Production and Proximate Analysis of Okpei (*Prosopis africana*) Seed Condiment

RESEARCH ARTICLE

***Yinka D. OLUWAFEMI**
Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria
yoluwafemi@unimed.edu.ng

Olorunjuwon O. BELLO
Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Titi A. OSHIN
Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Temitope C. EKUNDAYO
Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Isaac A. ADESINA
Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Adebisi M. TIAMIYU
Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Magnus Michael C. ANYAKUDO
Department of Physiology, University of Medical Sciences, Ondo City, Nigeria

This article is part of a special issue titled Sustainability, innovation, and development: A Festschrift in honour of Rt. Rev. Prof. Obeka Samuel Sunday.

ABSTRACT

A condiment is an edible substance that is added to some foods to impart or enhance its flavour or texture. This study aimed to determine the nutritional quality of Ogiri-okpei. The production and evaluation of Ogiri-okpei (*Prosopis africana*) seed condiment were studied. The cooked cotyledons were wrapped in small portions (30g) with blanched plantain leaves. The wrapped samples were fermented in a container for 1-5 days. Enumeration and identification of microorganisms in the Ogiri-okpei sample were carried out employing standard methods. The effects of fermentation time on the proximate composition and mineral content of the Ogiri-okpei sample were also evaluated. The phytochemicals and nutritional quality of the Ogiri-okpei (*Prosopis africana*) sample were determined. Bacterial isolates were identified as *Bacillus* species, *Micrococcus* species, *Lactobacillus* species, and *Staphylococcus aureus*. A comparison of the proximate composition of unfermented Ogiri-okpei with a five-day fermented Ogiri-okpei sample showed the following: moisture (3.72% and 21.98%), ash (6.33% and 3.3%), fat (19.08% and 20.34%), fibre (11.31% and 8.24%), protein (30.32% and 34.12%), and carbohydrate (29.35% and 12.06%), respectively. The unfermented Ogiri-okpei sample had the lowest amounts of calcium, magnesium, phosphorus, sodium, and potassium, while the highest amounts were observed in fermented samples after fermentation. Fermentation time significantly decreased carbohydrate, ash, and fibre but increased fat, moisture, and protein. Alkaloids, steroids, flavonoids, resins, and phenols were present. Saponin content was very high compared to other phytochemicals. Generally, it showed that the okpei sample possesses immense microbiological and nutritional benefits.

Methodology

Traditional fermentation of *Prosopis africana* seeds wrapped in plantain leaves for 1-5 days with microbiological analysis

Key Findings

Fermentation increased protein (from 30.32% to 34.12%) and improved mineral content with beneficial microorganisms.

Main Result

Ogiri-okpei condiment possesses significant microbiological and nutritional benefits as a traditional food flavouring.

Keywords: Fermented condiment, *Prosopis africana*, microorganisms, proximate analysis, nutritional quality, okpei seeds

INTRODUCTION

Prosopis africana, commonly known as African Mesquite, is also known by different native Nigerian names such as Kiriya (Hausa), Kohi (Fulani), Sam chi lati (Nupe), Ayan (Yoruba), Kpaye (Tiv), Ubwa (Igbo), and Okpei (Idoma). Ogiri-okpei is a food flavouring produced from fermented oil seeds such as egusi seeds, *Prosopis africana* (Mesquite seeds), castor oil seeds, fluted pumpkin seeds, and sesame seeds. It has a very strong aromatic smell that fills the whole house with its intense aroma once the Ogiri-okpei is added to the soup pot. Ogiri-okpei originated from West Africa, precisely the Igbo part of Nigeria, and it is characteristically dark-brown in appearance. Traditional fermented condiments are crucial ingredients in foods in West Africa due to their nutritional and sensory characteristics (Olasupo and Okorie, 2019). These fermented foods serve as a cheap source of plant protein for the populace, especially rural dwellers whose staple foods are mainly carbohydrate-based (Olasupo and Okorie, 2019). Different parts of Nigeria have different names for Ogiri-okpei; for example, the Yorubas call it Iru, while the Hausas call it Dawadawa.

Ogiri-okpei has remained a culinary staple from time immemorial, and it is interesting to mention that this spice has played and continues to play a major role in serving as a nutritive protein substitute (being produced from leguminous seeds) as well as serving as an aromatic flavouring for dishes, especially soups. This spice is almost unavoidable in several local dishes such as ofensala (white soup), melon egusi soup, ogbono soup, ofeakwu stew, yam porridge, etc. Although this spice is usually applied in very little quantity, its smell is unavoidably noticeable. Apart from Ogiri-okpei's distinctive taste and aroma, this spice is believed to be highly nutritive and beneficial to health. Economically, this local spice is marketed both in Nigeria and beyond; the spices are easily obtainable from any African shops in the Western world. Nutritionally, past studies reveal that fermented vegetable proteins are potential protein supplements, as lipase activities usually become very strong and on the rise during the period of fermentation.

01

Traditional Uses

Ogiri-okpei serves as both a nutritive protein substitute and aromatic flavouring for traditional Nigerian soups and dishes, especially among West African communities.

02

Cultural Significance

Known by various names across Nigeria's ethnic groups–Kiriya (Hausa), Ayan (Yoruba), Ubwa (Igbo), and Okpei (Idoma)–reflecting its widespread acceptance.

03

Nutritional Benefits

Fermentation increases nutrient levels, digestibility, and bioavailability, while decreasing antinutrients and increasing overall nutritional value.

Ogiri-okpei fits the bill in this scenario because it is produced from leguminous seeds that are highly proteinous and healthy. Ogiri-okpei has remained a culinary staple from time immemorial, and it is interesting to mention that this spice has played and continues to play a major role in serving as a nutritive protein substitute (being produced from leguminous seeds) as well as serving as an aromatic flavouring for dishes, especially soups. Diverse groups of microorganisms including Bacillus, Micrococcus, Leuconostoc, Staphylococcus, Enterobacteriaceae, and Lactic Acid Bacteria (LAB) have been reported to play active roles in the process. Therefore, this study aimed to determine the nutritional quality of Ogiri-okpei.

MATERIALS AND METHODS

Collection of Sample

A total of three hundred grams (300g) of Mesquite seeds were purchased from the main market (Oja Oba) in Ondo, Ondo State. The sample was aseptically placed in a clean polythene bag and taken to the laboratory for analysis.

Production of fermented Ogiri-okpei sample

Mesquite seeds were boiled for 2 hours and dehulled; the seeds were sorted to remove bad seeds and unwanted materials. The cooked cotyledons were wrapped with blanched plantain leaves. Then, it was left to ferment for 5 days at room temperature in the laboratory (Figure 1).

1

Mesquite Seed Preparation

Boil seeds for two hours, then dehull them using fingertips and rinse thoroughly with clean water.

2

Cotyledon Processing

Boil the cotyledons for one hour, allow them to cool, and then wrap them in blanched plantain leaves.

3

Wrapping and Fermentation

Pack the wrapped cotyledons in clean nylon and allow them to ferment for five days at room temperature.

4

Final Product: Ogiri-okpei

After five days of fermentation, the traditional Nigerian condiment, Ogiri-okpei, is produced.

Figure 1: Flow chart for the production of fermented Ogiri-okpei sample from Mesquite Seed.

Isolation of Microorganisms

One gram of fermented Mesquite seed (Ogiri-okpei) was thoroughly mashed with 9ml of normal saline water as a diluent in a McCartney bottle, and the contents were thoroughly mixed. The serial dilution method was used for the isolation of microorganisms from the sample collected. A one-in-ten serial dilution was made for the Ogiri-okpei sample. From appropriate dilution tubes, 0.5ml was taken with the aid of a sterile syringe and plated aseptically on different media, such as nutrient agar for bacterial isolation and potato dextrose agar for fungal isolation, using the pour plate technique. The plates were labelled, inverted, and incubated at 37°C for 24 hours according to the method of Guo et al. (2006).

Proximate Analysis Procedures

Determination of Moisture Content

Moisture content determination is an important factor that is critical in food quality, preservation, and resistance to deterioration. Moisture content of foods can be determined by a variety of methods. The moisture content of the sample was determined using an air oven (AOAC, 2015). The petri dishes were washed and dried in an air oven. The dishes were then transferred into a desiccator and allowed to cool. The weights of the petri dishes were determined. 3g of sample was weighed into a dry petri dish, and the contents were transferred into an oven maintained at a temperature of 105°C. The contents were allowed to dry at this temperature for 6 hours. The petri dishes with their contents were removed from the oven and placed in a desiccator. After cooling, the weight was recorded after drying to a constant weight. This analysis was carried out in duplicate, and the average value was recorded as moisture content. The percentage of moisture was calculated using the following equation:

$$\text{Moisture \%} = \frac{\text{Original sample weight (g)} - \text{Dried sample weight (g)} \times 100}{\text{Original sample weight (g)}}$$

Determination of Ash Content

Ash is the inorganic residue after the water and organic matter have been removed from a substance by heating in the presence of certain oxidising agents. The ash is not usually the same as the inorganic matter present in the original material since there may be losses due to volatilisation or chemical interaction between the constituents. The importance of ash content is that it gives an idea of the amount of mineral elements present and the content of organic matter in the sample. The organic matter accounts for quantitative constituents of protein, lipids or fat, carbohydrates, plus nucleic acid. The measure of ash content provides a measure of the total amount of minerals within a food. The principle of this method is based on the fact that minerals in a food substance are not destroyed on heating and also have low volatility compared to other components of the food, as adopted by AOAC (2015). Analysis of ash content can be done either by dry ashing, wet ashing, or plasma dry ashing. The method that is chosen for the analysis depends on the reason for the analysis, the type of food analysed, and also the equipment available. Ashing is also a preparation step in the analysis of specific minerals either by atomic spectroscopy or other traditional methods. For the majority of samples, dry ashing is incineration at high temperature (525°C or higher). It is accomplished in a muffle furnace. There are many different types of crucibles made of different materials such as quartz, porcelain, steel, or platinum. The crucible selection is based on cost, reactivity of the crucible to the sample, and resistance of the crucible to very high temperatures. Dry ashing has the advantages of not needing external reagents and requiring little attention.

Procedure

A clean crucible was pre-dried in an oven for 30 minutes at 100°C to assure total dryness of the crucible. It was then transferred into the desiccator to cool for 15 minutes and weighed on an electronic weighing balance. 1g of each sample was transferred into each of the appropriately labelled crucibles and then reweighed. Then, the crucibles with their contents were transferred into the muffle furnace at 550°C for about 5 hours. After complete ashing into a whitish colour, the crucibles were allowed to cool in a desiccator and then reweighed. The percentage of ash was then determined.

$$\text{Ash content (\%)} = \frac{\text{Weight of crucible with ash (g)} - \text{Weight of empty crucible (g)} \times 100}{\text{Weight of sample (g)}}$$

Determination of Crude Fat Content

Fats are defined as mixtures of various glycerides of fatty acids, which are sparingly soluble in water and certain organic solvents, e.g., ethyl ether, petroleum ether, acetone, ethanol, methanol, benzene. Extraction is carried out with a Soxhlet apparatus using ether or petroleum ether. The fat content may be determined by either the Soxhlet method, the Mojonnier method, or the Soxtherm automated method. The most conventional of these three is the Soxhlet method. The usual procedure is to continuously extract the fat content using 40/60 petroleum ether in a Soxhlet extractor. The ether extraction method is based on the principle that nonpolar components of the sample are easily extracted into organic solvents.

Procedure

A previously dried, fat-free thimble was weighed as W1. Five grams of sample was weighed into the thimble and recorded as W2. The thimble and the sample were carefully wrapped and tied. A washed and dried 500 ml round bottom flask was weighed as W3. The flask was half-filled with 40/60 petroleum ether, and the sample was dropped into the sample holder of the Soxhlet extraction apparatus. The Soxhlet extractor was fitted with a reflux condenser. The flask was then placed on a heating mantle, and the heat source was adjusted to allow it to boil gently at 340C. It was allowed to siphon for over 5 hours. The condenser was detached, and the thimble removed. Petroleum ether was distilled from the flask. The distilling flask containing the oil was air-dried at 1000C for exactly 5 minutes to remove solvent residues in the oil. This was put inside a desiccator to cool, and the weight was taken as W4. The percentage fat contained was determined thus:

$$\% \text{ Crude fat} = \frac{\textit{Weight} \text{ of Flask + oil} - \text{Weight of empty flask}}{\text{Initial weight of sample}} \times 100$$

$$(\%) \text{ Crude Fat} = \frac{\text{W4} - \text{W3}}{W2 - W1} \times 100.$$

Determination of Crude Fibre

Crude fibre is the portion of plant material which is not ash. Fibre was originally thought to be the indigestible portion of foodstuffs. However, the benefits of a diet high in fibre have been discovered. Foods with high fibre content can absorb cholesterol and toxic agents. It also raises the excretion of bile and sterols. It is known, however, that fibre consists of cellulose, which can be digested to a considerable extent by both ruminants and non-ruminants. The interest in fibre in food and feed has increased, based on the observed number of serious illnesses associated with diets low in fibre. Fibre swells and forms a gelatinous mass with high water retention capacity within the digestive system. Diseases such as constipation (where the intestine absorbs water and the volume of faeces will decrease), appendicitis, haemorrhoids, and diabetes mellitus have been related to a low-fibre diet in humans.

Procedure

The method described was employed. A small amount of finely ground sample (2g) was taken into a filter crucible and inserted into the hot extraction unit (Hot Extractor, Model-1017). A sufficient amount of pre-heated 0.128M H_2SO_4 was added into the reagent heating system. The mixture was digested for 30 minutes. Acid was then removed by filtering and washing with boiling water. The residue in the flask was boiled with the required amount of 0.223M KOH for 30 minutes and then filtered with subsequent washing in boiling water and acetone. The residual content, which comprises cellulose and lignin, was then dried in an oven at 105°C for a few hours and then ignited in a muffle furnace at 550°C for 3 hours. The loss of weight represented the crude fibre content. The percent crude fibre was calculated by the following formula:

$$\text{Crude fibre} = \text{weight of oven-dried sample (g)} - \text{weight of ash (g)}$$

$$\%\ \text{Crude fibre} = \frac{\text{Crude fibre} \times 100}{\text{Weight of sample (g)}}$$

Determination of Crude Protein

Proteins are necessary nutrients for the human body. They are one of the building blocks of body tissue and also serve as a fuel source. Protein is a nutrient that is important for the growth and maintenance of the body. Crude protein is calculated on the basis that protein is the only food composition that contains nitrogen.

Crude protein of the samples was estimated using the Kjeldahl method. A 0.5 g sample and a blank were analysed in the digestion tube. For digestion at high temperature, 10 ml of concentrated sulphuric acid and 1.1 g of digestion mixture were added to the tube. The digestion tubes containing samples were kept in a rack and digested for 45 minutes at 420°C in a fume cupboard, ensuring water supply and adequate gas outlets. After digestion, the samples were allowed to cool to room temperature for about 1 hour, and then 5 ml of sodium thiosulphate ($Na_2S_2O_3$, 33%) and 30 ml of sodium hydroxide (NaOH) solution were added to each distillation tube.

Distillation was carried out using 25 ml of Boric Acid (4%) and methyl red indicator and titrated with (0.2N). This process was stopped when the conical flask containing boric acid indicator solution reached the 100ml mark. The distillate was titrated using standard hydrochloric acid (HCl) until the endpoint was reached. At this stage, the purple colour obtained during distillation changed to dark yellow. The nitrogen values obtained were converted into the percentage of crude protein by multiplying with a factor of 6.25, assuming that protein contains 16% nitrogen.

The formula used for protein calculation is:

$$\% \text{ Nitrogen} = \frac{\text{Milliequivalent of nitrogen (0.014)} \times \text{titrant value (ml)} \times \text{strength}}{100}$$

$$\% \text{ Protein} = \% \text{ Nitrogen} \times 6.25$$

Determination of Carbohydrate Content

The carbohydrate (Cho) content of the sample was obtained by difference; that is, by subtracting the sum of the percentage contents of moisture, crude protein, lipid, ash, and crude fibre from 100 (AOAC, 2015).

$$\text{Carbohydrate (Cho) \%} = 100 - (\text{moisture \%} + \text{crude protein\%} + \text{crude lipid} + \text{ash} + \text{crude fibre}).$$

Determination of Mineral content of unfermented and fermented Ogiri-okpei sample from Mesquite Seed

The minerals Calcium (Ca), Iron (Fe), Magnesium (Mg), Sodium (Na), Potassium (K), and Phosphorus (P) were determined via atomic absorption spectrophotometry according to methods described by Balogun (2012). The Ogiri-okpei sample was weighed into beakers and ashed at 550°C overnight. The resulting white-ash residue was dissolved in 4 mL of concentrated hydrochloric acid and filtered into a 10 mL volumetric flask, and the volume made up with distilled water. The resulting extract was then subjected to analysis for its content of specific major minerals. Iron (Fe) was determined with an ICP-OES (Skunjins, 1998). The other elements Na, K, Mg, Ca, and P were determined by atomic absorption spectrophotometer (Pharmacia biotech Ultra spectrometry 4000) (AACC, 1995).

Determination of Potassium, Lead, and Cadmium Content of Unfermented and Fermented Ogiri-okpei Sample from Mesquite Seed

The determination of Potassium, Lead, and Cadmium was carried out by flame photometry according to methods adopted by Balogun (2012).

Physicochemical Screening of Unfermented and Fermented Ogiri-okpei Sample from Mesquite Seed

During isolation, the pH and Total Titratable Acidity of the Ogiri-okpei sample were determined using a digital pH metre according to the methods of Balogun (2012) and Eze et al. (2012). Five grams of the Ogiri-okpei sample at day zero and day five were used. The pH of the sample was measured using a pH metre, which was initially calibrated with standard buffers at pH 4.0 and 7.0. The pH test was carried out on the homogeneous mixture containing the samples and sterile normal saline solution by inserting the probe of the pH metre into the beaker containing the mixture, and the value was recorded.

For total titratable acidity, titration was carried out using a burette containing 0.1M NaOH solution, which was titrated against the sample. Three drops of phenolphthalein were added and mixed properly. Titration was then carried out until a faint pink colour appeared. Titratable acidity was found using the formula:

$$\text{Titratable acidity \%} = \frac{\text{Titre value} \times M \times 90 \times 100}{\text{Volume of sample} \times 1000}$$

Determination of Qualitative Anti-nutritional Factors of Unfermented and Fermented Ogiri-okpei Sample from Mesquite Seed

The qualitative determination of anti-nutritional factors such as Alkaloids, Saponins, Tannins, Phlobatannin, Anthraquinone, Flavonoid, Terpenoid, and Steroid was carried out employing the method of Debela (2002).

A. Determination of Alkaloid

About 0.5g of the extract was stirred with 5ml of 1% aqueous HCl on a steam water bath. 1ml of the filtrate was treated with a few drops of Dragendorff reagent, and blue-black turbidity was taken as preliminary evidence for the presence of alkaloid.

B. Determination of Saponin

The ability of saponin to produce frothing in aqueous solution was used as a screening test for saponin. About 0.5g of extract was shaken with distilled water in a test tube. Frothing which persisted on warming was taken as preliminary evidence for the presence of saponin.

C. Determination of Tannin

About 0.5g of the extract was stirred with 100ml of distilled water, filtered, and Ferric Chloride reagent was added to the filtrate. A blue-black-green or blue-green precipitate was taken as evidence for the presence of tannin.

D. Determination of Phlobatannin

The deposition of a red precipitate when 0.5g of the extract was boiled with 1% aqueous HCl was taken as evidence for the presence of phlobatannin.

E. Determination of Anthraquinone

Borntrager's test was used for the detection of anthraquinone. 0.5g of the extract was shaken with 10ml of benzene, filtered, and 5ml of 10% ammonia solution was added to the filtrate. The mixture was shaken, and the presence of a pink-red or violet colour in the ammonia layer indicated the presence of free anthraquinone.

F. Determination of Flavonoid

About 0.5g of the sample was stirred with 20ml of dilute ammonia solution; a yellow colouration was observed. The disappearance of the yellow colour after the addition of 1ml conc. H_2SO_4 indicated the presence of flavonoid.

G. Determination of Steroid

Twenty millilitres of acetic anhydride were added to 0.5g of the sample and filtered. 2 ml of conc. H_2SO_4 was added to the filtrate. There was a colour change from violet to blue or green, which indicated the presence of steroid.

H. Determination of Terpenoid

About 0.5g of the sample was mixed with 20 ml of chloroform and filtered. 3 ml of conc. H_2SO_4 was added to the filtrate to form a layer. A reddish-brown colour at the interface was observed, which indicated the presence of terpenoid.

I. Determination of Cardiac Glycosides

The procedure described by Sofowora was used. Ten millilitres of the sample were pipetted into a 250 ml conical flask. Fifty millilitres of chloroform were added and shaken on a vortex mixer for 1 hour. The mixture was filtered into a 100 ml conical flask. 10 ml of pyridine and 2 ml of 29% Sodium Nitroprusside were added and shaken thoroughly for 10 min. 3 ml of 20% NaOH was added to develop a brownish-yellow colour. Glycosides standard (Digitoxin): A concentration range from 0 - 50 mg/ml was prepared from stock solution. The absorbance was read at 510 nm.

Determination of Quantitative Antinutritional Content of Unfermented and Fermented Ogiri-okpei Samples from Mesquite Seed

Various quantitative determinations were carried out, including Total Phenol using the method of Singleton et al., 1999; total flavonoid using a colorimetric assay by Bao et al.; tannin determination following Makkar and Goodchild; saponin using the spectrophotometric method of Brunner; alkaloid determination following Harborne; terpenoid using a procedure by Sofowora; and steroid quantification as described by Sofowora.

RESULTS

Microbiological quality of Ogiri-okpei sample

The total bacterial counts of the Ogiri-okpei sample ranged from 4.46×10^5 - 3.0 ×10^7 cfu/ml as shown in Table 1. The cultural and microscopic characteristics of microbial colonies isolated from the Ogiri-okpei sample are shown in Table 2.

The identified bacterial species isolated from the Ogiri-okpei sample were Bacillus species, Micrococcus species, Lactobacillus, and Staphylococcus aureus. Bacillus species was the most predominant in the Ogiri-okpei sample, followed closely by Micrococcus species, Lactobacillus species, and then Staphylococcus aureus, which is the least frequently occurring organism, as shown in Table 1. The dominance of Bacillus species in fermented African condiments has been widely reported in similar studies (Fowoyo, 2017; Gberikon et al., 2015).

Table 1: Bacterial count of fermented Ogiri-okpei sample

Sample	Dilution factor 1 (10^-3)	Dilution factor 2 (10^-6)
Fermented	4.46×10^5	3.0×10^7

Table 2: Biochemical characterisation and identification of Bacterial isolates

Colony isolate	MR	VP	Citrate	Catalase	Glucose	Sucrose	Maltose	Fructose	Dextrose	Organism identified
1	-ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	+ve	*Bacillus* species
2	-ve	-ve	-ve	-ve	+ve	+ve	+ve	+ve	+ve	*Lactobacillus* species
3	+ve	+ve	-ve	+ve	+ve	+ve	+ve	+ve	+ve	*Staphylococcus aureus*
4	-ve	+ve	-ve	+ve	+ve	+ve	+ve	+ve	+ve	*Micrococcus* species
5	-ve	+ve	+ve	+ve	+ve	+ve	-ve	+ve	+ve	*Bacillus* species

Key: -ve = negative, +ve = positive, MR = Methyl Red, VP = Voges Proskauer.

Proximate analysis of unfermented and fermented Ogiri-okpei sample from Mesquite Seed

Protein and Carbohydrate are the most abundant nutritive macro-elements, while Fat, Moisture, Fibre, and Ash occurred in minimal quantities (Table 3).

Table 3: Proximate composition of unfermented and fermented Ogiri-okpei sample from Mesquite Seed (%)

Sample	Moisture	Ash	Fat	Fibre	Protein	Carbohydrate
Unfermented	3.72	6.23	19.08	11.31	30.32	29.35
Fermented	21.98	3.3	20.34	8.24	34.12	12.06

Mineral composition of unfermented and fermented Ogiri-okpei sample from Mesquite Seed

The mineral composition of the sample shows that Potassium was the most abundant element (58.19 mg/g-63.49 mg/g) in the sample analysed. Potassium, Magnesium, Sodium, Iron, Calcium, and Phosphorus were found in relatively minute quantities, while Lead and Cadmium were below detection limits in the Ogiri-okpei sample (Table 4).

Table 4: Mineral composition of fermented and unfermented Ogiri-okpei sample from Mesquite Seed (mg/g)

Each value is the average of duplicates.

Physicochemical screening of fermented and unfermented Ogiri-okpei sample from Mesquite Seed

The pH of the Ogiri-okpei sample ranged from (6.3-7.8) as shown in Table 5. The Total Titratable Acidity of the Ogiri-okpei sample ranged from (1.42-1.87) as shown in Table 6.

Table 5: pH of unfermented and fermented Ogiri-okpei sample from Mesquite Seed

Sample	pH
Unfermented	6.3
Fermented	7.8

Table 6: Total Titratable Acidity values of fermented and unfermented Ogiri-okpei sample from Mesquite Seed

Table 7: Qualitative anti-nutritional screening of Ogiri-okpei sample.

Sample	Alkaloids	Steroids	Flavonoids	Saponins	Tannins	Anthraquinones	Phlobatannis	Terpenoids	Legal test	Salkwoski test	Lieberman test
Unfermented	+	-	+	+	+	-	-	+	+	+	+
Fermented	+	-	+	+	+	-	-	+	+	+	+

(+) indicates the presence of phytochemicals and (-) indicates the absence of phytochemicals

Table 8: Quantitative anti-nutritional screening of Ogiri-okpei sample (%).

Sample	Alkaloids	Terpenoids	Flavonoids	Saponins	Tannins	Phenols	Glycoside
Unfermented	23.29	20.78	0.2135	25.55	5.18	8.9221	26.41
Fermented	13.21	14.35	0.6769	30.45	6.08	16.5459	15.39

DISCUSSION

The Ogiri-okpei sample with high moisture content, as detected by texture, had a stronger, more offensive ammoniacal smell, along with a characteristic rich, dark brown colour. The harder Ogiri-okpei sample not only had a slightly offensive smell, but also possessed a characteristic light brown colour.

Microbial analysis of the Ogiri-okpei sample indicated bacterial counts ranging from 4.46×10^5 to 3.0×10^7 cfu/ml and the predominance of *Bacillus* species. The presence of *Bacillus* species in the sample is expected, as they have been found to be associated with fermented legume seeds for Ogiri-okpei. *Bacillus* produces protease, which is responsible for the breakdown of proteins, and this contributes to the development of the texture and flavour of fermented foods. The presence of *Staphylococcus* species in the sample is also typical of the microflora of fermenting beans. *Staphylococcus* species have been associated with fermenting foods of plant origin, especially vegetable proteins.

The crude protein content of the Ogiri-okpei sample was very high, and this may be attributed to the role of *Bacillus subtilis* during fermentation, as they produce protease that acts on the legume seed to release more proteins. The protein content values were observed to vary with increasing moisture content, suggesting an association between both proximate factors. The crude fibre content was low. Locust beans are known to contain oligosaccharides that cause flatulence; therefore, the presence of crude fibre may be responsible for the digestibility of Ogiri-okpei. The ash content of the Ogiri-okpei sample is an indication that it is rich in minerals, although the values may be influenced mildly by a wide range of factors, including the length of fermentation time. The varying carbohydrate content of the sample may be due to the hydrolytic effect of microbial amylase, converting the carbohydrate into sugars easily utilisable by the isolated organisms during fermentation. *Bacillus* species are important sources of amylases; therefore, the high recovery rates of these organisms from the fermentation may account for their high amylase activity, thereby leading to a reduction in the carbohydrate. However, these results also suggest Ogiri-okpei as a good source of carbohydrate, and an even better one since it is balanced out by its high protein content.

Magnesium was found to be the most abundant mineral in both the unfermented and fermented samples, as well as being present in higher quantities than other minerals detected. Potassium was found to be the second highest mineral present in the analysed sample. The abundance of potassium in the Ogiri-okpei sample is in agreement with the observation of Aremu et al. (2006) that potassium is a predominant mineral in agricultural products. It helps in the regulation of body fluids and the maintenance of normal blood pressure. It also aids in controlling kidney failure, heart irregularities, and respiratory issues. Aremu et al. (2006) in related literature also observed that potassium was the most abundant mineral in *Prosopis africana* seed. The work of Nda-Umar et al. (2008) however reported a contrary result, stating that calcium is the most abundant mineral in Ogiri-okpei. Phosphorus was found to be the third highest mineral present in the analysed sample. The presence of calcium in this condiment was found to be the lowest in concentration but was still present in a sufficient amount because the element is needed for bone development and strong teeth. Sodium was also found in an appreciable amount, and this is desirable as it is known to aid digestion and other bodily functions. A moderate amount of iron was detected in the Ogiri-okpei sample. Iron carries oxygen to the cells and is necessary for the production of energy, synthesis of collagen, and the proper functioning of the immune system (Anhwange et al., 2008). Lead and cadmium, on the other hand, were not detected in the sample, similar to results obtained by Balogun (2012). This is preferred since these elements are known to be toxic to the human body.

Desirable flavour components of the condiment are presumably developed after an alkaline pH is reached. Organic acids, which may result from protein decomposition, may contribute to the darkening of colour (Achi, 2005). The alkaline pH of fermented Ogiri-okpei agrees with earlier reports by Achi (2005), Oguntoyinbo et al. (2001), Omafuvbe et al. (2003), and Ogunshe et al. (2007), all of whom recorded alkaline pH in fermented food condiments from vegetable proteins. Most fermented vegetable-protein condiments are characterised by a very strong, pungent smell. The increase in pH is generally due to the production of ammonia, which is characterised by the pungent smell of fermented condiments (Ogunshe et al., 2007). This provides an explanation for the slightly acidic unfermented sample. Aremu et al. (2006) also reported that ammonia production might be due to protease deaminase enzymes produced by *Bacillus* isolates. The Total Titratable Acidity of the fermented sample was higher than that of the unfermented one.

Phytochemical screening of both unfermented and fermented samples revealed the presence of alkaloids, flavonoids, saponins, glycosides, terpenoids, tannins, and phenols, while steroids, phlobatannin, and anthraquinones were below detection levels in the analysed samples. The Ogiri-okpei sample examined did not contain steroids, anthraquinones, and phlobatannin. Phenols have been shown to demonstrate antimicrobial properties (Macé et al., 2017). Saponins have been implicated in causing bloating and also reducing protein digestibility due to the formation of sparingly digestible saponin-protein complexes (Cheeke, 1971 and Das et al., 2012). Alkaloids possess anti-diarrhoeal and anti-dysenteric properties. Flavonoids, tannins, and terpenoids may either be beneficial or detrimental (De et al., 2014). These factors may however not perform significant functions since they occur in inconsiderable amounts in the unfermented and fermented samples analysed.

34.12%

Protein Content

Final protein content after fermentation, showing a significant increase from 30.32%.

30.45%

Saponin Content

Highest phytochemical component in fermented samples.

7.8

Alkaline pH

Final pH after fermentation, indicating alkaline conditions.

CONCLUSION

Ogiri-okpei has high nutritive value and thus could be a better alternative, with the added advantage of reduced health risks over the consumption of seasoning salts. This finding aligns with previous studies that have demonstrated the nutritional significance of fermented African condiments as protein sources (Agunwah et al., 2024).

This study demonstrates that an increase in fermentation time improved the quality of Ogiri-okpei. Generally, it showed that the Ogiri-okpei sample possesses nutritional benefits.

01

Nutritional Value

Ogiri-okpei demonstrates high nutritive value as a healthier alternative to commercial seasoning salts, with reduced health risks.

02

Fermentation Benefits

Extended fermentation time significantly improves the overall quality and nutritional profile of the Ogiri-okpei condiment.

03

Microbiological Safety

The presence of beneficial microorganisms like Bacillus species contributes to the fermentation process and product safety.

04

Traditional Food Value

Ogiri-okpei possesses immense microbiological and nutritional benefits, validating its traditional use in Nigerian cuisine.

ACKNOWLEDGEMENT

Not Applicable

CONFLICTS OF INTEREST

The author declares no conflict of interest

FUNDING

This research received no funding from any agency.

REFERENCES

Agunwah, I. M., Ogueke, C. C., Ahaotu, I., & Anukam, K. C. (2024). Microbiological evaluation of the indigenous fermented condiment okpeye available at various retail markets in the south-eastern region of Nigeria. *Heliyon*, *10*(3), e25493.

Anhwange, B. A., Ugye, T. J., & Nyiaatagher, T. D. (2008). Chemical composition of *Musa sapientum* (banana) peels. *Electronic Journal of Environmental Agricultural and Food Chemistry*, *8*, 437-442.

Aremu, M. O., Olonisakin, A., Atolaye, B. O., & Ogbu, C. F. (2006). Some nutritional and functional studies of *Prosopis africana*. *Electronic Journal of Environment Agriculture and Food Chemistry*, *6*, 1640-1648.

Balogun, M. A. (2012). A fermentation study and physicochemical analysis of *Prosopis africana* seeds to produce okpei, a local condiment. *University of Ilorin Institutional Repository*, 24-60.

Eze, V. C., Agwung-Fobellah, D., & Nnaji, K. (2012). Microbiological and physicochemical characteristics of soils contaminated with used generator oil. *Asian Journal of Science and Technology*, *4*(11), 20-25.

Fowoyo, P. T. (2017). Microbiological and proximate analysis of okpehe, a locally fermented condiment. *Food and Nutrition Journal*, *2*, 153.

Gberikon, G. M., Agbulu, C. O., & Yaji, M. E. (2015). Nutritional composition of fermented powdered *Prosopis africana* soup condiment with and without inocula. *International Journal of Current Microbiology and Applied Sciences*, *4*(2), 166-171.

Nda-Umar, U. I., Sunji, A. A., & Salawu, B. F. (2008). Selected mineral composition of Nigerian condiments. In E. T. Otunola (Ed.), *Proceedings of 32nd NIFST Annual Conference* (pp. 177-178). NIFST.

Ogunshe, A. A. O., Omotosho, M. O., & Ayanshina, A. D. V. (2007). Microbial studies and biochemical characteristics of controlled fermented afiyo–a Nigerian fermented food condiment from *Prosopis africana* (Guill and Perr.) Taub. *Pakistan Journal of Nutrition*, *6*, 620-627.

Oguntoyinbo, F. A., Tourlomousis, P., Gasson, M. J., & Narbad, A. (2011). Analysis of bacterial communities of traditional fermented West African cereal foods using culture-independent methods. *International Journal of Food Microbiology*, *145*, 205-210.

Oguntoyinbo, F. A., Sanni, A. I., Franz, C. M. A. P., & Holzapfel, W. H. (2007). In vitro fermentation studies for selection and evaluation of *Bacillus* strains as starter cultures for production of okpehe, a traditional African fermented condiment. *International Journal of Food Microbiology*, *113*, 208.

Olasupo, N. A., & Okorie, P. C. (2019). African fermented food condiments: Microbiology impacts on their nutritional values. In R. L. Solís-Oviedo & Á. de la Cruz Pech-Canul (Eds.), *Frontiers and new trends in the science of fermented food and beverages*. IntechOpen.

Omafuvbe, B. O., Falade, O. S., Oshuntogun, B. A., & Adewusi, S. R. A. (2003). Chemical and biochemical changes in African locust bean (*Parkia biglobosa*) and melon (*Citrullus vulgaris*) seeds during fermentation to condiments. *Pakistan Journal of Nutrition*, *3*, 140-145.

Singleton, V. L., Orthofer, R., & Lamuela-Raventos, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagents. *Methods in Enzymology*, *299*, 152-178.

Sofowora, A. (1995). *Medicinal plants and traditional medicine in Africa* (pp. 142-146). Spectrum.

ABOUT THE AUTHOR(S)

Yinka D. OLUWAFEMI

Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

yoluwafemi@unimed.edu.ng

Olorunjuwon O. BELLO

Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Titi A. OSHIN

Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Temitope C. EKUNDAYO

Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Isaac A. ADESINA

Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Adebisi M. TIAMIYU

Department of Microbiology, University of Medical Sciences, Ondo State, Nigeria

Magnus Michael C. ANYAKUDO

Department of Physiology, University of Medical Sciences, Ondo City, Nigeria

Received: June 30, 2025

Accepted: August 22, 2025

Published: November 19, 2025

Citation:

Oluwafemi, Y. D., Bello, O. O., Oshin, T. A., Ekundayo, T. C., Adesina, I. A., Tiamiyu, A. M. & Anyakudo, M. M. C. (2025). Production and Proximate Analysis of Okpei (*Prosopis africana*) Seed Condiment. SustainE, 3(3), 189-209. In A. A. Atowoju, E. O. Oyekanmi, A. A. Akinsemolu, & D. M. Duyile (Eds.), Sustainability, Innovation, and Development: A Festschrift in Honour of Rt. Rev. Prof. Obeka Samuel Sunday [Special issue]. https://doi.org/10.55366/suse.v3i3.10