Determination and Comprehensive Evaluation of Microbial Load on Smoked Fish Sold in Owerri Metropolis Markets

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Abstract- Microbial assessment of smoked Scomber scombrus spp. of fish procured from two major markets in Owerri metropolis was carried out to evaluate their microbiological quality and safety for human consumption. Freshly smoked fish samples were randomly purchased from selected vendors in each market and transported under aseptic conditions to the laboratory for analysis. The samples were analyzed using standard bacteriological and fungal culture media to determine the total viable counts and to identify the microorganisms present. The results revealed that the average bacterial counts ranged from 3.1×10^6 to 6.8×10^6 colony-forming units per gram (cfu/g), indicating a relatively high microbial load. In contrast, the average fungal counts ranged from 0.0 to 0.3×10^6 cfu/g, which, although lower than the bacterial counts, still suggests fungal contamination in some samples. A total of four bacterial species were isolated and identified: Staphylococcus aureus, Escherichia coli, Bacillus spp., and Salmonella spp. Additionally, three fungal species were isolated, namely Mucor spp., Yeast spp., and Aspergillus spp. The presence of these microorganisms, particularly pathogenic species such as Staphylococcus aureus, Escherichia coli, and Salmonella spp., raises significant public health concerns. The higher levels of microorganisms identified from smoked fish purchased in the markets can be attributed to poor handling practices, inadequate hygiene during processing, exposure to contaminated environments, and improper smoking and storage methods adopted by fish mongers. Improved sanitary measures and proper smoking techniques are therefore recommended to ensure product safety.

Keywords- Microbial Load, Smoked Fish, Markets, Fungi

I. INTRODUCTION

Food is fundamental to human survival, acting as both a source of energy and nutrients necessary for growth, maintenance, and physiological function (Obruche et al., 2025). Human societies throughout history have developed diverse methods for procuring, preserving, and preparing food. Among these methods, smoking stands out as one of the oldest and most widely practiced traditional techniques for preserving perishable food items, particularly fish (Abolagba & Melle, 2008). As global populations grow and food supply chains extend across borders, concerns about food safety and quality have become paramount. It is within this context that understanding the microbial load of smoked fish becomes critically important—not only for public health but also for economic sustainability, consumer confidence, and regulatory compliance (Umudi et al., 2025).

Smoked fish is valued worldwide for its enhanced flavor, extended shelf life, and high nutritional content, including proteins, essential fatty acids, vitamins, and minerals. In many cultures, particularly in Africa, Asia, and coastal regions of the Americas, smoked fish constitutes a significant portion of dietary protein intake (Itodo et al., 2021). In Nigeria, fish is an essential dietary component, and smoked fish specifically is highly patronized due to its taste, availability, and affordability (Erienu et al., 2022). The smoking process, involving exposure to heat and smoke from burning wood or other fuel sources, inhibits microbial growth by reducing moisture content and depositing antimicrobial compounds present in smoke (Abeokuta et al., 2025).

However, despite these preservative effects, smoked fish remains susceptible to microbial contamination at various points—from harvesting and processing to transportation and retail distribution. Foodborne diseases, caused by pathogenic microorganisms such as Salmonella, Escherichia coli, Staphylococcus aureus, Listeria monocytogenes, and various species of molds and yeasts, pose significant health risks globally (Umudi et al., 2025). According to the World Health Organization (WHO), an estimated 600 million people fall ill annually from contaminated food, resulting in approximately 420,000 deaths. Microbial contamination of food products not only leads to acute infections but may also result in chronic health problems, including kidney failure, neurological disorders, and cancer (Obruche et al., 2019).

Therefore, assessing the microbial load of foods, especially widely consumed ones like smoked fish, is essential for evaluating safety, guiding policy, and protecting public health. Microbial load refers to the number of microorganisms present on or in a food sample. In food microbiology, this is quantified in terms of colony forming units (CFU) per gram or milliliter, representing viable bacteria, yeasts, or molds capable of replication (Ogwuche & Obruche, 2020). A high microbial load in smoked fish may not only signal potential spoilage but also reflect inadequate processing techniques, poor hygiene practices, substandard storage conditions, or contamination during handling and sale (Ekpo et al., 2023). Factors influencing microbial load in smoked fish include the quality of the raw fish, smoking temperature and duration, smoking environment, sanitation of processing surfaces, water quality used for washing or cooling, packaging materials, ambient temperature and humidity, and the length of time between processing and sale (Obruche et al., 2018).

In developing urban centers like Owerri Metropolis, in Imo State, Nigeria, smoked fish represents a staple food item sold in markets, roadside stalls, and retail outlets. Owerri, being a commercial and administrative hub in the southeastern region of Nigeria, has a vibrant market system where fish and other perishable products are traded daily (Goldman, 1997; Umudi et al., 2025). The market dynamics in such urban centers often involve rapid turnover of products, high consumer demand, and varied levels of food safety compliance among vendors. Given these circumstances, the risk of microbial contamination in smoked fish sold within the metropolis warrants systematic investigation (Obruche et al., 2019).

Despite the widespread consumption of smoked fish and its economic importance, there remains limited empirical data on the microbiological quality of smoked fish sold in many Nigerian cities, including Owerri (Ekpo et al., 2025). Previous studies in other regions have reported variable microbial loads in smoked fish, with instances of contamination by pathogenic bacteria and spoilage organisms exceeding acceptable limits set by regulatory agencies. These findings highlight the need for localized research to assess microbial contamination levels, identify potential contamination sources along the value chain, and provide evidence-based recommendations for improved food safety practices. In the context of Owerri, with its unique demographic, climatic, and market characteristics, this study provides an opportunity to highlight local practices that influence food quality. The tropical climate characterized by high temperatures and humidity can accelerate microbial growth, particularly when smoked fish is

inadequately processed or stored. Additionally, the influx of people into the metropolis for commerce and employment increases demand for ready-to-eat and preserved foods, making the safety of smoked fish both a nutritional priority and a public health concern (Olokor et al., 2007). In summary, the study of microbial load in smoked fish sold in Owerri Metropolis bridges the gap between traditional food preservation methods and contemporary public health standards. It underscores the intersection of culture, economics, nutrition, and microbiology, situating a common food item within the broader discourse on food safety and quality assurance (Festus-Amadi et al., 2021). By evaluating the microbial status of smoked fish in local markets, this research contributes valuable insights that can support improved processing practices, enhanced regulatory oversight, and ultimately, the protection of consumer health.

II. MATERIALS AND METHOD

Study Area
The study was carried out within Owerri Municipal Council in Imo State, Nigeria. Imo State is one of the thirty six states in Nigeria. Imo State is located in the south Eastern part of Nigeria and Lies longitude 6o35' East and 7o28 East and between latitude 5o10' North and 5o57 North. It has a total land area of about 5,067.20 km2. Imo State is made up of distinct Zones namely: Okigwe, Orlu and Owerri. It is also delineated in 27 local governments Area (Obruche et al., 2019).

Sample Collection
A total of two smoked fish samples (Scombia, scombia) were collected from two different street markets in Owerri, Imo State. Sample A was collected from student's market, Imsu front gate, sample 2 was collected from works layout market. Samples were labeled SA and SB and were transported in a sterile nylon bag down to the Micrrobiology Laboratory, Imo State University, Owerri, Imo State.

Sample Preparation
The methods of sample preparation were similar to those outlined by Ekpo et al. (2023), with some minor adjustments.Glass wares sterilization and media preparation were carried out following standard methods (FAO, 2005). One gram of the fish sample from the gills, skin, and intestine macerated was weighed into 9 mL of distilled water in a test tube. This was done for different parts of fish, for sample A and was taken as the original stock, labeled SAG (10-1) for gills, SAS (10-1) for skin, SAI (10-1) for intestine. Using a sterile 1ml pipette, 1 mL of the original stock solution was transferred into 9ml of sterile distilled water of the second test tube and mixed thoroughly to give 10-2 dilution hence labeled SAG (10-2), SAS(10-2) and SAI (10-2). The dilution continued with a sterile pipette until the tenth test tube (1010), 1ml was discarded from the tenth test tube. This procedure was also followed for the second sample (SB).

Sample Culture
Nutrient agar, MacConkey agar, Salmonella Shigella agar, Mannitol salt agar, and Potato dextrose agar were prepared following manufacturers instruction and sterilized using autoclave for 15minutes at 121oC (except for SSA, which is been sterilized using water bath). It was then removed and allowed to cool before it was poured into plates. The plates were then allowed to set, after which 0.1 mL of the serial diluted sample (A and B) from different parts of the smoked fish (i.e skin, gills, and intestine) and were inoculated on the surface of the well dried agar plates in duplicates. With the help of a sterile glass rod, the inoculums were properly spreaded on the surface of the media. The agar plates were labeled on the bottom with the sample code. Plates for bacteriological studies were inverted and were incubated for 37oC for 24hrs and fungal plates were incubated at room temperature for 5 days (Umudi et al., 20225).

Microbial Count

Each bacteria isolates obtained was counted and estimated according to methods Miles and Mistra (Umanah, 2005) while fungi colonies were also counted and estimated. The results were recorded.

Microbiological Analysis

The samples were analyzed for Total Heterophilic Bacterial Counts, Total Staphylococcus Count, Total Coliform Count, Total Salmonella Shigella count, and Total Fungal Count.

Microbial Identification

Bacteriological test like motility test, gram test, Biochemical test such as; catalase test, coagulase test, oxidase test, indole test, and citrate test. Triple sugar iron agar (TSI) was used to differentiate enterics based on the ability to reduce sulfur and ferment carbohydrates (Umudi et al., 2025).

Fungal Identification

Lactophenol Cotton Blue Solution is a mounting medium and staining agent used in the preparation of slides for microscopic examination of fungi. Fungal elements are stained intensely blue (Ugochukwu et al., 2025).

III. RESULTS AND DISCUSSION

At the end of the culture, the average microbial load was determined and recorded as shown in table 1-6. The total heterophilic bacteria count ranges from 3.1 to 13.8 X106 cfu/g while total fungi count ranges from 0.0 to 0.3X106 cfu/g as shown in table 1.

Table 1: Average Microbial Count in Fish samples.

Sample	body parts	average bacterial count (10^6 Cfu/g)	average fungal count(10^6 Cfu/g)
A	skin	3.1	0.0
	intestine	4.9	0.2
	gill	4.2	0.0
B	skin	13.8	0.3
	Intestine	10.7	0.3
	Gill	6.8	0.0

Table 2 shows the morphological and cultural characteristics of bacteria isolates on smoked fish Scombia scombia. Isolates on different plates exhibited different morphological features like shape, edge, colour, diameter, e.t.c.

Table2: Morphological and Cultural Characteristics of the Bacteria Isolates on Smoked Scombia scombia.

S/N	Gram reaction	shape	culture medium	description of colonies	suspected microoragnism
1	-	Straight rod	SSA	creamy brown, 2-3mm in diameter With black centre. Elevated and entire	Salmonella spp.
2	+	clustered cocci	MSA	deep yellow colonies of about 0.75mm having uniform coloration	Staphylococcus spp.
3	-	straight rod	NA	whitish, raised with rough edges	NSO

4	-	Straight rod	MAC	pink red, raised with entire edges
Escherichia coli.				
5	-	straight rod	MAC	colorless, raised with entire edge,
NSO				
6	-	rod shaped	NA	creamy white, large and flat
NSO				

-, ------negative +,-------- positive NSO,---- no suspected organism

Table 3 shows the result of the biochemical isolates and the identified bacteria. Isolates where either positive or negative to different test. Identified bacteria are Escherichia coli, Salmonella species, Bacillus species, and Staphylococcus species.

Table 3: biochemical results of isolated bacteria.

Motility	glu.	Lac.	Suc	indole	MR	V.P	citrate	oxidase	Coagulase	Catalase	Identified Organism
+	+	+	+	+	+	-	-	-	-	+	*Escherichia coli*
+	+	+	+	-	-	+	-	+	-	+	*Bacillus spp.*
-	+	+	+	-	-	+	-	-	+	+	*Staphylococcus spp.*
+	+	-	-	-	+	-	-	-	-	+	*Salmonella spp.*

Glu.,---- glucose, +,-----positive Lac.,---- lactose -, ----negative Suc.,----sucrose MR,---methyl red VP, ---voges proskuer.

Table 4 shows the morphological and microscopic result of fungi identified with the help of lacto phenol cotton blue. Isolated fungi are Yeast species, Mucor and Aspergilus species.

Table 4: Morphological and Microscopic Appearance of Fungi Isolates

Morphological Characteristics	Microscopic appearance of colonies in lacto phenol Cotton blue preparation	Identified Fungi
Initially white to yellow but	the vesicle of the conidiospores is large and globase,	*Aspergilus spp.*
Becomes distinctly black as colony	bearing 2 series of sterigmata over its entire surface.	
develops	the conidia are brown to black and rough walled.	
Cotton-like, white in color to gray *Mucor spp.*	simple and form apical, globular sporangia that are	
	Supported and elevated by a column-shaped columella	
Creamy white *Yeast*	are bi-polar budding cells with lemon-shaped mother tips	

Table 5 and 6 shows the % occurrence of bacteria species and fungi species respectively.

Table 5: Percentage Occurrence of Bacteria in the smoked Fish Samples

Sample	isolates	number	Percentage (%)
A	*Bacillus spp.*	2	28.6
	Escherichia coli	2	28.6
	Staphylococcus spp.	2	28.6
	Salmonella spp.	1	14.3
B	*Bacillus spp.*	2	18.2
	Escherichia coli	3	27.3
	Staphylococcus spp.	3	27.3
	Salmonella spp.	3	27.3

Table 6: Percentage Occurrence of Fungi in the smoked Fish Samples

Sample	isolate	number	percentage (%)
A	*Yeast spp.*	1	14.3
	Mucor spp.	1	14.3
	Aspergilus spp.	0	0.0
B	*Yeast spp.*	2	28.6
	Mucor spp.	2	28.6
	Aspergilus spp.	1	14.3

IV. DISCUSSION

This study shows that pathogenic bacteria and fungi are present in smoke Scombia scombia sold in students market and works layout market, in Imo State. According to International Commission on Microbiological Specification for Food (Umudi et al., 2025), the maximum recommended bacteria count for good quality product is 5.0×10^5. Bacteria present in the fish samples include Bacillus spp., Staphylococcus spp., Escherichia coli, and Salmonella spp. The occurrence of Staphylococcus spp. and Escherichia coli in the smoked fish were in accordance with Obruche et al. (2019) when he stated that these organisms were the commonest microorganisms associated with smoked fish. The presence of Staphylococcus spp. in fish samples according to Abeokuta, et al., (2025) might have been through contamination by handling.

The bacteria group of Staphylococcus spp. according to Obruche et al., (2018) reported that it was one of the most common causes of human diseases and they constitute the normal flora of human skin and mucous membrane without resulting in a diseased conditions. The bacteria class may also cause superficial and systematic infections such as boils, impetigo and follicalitis while more serious and more common infections could be pneumonia, bacteremia and other infections of the bones and wounds. Also, Escherichia coli usually cause diarrhea and kidney damage as well as complicated community acquired urinary tract infections. The fungi present in the fish samples are Yeast spp., Mucor spp., and Aspergilus spp. It was observed in the study that the presence of fungi, particularly aflatoxigenic molds produced mycotoxin, which has pathogenic effects on man; it destroys the liver and kidney failure

resulting to death. The presence of the organisms could be as a result of handling during smoking and also cross contamination during storage, after smoking and handling during sales of smoked fish.

V. CONCLUSION

In conclusion smoked fish (Scombia scombia) from students market and works layout market were heavily contaminated with many bacteria species including members of the genera Escherichia, Staphylococcus, Bacillus, and Salmonella due to the greater unhygienic conditions of the environment. The public health concern of smoked fish (Scombia scombia) is therefore the poor handling and processing either by processors, marketers or the consumers. This has greatly contributed to the contamination of these products by various pathogenic microorganisms which makes their consumption hazardous to health.

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