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Bacteriological Spectrum and Antibiogram of Isolates Obtained from Smoked Fish Sold in Federal Capital Territory, Abuja, Nigeria

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Abstract:- **Fish and fish products are common vehicles in the transmission of opportunistic pathogenic microorganisms if not properly processed and handled. The presence of potentially harmful and multidrug-resistant bacteria in sold smoked fish presents a public health threat. This study assessed the bacteriological spectrum and antibiogram of isolates obtained from four species of smoked fish sold in Wuse, Bwari, Dutse and Karmo markets, Abuja, Nigeria. The bacterial species present in eighty (80) fish samples were isolated and identified using standard bacteriological methods while the Kirby Bauer disc-diffusion method was adopted in the determination of the antibiogram pattern of the isolates. Results revealed the presence of eleven bacterial genera with pathogenic potentials including *Shigella dysenteriae*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Enterobacter aerogenes*, *Salmonella* species, *Streptococcus pyogenes*, *Bacillus subtilis*, *Klebsiella* species, *Proteus mirabilis* and *Corynebacterium* species. The overall prevalence rates from various markets show that *P. aeruginosa* was the most abundant (54.38%) followed by *S. aureus* (40.99%), *E. coli* (38.00%), *S. pyogenes* (24.00%), while *E. aerogenes* (21.00%) was the least isolated bacterium. Susceptibility testing shows that all the identified isolates were susceptible to cefixime and showed variable resistance rates to other antibiotics such as sulfamethoxazole+trimethoprim (81%), penicillin (72%), tetracycline (54%), gentamycin (81%), erythromycin (18%), ampicillin (81%), kanamycin (72%), neomycin (72%), cloxacillin (63%), ofloxacin (81%) and ciprofloxacin (18%). All the isolates were 100% resistant to at least three antibiotics used except *B. subtilis* which was 100% resistant to only two antibiotics. The multiple antibiotic resistance (MAR) index of all isolates indicates values higher than 0.2 except *B. subtilis*, which has a MAR index of 0.16. The isolated bacteria were multidrug-resistant (resistant to 3 or more antibiotics) except *B. subtilis*. MAR indexes above 0.2 showed that the bacterial isolates are from a high-risk source where antibiotics were frequently used. These significant findings call for effective risk assessment protocols and management measures that protect human health.**

Keywords:- *Bacteriological, Spectrum, Antibiotics, Smoked Fish, Resistance.*

I. INTRODUCTION

In many countries of the world, fish is considered to be a good source of essential proteins. According to FAO [1], fish is the most important single source of high-quality protein providing about 16% of the animal protein consumed by the world's population. In Africa, fish constitutes about 17% of animal protein consumed [2, 3]. Fish has high nutritional values such as low saturated fat and is a good source of essential fatty acids, omega-3 fatty acids which cannot be synthesized by the human body [4]. Fishes contain low fat and cholesterol and are highly digestible making them suitable for infants, children, and the elderly. It is relatively cheap compared to other meat products such as beef and poultry; hence, it is more affordable to most people [4, 5].

In Abuja, Nigeria, fish products are the most important source of animal proteins [6]. Traditional smoking, one of the main methods used for fish preservation in the country [7], generates two types of end products, smoked fish (SF) and smoked-dried fish (SDF), used for local consumption or exported to neighbouring countries. Nevertheless, fish and fish products are involved in 10%-20% of foodborne diseases [8]. Fishes in their natural habitat or reared are constantly exposed to numerous microbes [3]. These microbes, as parasites, create some damage in fish farms, and the diseases caused by microbes are accountable for heavy loss [4]. They ultimately could cause foodborne diseases among humans if not properly processed.

There has been an increase in the use of antibiotics (approved or unapproved) in aquaculture, either as growth promoters or as curative agents [5, 6]. The use of these antibiotics in the fishery is a serious concern to public health with regards to serving as potential sources for the spread of antibiotic-resistant pathogenic organisms such as *Campylobacter* species, *Staphylococcus aureus*, *Escherichia coli*, *Salmonella* species, *Pseudomonas* species, *Serratia* species, *Salmonella* species, *Klebsiella* species, *Shigella* species and *Bacillus* species, which have been isolated from fishes all over the world including Nigeria [5,7,11].

However, less attention is paid to the potential risk of antibiotics used in the aquaculture industries, which compromises human health [5]. In addition, the transfer of

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resistant organisms through the consumption of contaminated fish enhances a substantial risk of environmental contamination because of the practice of using medicated feeds to treat whole pens [9].

Antibiogram study is an important tool for monitoring antibiotic resistance and provides a view of the resistance pattern over time. It also aids in the evidence-based selection of antibiotics for the empirical treatment of infections in an area [10]. This study, therefore, was designed to determine the bacteriological spectrum and antibiogram of isolates in commercially available smoked fishes sold in Wuse, Bwari and Dutse markets, Abuja, Nigeria.

II. RELATED WORK

A few previous studies have evaluated the bacteriological quality and antimicrobial profile of isolates obtained from smoked fish in Nigeria. For instance, the antibiotic sensitivity pattern of microorganisms isolated from smoked and frozen fishes sold in Benin and Warri Metropolis, Nigeria was investigated. Results indicated the isolation of different pathogenic bacteria including *Staphylococcus aureus*, *E. coli*, *Pseudomonas* sp., *Bacillus* sp. and *Micrococcus* sp. with varying sensitivity and resistance rates to commonly used antibiotics [10]. In another research, the microbial quality of smoked *Trachurus trachurus* sold in some markets of three South-South States, Nigeria was assessed. Findings revealed the presence of bacterial diversity such as *Staphylococcus aureus*, *Escherichia coli*, *Bacillus*, *Salmonella*, *Shigella*, *Pseudomonas*, *Micrococcus*, *Proteus* and *Streptococcus* species with high Total Heterotrophic bacterial count (6.384-6.608cfu/g) and Total Coliforms count (4.170–4.741cfu/g) [11]. In addition, a comparative assessment of the microbiological quality of smoked and fresh fish sold in Benin City and its public health impact on consumers was assayed. Results showed that the bacteria isolated were *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, *Proteus mirabilis*, *Acinetobacter* spp., *Streptococcus pyogenes*, *Klebsiella* spp., *Micrococcus luteus*, *Enterobacter aerogenes*, *Flavobacterium* spp., *Corynebacterium* spp., *Serratia marcescens* and *Staphylococcus epidermidis* with high bacterial load [12]. Nevertheless, there is still a paucity of information on the prevalence of bacteria in smoked fish isolated from other states of Nigeria and antibiotic profiling of bacterial isolates, hence the need to carry out this study.

III. MATERIALS AND METHODS

- *Study Design and Sample Collection*

A total of eighty (80) randomly selected smoked fish species, obtained from different vendors in Wuse, Bwari, Dutse and Karmo markets, FCT, Abuja, were analyzed for bacteria contamination. Four (4) common smoked fish species were used in this study, including *Clarias gariepinus* (African mud catfish), *Oreochromis niloticus* (tilapia), *Sardinella eba* (herring) and *Scombia scombia* (mackerel). Twenty (20) samples were collected (at the first visit) from each market giving a representation of five (5) fish of each species. This was repeated three times. The fish were purchased, labelled and placed in sterile containers and transported to the laboratory for bacteriological analysis.

Fig 1 Smoked African mud catfish (C. Gariepinus)

Fig 2 Smoked Mackerel (Scombia Scombia)

Fig 3 Smoked Tilapia Fish (O. Niloticas)

Fig 4 Smoked Herring (Sardinella Eba)

- *Preparation of Samples and Enumeration of Bacteria*

The fish samples were surface sterilized separately in 3.5% sodium hypochlorite solution (w/v) with constant

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agitation for 7 minutes, rinsed thoroughly with sterile distilled water until the traces of hypochlorite were removed and were then dried in an oven at 45°C for 24 hours. The heads, muscles and tails of the fish samples were pulverized separately using a blender (maker). Ten grams (10g) of the ground sample was dissolved in a test tube containing 90ml of sterile peptone physiological saline to form a stock culture (1 part of the sample in 9 parts of the peptone physiological saline). The sample bottles were placed on a rotator shaker at 120 RPM for 1 hour. 10-fold dilutions were subsequently prepared with peptone physiological saline [13]. 0.1ml aliquots of 10^{-2}, 10^{-3} and 10^{-4} dilution were aseptically removed with a sterile pipette and transferred into labelled sterile Petri dishes and then about 18 – 20ml melted Nutrient agar were added by pour plate method. After rotating gently, the plates were incubated at 37°C for 24hrs. Enterobacteriaceae were cultured on Violet Red Bile Glucose and Salmonella-Shigella agar and incubated at 37°C for 24 hours while Staphylococci were cultured on mannitol salt agar (Oxoid) after incubation at 30°C for 48 hours. Coliforms were cultured on Eosin Methylene Blue (EMB, Oxoid) after 24 hours of incubation at 37°C for 24 hrs.

- *Identification of Bacteria*

Isolates were repeatedly subcultured on respective media to produce pure cultures by the streak plate technique. Bacterial plates were incubated at 37° C for 24 hours. Pure cultures were preserved in the refrigerator at 4°C for identification and character24-hour-old24 hour old culture was prepared from each plate for identification and characterization purposes. Bacteria isolates were identified based on their cultural characteristics, Gram staining reaction and various biochemical identification tests such as oxidase, indole, citrate and catalase.

- *Antibiogram Profiling*

At least 4-5 well-isolated colonies of the same morphological type from a pure culture were selected and swabbed using a sterile cotton swab [14]. The colonies were transferred into sterile 0.85% physiological saline water (PBS), and the bacteria were emulsified until the turbidity is similar to the 0.5 McFarland standard. Another sterile swab was immersed in PBS suspension, and the swab was pressed against the walls of the Bijoux bottle above the fluid level to remove excess fluid. The swab was then streaked in 3 different directions over the surface of a plate of Mueller-Hinton agar (MHA) such that a uniform well-spread-out inoculation is achieved. The inoculated plates were allowed to stand for 3–5 minutes so that the inoculum can dry. The antibiotic disc dispenser was retrieved from the refrigerator and left on the bench for 15 minutes at room temperature. The standard antibiotic discs (Oxoid) containing tetracycline (30µg), erythromycin (15µg), sulfamethoxazole-trimethoprim combination (25 µg), penicillin (10 µg), gentamycin (10 µg), ampicillin (10 µg), kanamycin (30 µg), neomycin (10 µg), cloxacillin (5 µg), ofloxacin (5µg), cefixime (5µ) and ciprofloxacin (15µg) were dispensed onto well-labelled inoculated MHA plates using the disc dispenser. The plates were allowed to stand for a few minutes and were incubated at 37°C for 24 hours within 15 minutes of applying [14]. Antibiotic sensitivity was checked by measuring the zone of inhibition (zone of clearance) from the back of the plate to the nearest mm using a ruler. The zone of inhibitions was recorded and used to establish if the bacterial isolates were resistant, intermediate, and sensitive using reference standards [15].

- *Multiple Antibiotic Resistance (MAR) Among the Isolated Bacteria*

The MAR index when applied to a single isolate is defined as **a/b**, where "**a**" represents the number of antibiotics to which the isolate was resistant and "**b**" represents the number of antibiotics to which the isolate was exposed. For example, if the isolate was exposed to twelve antibiotics and was tolerant to six antibiotics, the index for the isolate would be 6/12 or 0.50 [16] [17]. The MAR index was calculated for all the bacterial isolates.

- *Data Analysis*

Percentage occurrences of bacteria isolates were calculated as the number of times the bacterial species were identified over the total number of all the bacterial species identified multiplied by 100. The overall resistance rates of each antibiotic were calculated as the number of bacteria resistant to the antibiotic over the total number of bacteria isolates tested.

IV. RESULTS

ISSN No:-2456-2165

➢ *Bacteria Isolation and Identification*

The bacteria isolated and identified include *Shigella dysenteriae*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Enterobacter aerogenes*, *Salmonella* species, *Streptococcus pyogenes*, *Bacillus subtilis*, *Klebsiella* species, *Proteus mirabilis* and *Corynebacterium* species (Table 1).

Table 1 Summary of Morphological and Biochemical Characteristics of Bacteria Isolated from Smoked Fish Samples

Morphological characteristics	**Gram stain**	**Microscopic features**	**Catalase test**	**Coagulase**	**Indole test**	**Methyl Red**	**Voges Proskauer**	**Oxidase test**	**Citrate test**	**Glucose**	**Probable Organism**
Small circular opaque colonies	-	Short red rod	-	NA	+	+	-	-	-	+	E. coli
Opaque colonies	-	Slender rod	+	NA	-	+	-	-	-	+	Salmonella sp.
Bright-green colonies	-	Long red slender rod	+	NA	-	NA	NA	+	-	+	P. aeruginosa
White-greyish colonies, smooth surface	+	Purple cocci in chains	+	-	-	NA	-	-	-	+	Streptococcus pyogenes
Greyish-black opaque colonies	+	Club-shaped	+	-	NA	NA	-	-	-	-	Corynebacterium sp.
Pink-mucoid colonies	-	Short oval rod	-	NA	-	+	-	-	+	+	Klebsiella sp.
Pale smooth transparent colonies	-	Slender rod	-	NA	-	+	-	-	-	+	Shigella sp.
Pale round swarming colonies	-	Long slender rod	+	NA	-	+	-	-	+	+	Proteus mirabilis
Pink colonies	-	Slender mucoid rod	+	NA	-	-	+	-	+	+	E. aerogenes
Golden-yellow colonies	+	Purple cocci clusters	+	+	-	+	+	-	-	+	Staphylococcus aureus
Milky raised large colonies	+	Slender purple rod	+	NA	-	NA	+	-	-	+	Bacillus subtilis

Note: NA – Not Applicable, Negative (-), Positive (+)

Figure 1 below shows the percentage occurrences of the isolated bacteria: *Pseudomonas aeruginosa* (17.39%), *Shigella dysenteriae* (15.03%), *Escherichia coli* (10.23%), *Staphylococcus aureus* (8.49%), *Enterobacter aerogenes* (5.59%), *Proteus mirabilis* (8.79%), and *Salmonella* species (7.35%), *Corynebacterium* species (8.25%), *Bacillus subtilis* (7.35%), *Streptococcus pyogenes* (7.70%) and *Klebsiella* species (10.04%). The result shows that *P. aeruginosa* (17.39%) was the most dominant species among the isolates from the Wuse market.

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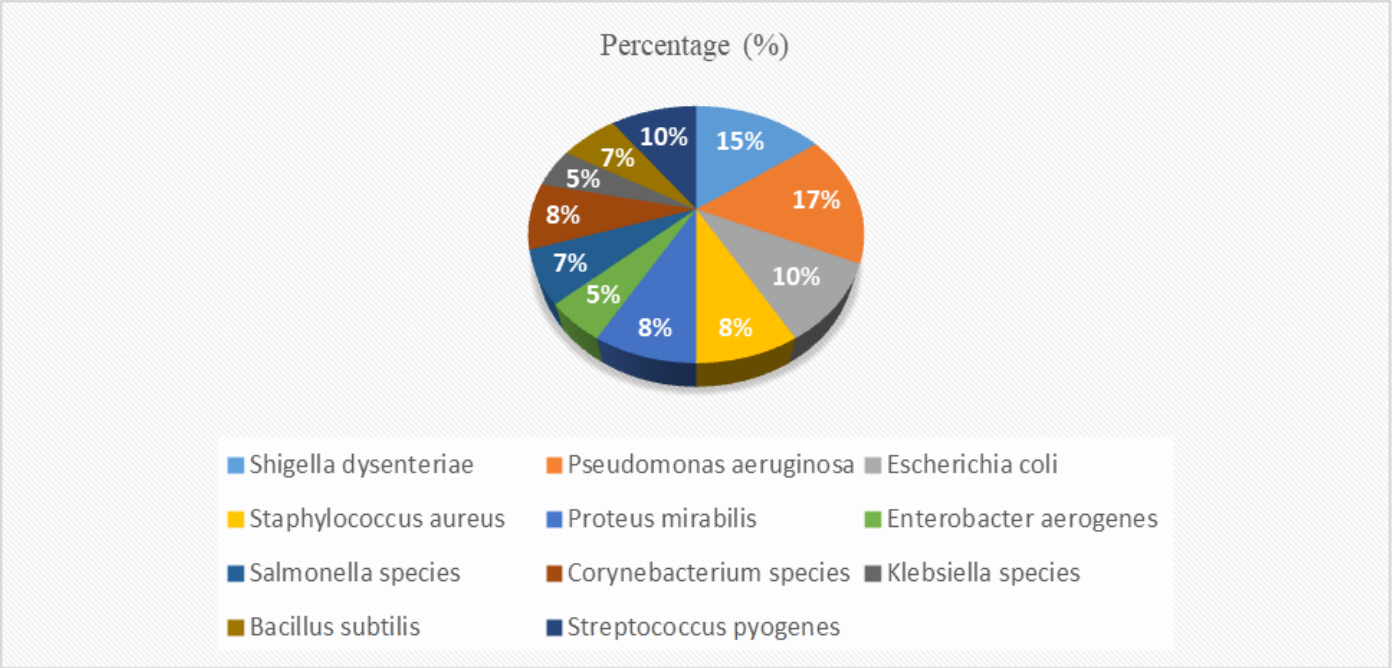

Fig 5 Percentage Occurrence of Bacterial Isolates in Wuse Market

The percentage occurrence of bacterial isolates obtained from the Bwari market is represented in Figure 2. Results indicate that *P. aeruginosa* had the highest prevalence (16.33%) followed by *S. dysenteriae* (15.00%) while *Klebsiella* sp. and *Enterobacter aerogenes* had the least prevalence (5.00% each). Other bacterial isolates include *S. aureus, P. mirabilis* and *Corynebacterium* sp. (8.33% each); *E. coli* had 10.00% and *Bacillus subtilis* had a 6.66% prevalence rate.

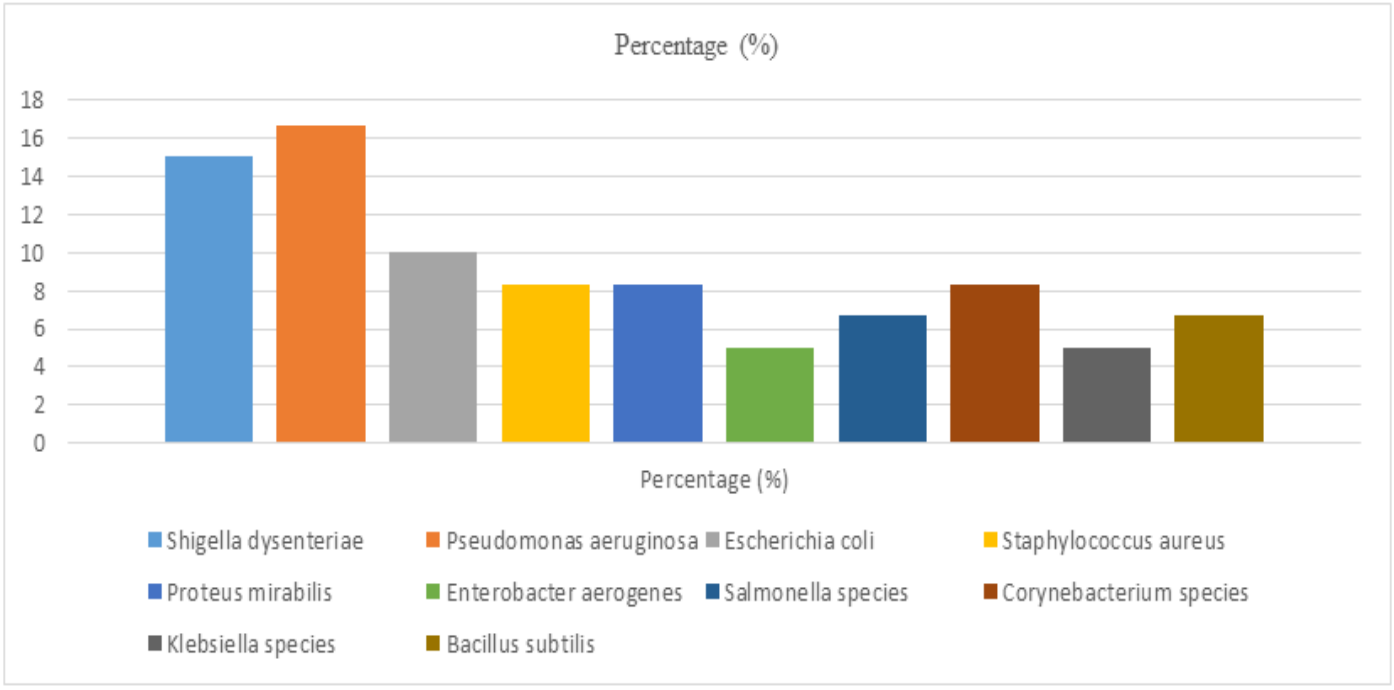

Fig 6 Percentage Occurrence of Bacterial Isolates in Bwari Market

Figure 3 presents the percentage occurrence of bacteria isolated from Dutse market. Results indicate that *Pseudomonas aeruginosa* was the most abundant (16.66%) while *Enterobacter aerogenes* and *Klebsiella* species were the least prevalent (5.00% each). *Shigella dysenteriae* had a 15.00% prevalence, *E. coli* (10.00%) while *S. aureus, Proteus mirabilis* and *Corynebacterium* sp. had 8.33% each. *Salmonella* sp. and *Bacillus subtilis* had 6.66% while *Streptococcus pyogenes* had 10.08%.

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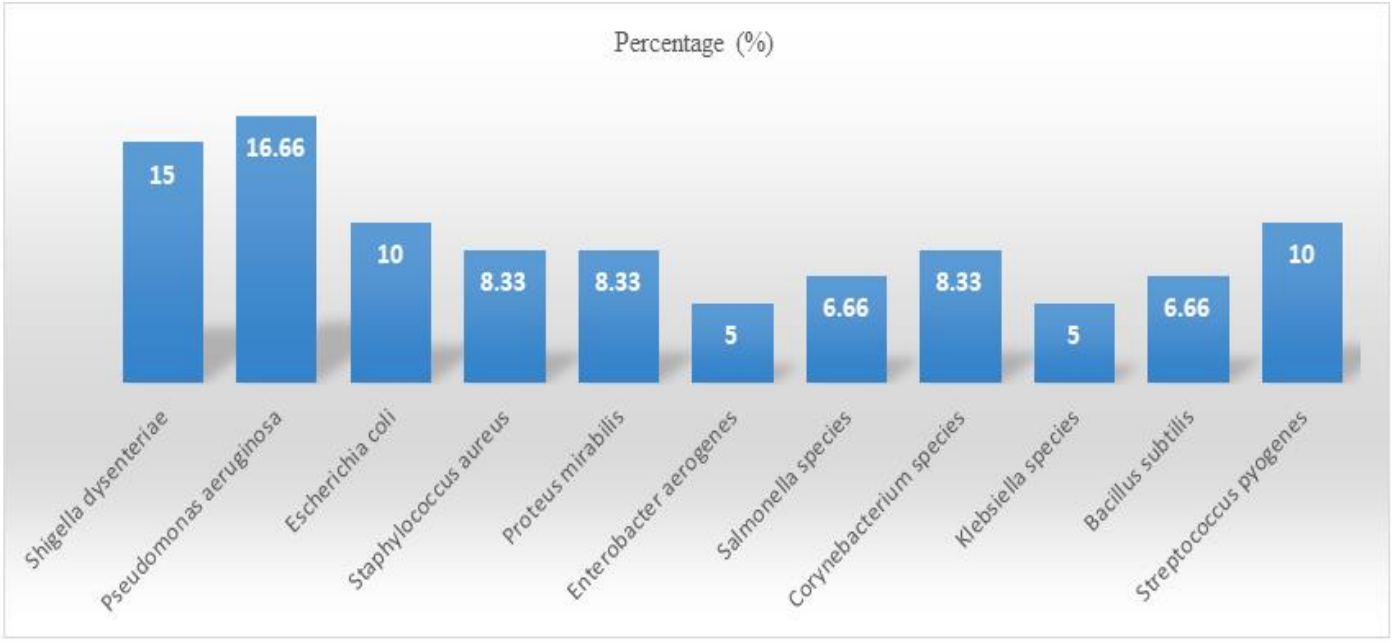

Fig 7 Percentage Occurrence of Bacterial Isolates in Dutse Market

Salmonella sp. (18.37%) was the most dominant bacteria among the isolates from the samples obtained from Karmo market as revealed in Figure 4. According to the result, the prevalence of *E. coli* was 8.16%, *Staphylococcus aureus* (16.33%), *Shigella dysenteriae* (12.24%), *Enterobacter aerogenes* (6.12%), *Proteus mirabilis* (8.16%), *Pseudomonas aeruginosa* (4.08%), *Bacillus subtilis* (6.12%), *Streptococcus pyogenes* (4.08%) and *Klebsiella* species (16.33%).

All the identified isolates were susceptible to Cefixime and showed variable resistance rates to each antibiotic as shown in Table 3. Overall resistance rates for each antibiotic for all the organisms identified are sulfamethoxazole+trimethoprim (81%), penicillin (72%), tetracycline (54%), gentamycin (81%), erythromycin (18%), ampicillin (81%), kanamycin (72%), neomycin (72%), cloxacillin (63%), ofloxacin (81%) and ciprofloxacin (18%). All the isolates have a 100% resistance to at least three antibiotics used except for *Bacillus subtilis*, which was 100% resistant to only two antibiotics. It is concluded that all the bacterial isolates from fish sold at informal markets were multidrug resistant except for *Bacillus subtilis*. Few species of bacterial isolates were intermediate and were not considered resistant but were bunched in the susceptible group.

The MAR index of all isolates shows values higher than 0.2 except *Bacillus subtilis* which has a MAR index of 0.16 (Table 4). From Table 4, all the isolated bacteria were multidrug-resistant (resistant to 3 or more antibiotics) except for *Bacillus subtilis* and *Proteus mirabilis*. Table 4 also shows the MAR indexes of the isolated bacteria ranging from 0.16 to 0.91. *Staphylococcus aureus*, *Salmonella* species, and *Corynebacterium* species have the highest MAR index value of 0.91, 0.75 and 0.75, respectively.

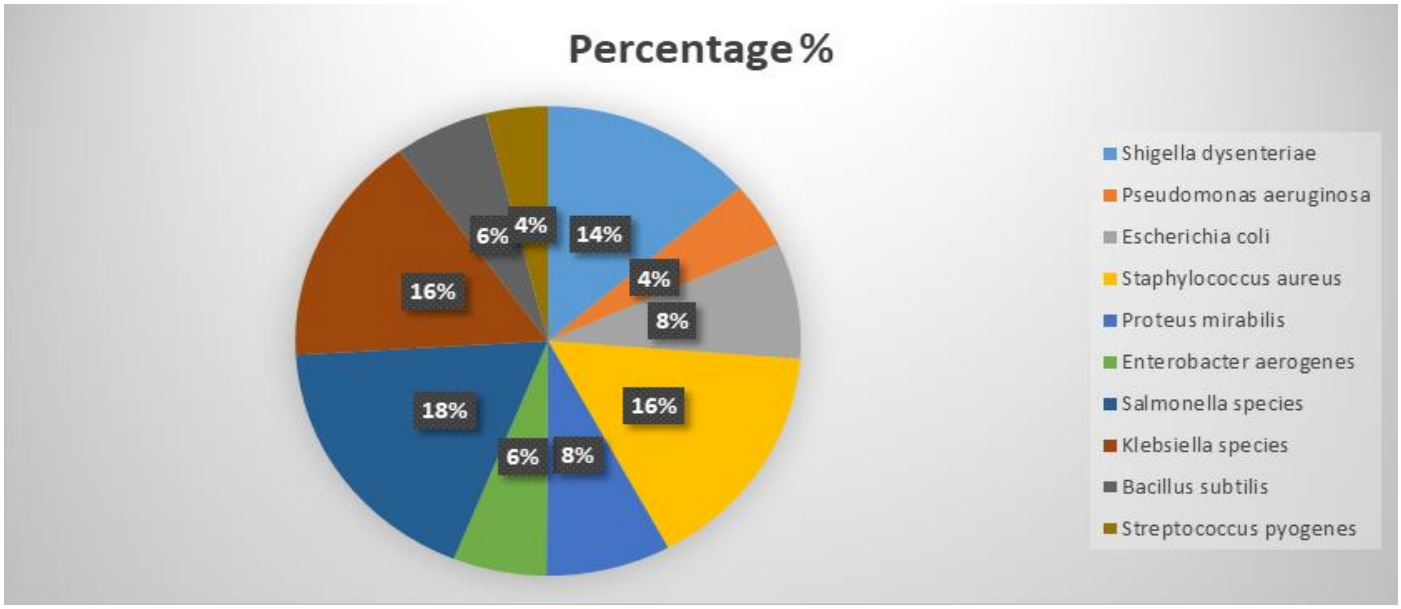

Fig 8 Percentage Occurrence of Bacterial Isolates in Karmo Market

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Table 3 Resistance Rate of Bacteria Isolates to Antibiotics

Bacteria	SXT	PEN	TET	GEN	ERY	AMP	KAN	NEO	CLO	OFL	CEF	CPX
Shigella dysenteriae	0	50	100	0	100	59	100	100	97	100	100	100
Staphylococcus aureus	20	30	80	0	0	0	10	0	30	50	100	74
P. aeruginosa	0	0	0	0	100	100	0	0	100	0	100	62
Escherichia coli	0	100	57	0	100	47	0	100	50	45	100	100
Enterobacter aerogenes	25	100	100	0	100	100	0	100	100	50	100	100
Salmonella species	10	0	0	10	100	27	0	0	0	38	100	100
Streptococcus pyogenes	0	25	100	0	100	0	0	0	0	25	100	100
Bacillus subtilis	100	0	100	100	100	0	100	100	100	100	100	100
Klebsiella species	0	100	50	0	50	50	0	100	50	35	100	100
Proteus mirabilis	100	0	100	100	100	50	62	45	39	70	100	100
Corynebacterium species	46	75	95	19	100	80	15	87	100	86	100	100
Overall Resistance rates (%)	81	72	54	81	18	81	72	72	63	81	0	18

- SXT: Sulfamethoxazole+Trimethoprim, PEN: Penicillin, TET: Tetracycline, GEN: Gentamycin, ERY: Erythromycin, AMP: Ampicillin, KAN: Kanamycin,
- NEO: Neomycin, CLO: Cloxacillin, OFL: Ofloxacin, CEF: Cefixime, CPX: Ciprofloxacin.

Table 4 Multidrug Resistance and MAR Index of the Isolated Bacteria

Isolate	MDR isolate	MAR index
Shigella dysenteriae	Positive	0.41
Staphylococcus aureus	Positive	0.91
Pseudomonas aeruginosa	Positive	0.66
Escherichia coli	Positive	0.58
Enterobacter aerogenes	Positive	0.33
Salmonella species	Positive	0.75
Streptococcus pyogenes	Positive	0.66
Bacillus subtilis	Negative	0.16
Klebsiella species	Positive	0.66
Proteus mirabilis	Negative	0.50
Corynebacterium species	Positive	0.75

MDR: Multidrug Resistance, MAR Index: Multiple Antibiotic Resistance Index

V. DISCUSSION

Bacteriological investigations are of great significance in the genuine diagnosis of disease, identification of foodborne pathogens, the conceptualization of treatment regimens and monitoring of antibiotics resistance development. The present study was aimed at determining the percentage occurrence and antibiogram profile of bacteria in smoked fishes sold in four major markets in the Federal Capital Territory, Abuja, Nigeria. When considered from the public health perspective, the growth and presence of potentially harmful microorganisms in commercially sold smoked fishes is unacceptable and presents a public health threat [17]. The results of this study demonstrated the significant presence of pathogenic bacterial species in commercially sold smoked fishes in Abuja City, Nigeria.

The four (4) bacteria genera isolated in this study (Tables 1) corroborate with the bacteria genera (*Pseudomonas*, *Escherichia*, *Klebsiella*, and *Proteus*) isolated from smoked and smoked-dried fishes in Benin [18] and 3 bacteria genera (*Escherichia*, *Staphylococcus* and *Pseudomonas*) isolated in rural aquaculture projects in Zimbabwe [19]. This study also agrees with 3 genera (*Pseudomonas*, *Escherichia*, and *Staphylococcus*) isolated from smoked fish in India [20]. More bacterial genera (8) were isolated in this research than those reported in previous investigations [10], [20] and [21]. The overall prevalence rates of the isolated bacteria shown in Figures 1-4 revealed that *Pseudomonas aeruginosa* was the most abundant (54.38%) followed by *S. aureus* (40.99%), and *E. coli* (38.00%), which disagrees with the findings reported by [20], where *S. aureus* was the most abundant. Isolation and identification of enteric bacteria (*E. coli*, *P. mirabilis*, *Klebsiella*, and *E. aerogenes*) in the samples is a clear indication of environment and faecal pollution either from humans or from animals as well as poor handling practices [18], [19] and [20]. Thus, proper cooking is needed to avert the likelihood of food poisoning. The identification of *S. aureus* indicates multisource pollution of fish from sewage effluents, humans during handling, and industrial and agricultural wastes. *S. aureus* produces a variety of extracellular enzymes and toxins that are responsible for food poisoning and can rapidly develop resistance to many antimicrobial agents and pose treatment challenges [7] [8] and [26]. The isolation of *P. aeruginosa* from the fish samples is germane because it plays a considerable role as a potentially pathogenic bacteria for humans, as an indicator of food quality and as a good spoilage index [25]. *S. dysenteriae* can cause serious diarrhoea, especially amongst

children and immunosuppressed individuals [1]. *P. mirabilis* is a commensal in warm-blooded animals; hence, its presence might be due to faecal contamination. *P. mirabilis* is an opportunistic pathogen which primarily affects those with weak immune systems [5]. The observed presence and high percentage occurrence of *P. aeruginosa* and *S. aureus* in all the markets in this study could be attributed to its wide range of habitats including human body parts, which may be a source of contamination for the freshwater food [16].

Antibiogram studies revealed that all the isolates have 100% resistance to at least three antibiotics used except for *Bacillus subtilis*, which was 100% resistant to only two antibiotics. This implies that the bacterial strains were multidrug-resistant to various antibiotics used except *B. subtilis*. However, all bacteria were sensitive to cefixime, and this agrees with findings by [27]. The results also indicated that *P. aeruginosa* demonstrated the highest percentage resistance (100% resistance to seven drugs, including sulfamethoxazole & trimethoprim, penicillin, tetracycline, gentamycin, neomycin and ofloxacin). These findings lend credence to other empirical studies, which reported multidrug resistance in *P. aeruginosa* isolated from smoked fish [1], [28] and [29]. The study of antibiotic resistance in pathogenic bacteria from fish is important, as it might indicate the extent of alteration of water ecosystems by anthropogenic activities. The resistance of the bacterial isolates to antibiotics could be elucidated by the possibility of the uncontrolled use of these antimicrobials in aquaculture either as growth promoters or curative agents [5] [6]. More importantly, many of these agents are non-biodegradable, thus increasing antibiotic selective pressure in the water, facilitating the transfer of antibiotic-resistant genes between aquatic bacteria, including fish and human pathogens, and allowing the presence of residual antibiotics in commercialized fish [10], [22] and [23].

The MAR indices of all isolates show values higher than 0.2 except for *B. subtilis* which has a MAR index of 0.16 (Table 4). Those multidrug-resistant bacteria with MAR indexes greater than 0.2 indicate that they are from high-risk sources where antibiotics are frequently used [27]. These pathogenic bacteria might have evolved resistance to several antibiotics due to the indiscriminate use of antimicrobial agents.

VI. CONCLUSION AND RECOMMENDATION

This study revealed that bacterial species including enteric pathogens are abundantly available in smoked fishes. Consumers of improperly cooked smoked fish are at risk of contracting gastrointestinal diseases. To prevent the occurrence of these infections**,** this study advocates the need for the adoption of good processing practices and proper preservation of smoked fish products, hygiene, and high safety standards to maintain the market worthiness of the final products. In addition, these problems could be adverted by improving the marketing strategies for smoked fish. As such, show glass can be deployed for the selling of smoked fish to reduce the possible transfer of microorganisms in over-crowded markets; and to prevent an eminent outbreak of diseases by antibiotic-resistant strains, farmers should be dissuaded from irrational use of antibiotics in fish farming.

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