereal gruel popularly known as *pap*, *akamu*, *ogi* or *koko* prepared from guinea corn, millet or/and maize to feed children above 6 months of age when breast milk becomes inadequate to provide their nutritional requirements [8].

The production of ogi from maize is usually a spontaneous fermentation process. A consortium of microorganisms associated with the process are members of the genera *Lactococcus*, *Lactobacillus*, *Leuconostoc*, *Pediococcus*, *Micrococcus*, *Streptococcus*, *Bacillus*, *Candida*, *Saccharomyces*, *Aspergillus*, *Candida*, *Fusarium*, *Penicillium* and *Cladosporium*. There are other microorganisms which could also be present during fermentation of ogi [9]. The sour taste of ogi porridge is similar with yoghurt. The colour of ogi porridge is dependent on the colour of cereal used as the raw material [9,10]. Although, ogi does not have a sweet taste, the popular notion that any food that has a good taste and sweet is nutritious is not always so [11]. The problem of sour taste and poor nutritional content associated with plain ogi was solved by blending powdered pap made from maize with malted maize and carrot powder [12].

Production of ogi in many households take place in unhygienic environment. The use of non-potable water during processing of ogi is one of the major sources of undesirable microorganisms in the product which raises safety concerns for consumers especially children. In the course of spontaneous fermentation of ogi, the presence of undesirable microorganisms which include *Aspergillus flavus*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Streptococcus pyogenes*, *Salmonella* spp., *Bacillus subtilis*, *B. cereus* and members of *Enterbacteriaceae* have been reported [9]. Research findings revealed that many samples of commercially available wet-milled ogi made from maize were contaminated with potentially pathogenic microorganisms which include *Aspergillus niger*, *Mucor* sp., *Fusarium* sp., *Bacillus subtilis*, *Streptococcus* sp., *Staphylococcus* sp., *Klebsiella* sp., *Salmonella*

sp., *Citrobacter* sp., *Pseudomonas* sp., *Micrococcus* sp. and *Escherichia coli* [5,13, 14]. The common practice of using stored maize instead of fresh maize to prepare ogi increases the risk of producing a contaminated product [15].

Traditionally, wet-milling, steeping and sieving processes involved in the production of ogi result in loss of nutrients such as protein, minerals and vitamins [16,17]. Despite several efforts made by many researchers to improve traditional processing methods of wet-milled ogi, encourage ogi processors to also prepare powdered ogi, enlighten them of the need to carry out their activities under hygienic conditions and use treated water in processing ogi, many producers of the fermented product at the cottage level are yet to embrace the improved methods and implement the research recommendations [9,18,19]. The process of drying wet ogi into powdered ogi has been reported to extend the shelf life of the product, reduce the level of some nutrients and microbial contamination of the product [5]. According to Bolaji et al. [18], drying wet ogi which becomes ogi flour or powdered ogi makes it easier to fortify the product. Due to poor nutritional composition of powdered maize ogi, Abioye and Aka [20], Aminigo et al. [21], Moses et al. [22], Inyang and Effiong [7] fortified the product with moringa, okra seed meal, unfermented locust bean seed, periwinkle meat flour, respectively. The nutritional composition and functional properties of powdered ogi fortified with plant or animal protein from various sources have been studied [23,24,25]. However, few studies on microbiological quality of powdered ogi fortified with common food sources rich in protein and other nutrients have been reported [11]. According to Ajala and Taiwo [26], the moisture, protein, fat, ash, fiber and carbohydrate content of powdered yellow maize ogi is 9.08%, 8.90%, 4.73%, 1.56%, 3.13% and 72.51%, respectively. Abioye and Aka [20] reported that powdered ogi contain calcium (125.01%), magnesium (36.67%), iron (4.67%), potassium (21.67%), zinc (0.23%) and copper (0.37%). Due to inadequate nutrients, fortification of cereal based diets such as ogi porridge and powdered ogi with soybean, groundnut, ginger, garlic during processing could improve the level of nutrients and flavour of the product [6,27]. Despite research efforts in that direction with very interesting findings, there is dearth of information on powdered ogi fortified with African walnut widely reported to be nutritious.

African walnut (*Tetracarpidium conophorum*) is known by the Igbo, Hausa and Yoruba tribes in Nigeria as 'ukpa', 'gawudi bairi' and 'awusa' or 'asala', respectively. Studies have shown that African walnut is a rich source of protein (20-24%) and fat (46-49%). It also contains 5.9% crude fibre and 2.8% ash [28,29]. African walnut grows abundantly in eastern and western part of Nigeria [30]. The minerals content of African walnut include Fe (68.00 mg/Kg), K (4029.14 mg/Kg), Ca (3014.28 mg/Kg), Cu (14.00 mg/Kg), Zn (24.01 mg/Kg), Na (3480.00 mg/Kg), and Mn (19.00 mg/Kg) [31]. In addition to nutritional benefits, African walnut possess wound healing, antioxidant, male fertility, antihyperglycaemic, antiulcer, antichelating, anticholesterol, and antimicrobial activity [32].

The cultivation of African walnut is mainly because of the nut which serve as a snack after it had been cooked. Ready-to-eat African walnut displayed in local markets are usually exposed. Many persons are fond of eating walnut not minding microbial contamination and poor shelf life of the snack. Consequently, they stand a risk of eating spoiled walnuts. A study carried out by Akin-Osanaiye and Ahmad [33] reported the presence of *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Salmonella typhi*, *Staphylococcus epidermidis*, *Escherichia coli*, *Aspergillus niger*, *A. fumigatus* and *Candida albicans* in spoiled samples of African walnut. However, processing of African walnut into flour could prevent spoilage and extend the shelf life of walnuts. The flour obtained from African walnut could be used as a composite flour for various applications in the food industry [31,33,34]. Due to rich nutritional content of African walnut, fortification of nutrient-deficient powdered maize ogi with walnut flour has the potential of improving the level of nutrients in powdered maize ogi. Therefore, this study is aimed at determining the microbiological quality, proximate composition and functional properties of powdered maize ogi fortified with walnut flour as well as evaluate the sensorial properties of porridge prepared using powdered maize ogi fortified with walnut flour.

2. MATERIALS AND METHODS

Maize grains and African walnut were purchased from Mile 3 and Rumuokoro markets, respectively. Both markets are located in Port Harcourt, Rivers State, Nigeria. All the materials were purchased using sterile polythene bags and quickly transported to the microbiology

laboratory, University of Port Harcourt for analysis. Fig. 1 shows the flow chart for production of powdered ogi using the method described by Stephen et al. [1] with slight modification. Presented in Fig. 2 is the flow chart for preparation of walnut flour using the method described by Barber and Obinna-Echem [30] with slight modifications.

2.1 Preparation of Ogi and African Walnut Composite Flour

The dried maize ogi flour and walnut flour were mixed in the following proportions 100:0; 90:10; 80:20 and 70:30 represented as AZ; BY; CX and DW, respectively. The different flour

proportions were packaged in clean and sterile plastic containers, properly covered, labeled and stored pending further analyses.

2.2 Serial Dilution

The method described by Adegbehingbe [35] was used in preparing stock solutions of different flour composition which comprise of dried maize ogi and walnut flour. Aseptically, 5 g of each composite flour was poured into sterile 250 ml conical flask containing 45 ml of distilled water. The mixture was well shaken to form a suspension. Ten-fold serial dilution (1:10, 1:100, 1:1000, 1:10000, 1:100000) of the different flour suspensions were prepared.

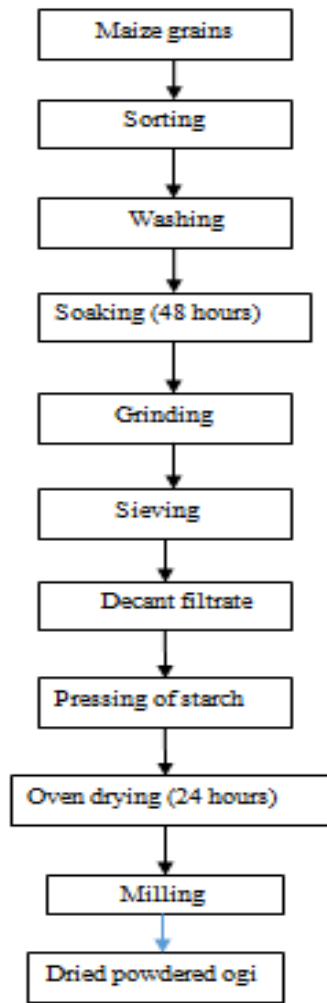


Fig. 1. Flow chart for the production of powdered maize ogi

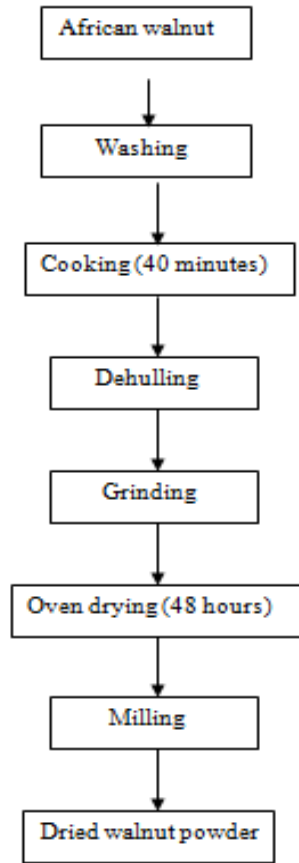


Fig. 2. Flow chart for the production of dried walnut flour

2.3 Microbiological Analysis

2.3.1 Total heterotrophic bacterial count

Under aseptic conditions, two dilutions (10^{-4} and 10^{-5}) of each composite flour were inoculated into nutrient agar (NA) plates using the spread plate method. The inoculated plates were incubated at 37°C for 24 h. Thereafter, the total viable count observed in the culture plates were noted. The number of colonies in each sample was calculated and expressed as colony forming units per gram (CFU/g) using the formula below.

$$\text{CFU/g} = \text{no. of colonies} \times \frac{1}{\text{dilution factor}} \times \frac{1}{\text{volume plated}}$$

2.3.2 Total fungal count

Two dilutions (10^{-4} and 10^{-5}) of each composite flour were inoculated into potato dextrose agar (PDA) medium under aseptic conditions.

Incubation of the inoculated plates were done at room temperature ($28 \pm 2^{\circ}\text{C}$) for 5 days. Thereafter, the plates were observed for microbial growth and total viable counts were noted. Calculation of the total fungal count was determined using the formula below. The results were expressed as colony forming units per gram (CFU/g).

$$\text{CFU/g} = \text{no. of colonies} \times \frac{1}{\text{dilution factor}} \times \frac{1}{\text{volume plated}}$$

2.3.3 Isolation of pure isolates

To obtain pure culture, the representative bacterial and fungal colonies were subcultured using streak method into freshly prepared NA and PDA plates, respectively. The inoculated plates were incubated at 37°C for 24 h for bacterial growth; room temperature ($28 \pm 2^{\circ}\text{C}$) for 5 days for fungal growth. Thereafter, the pure cultures were transferred into agar slants inside Bijou bottles and stored in a refrigerator

until further identification of the isolates were concluded.

2.3.4 Identification of bacterial isolates

The bacterial isolates were identified based on their morphological growth and different biochemical tests carried out. Gram staining and biochemical tests which include catalase test, oxidase test, citrate test, motility test, indole test, methyl red- Voges Proskauer test (MR-VP), sugar fermentation and triple sugar iron were carried out using the method described by Isu and Onyeagba [36].

2.3.5 Identification of fungal isolates

The fungal isolates were identified based on their morphological appearance. Also, wet mount of the fungal isolates were prepared. Few drops of normal saline were dropped on a clean, grease-free slide and small portion of the fungal isolate was dropped on the slide. The content of the slide was gently mixed and covered with a cover slip. Thereafter, it was viewed under the microscope using x10 magnification in line with the method described by Isu and Onyeagba [36].

2.4 Functional Properties

2.4.1 Water absorption capacity

The water absorption capacity of maize ogi flour fortified with walnut flour and unfortified maize ogi flour were determined using the centrifuge method of Sosulski [37]. Exactly 1.5 g of the sample was weighed into the centrifuge tube and 9 ml of distilled water was added into it. With a glass rod, the content of the centrifuge tube was stirred for 30 s after which the suspension was allowed to rest for 10 min. This procedure was repeated at intervals during which the particles that adhered to the sides of the centrifuge tube was scrubbed using the glass rod. The suspension was mixed 7 additional times to ensure that an even suspension (each period lasting for 20 s, with 10 min resting period after each mixing). The tube was centrifuged at 5100 rpm for 25 min. Thereafter, the water (supernatant) was decanted and the percentage of absorbed water was calculated as the ratio of weight retained by the sample multiplied by 100.

$$\text{Water absorption} = \frac{\text{Centrifuge} + \text{sample}}{\text{Weight of sample}}$$

2.4.2 Bulk density

The bulk density of maize ogi flour fortified with walnut flour and unfortified maize ogi flour were determined using the method described by Murphy et al. [38]. Tap water was filled to the 10 ml mark of a measuring cylinder and the volume was noted. Thereafter, the measuring cylinder was emptied and properly cleaned. The composite flour sample was poured inside the graduated cylinder up to the 10 ml mark. The cylinder was tapped (agitated) for 5 min in order to eliminate air space between the flour blends inside the cylinder. The weight of the sample was noted.

$$\text{Bulk density} = \frac{\text{Weight of sample}}{\text{Volume of sample}}$$

2.4.3 Swelling index

The swelling index of maize ogi flour fortified with walnut flour and unfortified maize ogi flour were estimated using the method described by Leach et al. [39]. Three grams (3 g) of the sample was weighed and transferred into a clean test tube. The weight of both the sample and the test tube was ascertained. The sample was dispersed with a stirrer in 50 ml of water. The resulting suspension was heated at 60°C for 15 min. in a thermostat water bath. During the process of heating, the slurry was stirred gently to prevent clumping. The slurry was cooled to room temperature (25±2 °C) and then centrifuged at 2200 rpm for 15 min. The supernatant was decanted and the resulting residue was weighed and the swelling index was calculated as the ratio of the difference in weight of the flour multiplied by 100.

$$\text{Swelling Index} = \frac{W_{tf} - W_{ti}}{W_{ti}} \times 100$$

Where: W_{tf} = Final weight of sample after centrifugation

W_{ti} = Initial weight of sample before centrifugation

2.4.4 Oil absorption capacity

The oil absorption of maize ogi flour fortified with walnut flour and unfortified maize ogi flour were determined using the centrifuge method described by Beuchat [40] with slight modification by Adepeju et al. [41]. One gram (1 g) of the sample was mixed with 10 ml of pure oil (Canola oil) for 60 sec. The mixture was allowed to stand for 10 min at room

temperature (28 ± 2 °C). Thereafter, the mixture was centrifuged at 4000 rpm for 30 min. and the separated oil was decanted carefully. The tube was allowed to drain at an angle of 45° for 10 min after which it was weighed. Oil absorption was expressed as the percentage increase of the sample weight.

$$\text{Oil absorption} = \frac{\text{Centrifuge+Sample}}{\text{Weight of sample}}$$

2.4.5 Emulsion capacity

The emulsion capacity of maize ogi flour fortified with walnut flour and unfortified maize ogi flour were determined using the method described by Adeleke and Odedeji [42]. Two gram (2 g) of the sample was blended with 25 g of distilled water for 30 s using a blender at 1600 rpm. After complete dispersion, refined oil (corn oil) was added from a burette and blended until there was a separation into two layers of water and fat. The emulsion capability was expressed as millilitre of oil emulsified by 1g of flour.

2.4.6 Gelatinization temperature

The gelatinization temperature of maize ogi flour fortified with walnut flour and unfortified maize ogi flour were determined using the method described by Shinde [43]. One gram (1 g) of the flour sample was transferred into a test tube and 10 ml of distilled water was added. The sample was heated slowly in a water bath and continuously stirred until gelatinization occurred. At complete gel formation the prevailing temperature (°C) was noted.

2.5 Proximate Analysis

2.5.1 Protein content

The Kjeldahl method was adopted. The first stage involves digestion. Exactly 0.1 g of the sample was weighed into a clean conical flask (250 ml capacity) and 3 g of digestion catalyst was added to the content of the flask followed by 20 ml concentrated sulfuric acid. The sample was heated to digest the content from black to sky-blue colouration. The digest was cooled to room temperature (28 ± 2 °C) and diluted using 100 ml distilled water. The second stage involves distillation. Twenty milliliter (20 ml) of diluted digest was measured into a distillation flask and the flask was held in place

on top of hot plate. The distillation flask was attached to a Liebig condenser connected to a receiver containing 10 ml of 2% boric acid indicator. Forty milliliter (40 ml) of sodium hydroxide was injected into the digest through a syringe attached to the mono-arm steelhead until the digest became ammonia gas passing through the condenser into the receiver beaker. The colour of the boric acid changed from purple to greenish as ammonia distillate was introduced into the boric acid. The isolate was titrated with standard 0.1N hydrochloric acid solution back to purple from greenish. The volume of hydrochloric acid added to effect this change was recorded as titer value.

$$\% \text{ organic nitrogen} = \frac{\text{titer value} \times 1.4 \times 100 \times 100}{1000 \times 20 \times 0.1}$$

Where:

titer value = the volume of HCl used in titrating the ammonium distillate

1.4 = Nitrogen equivalent to the normality of HCl used in the titration 0.1N

100 = the total volume of digest dilution

100 = percentage factor

1000 = conversion factor from gram to milligram

20 = integral volume of digits analyzed or diluted

0.1 = the weight of the sample in gram digested

2.5.2 Carbohydrate content

Exactly 0.1 g of the sample was weighed into a 25 ml volumetric flask. One milliliter (1 ml) of distilled water and 1.3 ml of 62% perchloric acid was added to the content of the flask and swirled for 20 min to homogenize completely. The content of the flask was made up to 25 ml mark using distilled water and stoppered. The solution formed was filtered through a glass filter paper. One milliliter (1 ml) of the filtrate was collected and transferred into a 10 ml test tube. The content of the test tube was diluted to volume using distilled water. One milliliter (1 ml) of the working solution was pipette into a clean test tube and 5 ml Anthrone reagent was added. One ml (1 ml) of distilled water and 5ml Anthrone reagent was mixed. The whole mixture was read at 630 nm wavelength using 1 ml distilled water and 5 ml Anthrone reagent prepared as blank. Glucose solution (0.1 ml) was also prepared and was treated as the sample with Anthrone reagent. Absorbance of

the standard glucose was read and the value of carbohydrate as glucose was calculated using the formula below:

$$\% \text{ CHO as glucose} = \frac{25 \times \text{absorbance of sample}}{\text{Absorbance of standard glucose}}$$

2.5.3 Moisture content

One gram (1 g) of sample was weighed into a pre-weighed clean dried porcelain evaporating dish. The sample contained in the evaporating dish was placed in an oven maintained at a temperature of 105 °C for 3 h. The evaporating dish containing the sample was cooled inside a desiccator to room temperature (28±2 °C) and re-weighed. The values obtained were used to calculate the moisture content of the sample using the formula below.

% moisture =

$$\frac{\text{Weight of fresh sample} - \text{Weight of dried sample}}{\text{Weight of sample used}} \times 100$$

2.5.4 Lipid content

The method used was Soxhlet fat extraction method. Two gram (2 g) of sample was inserted in a filter paper and placed in a soxhlet extractor. The extractor was placed in a pre-weighed dried distillation flask. Then, the solvent (acetone) was introduced into the distillation flask through the condenser attached to the soxhlet extractor. The set up was held in place with a retort stand clamp. Cooled water jet was allowed to flow into the condenser and the heated solvent was reflected as a result. The lipid in the solvent chamber was extracted in the process of continuous refluxing. When the lipid was observably extracted completely from the sample, the condenser and the extractor was disconnected and the solvent was evaporated to concentrate the lipid. The flask was then dried in the air oven to constant weight and re-weighed to obtain the weight of lipid in the sample.

% lipid =

$$\frac{\text{Weight of flask and extract} - \text{Weight of empty flask}}{\text{Weight of sample extracted}} \times 100$$

2.5.5 Ash content

Furnace incineration gravimetric method as described by Innocent et al. [44] was used in determining the ash content of the flour samples. One gram (1 g) of the dried sample

was weighed into a clean porcelain crucible which was previously preheated and weighed. The crucible containing the sample was inserted into a muffle furnace at 550 °C for 3 h. The crucible was removed from the muffle furnace and placed in a desiccator to cool and reweighed. Weight of the ash was determined by difference. The result was expressed as a percentage of the weight of the initial sample incinerated in the muffle furnace.

% ash =

$$\frac{\text{Weight of crucible + ash sample} - \text{Weight of crucible and sample after ashing}}{\text{Weight of sample}} \times 100$$

2.5.6 Crude fiber content

The method described by Innocent et al. [44] was adopted in determining fiber content of the flour samples. Five grams (5 g) of the flour sample was weighed and poured in 150 ml solution containing 1.25 g H₂ SO₄ per 100 ml. Under reflux, the solution was allowed to boil for 30 min. Using a two-fold muslin cloth inserted on a fluted funnel, the solution was filtered and washed with boiling water continuously until it was noticed not to be acidic. The residue obtained was transferred to the flask boiled for 30 min. with 150 ml of solution containing 1.25 g of carbonate free NaOH per 100 ml. On completion of washing, the sample was kept to drain and become dry before it was transferred into a pre-weighed crucible. The crucible and the content was dried by placing it inside an oven at 105 °C until a constant weight was achieved. Finally, the sample was incinerated inside a muffle furnace. The weight of the ash was recorded. The recorded value was used to determine the fiber content using the formula below.

% Crude fiber = 100 (W₂ - W₃)

Where: W₂ = Weight of crucible + sample after oven drying

W₃ = Weight of crucible + sample after incineration

2.6 Sensory Evaluation

The method described by Larmond [45] was used for sensory evaluation of the samples (ogi porridge made from unfortified maize ogi flour and ogi porridge made from maize ogi flour fortified with different proportions of walnut flour). A twelve member panelists were used to

evaluate the sensorial properties of the samples. The panelists were semi-trained, but verbally admitted they were regular consumers of ogi porridge and familiar with the quality of the product. Selection of the panelists was based on availability and interest. The fortified flour samples were made into porridge by mixing 80 g of the ogi-walnut flour dissolved in 40 ml of potable water followed by addition of boiling water to gelatinize. The same procedure is applicable to the preparation of ogi porridge using unfortified maize ogi flour. The samples were coded in a random order and served hot to the sensory panelists. A copy of sensory evaluation form containing 9 - point Hedonic scale for each coded sample was issued to each of the panelists. The panelists rated the samples according to a scale of 1-9 which implies that 1 is extremely disliked; 9 is extremely liked. The sensory attributes of the samples evaluated by the panelists were colour, taste, texture, smell and overall acceptability. The panelists were given cracker biscuit and potable water to rinse their mouth after evaluating each sample to avoid carry over taste.

2.7 Statistical Analysis

The data generated in this study were subjected to One-way Analysis of variance (ANOVA) using Statistical Package for Social Sciences (IBM, SPSS) version 23. A probability value at $p < 0.05$ was considered to be statistically different using Duncan multiple range test which evaluated the differences between means.

3. RESULTS

Depicted in Fig. 3 is the total heterotrophic bacterial count (THBC) and total fungal count (TFC) of powdered maize ogi and different portions of powdered maize ogi fortified with walnut flour. The result shows that the sample that had the highest ($7.41 \log_{10}\text{CFU/g}$) and lowest ($7.01 \log_{10}\text{CFU/g}$) heterotrophic bacterial count is 100% powdered maize ogi and 90% powdered maize ogi fortified with 10% walnut flour, respectively. In contrast, 100% powdered maize ogi which recorded the highest THBC among all the flour formulations had the lowest fungal count ($4.23 \log_{10}\text{CFU/g}$) whereas 70% powdered maize ogi fortified with 30% walnut flour had the highest fungal count ($4.45 \log_{10}\text{CFU/g}$).

Presented in Table 1 is the morphological characterization of bacteria isolated from powdered maize ogi and different portions of

powdered maize ogi fortified with walnut flour. Characterization and identification of bacterial isolates from powdered maize ogi and different portions of powdered maize ogi fortified with walnut flour is depicted in Table 2. The probable bacterial isolates were *Corynebacterium* spp., *Micrococcus* spp., *Lactobacillus* spp., *Streptococcus* spp., *Citrobacter* spp., *Pseudomonas* spp. and *Bacillus* spp. Depicted in Table 3 is the macroscopy and microscopy of fungal isolates from powdered maize ogi and different portions of powdered maize ogi fortified with walnut flour. *Aspergillus* spp., *Rhizopus* spp., *Geotrichum* spp. and *Mucor* spp. were the probable fungal isolates from powdered maize ogi and different portions of powdered maize ogi fortified with walnut flour.

Depicted in Fig. 4 and 5 is the frequency of occurrence of the bacterial and fungal isolates, respectively. Among the bacterial isolates, *Corynebacterium* spp. (27%) and *Streptococcus* spp. (7%) had the highest and least percentage occurrence. Meanwhile, *Aspergillus* spp. (45%) and *Mucor* spp. (11%) had the highest and least percentage occurrence among the fungal species, respectively.

The proximate composition of powdered maize ogi and different portions of powdered maize ogi fortified with walnut flour is presented in Table 4. The results show that there is a significant difference ($p < 0.05$) between the values recorded for each of the proximate parameters among the samples with the exception of protein content. The protein contents of powdered maize ogi fortified with different proportions of walnut flour were within the range of 1.14 ± 0.20 - $1.31 \pm 0.38\%$ whereas the value reported for unfortified powdered maize ogi is $0.88 \pm 0.08\%$. The lipid content of unfortified powdered maize ogi is $2.00 \pm 0.75\%$ whereas the values reported for powdered maize ogi fortified with different proportions of walnut flour were within the range of 4.80 ± 0.85 - $15.20 \pm 0.61\%$. The moisture, carbohydrate, ash and fibre content of powdered maize ogi and powdered maize ogi fortified with different proportions of walnut flour were within the range of 30.69 ± 0.49 - $37.93 \pm 0.60\%$, 47.44 ± 0.78 - $60.88 \pm 0.58\%$, 0.40 ± 0.06 - $0.50 \pm 0.06\%$ and 1.02 ± 0.11 - $1.61 \pm 0.16\%$, respectively.

Presented in Table 5 is the functional properties of unfortified powdered maize ogi and powdered maize ogi fortified with different proportions of walnut flour. The results showed that there is a

significant difference ($p < 0.05$) between the values reported for each of the functional properties among the samples with the exception of bulk density. The bulk density, water absorption capacity, oil absorption capacity, swelling index, emulsion capacity and gelatinization temperature of unfortified

powdered maize ogi and powdered maize ogi fortified with different proportions of walnut flour were within the range of $0.56 \pm 0.06 - 0.61 \pm 0.06$ g/ml, $2.60 \pm 0.11 - 3.35 \pm 0.35$ g/g, $1.56 \pm 0.06 - 1.80 \pm 0.08$ g/g, $1.99 \pm 0.10 - 18.89 \pm 0.21\%$, $2.98 \pm 0.14 - 5.62 \pm 0.17\%$ and $75.6 \pm 0.48 - 82.4 \pm 0.58$ °C, respectively.

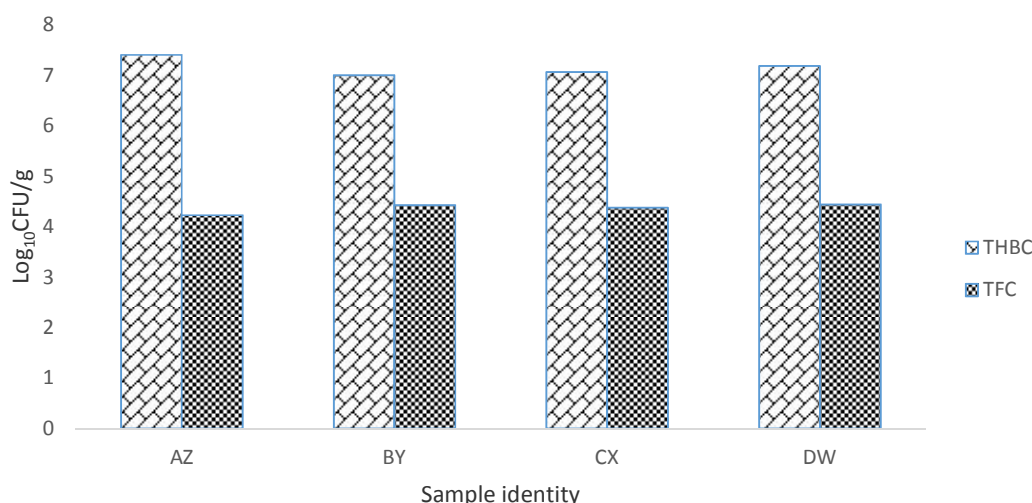


Fig. 3. Total heterotrophic bacterial count (THBC) and total fungal count (TFC) of powdered maize ogi and different portions fortified with walnut flour

Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour

Table 1. Morphological characterization of bacteria isolated from maize ogi flour and different portions fortified with walnut flour

Isolate identity	Surface	Shape	Elevation	Edge	Colour
AZ1	Smooth	Granular	Convex	Entire	Gray
AZ2	Smooth	Circular	Convex	Entire	Yellow
AZ3	Smooth	Circular	Convex	Entire	White
AZ4	Smooth	Spherical	Convex	Entire	White
BY1	Smooth	Circular	Convex	Entire	White
BY2	Smooth	Granular	Convex	Entire	Gray
BY3	Smooth	Circular	Convex	Entire	Yellow
CX1	Moist	Circular	Convex	Entire	Translucent
CX2	Smooth	Circular	Flat	Entire	White
CX3	Smooth	Granular	Convex	Entire	Gray
CX4	Smooth	Circular	Convex	Entire	Shiny, slight yellow
DW1	Smooth	Circular	Convex	Entire	Shiny, slight yellow
DW2	Moist	Circular	Convex	Entire	Translucent
DW3	Smooth	Granular	Convex	Entire	Gray
DW4	Smooth	Circular	Flat	Entire	White

Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour

Table 2. Characterization and identification of bacterial isolates from powdered maize ogi and different portions fortified with walnut flour

Isolate Identity	Gram Stain	Catalase	Oxidase	Slant	Butt	Gas	H ₂ S	Indole	MR	VP	Citrate	Motility	Glucose fermentation	Lactose fermentation	Probable isolate
AZ1	+	-	-	B	A	-	-	-	-	-	-	-	A	-	<i>Corynebacterium</i> spp.
AZ2	+	+	-	A	A	-	-	-	-	-	-	-	A	-	<i>Micrococcus</i> spp.
AZ3	+	-	+	A	A	-	+	+	-	-	-	-	A	A	<i>Lactobacillus</i> spp.
AZ4	+	-	+	B	B	-	-	-	+	+	-	-	A	-	<i>Streptococcus</i> spp.
BY1	+	-	+	A	A	-	+	+	-	-	-	-	A	A	<i>Lactobacillus</i> spp.
BY2	+	-	-	B	A	-	-	-	-	-	-	-	A	-	<i>Corynebacterium</i> spp.
BY3	+	+	-	A	A	-	-	-	-	-	-	-	A	-	<i>Micrococcus</i> spp.
CX1	-	+	-	A	A	-	-	-	-	-	+	-	AG	A	<i>Citrobacter</i> spp.
CX2	+	-	-	B	A	-	-	-	-	-	-	-	A	-	<i>Bacillus</i> spp.
CX3	+	-	-	B	A	-	-	-	-	-	-	-	A	-	<i>Corynebacterium</i> spp.
CX4	-	-	-	A	A	-	-	-	-	-	-	-	A	-	<i>Pseudomonas</i> spp.
DW1	-	-	-	A	A	-	-	-	-	-	-	-	A	-	<i>Pseudomonas</i> spp.
DW2	-	+	-	A	A	-	-	-	-	-	+	-	AG	A	<i>Citrobacter</i> spp.
DW3	+	-	-	B	A	-	-	-	-	-	-	-	A	-	<i>Corynebacterium</i> spp.
DW4	+	-	-	B	A	-	-	-	-	-	-	-	A	-	<i>Bacillus</i> spp.

Key: + represent Positive; - represent Negative; MR = Methyl red; VP = Voges Proskauer; A = Acid production; B = Alkaline production; AG = Acid and Gas production; AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour

Table 3. Macroscopy and microscopy of fungal isolates from maize ogi flour and different portions fortified with walnut flour

Sample code	Macroscopy	Microscopy	Probable organism
AZ1	Irregular and whitish, turns yellow, then green colour.	Branched mycelium, conidiospores are enlarged at the tip forming a rounded vesicle which is covered with flask-shaped sterigmata that produced chains of rough conidia.	<i>Aspergillus</i> spp.
AZ2	White mycelia that looks cottony.	Aseptate hyphae of large diameter.	<i>Rhizopus</i> spp.
BY1	Irregular and whitish, turns yellow, then green colour.	Branched mycelium, conidiospores are enlarged at the tip forming a rounded vesicle which is covered with flask-shaped sterigmata that produced chains of rough conidia.	<i>Aspergillus</i> spp.
BY2	White mycelia that looks cottony.	Aseptate hyphae of large diameter.	<i>Rhizopus</i> spp.
CX1	Irregular and whitish, turns yellow, then green colour.	Branched mycelium, conidiospores are enlarged at the tip forming a rounded vesicle which is covered with flask-shaped sterigmata that produced chains of rough conidia.	<i>Aspergillus</i> spp.
CX2	Surface is slightly raised, black reverse and velvety texture.	Coarse hyphae with segmented rectangular arthrospores with different sizes and round at their edges.	<i>Geotrichum</i> spp.
DW1	Irregular and whitish, turns yellow, then green colour.	Branched mycelium, conidiospores are enlarged at the tip forming a rounded vesicle which is covered with flask-shaped sterigmata that produced chains of rough conidia.	<i>Aspergillus</i> spp.
DW2	Black surface with a velvet whitish surrounding, the reverse is creamy and crack colony.	Non septate, non-branched sporangiospores, no stolons and rhizoids.	<i>Mucor</i> spp.
DW3	Surface is slightly raised, black reverse and velvety texture.	Coarse hyphae with segmented rectangular arthrospores with different sizes and round at their edges.	<i>Geotrichum</i> spp.

Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour.

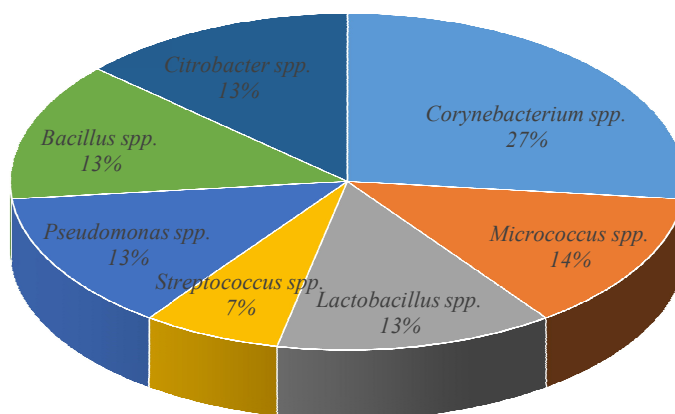


Fig. 4. Frequency of occurrence of bacterial isolates from 100% powdered maize ogi and different portions fortified with walnut flour

Table 4. Proximate composition of powdered maize ogi and different portions fortified with walnut flour

Sample Identity	Moisture (%)	Carbohydrate (%)	Lipid (%)	Protein (%)	Ash (%)	Fibre (%)
AZ	34.15±0.23 ^b	60.88±0.58 ^c	2.00±0.75 ^a	0.88±0.08 ^a	0.50±0.04 ^a	1.61±0.16 ^b
BY	31.77±0.95 ^a	60.33±0.74 ^c	4.80±0.85 ^b	1.14±0.20 ^a	0.40±0.06 ^a	1.56±0.10 ^b
CX	30.69±0.49 ^a	51.29±0.86 ^b	15.20±0.61 ^d	1.23±0.27 ^a	0.50±0.06 ^a	1.09±0.13 ^a
DW	37.93±0.60 ^c	47.44±0.78 ^a	11.40±0.62 ^c	1.31±0.38 ^a	0.90±0.04 ^b	1.02±0.11 ^a

Values show the means of duplicate analysis ±SD. Means with different superscript along the column are significantly different ($p < 0.05$). Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour

Table 5. Functional properties of powdered maize ogi and different portions fortified with walnut flour

Sample Identity	Bulk density (g/ml)	Water absorption (g/g)	Oil absorption (g/g)	Swelling index (%)	Emulsion capacity (%)	Gelatinization temperature (°C)
AZ	0.56±0.06 ^a	3.35±0.35 ^b	1.80±0.08 ^b	1.99±0.10 ^a	2.98±0.14 ^a	82.4±0.58 ^b
BY	0.57±0.04 ^a	3.16±0.11 ^{ab}	1.60±0.08 ^{ab}	17.27±0.16 ^c	5.58±0.14 ^c	80.9±0.88 ^b
CX	0.58±0.03 ^a	2.96±0.14 ^{ab}	1.64±0.09 ^{ab}	18.89±0.21 ^d	4.74±0.11 ^b	75.6±0.48 ^a
DW	0.61±0.06 ^a	2.60±0.11 ^a	1.56±0.06 ^a	8.10±0.23 ^b	5.62±0.17 ^c	76.8±0.42 ^a

Values show the means of duplicate analysis ±SD. Means with different superscript along the column are significantly different ($p < 0.05$). Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour

The average sensory score for each sensory attribute (overall acceptability, mouthfeel, aroma, taste, appearance, and colour) assigned to unfortified ogi porridge and ogi porridge made from 90% powdered maize ogi fortified with 10% walnut flour, 80% powdered maize ogi fortified with 20% walnut flour and 70% powdered maize ogi fortified with 30% walnut flour are presented in Figs. 6-11.

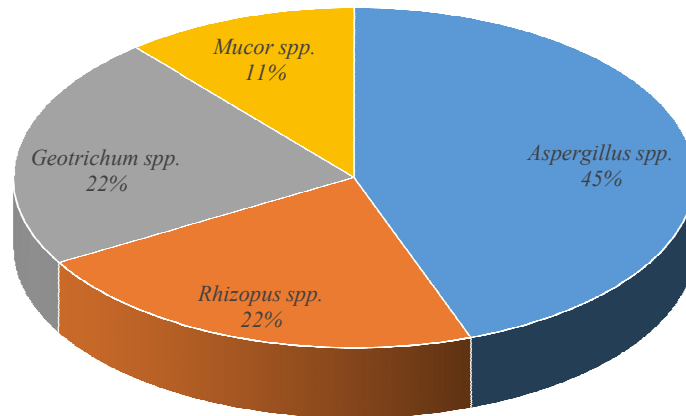


Fig. 5. Frequency of occurrence of fungal isolates from 100% powdered maize ogi and different portions fortified with walnut flour

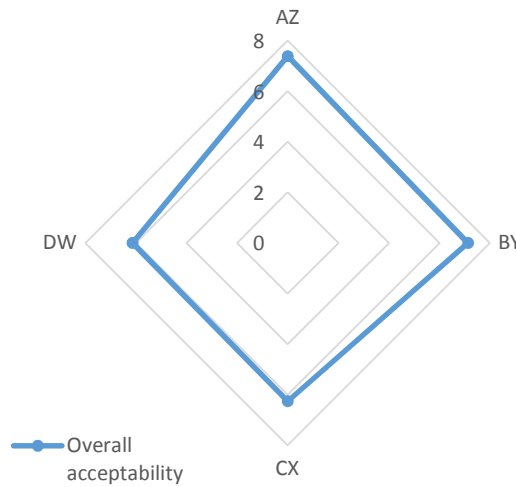


Fig. 6. Overall acceptability of ogi porridge and different portions fortified with walnut flour
 Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour. Interpretation of the 9-point Hedonic scale: 9 - Like extremely; 8 - Like very much; 7 - Like moderately; 6 - Like slightly; 5 - Neither liked nor disliked; 4 - Disliked slightly; 3 - Disliked moderately; 2 - Disliked very much; 1 - Disliked extremely

4. DISCUSSION

4.1 Microbiological Quality

4.1.1 Bacterial and fungal population

In this study, the result presented in Fig. 3 shows that bacteria was predominant than fungi in the samples which comprise of 100% powdered

maize ogi, 90% powdered maize ogi fortified with 10% walnut flour, 80% powdered maize ogi fortified with 20% walnut flour and 70% powdered maize ogi fortified with 30% walnut flour. A possible reason for this observation is that larger population of bacteria than fungi are involved in fermentation of maize for ogi production. Bello et al. [13] reported that the highest aerobic bacteria count (1.71×10^6 CFU/g)

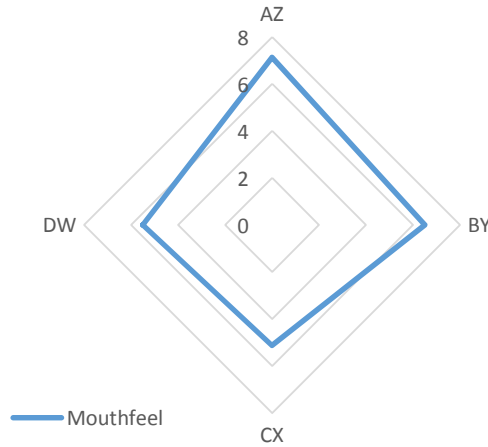


Fig. 7. Mouthfeel of ogi porridge and different portions fortified with walnut flour
 Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour. Interpretation of the 9-point Hedonic scale: 9 - Like extremely; 8 - Like very much; 7 - Like moderately; 6 - Like slightly; 5 - Neither liked nor disliked; 4 - Disliked slightly; 3 - Disliked moderately; 2 - Disliked very much; 1 -Disliked extremely

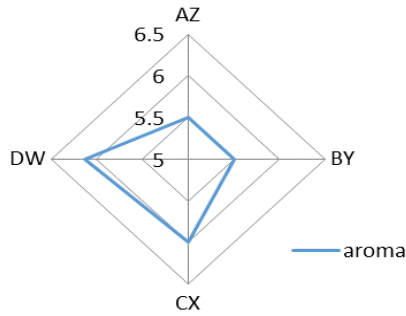


Fig. 8. Aroma of ogi porridge and different portions fortified with walnut flour
 Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour. Interpretation of the 9-point Hedonic scale: 9 - Like extremely; 8 - Like very much; 7 - Like moderately; 6 - Like slightly; 5 - Neither liked nor disliked; 4 - Disliked slightly; 3 - Disliked moderately; 2 - Disliked very much; 1 -Disliked extremely

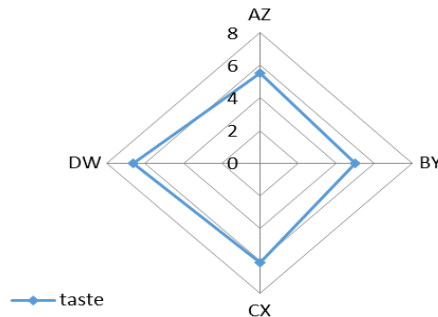


Fig. 9. Taste of ogi porridge and different portions fortified with walnut flour
 Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour. Interpretation of the 9-point Hedonic scale: 9 - Like extremely; 8 - Like very much; 7 - Like moderately; 6 - Like slightly; 5 - Neither liked nor disliked; 4 - Disliked slightly; 3 - Disliked moderately; 2 - Disliked very much; 1 -Disliked extremely

was higher than the highest fungal count (3.2×10^3 CFU/g) encountered during fermentation of maize for ogi production. According to Okwute and Olafiaji [8], a consortium of moulds which constitute the microflora associated with fermenting maize were eliminated during steeping within a period of 6 hours. The result presented in Fig. 3 shows that total heterotrophic bacterial count in 100% powdered ogi is higher than the values reported for powdered maize ogi fortified with different proportions of walnut flour. Although the antimicrobial properties of walnut reported by some researchers were contradictory

[31,46], the reduction in bacterial population in powdered maize ogi fortified with different portions of walnut flour when compared with 100% powdered maize ogi suggests that walnut flour inhibited the growth and multiplication of bacterial population in powdered maize ogi flour. On the contrary, powdered maize ogi fortified with different portions of walnut flour had higher fungal count than what was recorded for 100% powdered maize ogi which also suggest that walnut flour did not exhibit inhibitory activities against fungal population in powdered maize ogi.

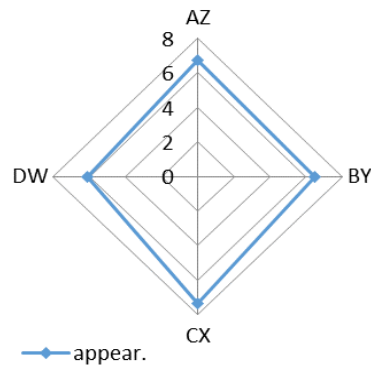


Fig. 10. Appearance of ogi porridge and different portions fortified with walnut flour

Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour. Interpretation of the 9-point Hedonic scale: 9 - Like extremely; 8 - Like very much; 7 - Like moderately; 6 - Like slightly; 5 - Neither liked nor disliked; 4 - Disliked slightly; 3 - Disliked moderately; 2 - Disliked very much; 1 - Disliked extremely

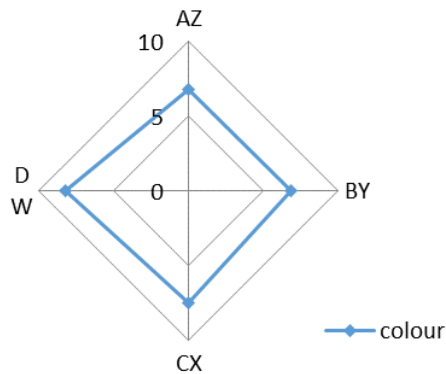


Fig. 11. Colour of ogi porridge and different portions fortified with walnut flour

Key: AZ = 100% maize ogi flour; BY = 90% maize ogi flour: 10% walnut flour; CX = 80% maize ogi flour: 20% walnut flour; DW = 70% maize ogi flour: 30% walnut flour. Interpretation of the 9-point Hedonic scale: 9 - Like extremely; 8 - Like very much; 7 - Like moderately; 6 - Like slightly; 5 - Neither liked nor disliked; 4 - Disliked slightly; 3 - Disliked moderately; 2 - Disliked very much; 1 - Disliked extremely

4.1.2 Bacterial and fungal isolates

A recent study carried out by Emeka-Ike et al. [12] which involved microbiological analysis of powdered pap made from maize and malted maize with carrot reported the presence of *Lactobacillus* sp., *Bacillus* sp., *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Escherichia coli*, *Saccharomyces cerevisiae*, *Penicillium* sp. and *Aspergillus* sp. Some of these microbial genera were also reported in this study. The environment and inherent microbial flora of walnut and maize were possible sources of microbial contaminants of powdered maize ogi and portions of powdered maize ogi fortified with walnut flour. Some of the microorganisms reported in this study were also reported by Bello et al. [13] in a research that involved 4 days monitoring of fermentation of maize-based ogi sampled from different locations at the point of preparation in Ondo State, Nigeria. In other related studies, Ezendianefo and Dimejesi [47]; Ogodo et al. [5] also reported the presence of similar bacteria and fungi genera found in powdered ogi fortified with walnut flour in commercialized ogi sampled from different locations. The presence of different bacterial and fungal species in large population in powdered ogi and different proportions of powdered ogi fortified with walnut flour contradicts the assumption that flour generally should be microbiologically safe due to low water activity [48].

4.1.3 Frequency of occurrence of bacterial and fungal isolates

Among the bacterial isolates reported in this study, *Corynebacterium* spp. (27%) and *Streptococcus* spp. (7%) had the highest and least frequency of occurrence while the corresponding fungal isolates were *Aspergillus* spp. (45%) and *Mucor* spp. (11%), respectively. In a related study which involved the production of powdered pap from maize and malted maize with carrot, Emeka-Ike et al. [12] reported frequency of occurrence of bacterial isolates which include *Lactobacillus* sp. (36%), *Bacillus* sp. (25%), *Staphylococcus aureus* (16%), *Pseudomonas* sp. (12%) and *Escherichia coli* (11%) while the fungal isolates were *Saccharomyces cerevisiae* (62%), *Penicillium* sp. (20%) and *Aspergillus* sp. (18%). This result has little similarity with the findings from this study.

4.2 Proximate Composition

4.2.1 Protein content

The protein content of 100% powdered maize ogi is $0.88 \pm 0.08\%$ while powdered ogi fortified with different portions of walnut were within the range of 1.14 ± 0.20 - $1.31 \pm 0.38\%$. The increase in protein content observed as the proportion of walnut flour used in fortifying powdered ogi increased could be attributed to protein content of walnut flour. This trend is in agreement with similar studies that involves fortifying powdered ogi with unfermented locust beans [22], moringa [20] and periwinkle meat flour [7]. However, processing of walnut into flour which involves heating process probably eliminated substantial amount of protein in walnut flour. This could explain the slight increase in protein content of powdered ogi fortified with walnut flour considering the protein content of African walnut. There is no significant difference ($p > 0.05$) in protein content among the fortified and unfortified maize ogi flour. Worthy to note is that protein contents of all the samples were low and unacceptable because it will not meet the recommended protein content stipulated for complementary foods. According to the requirement, infants between the ages of 0 to 2 years require 13 g/d quantity of protein [44]. Arinola and Adesina [49] reported that protein content of raw African walnut is 29.14%, but when the sample was boiled with the shell, without the shell or roasted with the shell the amount of protein reduced to 24.13%, 22.47% and 24.25%, respectively. They attributed the reduction in protein content to solubilisation and/or denaturation of some nitrogenous compounds in the course of processing walnut. In a separate study, Moses et al. [22] reported that protein content of powdered ogi is 6.50%. The protein content reported in this study deviated from the research findings reported by Moses et al. [22] and Arinola and Adesina [49].

4.2.2 Lipid content

The lipid content of powdered maize ogi fortified with 10%, 20% and 30% portion of walnut flour is $4.80 \pm 0.85\%$, $15.20 \pm 0.61\%$ and $11.40 \pm 0.62\%$ while the value reported for 100% powdered maize ogi is $2.00 \pm 0.75\%$, respectively. There is significant difference ($p < 0.05$) in lipid content among the fortified and unfortified maize ogi flour. The result shows that lipid content of powdered maize ogi significantly increased after walnut flour was added to the sample. A

combination of factors such as quantity of walnut flour added to powdered maize ogi, high amount of lipids in walnut and application of dry heat during processing of walnut flour could be responsible for increase in quantity of lipids in powdered maize ogi fortified with different proportions of walnut flour. According to Arinola and Adesina [49], extraction and release of oil from oil seeds is enhanced by dry heat. Research findings from the study stated that fat content of raw African walnut is 54.14%, but when it was boiled with the shell, without the shell or roasted with the shell, the fat content increased to 61.75%, 62.65% and 60.52%, respectively.

4.2.3 Fibre content

Low crude fibre content of powdered maize ogi and different proportions of maize ogi flour fortified with walnut flour within the range of 1.02 ± 0.11 - $1.61 \pm 0.16\%$ could be attributed to wet-milling and sieving during the production of maize ogi. The result from this study shows that fortification of maize ogi flour with walnut flour did not improve the fibre content of the composite flour. There is no significant difference ($p > 0.05$) between the fibre content of 100% maize ogi flour (sample AZ) and the result recorded for 90% maize ogi flour fortified with 10% walnut flour (Sample BY). Similarly, the fiber content of 80% maize ogi flour fortified with 20% walnut flour (Sample CX) and the result recorded for 70% maize ogi flour fortified 30% walnut flour (Sample DW) are not significantly different ($p > 0.05$). Crude fibre is important in a diet because it reduces the rate at which glucose is released into the blood stream, enhances bowel movement, digestibility as well as prevent bowel cancers [49].

4.2.4 Ash content

The result from this study shows that ash content of 100% powdered maize ogi and different proportions of powdered maize ogi fortified with 10%, 20%, and 30% walnut flour is very low. The ash content of 70% maize ogi flour fortified with 30% walnut flour (Sample DW) is significantly different ($p < 0.05$) from the result recorded for the fortified maize ogi flour (Sample BY and CX) and unfortified maize ogi flour (Sample AZ). However, there is no significant difference ($p > 0.05$) in ash content of Sample BY, CX and AZ. Generally, ash content of food is an indication of the level of minerals present in the food. Nutritionally, ash content has been reported to enhance the metabolism of fat, carbohydrate and other

organic compounds [50]. The ash content of 100% powdered maize ogi is $0.50 \pm 0.04\%$ while the values reported for powdered maize ogi fortified with different proportions of walnut flour were within the range of 0.40 ± 0.06 - $0.90 \pm 0.04\%$. According to Moses et al. [22] and Ndie et al. [34], the ash content of powdered ogi and African walnut is 1.80% and 2.4%, respectively. Both results is at variance with the ash content of powdered maize ogi and different proportions of powdered maize ogi fortified with walnut flour.

4.2.5 Carbohydrate content

Although, the carbohydrate content of powdered maize ogi and different proportions of powdered maize ogi fortified with walnut flour is generally high, reduction in carbohydrate content was reported with increase in proportion of walnut flour used in fortifying powdered maize ogi. This could be attributed to lower amount of carbohydrate in walnut flour when compared with maize ogi flour. There is no significant difference ($p > 0.05$) in carbohydrate content of unfortified maize ogi powder (Sample AZ) and the result recorded for 90% maize ogi flour fortified with 10% walnut flour (Sample BY). According to Ajala and Taiwo [26], the carbohydrate content of ogi flour is as high as 72.51% whereas the value reported for African walnut flour (16.9%) is significantly lower [34].

4.2.6 Moisture content

The moisture content of powdered ogi and different proportions of powdered ogi fortified with walnut flour within the range of 30.69 ± 0.49 - $37.93 \pm 0.60\%$ is considerably high. This result is at variance with moisture content of ogi flour (9.08%) and African walnut flour (9.5%) reported by Ajala and Taiwo [26] and Ndie et al. [34], respectively. It is widely reported that food that has high moisture content is favourable for the growth and multiplication of microorganisms involved in food spoilage which translate to shorter shelf life of the product. There is no significant difference ($p > 0.05$) in moisture content of 90% maize ogi flour fortified with 10% walnut flour (Sample BY) and the result recorded for 80% maize ogi flour fortified with 20% walnut flour (Sample CX).

4.3 Functional Properties

4.3.1 Water absorption capacity

The water absorption capacity of powdered ogi is 3.35 ± 0.35 g/g. Increase in proportion of walnut

flour in powdered maize ogi probably resulted in the reduction of water absorption capacity of the samples which were within the range of 2.60 ± 0.11 - 3.16 ± 0.11 g/g. There is no significant difference ($p > 0.05$) in water absorption capacity of 90% maize ogi flour fortified with 10% walnut flour (Sample BY) and the result recorded for 80% maize ogi flour fortified with 20% walnut flour (Sample CX). In a related study, Bolaji et al. [18] reported that water absorption capacity of ogi powder is within the range of 1.0-2.75 g/g. According to Jude-Ojei et al. [23], the suitability of any baked flour is determined by water absorption which is a critical function of protein content in diverse food products. Water absorption capacity of a food product is a measure of the ability of a food product to associate with available water under the condition that it is limited. Intrinsic factors such as protein conformation, amino acid composition, and hydrophobicity or surface polarity have been identified as being able to influence the water and oil binding capacity of protein in a food substance. Low protein content of powdered ogi fortified with walnut flour is disadvantageous because it is insufficient to bind with oil and retain flavour desired in a food system. The use of 100% powdered ogi and different proportions of powdered ogi fortified with walnut flour reported to have a low oil absorption capacity in food preparation is expected to affect flavour and mouthfeel of the product.

4.3.2 Oil absorption capacity (OAC)

The result from this study shows that oil absorption capacity of powdered maize ogi is 1.8 ± 0.08 g/g while the values recorded for powdered ogi fortified with different quantities of walnut flour were within the range of 1.56 ± 0.06 - 1.60 ± 0.08 g/g. There is no significant difference ($p > 0.05$) in oil absorption capacity of 90% maize ogi flour fortified with 10% walnut flour (Sample BY) and the result recorded for 80% maize ogi flour fortified with 20% walnut flour (Sample CX). In a related study, Bolaji et al. [18] reported that oil absorption capacity of ogi powder is within the range of 0.8-1.05 g/g. This study shows that OAC of powdered maize ogi fortified with walnut flour reduced as the proportion of walnut flour incorporated into the sample increased. This property makes it less desirable to use such flour samples in food systems that requires oil absorption which enhances flavour and mouthfeel [51]. Protein content has been identified as the major chemical component of food that affects OAC. It can be inferred that low

protein content of powdered maize ogi fortified with walnut flour contributed significantly in reducing OAC of the composite flour.

4.3.3 Emulsion capacity

The emulsion capacity of powdered maize ogi is $2.98 \pm 0.14\%$ while the values recorded for powdered maize ogi fortified with 10%, 2% and 30% walnut flour is $5.58 \pm 0.14\%$, $4.74 \pm 0.11\%$ and $5.62 \pm 0.17\%$, respectively. Higher emulsion capacity of powdered maize ogi fortified with walnut flour when compared with unfortified powdered maize ogi could be attributed to hydrophobicity of protein influenced by pH, solubility and concentration. According to Jude-Ojei et al. [23], the formation and stabilization of emulsions enhanced by the capacity of protein present in food have useful applications in certain food products such as cake, frozen desserts and coffee whiteners. There is no significant difference ($p > 0.05$) in emulsion capacity of 90% maize ogi flour fortified with 10% walnut flour (Sample BY) and the result recorded for 70% maize ogi flour fortified with 30% walnut flour (Sample DW).

4.3.4 Bulk density

The bulk density of powdered maize ogi and powdered maize ogi fortified with different proportions of walnut flour were within the range of 0.56 ± 0.06 - 0.61 ± 0.06 g/ml. This result is in agreement with a similar study carried out by Jude-Ojei et al. [23]. There is no significant difference ($p > 0.05$) in bulk density among the fortified maize ogi flour (Sample BY, DW and CX) and the unfortified maize ogi flour (Sample AZ). In a related study, Bolaji et al. [52] reported that bulk density of ogi powder subjected to varying soaking time and drying temperature range between 0.625-0.678 g/ml. Low bulk density of the various formulations of powdered maize ogi fortified with walnut flour and unfortified maize ogi reported in this study is desirable because the flour formulations are suitable to use in formulating complimentary foods. The strength and amount of packaging material, texture, energy density and mouthfeel is influenced by bulk density of flour.

4.3.5 Swelling index

Higher swelling index of powdered ogi fortified with different proportions of walnut flour which is within the range of 8.10 ± 0.23 - $18.89 \pm 0.21\%$ compared with $1.99 \pm 0.10\%$ swelling index of

100% powdered maize ogi could be attributed to protein content of walnut flour exhibiting high affinity for water molecules [23]. There is significant difference ($p < 0.05$) in swelling index among the fortified maize ogi flour (Sample BY, DW and CX) and the unfortified maize ogi flour (Sample AZ).

4.3.6 Gelatinization temperature

Gelatinization temperature refers to the temperature at which gelatinization of starch occurs [53]. The results show that gelatinization temperature of powdered maize ogi fortified with increasing quantity of walnut flour reduced from 80.9 ± 0.88 - 76.8 ± 0.42 °C whereas the value reported for unfortified powdered maize ogi is 82.4 ± 0.58 °C. The implication of this result is that ogi-porridge prepared using 70% powdered maize ogi fortified with 30% walnut flour will gel at a lower temperature than ogi-porridge prepared using powdered maize ogi, 80% and 90% powdered maize ogi fortified with 20% and 10% walnut flour, respectively. This trend was reported by Innocent et al. [44] from a related study that involved production of soy-akamu powder made from sorghum and sprouted soybean flour blends. There is no significant difference ($p > 0.05$) in gelatinization temperature of unfortified maize ogi powder (Sample AZ) and the result recorded for 90% maize ogi flour fortified with 10% walnut flour (Sample BY). Similarly, the gelatinization temperature of 80% maize ogi flour fortified with 20% walnut flour (Sample CX) and the result recorded for 70% maize ogi flour fortified 30% walnut flour (Sample DW) are not significantly different ($p > 0.05$).

4.4 Sensory evaluation

4.4.1 Colour

It is striking that the colour (sensorial attribute) of unfortified maize ogi porridge (akamu) was assigned the highest sensory score when compared with the sensory score assigned to other sensory attributes of all the samples. This result could be attributed to familiarity of the characteristic colour of unfortified maize ogi porridge by the sensory panelist. It was observed that sensory score assigned to colour of maize ogi porridge fortified with walnut flour reduced as the quantity of the flour incorporated into the sample increased. Probably, the walnut flour added to ogi porridge changed the characteristic colour of the sample which the panelist were not familiar with.

4.4.2 Taste

Although the interpretation (like slightly) of the sensory score assigned to the taste of unfortified ogi porridge and ogi porridge fortified with 10% walnut flour is the same, the average sensory score of the former is slightly higher. A slightly lower sensory score was assigned to the taste of ogi porridge made from 80% and 70% powdered maize ogi fortified with 20% and 30% walnut flour, respectively. Although the interpretation of both sensory scores are the same (neither liked nor disliked), the sensory score assigned to the taste of ogi porridge made from 80% powdered maize ogi fortified with 20% walnut flour is slightly higher. It can be deduced that increase in quantity of walnut flour added to ogi porridge affected the taste of the sample.

4.4.3 Aroma

The sensory score assigned to the aroma of unfortified ogi porridge (akamu) is slightly higher than the sensory score assigned to ogi porridge fortified with 10% walnut nut flour. However, the interpretation of the sensory scores are the same (like slightly). A slightly lower sensory score was assigned to the aroma of ogi porridge made from 80% and 70% powdered maize ogi fortified with 20% and 30% walnut flour, respectively. However, the average sensory scores are the same (neither liked nor disliked). The sensory score assigned to aroma of all the samples show a reduction in sensory score as the quantity of walnut flour added to ogi porridge increased with one exception. This trend could be attributed to walnut flour incorporated into porridge ogi.

4.4.4 Appearance

The sensory score assigned to the sensorial attribute (appearance) of ogi porridge made from 90% powdered maize ogi fortified with 10% walnut flour is higher than the sensory score assigned to other samples. The sensory score assigned to the sample (ogi porridge made from 90% powdered maize ogi fortified with 10% walnut flour) is interpreted as like moderately. It was observed that increase in quantity of walnut flour incorporated into ogi porridge slightly reduced the sensory score for the sample appearance. However, the same interpretation (liked slightly) is given to the sensory scores assigned to ogi porridge made from 100% maize-based powdered ogi, 80% and 70% powdered maize ogi fortified with 20% and 30% walnut flour, respectively. Since the sensory score

assigned to the sensory attribute (appearance) of ogi porridge made from 100% maize-based powdered ogi is the least among all the samples evaluated, it can be deduced that addition of walnut flour improved the appearance of ogi porridge.

4.4.5 Mouthfeel

The sensory attribute (mouthfeel) of ogi porridge made from 100% powdered maize ogi was assigned the highest sensory score among all the samples evaluated. The sensory attribute is interpreted as like moderately. A slightly lower sensory score interpreted as like slightly was assigned to ogi porridge made from 90% powdered maize ogi fortified with 10% walnut flour. Although the sensory score assigned to ogi porridge made from 70% powdered maize ogi fortified with 30% walnut flour is slightly higher than the sensory score assigned to ogi porridge made from 80% powdered maize ogi incorporated with 20% walnut flour, the sensory score assigned to both samples have the same interpretation (neither liked nor disliked). Considering the sensory scores assigned to mouthfeel of the samples, it can be inferred that increase in quantity of walnut flour added to ogi porridge reduced the rating of the product.

4.4.6 Overall acceptability

Although the sensory score assigned to overall acceptability of ogi porridge made from 100% powdered maize ogi and 90% powdered maize ogi fortified with 10% walnut flour had the same interpretation (like moderately), the average sensory score assigned to the former is slightly higher. A slightly lower sensory score was assigned to the sensory attribute (overall acceptability) of ogi porridge fortified with 20% and 30% walnut flour. Although the interpretation of the sensory score of both samples are the same (like slightly), the sensory score assigned to ogi porridge fortified with 20% walnut flour is slightly higher. Based on the sensory scores assigned to overall acceptability of all the samples, it can be deduced that increase in proportion of walnut flour used in fortifying the maize ogi flour reduced the sensory scores. In a related study, Barber and Obinna-Echem [30] reported that the level of likeness of wheat-African walnut cookies in terms of appearance, taste, texture, flavor and overall acceptability reduced with increase in proportion of African walnut flour added to wheat flour. Abioye and Aka [20] reported that maize ogi fortified with

10% moringa share similar sensory characteristics with unfortified maize ogi (the most preferred product). The research findings of Barber and Obinna-Echem [30], Abioye and Aka [20] are in agreement with the interpretation of sensory result for overall acceptability of ogi porridge evaluated in this study.

5. CONCLUSION

The bacterial genera/population encountered in unfortified powdered maize ogi and the samples fortified with different portions of walnut flour were higher than the fungal genera/population recorded for the samples. Among the bacteria isolates, *Corynebacterium* spp. (27%) and *Streptococcus* spp. (7%) recorded the highest and least frequency of occurrence while the corresponding fungal isolates were *Aspergillus* spp. (45%) and *Mucor* spp. (11%), respectively. Proximate analysis revealed that protein, lipid and ash content of maize ogi flour fortified with walnut flour and functional properties of the samples which include bulk density, emulsion capacity and swelling index increased as the amount of walnut flour added to the samples increased with few exceptions. Based on the sensory report, ogi porridge made from 90% powdered maize ogi fortified with 1% walnut flour is preferable than using other formulations of fortified maize ogi flour. Although maize ogi flour fortified with walnut flour is richer in essential nutrients than the unfortified flour, all the sensory attributes with the exception of appearance of ogi porridge made from unfortified maize ogi flour were somewhat preferable than what was obtainable in ogi porridge made from maize ogi flour fortified with walnut flour.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Stephen B, Oladeji CTA, Ibronke SI. Physico-chemical and nutritional evaluation of co-processed fermented yellow maize ogi (an infant diet) and carrot blends. *Annals Food Sci Tech.* 2014;15(1):82-91.
2. Barber LI, Obinna-Echem PC, Ogburia EM. Proximate composition micronutrient and sensory properties of complementary food formulated from fermented maize,

- soybeans and carrot flours. Sky J Food Sci. 2017:6(3):033-039.
3. Bintu BP, Hajjagana L, Falmata AS, Modu S, Shettima Y. Studies on the evaluation of the nutritional quality, chemical composition and rheological characteristics of a cereal fortified with legume as a weaning food blend. Intl J Biotech Food Sci. 2015:3(1):1-9.
 4. Olanipekun OT, Ejigbo EA, Ogunwale KO, Omolade OE. Spice addition enhanced nutritional and keeping qualities of whole quality protein maize (QPM) ogi. Am J Resear Comm. 2020:8(4):10-25.
 5. Ogodo AC, Ugbogu OC, Ekeleme UG. Bacteriological quality of commercially prepared fermented ogi (akamu) sold in some parts of south eastern Nigeria. Intl J Nutri Food Engr. 2015:9(6):685-688.
 6. Odewole MM, Sunmonu MO, Opaleke DO, Adeyinka-Ajiboye O, Sani ROA, Aiyejoritan MT. Croat J Food Sci Tech. 2017:9(2):108-113.
 7. Inyang UE, Effiong WE. Chemical composition, functional and sensory properties of maize ogi fortified with periwinkle meat flour. Intl J Nutri Food Sci. 2016:5(3):195-200. DOI: 10.11648/j.ijnfs.20160503.17. Available: <http://www.sciencepublishinggroup.com/ijnfs>
 8. Okwute LO, Olafiaji B. The effects of ginger (*Zingiber officinale*) on the microbial load of a Nigerian traditionally fermented maize paste (ogi). Am J Resear Comm. 2013:1(9):84-98.
 9. Adisa AM, Enujiugha VN. Microbiology and safety of ogi fermentation: a review. Euro J Nutri Food Safety. 2020:12(5):90-100.
 10. Adelekan AO, Oyewole OB. Production of ogi from germinated sorghum supplemented with soybeans. Afri J Biotech. 2010:9(42):7114-7121.
 11. Bristone C, Chibueze EO, Badau MH, Katsala LH. Production of powdered maize ogi (indigenous complementary food) flours complemented with soybean and sorghum malt. MAYFEB J Agric Sci. 2016:3:1-14.
 12. Emeka-Ike PC, Ike CC, Nwokorie CC, Ogwuegbu HO. Food safety processing and evaluation of powdered pap from maize and malted maize with carrot. Elixir Food Science. 2019:132 53452-53457.
 13. Bello OO, Bello TK, Amoo OT, Atoyebi YO. Comparative evaluation of microbiological and nutritional qualities of various cereal-based paps (ogi) in Ondo state, Nigeria. Intl J Environ Agric Biotech. 2018:3(2): 676-685. Available: <http://dx.doi.org/10.22161/ijeab/3.2.49>
 14. Eromosele O, Ndukwe CK, Omonu R, Asadu K, Okpara KO. Bacteriological quality of commercially prepared fermented ogi (Akamu) sold in some parts of Afikpo Area in Ebonyi State. World J Bio Pharm. Health Sci. 2020:04(03):077-081. DOI: 10.30574/wjbphs
 15. Jonathan GS, Ogunsanwo OB, Asemoloye MD. Analysis of nutrient, fungal and aflatoxin compositions of ogi processed with stored and fresh maize. J Food Proc Tech. 2019:10(1): 1-9. DOI: 10.4172/2157-7110.1000773
 16. Grace TOO. Effect of dry and wet milling processing techniques on the nutrient composition and organoleptic attributes of fermented yellow maize (*Zea mays*). Afri J Food Sci. 2009:3(4):113-116.
 17. Olayiwola JO, Inyang V, Bello MA. Bacteriological and proximate evaluation of ginger-fortified fermented maize (ogi). Am J Food Tech. 2017:12(6):374-378. DOI: 10.3923/ajft.2017.374.378
 18. Bolaji OT, Adepoju PA, Olalusi AP. Economic implication of industrialization of a popular weaning food 'ogi' production in Nigeria: a review. Afri J Food Sci. 2015:9(10):495-503. DOI: 10.5897/AJFSJ2014.1196. Available: <http://www.academicjournals.org/AJFS>
 19. Izah SC, Kigigha L, Okowa IP. Microbial quality assessment of fermented maize ogi (a cereal product) and options for overcoming constraints in production. Biotech. Resear. 2016:2(2):81-93.
 20. Abioye VF, Aka MO. Proximate composition and sensory properties of moringa fortified maize 'ogi'. J Nutri Food Sci. 2015:S12:001-004. DOI:10.4172/2155-9600.S12-001
 21. Amingo ER, Akingbala JO. Nutritive composition and sensory properties of ogi fortified with okra seed meal. J Appli Sci Environl Mgt. 2004:8(2):23-28.
 22. Moses MO, Adepegba AO, Ajayi A, Akoja SS. Proximate composition and sensory qualities of powdered ogi (fermented maize meal) fortified with powdered unfermented locust bean seeds (*Pakia*

- biglobosa*). J Glob Biosci. 2017:6(10): 5289-5295.
23. Jude-Ojei BS, Ajala L, Ajayi IO, Emmanuel OA, Oni SS. Physico-chemical and sensory qualities of maize ogi supplemented with fermented *Moringa oleifera* seed. Intl J Sci Engineer Appli Sci. 2017:3(7):7-16.
 24. Obiegbuna JE, Nwankwo JA, Ozue JO, Okolo AC. Evaluation of yield and physicochemical properties of single cereal grain akamu and pre- and post-processed multigrain cereal akamu powders. Intl J Food Nutri Resear. 2019:3(29):1-11.
 25. Ogori AF, Uzor OA, Hleba L, Císarová M, Glinushkin A, Laishevtcev A, Derkanosova A, Igor P, Plygun S, Shariati MA. Physicochemical, functional and sensory properties of acha-tamba based ogi enriched with hydrolysed soy peptides. J Microbiol Biotech Food Sci. 2020:9(4):824-830. DOI: 10.15414/jmbfs.2020.9.4.823-830
 26. Ajala AS, Taiwo TF. Study on supplementation of 'ogi' with oyster mushroom flour (*Pleurotus ostreatus*). J Nutri Health Food Engineer. 2018:8(3):287-291.
 27. Ukaegbu PO, Anyika JU. Chemical analysis and nutrient adequacy of maize gruel (pap) supplemented with other food sources in Ngor-Okpala LGA, Imo State, Nigeria. J Bio Agric Healthcare. 2012:2(6):13-21.
 28. Gbadamosi SO, Abiose SH, Aluko RE. Solubilization, amino acid composition and electrophoretic characterization of conophur nut (*Tetracarpidium conophorum*) proteins. Intl Food Resear J. 2012:19(2):651-656.
 29. Dauda AO, Abiodun OA, Akintayo OA, Babayaju AA, Salami KO, Oyekanmi IA. Influence of walnut on the nutritional and physicochemical properties of biscuits made from whole wheat. Agrosearch. 2020:20(1):45-58.
 30. Barber LI, Obinna-Echem PC. Nutrient composition, physical and sensory properties of wheat-African walnut cookies. Sky J Food Sci. 2016:5(4):024-030.
 31. Oke OS, Oyaniyi T, Adewumi OT, Bamigboye OT, Lawah MO, Jatto KA, Adara CT, Marizu JT, Ogunbela AA. Economic, nutritional and medicinal values of African walnut (*Tetracarpidium conophorum*) in Nigeria (Hutch. & Dalziel): a review. J. Resear Fores Wild Environ. 2020:12(2):80-89.
 32. Kanu AM, Kalu JE, Okorie AC. Nutritional and health values of African walnut (*Tetracarpidium conophorum*). Intl J Sci Tech Resear. 2015:4(09):215-220.
 33. Akin-Osanaiye BC, Ahmad AA. Nutrient composition analysis of African walnut (*Tetracarpidium conophorum*) and isolation of microorganisms responsible for its spoilage. Direct Resear J Agric Food Sci. 2018:6(7):173-181. DOI:https://doi.org/10.26765/DRJAFS.2018.3906
 34. Ndie EC, Nnamani CV, Oselebe HO. Some physicochemical characteristics of defatted flours derived from African walnut (*Tetracarpidium conophorum*): an underutilized legume. Pak J Nutri. 2010:9(9):909-911.
 35. Adegbehingbe KT. Fermented sprouted and unsprouted maize for ogi production. Intl J Adv Resear. 2013:1(10):428-434.
 36. Isu NR, Onyeagba RA. Staining of microbial cells in: *Basic Practicals in Microbiology*, Second Enlarged Edition Fasmen Communications, Okigwe, Imo State. 2002;45-46:204-209.
 37. Sosulski FW. The centrifuge method of determining flour absorption in hard red spring wheats. Cereal Chem. 1962;39:344-350.
 38. Murphy MG, Skonberg DI, Camire ME. Chemical composition and physical properties of extruded snacks containing crab-processing products. J Food Sci Agric. 2003;83:1163-1167.
 39. Leach IS, Taylor GB, Lopez AS. Functional and storage properties of millet and sorghum flour blends. Cereal Chem. 1995;48:518-526.
 40. Beuchat LR. Functional and electrophoretic characteristics of succinylated peanut flour protein. J. Agric Food Chem. 1977;25:258-261.
 41. Adepeju AB, Gbadamosi SO, Adeniran AH, Omobuwajo TO. Functional and pasting characteristics of breadfruit (*Artocarpus altilis*) flours. Afri J Food Sci. 2011;25:258-261.
 42. Adeleke RO, Odedeji JO. Functional properties of wheat and sweet potato flour blends. Pak J Nutri. 2010:9(6):535-538.
 43. Shinde BG. Isolation and characterization of starch horse grain. Unpublished M.Sc.

- Thesis. Mahatma Phule Krishi Vidyapeeth, Rahuri (India); 2001.
44. Innocent ON, Lucy EN, Joel N, Anthony UN. Quality characteristics of soy-akamu powder formulated from sorghum and sprouted soybean flour blends for complementary feeding. *World J Food Sci Tech*. 2019;3(4):48-57. DOI:10.11648/j.wjfst.20190304.12. Available:<http://www.sciencepublishinggroup.com/j/wjfst>
45. Larmond E. Methods for sensory evaluation of food. Food Research Institute Central Experimental Farm, Ottawa Canada 1977;1637.
46. Ayodeji AE, Aliyu N. *Tetracarpidium conophorum* (African walnut) Hutch. & Dalziel: Ethnomedicinal uses and its therapeutic activities. *J Med Plants Econ Dev*. 2018;2(1):1-10. Available:<https://doi.org/10.4102/jomped.v2i1>.
47. Ezendianefo JN, Dimejesi SA. Microbial quality of 'akamu' (ogi) sold in Nnewi markets, Anambra State, Nigeria. *IOSR J Pharm Bio Sci*. 2014;9(3.4):33-35.
48. Odu NN, Elenwo M, Maduka N. Microbiological quality of packaged and exposed cassava, yam and plantain flour sold in markets and supermarkets in Port Harcourt metropolis, Nigeria. *Am J Microbiol Resear*. 2019;7(2): 57-62. DOI: 10.12691/ajmr-7-2-4.
49. Arinola SO, Adesina K. Effect of thermal processing on the nutritional, antinutritional, and antioxidant properties of *Tetracarpidium conophorum* (African walnut). *J Food Proc*. 2014;1-4. Available:<http://dx.doi.org/10.1155/2014/418380>
50. Ogori AF, Amove J, Saadi AM. Quality characteristics of ogi supplemented with cashew nut flour. *J Nutra Food Sci*. 2020;6(1:6):1-4.
51. Chandra S, Samsher S. Assessment of functional properties of different flours. *Afri J Agric Resear*. 2013;8(38):4849-4852. DOI:10.10.5897/AJAR2013.6905. Available:<http://www.academicjournals.org/AJAR>
52. Bolaji OT, Oyewo AO, Adepoju PA. Soaking and drying effect on the functional properties of ogi powder produce from some selected maize varieties. *Am J Food Sci Tech*. 2014;2(5):150-157. DOI: 10.12691/ajfst-2-5-3. Available:<http://pubs.sciepub.com/ajfst/2/5/3>
53. Chandra S, Singh S, Kumari D. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. *J Food Sci Tech*. 2015;52(6):3681-3688. DOI:10.1007/s13197-014-1427-2

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