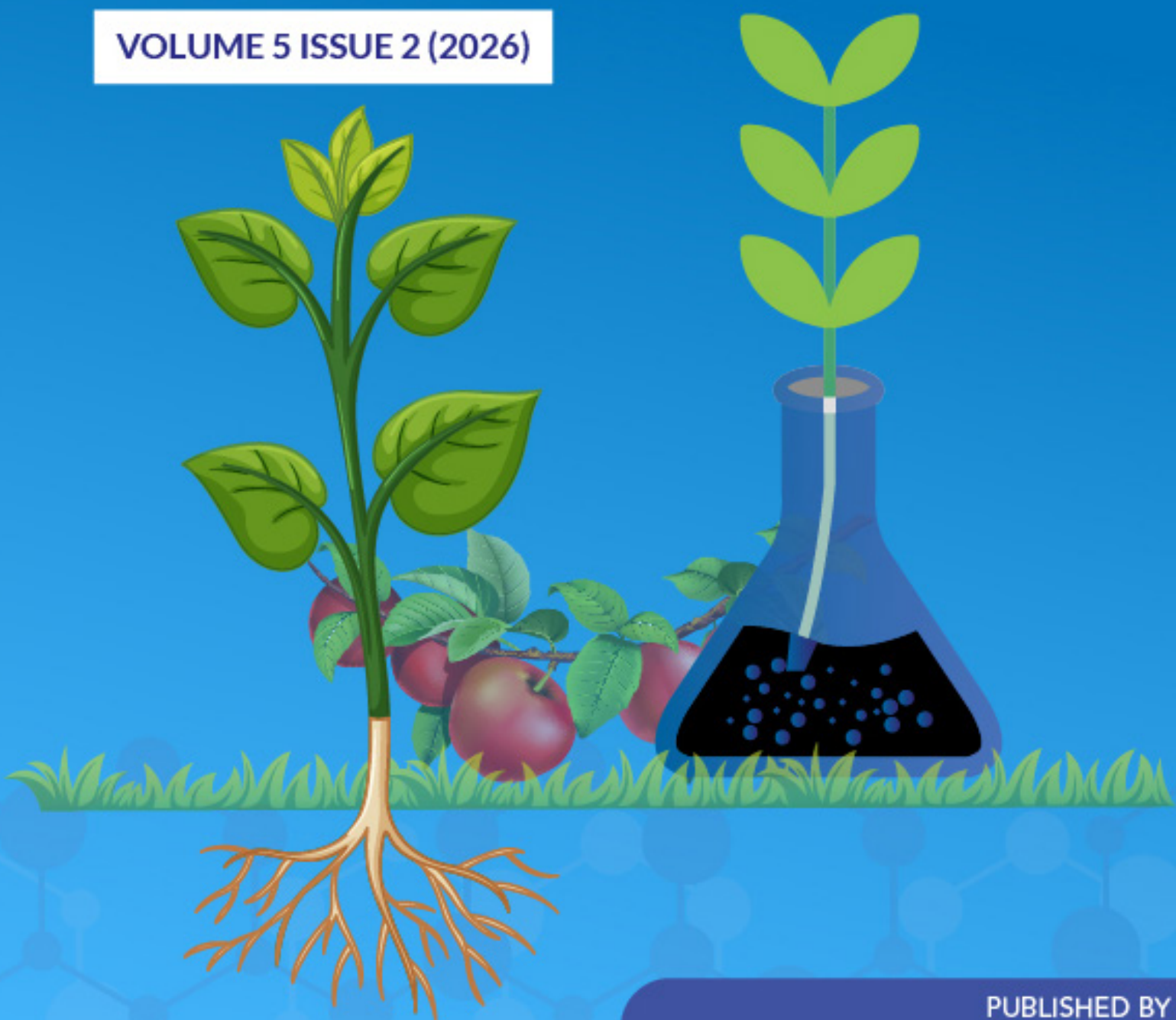




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Nutritional Quality and Food Safety of Indigenous Foods: An Integrated Assessment of Dry Fish and Fermented Oil Bean Seed (Ukpaka)

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ABSTRACT

Indigenous foods are widely consumed because of their nutritional importance, availability and affordability. However, some factors, including inadequate processing, handling, and storage, may compromise their nutritional quality and safety. Therefore, this study assessed the nutritional quality and food safety of dry fish and fermented oil bean seed (Ukpaka) obtained from Eke Agbani Market, Enugu State, Nigeria. The dry fish and fermented oil bean seed collected from different vendors were respectively inoculated into Nutrient Agar (NA), MacConkey Agar, Salmonella-Shigella Agar (SSA), de Man Rogosa Sharpe (MRS) agar and Sabouraud Dextrose Agar (SDA). The inoculated plates were incubated at 37°C for 24–48 h, except for SDA plates which were incubated at 28°C for 7 days. The isolates were identified using phenotypic characterization (colony appearance, Gram reaction, and biochemical properties) and molecular characterization (PCR, 16S rRNA gene sequencing and ITS sequencing). Aflatoxin analysis, and proximate composition assessment were carried out on the indigenous foods. The total viable bacterial counts were 3.2×10^4 CFU/g for dry fish and 7.8×10^5 CFU/g for fermented oil bean seed, while coliform counts for both foods were 1.4×10^3 and 3.5×10^4 CFU/g, respectively. Lactic acid bacteria count in fermented oil bean seed 6.4×10^5 CFU/g while none was detected in dry fish. The isolates were *Staphylococcus aureus* and *Escherichia coli* (from dry fish), *Lactobacillus plantarum*, (from fermented oil bean seed) and *Aspergillus niger* (from both food samples). Aflatoxin analysis revealed the presence of aflatoxins B₁, B₂, G₁, and G₂ in both indigenous foods with aflatoxin B₁ recording the highest concentrations of 0.178214 µg/kg and 0.52841 µg/kg in dry fish and fermented oil bean seed samples respectively. The fermented oil bean seed had a moisture content of 59.283%, protein (26.950%), fat (3.029%), crude fibre (3.117%), ash (2.089%), and carbohydrate (5.532%). The dry fish had a moisture content (11.25%), protein (58.4%), fat (0.83%), crude fibre (0.9%), ash (11.15%), and carbohydrate (18.15%). The findings demonstrate that dry fish and fermented oil bean seed are nutritional importance but they may also harbor several microorganisms including beneficial and pathogenic organisms and as well as aflatoxins. Therefore, improved hygienic handling, processing, and storage practices are essential to preserve the nutritional quality of these indigenous foods and to ensure consumers' safety.

INTRODUCTION

Indigenous food products are commonly consumed due to their availability, affordable and their nutritional quality in Nigeria. Among these indigenous foods, dry fish and fermented oil bean seed commonly known as ukpaka, are widely consumed across different regions of the country. These food products are good sources of high-quality protein, essential fatty acids, vitamins, minerals, and other nutritional benefits (Liu *et al.*, 2023). The increasing demand for these food products has led to their widespread production and marketing, often under conditions that may compromise their safety and quality.

Fish is highly nutritious, but due to its rich nutrient composition, it is also highly susceptible to microbial spoilage when processed, dried, transported, or stored under unhygienic conditions (Adebayo-Tayo *et al.*, 2008). Exposure of dried fish to contaminated environments, can lead to contamination by microorganisms including bacteria, yeasts, and molds. Some of these microorganisms may be pathogenic and capable of causing foodborne

illnesses which pose significant public health concern, particularly in developing countries like Nigeria.

Apart from microbial contamination, dried fish may also be exposed to fungal growth particularly members of the genera *Aspergillus*, *Penicillium*, and *Fusarium* during storage, especially under humid conditions. These fungi are capable of producing mycotoxins (aflatoxins) which may be toxic to the consumer (Imade *et al.*, 2021). Aflatoxins are known to cause liver damage, immune suppression, and increased risk of hepatocellular carcinoma in humans (Williams *et al.*, 2004).

Fermented oil bean seed (ukpaka) is another important indigenous food product commonly consumed in southeastern Nigeria. This food is produced through the traditional fermentation of oil bean seeds, a process that enhances flavor, texture, digestibility, and nutritional quality. However, its production often lack standardization and may expose the product to microbial contamination through various means including water, equipment, handlers, and the surrounding environment. Ogueke

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and Ariati (2005) have reported the presence of both beneficial and potentially harmful microorganisms in fermented oil bean seed, highlighting the need for continuous assessment of its microbial safety. Their consumption may pose significant health risks, particularly when pathogenic bacteria are present in high numbers. In addition to microbial safety, the nutritional composition of these food products is important because it provides information on the levels of moisture, crude protein, crude fat, crude fiber, ash, and carbohydrate present in food products. These parameters are useful indicators of nutritional quality and shelf stability a particular food product.

The dry fish and fermented oil bean seed are widely consumed but their microbiological quality, aflatoxin contamination, and nutritional characteristics assessment remains limited in many local markets. Therefore, this

study was undertaken to assess the microbiological quality, aflatoxin contamination and proximate composition of dry fish and fermented oil bean seed (ukpaka) in the selected market in Enugu State, Nigeria. The findings will provide valuable information on the safety and nutritional status of these indigenous food products and contribute to improving the food quality and ensure consumer's safety.

MATERIALS AND MATHODS

Collection of the Indigenous Food Samples

Dry fish and fermented oil bean seed (ukpaka) samples used in this study were obtained from Eke Market located in Agbani, Enugu State, Nigeria. They were placed in sterile bags, and transported to the Microbiology Laboratory, Enugu State University of Science and Technology (ESUT) for analysis.



Fermented oil Bean Seed (ukpaka)



Dry Fish

Figure 1: Image of Assessed Indigenous Food Products

Preparation of Samples

Each of the samples (10g) was ground using sterile mortar and pestle and then aseptically transferred into a sterile flask containing 90 mL of sterile distill water and homogenized to obtain the initial dilution. Ten-fold serial dilutions were subsequent prepared using the sterile diluent and was then used for microbial examination.

Microbial Examination of the Indigenous Food products

The diluted samples (10^4) were respectively inoculated into Nutrient Agar (for the determination of the total heterotrophic bacterial count), MacConkey Agar (for the enumeration of coliform organisms), Salmonella-Shigella Agar (for the isolation of enteric pathogens belonging to the genera Salmonella and Shigella), de Man Rogosa Sharpe (MRS) agar for lactic acid bacteria isolation) whereas fungal populations were enumerated on Sabouraud Dextrose Agar (SDA). The inoculated plates were incubated at 37°C for 24–48 h while Sabouraud

Dextrose Agar plates were incubated at 28°C for 7 days. The developed colonies were counted using a colony counter and were expressed as colony-forming units per gram (CFU/g) of sample.

Identification of the Isolates

For phenotypic identification, the pure culture of the bacterial isolates were characterized using their colony appearance on their respective medium, Gram staining reaction, and biochemical properties Fungal isolates were identified based on colony characteristics on SDA plates and microscopic examination using lactophenol cotton blue staining.

The molecular identification of bacteria and fungi isolates were done as described by Nwachukwu and Chioke (2026) and Onyia *et al.* (2025). The genomic DNA was extracted from bacterial and fungal isolates using the ZR Fungal/Bacterial DNA MiniPrep Kit (Zymo Research, USA) according to the manufacturer's protocol. The quality and integrity of the extracted DNA were assessed

by agarose gel electrophoresis using 1% agarose gel, while PCR products were analyzed on 2% agarose gel stained with EZ-Vision DNA stain and visualized under UV illumination.

For bacterial identification, the 16S rRNA gene was amplified in a 25 µL reaction mixture containing 12.5 µL of 2× Taq Master Mix (New England Biolabs), 1 µL each of 10 µM forward primer 27F (5'-AGAGTTTGTATCMTGGCTCAG-3') and reverse primer 1525R (5'-AAGGAGGTGWTCCARCCGC-3'), 2 µL template DNA, and 8.5 µL nuclease-free water.

For fungal identification, the Internal Transcribed Spacer (ITS) region was amplified using the universal fungal primers ITS1 (5'-TCCGTAGGTGAACCTGCGG-3') and ITS4 (5'-TCCITCCGCTTATTGATATGC-3'). PCR amplification was carried out in a 25 µL reaction mixture containing 12.5 µL of 2× Taq Master Mix, 1 µL each of the forward and reverse primers, 2 µL template DNA, and 8.5 µL nuclease-free water.

The amplified products from both bacterial and fungal isolates were sequenced using an Applied Biosystems 3500 Genetic Analyzer and the BigDye® Terminator v3.1 Cycle Sequencing Kit according to the manufacturer's instructions. Sequence chromatograms were edited and analyzed using Geneious Prime software. The obtained sequences were compared with reference sequences in public databases for species identification and subsequently deposited in the NCBI GenBank database for accession number assignment (Nwachukwu et al., 2026).

Determination of Aflatoxin Content in the food products

The determination of aflatoxin content in the food products was carried out as described by Nwachukwu *et al.* (2026). Aflatoxins were extracted from the samples using a methanol-deionised water mixture (80:20, v/v) and were purified from the extract using an Aflaclean immunoaffinity column (LCTech, Germany). The concentrations of aflatoxins quantified using an Agilent 1100 high-performance liquid chromatography (HPLC) system equipped with a diode array detector (DAD).

Proximate Composition of the food products

Moisture Content Determination

Moisture content was determined using the oven-drying method. Clean Petri dishes were washed, dried in an oven, and cooled in a desiccator before use. Approximately 2.0 g of each sample was accurately weighed into pre-weighed Petri dishes. The initial weight (W1) was recorded.

Thereafter, the samples were dried in a hot-air oven at 105°C for 2 hours. After drying, the dishes were cooled in a desiccator and reweighed. Drying was repeated at 1-hour intervals until constant weight (W2) was obtained and moisture content calculated as described below.

$$\% \text{ Moisture} = (W1 - W2) / \text{Weight of sample} \times 100$$

Where W1 = weight of Petri dish + sample before drying
W2 = weight of Petri dish + sample after drying.

Ash Content Determination

Ash content was determined by incineration method. A clean platinum crucible was dried, cooled and weighed (W1). Then 2.0g of each of the sample was added and weighed (W2) and was incinerated in a muffle furnace at 550°C for 3 hours. Thereafter, the crucible was cooled in a desiccator and then reweighed (W3), thereafter the ash content was calculated as described below.

$$\% \text{ Ash} = (W3 - W1) / (W2 - W1) \times 100$$

Crude Fibre Determination

The defatted sample (2.0 g) was refluxed with 1.25% H₂SO₄ for 30 minutes, filtered, washed, and boiled with 1.25% NaOH for 30 minutes, then the residue was filtered, dried, and incinerated. The crude fibre was calculated using the formula below.

$$\% \text{ Crude fibre} = \text{Loss in weight after incineration} / \text{Weight of sample} \times 100$$

Crude Fat Determination (Soxhlet Method)

Each of the sample (2.0g) was extracted using petroleum ether (40–60°C) in a Soxhlet apparatus for 6 hours. The extract was dried and weighed and the fat content calculated as described below.

$$\% \text{ Fat} = (\text{Weight of flask + oil} - \text{empty flask}) / \text{Weight of sample} \times 100$$

Crude Protein Determination (Kjeldahl Method)

Each of the sample (0.5 g) was digested with concentrated H₂SO₄ in the presence of catalyst. The digest was distilled with NaOH and ammonia was trapped in boric acid and titrated with HCl. The percentage protein content was obtained using the formula below:

$$\% \text{ Nitrogen} = \text{Titre} \times 0.01 \times 14 \times 4$$

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

Carbohydrate Determination

Carbohydrate was determined by difference as described below.

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

Data Analysis

All analyses were carried out in triplicate and the values obtained were expressed as mean ± standard deviation. Statistical evaluation of the data was performed using SPSS software, and differences among mean values were considered significant at a probability level of less than 0.05.

RESULTS AND DISCUSSION

Microbial Counts of Dried Fish and Fermented Oil bean Seed (Ukpaka)

The microbial counts obtained from dried fish and fermented oil bean seed (Ukpaka) varies. The total viable count observed in ukpaka (7.8×10^5 CFU/g) was higher than that of dried fish (3.2×10^4 CFU/g). This higher microbial load in ukpaka may be attributed

to the fermentation process, which provides favorable environmental conditions such as adequate moisture and nutrients for microbial growth. This findings is in line with Achi (2005) reports that stated that fermented foods are naturally associated with increased populations of microorganisms due to the metabolic activities of fermenting microorganisms present.

Similarly, the coliform count observed in ukpaka (3.5×10^4 CFU/g) was substantially higher than the value obtained for dried fish (1.4×10^3 CFU/g). The elevated coliform count in ukpaka may suggest contamination from processing equipment, water sources, packaging materials, or poor hygienic practices during production. Similarly, Liu *et al.* (2023) have reported the occurrence of coliforms in fermented oil bean seed highlighting that their present was due to inadequate sanitation and environmental exposure during processing.

No lactic acid bacteria (LAB) were detected in dried fish,

whereas a high LAB count of 6.4×10^5 CFU/g was observed in ukpaka. The presence of LAB in ukpaka could be attributed that these organisms are naturally associated with raw materials and can grow during fermentation. The absence of LAB in dried fish may be due to the low moisture content and preservation methods employed which create unfavorable conditions for the growth of these bacteria.

The relatively lower microbial counts observed in dried fish may be linked to dehydration, as drying reduces the moisture content in the fish and hence limits microbial growth. However, the presence of viable bacteria and coliforms indicates that dry fish may be contaminated during handling or storage. Similar result was reported by Fagbohun and Lawal (2015), who stated that dried fish products may harbor microorganisms as a result of inadequate hygiene during post-processing.

Table 1: Microbial Counts of Dried Fish and Fermented Oil bean Seed (Ukpaka)

Microbial Parameter	Dried Fish(CFU/g)	Ukpaka(CFU/g)
Total Viable Count	3.2×10^4	7.8×10^5
Coliform Count	1.4×10^3	3.5×10^4
Lactic Acid Bacteria Count	-	6.4×10^5

The Identification of Isolates from Dried Fish and Fermented oil Bean Seed (ukpaka)

The identification of isolates from dried fish and ukpaka revealed the presence of diverse microorganisms from the assessed food products (Table 2&3). The bacterial isolates identified were *Staphylococcus aureus*, *Escherichia coli*, and *Lactobacillus* spp. while the fungal isolates identified as *Aspergillus niger*.

The isolation of *Staphylococcus aureus* from dried fish could be as a result that this organism is commonly associated with human skin, nasal passages, and hands and is often introduced into foods through poor handling practices. Therefore its presence suggests possible contamination during processing, packaging, or marketing (Jay *et al.*, 2005).

The occurrence of *Escherichia coli* in the dry fish sample may suggest contamination from water, equipment, handlers, or the surrounding environment. The detection of *E. coli* raises concerns regarding the microbiological safety of the product, as some strains are capable of causing gastrointestinal illnesses.

The isolation of both *Escherichia coli* and *Staphylococcus aureus* from dry fish in the present study is also consistent with the findings of Ibrahim *et al.* (2022) that isolated both *E. coli* and *S. aureus* from smoked catfish sold in a Nigerian market. Similarly, Umezurike *et al.* (2024) reported *E. coli* among the bacterial isolates recovered from smoked fish sold in selected markets in Ibadan, Nigeria. These findings indicate that smoked or dried fish can become contaminated with pathogenic or indicator organisms which could be during processing, handling, transportation, marketing and storage.

The isolation of *Lactobacillus plantarum* exclusively from Ukpaka confirms active fermentation. Lactic acid bacteria play important roles in fermentation through the production of organic acids, hydrogen peroxide, and antimicrobial compounds that inhibit undesirable microorganisms. The findings from this study is similar with that of Obi *et al.* (2023) who reported the occurrence of *Lactobacillus plantarum* in the fermented African oil bean seed assessed. The occurrence of *Aspergillus* species in both dried fish and Ukpaka is noteworthy because some species within this genus are capable of producing mycotoxins such as aflatoxins, which pose significant health risks to consumers. The presence of *Aspergillus* species in the samples may be due to contamination from different sources such as dust, processing or storage equipment (Pitt and Hocking, 2009). The detection of fungal contamination in the dry fish sample is consistent with reports of Adeoye *et al.* (2025) who stated that dried fish products may be contaminated with molds during drying and post-drying handling, particularly under conditions that favour fungal growth.

Obi *et al.* (2023) reported the recovery of *A. niger*, *Saccharomyces cerevisiae*, *Rhizopus* spp., *Candida* spp., and *Fusarium* spp. during the fermentation of African oil bean seed. The present finding also agrees with Fagbohun and Lawal (2015), who reported *Aspergillus niger* among the fungi associated with smoked-dried fish marketed in Ado-Ekiti, Nigeria. Similarly, Adesokan *et al.* (2016) reported *A. niger* among the fungal isolates recovered from smoked-dried fish samples collected from markets in Ibadan, Nigeria.

Table 2: Identification of the Bacterial Isolates from Dried Fish and Fermented oil bean seed (Ukpaka)

Isolate Code	Colony Characteristics	Gram Reaction	Catalase	Oxidase	Citrate	Indole	Methyl Red	Voges-Proskauer	Coagulase	% Pairwise Identity	Accession Number	Related Organism
DF1	Golden yellow colonies on mannitol salt agar	Gram + cocci	+	-	+	-	+	+	+	90.20	NR-113956.1	<i>Staphylococcus aureus</i>
DF2	Pink colonies on MacConkey agar/ large blue black colonies with green metallic sheen on Eosin methylene blue agar	Gram - rods	+	-	-	+	+	-	-	82.40	AP027528	<i>Escherichia coli</i>
UG1	Small round creamy colonies with smooth surfaces on De Man-Rogosa-Sharpe (MRS) agar	Gram + rods	-	-	-	-	-	-	-	98.4	AY383631	<i>Lactobacillus plantarum</i>

Table 3: Identification of Fungal Isolates from Dried Fish (DF) and Ukpaka (UG) Samples

Isolate Code	Colony Appearance on SDA	Microscopic Characteristics	% Pairwise Identity	Related Organism
DF1	Black powdery colonies	Septate hyphae with black conidia	89.2	<i>Aspergillus niger</i>
UG1	Yellow-green colonies	Rough conidiophores with radiating conidia	90.4	<i>Aspergillus niger</i>

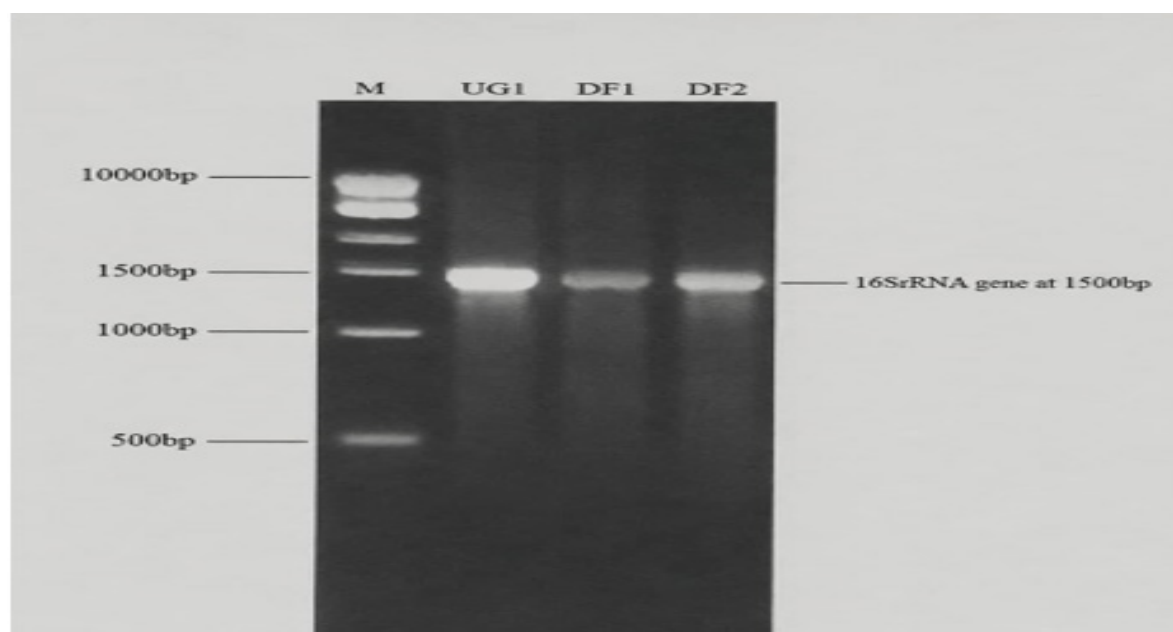


Figure 2: The Amplification of 16SrRNA Gene of the Bacterial Isolates

Note: UG1= *Lactobacillus plantarum*; DF1= *Staphylococcus aureus*; DF2= *Escherichia coli*

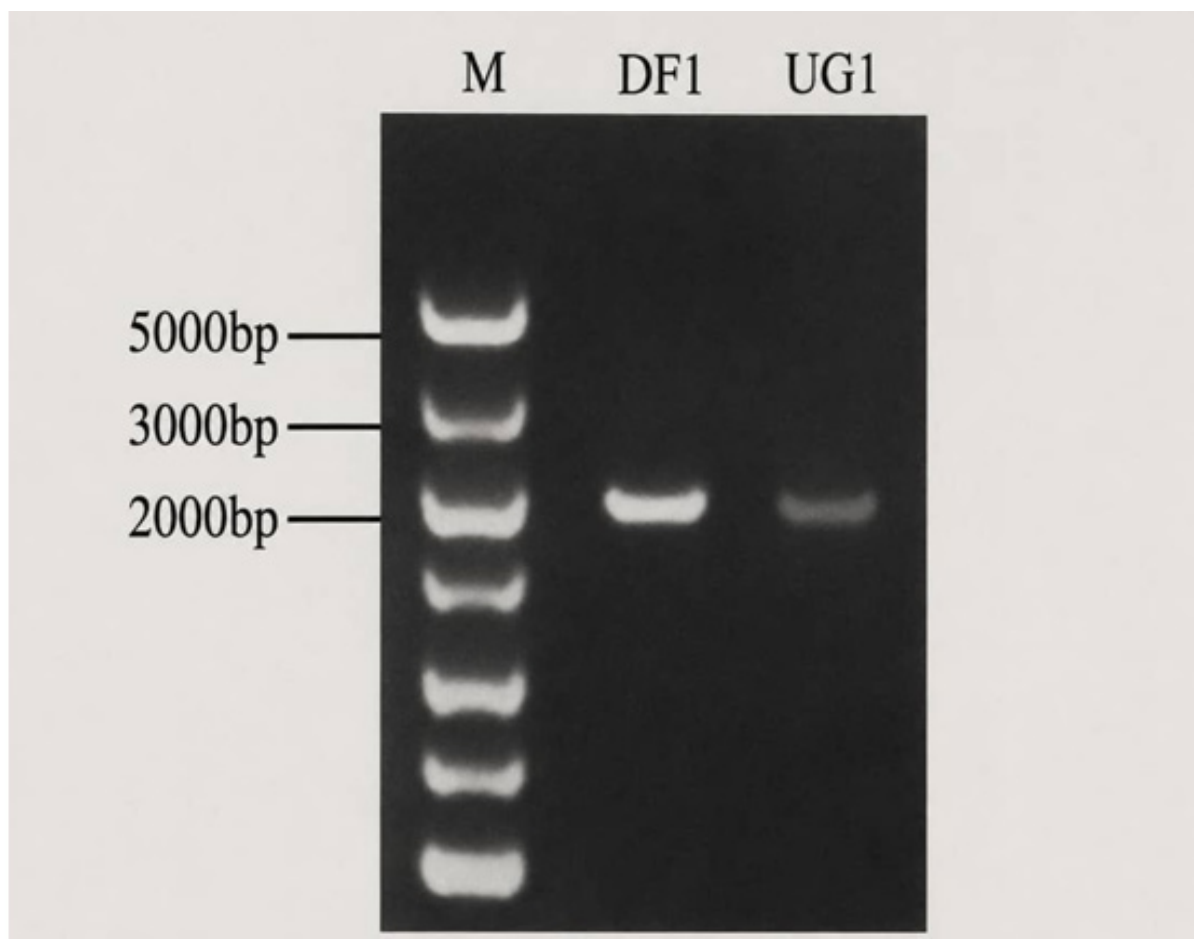


Figure 3: Gel Image of Amplified ITS region by the Fungal Isolates

Note: DF1= *Aspergillus niger*; UGI= *Aspergillus nige*

Aflatoxins Detection from Dried Fish and Fermented Oil Bean Seed (Ukpaka)

Several aflatoxins were detected in both dried fish and fermented oil bean seed (Ukpaka) samples, but the concentrations detected were low. The same type of aflatoxins were detected in all the sample but of different concentration. Aflatoxin B1 (0.178214 µg/kg), Aflatoxin B2 (0.00664275 µg/kg), Aflatoxin G1 (0.00384745 µg/kg), Aflatoxin G2 (0.00312370 µg/kg), Aflatoxin M1 (0.11684 µg/kg), and Aflatoxin M2 (1.18014 µg/kg) were detected in dried fish. Aflatoxin B1 (0.52841 µg/kg), Aflatoxin B2 (0.02104 µg/kg), Aflatoxin G1 (0.01603 µg/kg), and Aflatoxin G2 (0.0042 µg/kg) were detected in fermented oil bean seed.

Among all the aflatoxins detected, Aflatoxin B1 (AFB1) was the predominant toxin in both food products. This finding is in line with other reports where AFB1 was observed as the most common aflatoxin produced by *Aspergillus* species in food products (IARC, 2012). The concentration of AFB1 was higher in fermented oil bean seed than in dried fish, suggesting that the oil bean seed may provide more favorable conditions for fungal growth

and toxin production during processing, fermentation, or storage. The detection of aflatoxins in the samples supports the isolation of *Aspergillus* species in both food products as these organisms are known for aflatoxins production under suitable conditions.

The higher concentration seen in Aflatoxins B2 agrees with reports that AFB1 is usually produced in greater quantities than the other types of aflatoxin in contaminated foods (Williams *et al.*, 2004).

The detected aflatoxin levels were far below the maximum limits of 4 to 20 µg/kg established by many food safety authorities (European Commission, 2023). The detection of several aflatoxin types in both assessed food products is of great concern because the continuous consumption of these aflatoxins even at low concentrations, may contribute to chronic exposure which may lead to several side effects including liver damage, immunosuppression, growth impairment, and hepatocellular carcinoma (IARC, 2012). Therefore, proper storage practices, proper processing and hygienic handling are essential to minimize fungal contamination and subsequent aflatoxin production.

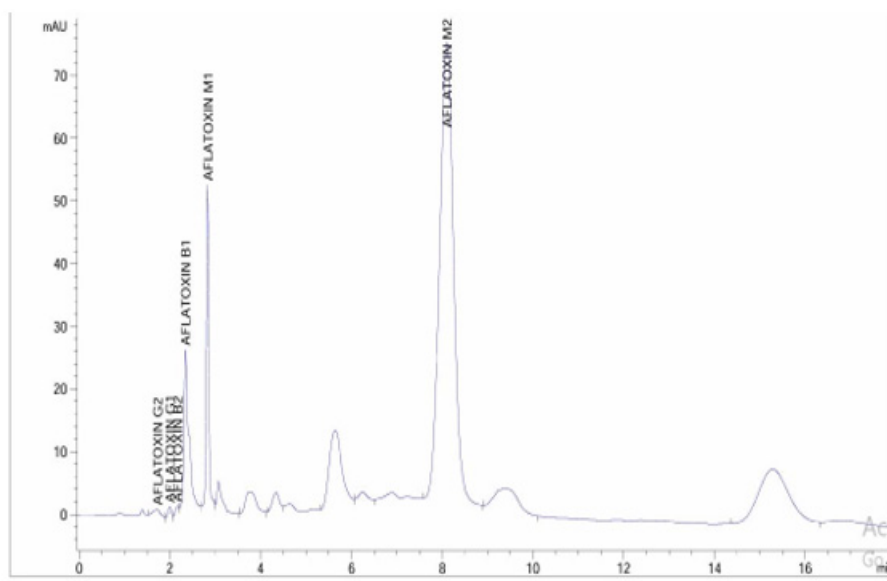


Figure 4: HPLC Chromatogram Showing the detection of Aflatoxins in the Dry Fish Samples.

Note: Aflatoxin B1= 0.178214 $\mu\text{g}/\text{kg}$; Aflatoxin B2=0.00664275 $\mu\text{g}/\text{kg}$; Aflatoxin G1=0.00384745 $\mu\text{g}/\text{kg}$; Aflatoxin G2=0.00312370 $\mu\text{g}/\text{kg}$; Aflatoxin M1= 0.11684 $\mu\text{g}/\text{kg}$; Aflatoxin M2=1.18014 $\mu\text{g}/\text{kg}$.

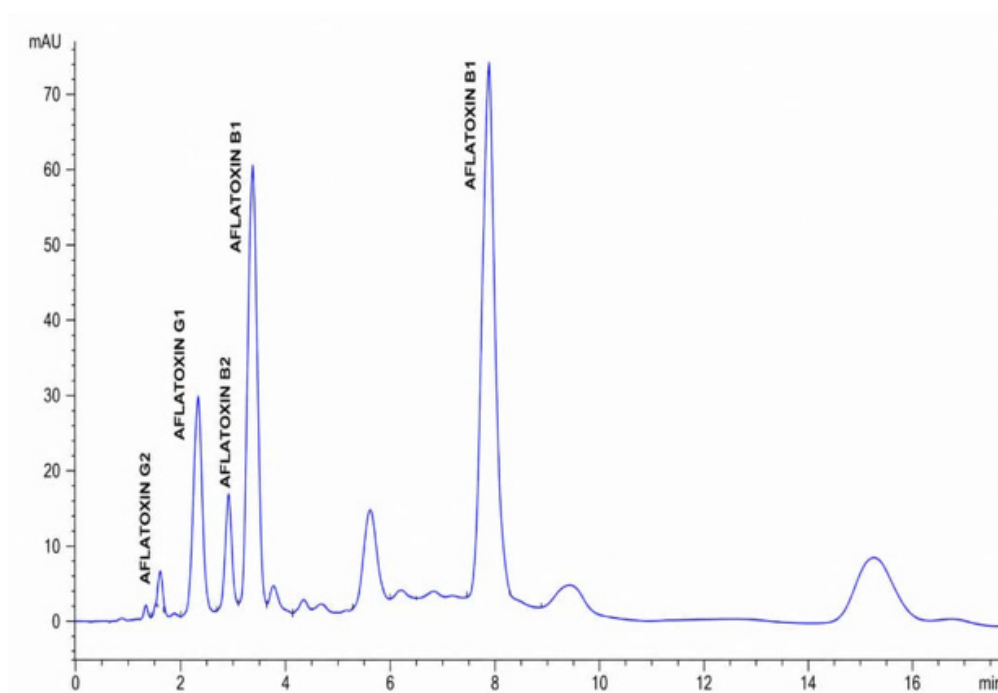


Figure 5: HPLC Chromatogram Showing the detection of Aflatoxins in the Fermented Oil Beans (Ukpaka) Samples.

Note: Aflatoxin B1= 0.52841 $\mu\text{g}/\text{kg}$; Aflatoxin B2=0.02104 $\mu\text{g}/\text{kg}$; Aflatoxin G1=0.01603 $\mu\text{g}/\text{kg}$; Aflatoxin G2=0.0042 $\mu\text{g}/\text{kg}$.

The Proximate Analysis of Dried Fish and Fermented Oil Bean Seed (Ukpaka)

The proximate analysis of dried fish and fermented oil bean seed (ukpaka) revealed marked differences in their nutritional composition. These differences may be attributed to the inherent nutritional characteristics of the raw materials and the different processing methods

employed in producing the two food products. Obianom *et al.* (2024) and Bongio *et al.* (2025) reported that fermentation can substantially influence the proximate composition of African oil bean seed, with changes occurring in moisture, protein, fat, fibre, ash, and carbohydrate contents as fermentation progresses.

The moisture content of fermented oil bean seed

(59.283%) was considerably higher than that of dried fish (11.25%). The high moisture content of ukpaka may be associated with the retention of water during fermentation, whereas the substantially lower value observed in dried fish reflects the removal of moisture during drying. The reduction of moisture through drying is an important preservation strategy because lower water availability generally limits microbial multiplication and slows food deterioration. Similar findings were reported by Eluchie *et al.* (2021) who observed the moisture contents of 48–51% in fermented ukpaka indicating that fermented oil bean products can retain considerable amounts of moisture. The moisture content obtained from the assessed dried fish sample was higher than that reported by Deka (2026) who observed moisture content ranged from 2.87% to 6.92 % in dried freshwater fish species from Assam, India.

The crude protein content was considerably higher in dried fish (58.40%) than in fermented oil bean seed (26.95%). The high protein value obtained for the dried fish reflects the importance of fish as a concentrated source of dietary protein. The protein content observed in fermented oil bean seed was also appreciable, indicating its potential contribution to plant-based protein intake. Higher protein content ranging from 37.45% to 58.24 % was observed in dried fish samples assessed by Deka (2026). Also fermented African oil bean seed was reported to increase in protein content following fermentation, suggesting that fermentation can modify the nutritional composition and improve the relative availability of some nutrients (Obianom *et al.*, 2024; Ogueke *et al.*, 2010).

The crude fat content of fermented oil bean seed (3.029%) was higher than that of dried fish (0.15%). This difference may be related to the naturally lipid-rich nature of African oil bean seed. Agbo (2024) reported that fermented oil bean seed had a relatively high lipid content compared with other fermented indigenous seeds. The low fat value observed in the dried fish may be influenced by the fish species, processing history, and drying conditions. However higher lipid content (7.35%) was reported by Raze *et al.* (2017) from dried fish samples collected from the local market of Cox's Bazar. Thus,

variation in lipid content between the two products may be expected because they originate from fundamentally different biological materials.

The crude fibre content of fermented oil bean seed (3.117%) was higher than that of dried fish (0.90%). The higher value observed in fermented oil bean seed is expected because oil bean seed is a plant-based food containing structural plant components, whereas fish muscle contains very little dietary fibre. Agbo (2024) similarly reported a relatively high fibre content in fermented oil bean seed further demonstrating the contribution of African oil bean seed to dietary fibre intake.

The ash content of dried fish (11.15%) was substantially higher than that of fermented oil bean seed (2.089%). Since ash represents the inorganic residue remaining after combustion, it provides an indication of the mineral fraction of a food. The higher ash value obtained for dried fish suggests a greater concentration of mineral constituents in the analyzed sample. Similarly, ash content ranging from 2.58-2.90% were observed from the assessed dried fish samples (Didia *et al.*, 2024). However, lesser ash content (10.08%) was reported from sun-dried fish products in Lake Tana, Ethiopia (Birie *et al.*, 2025).

The calculated carbohydrate content was 18.15% in dried fish and 5.532% in fermented oil bean seed. The lower carbohydrate value in fermented oil bean seed, may partly reflect microbial utilization of available carbohydrates during fermentation. This result was supported by Obianom *et al.* (2024) and Didia *et al.* (2024) findings, who reported carbohydrate content of 3.34-8.02% in fermented African oil bean seed assessed.

The observed differences of proximate analysis in both samples highlight the complementary nutritional value of animal- and plant-derived traditional foods. Nevertheless, proximate composition can vary considerably according to raw-material variety, fermentation duration, drying conditions, processing methods, and storage practices. Fermented oil bean seed have similarly demonstrated considerable changes in proximate composition (Eluchie *et al.*, 2021).

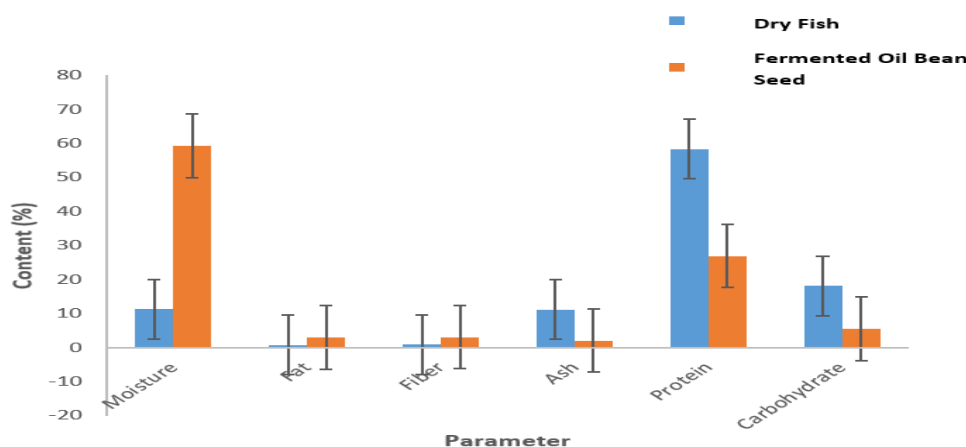


Figure 6: Proximate Analysis of Dried Fish and Fermented Oil Bean Seed (Ukpaka)

CONCLUSION

The study demonstrates that dry fish and fermented oil bean seed (Ukpaka) are highly nutritional food products but may harbor both beneficial and pathogenic organisms as well as aflatoxins. Therefore, strengthening hygienic practices among processors and vendors, promoting appropriate storage methods, and implementing routine quality monitoring are encouraged to ensure consumers' safety.

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