



## **Microbiological Assessment of Smoked Fishes from Various Processing Points in Ado Ekiti Metropolis**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The purpose of the research is to isolate and characterize the bacteria present in smoked fish sold in various processing site in Ado Ekiti Metropolis. Fifty (50) samples of five (5) species of fish (Mackerel: Scomber scomber, Blue whiting: Micromesistius poutassou, Catfish: Clarias gariepinus, Herrings: Clupea harengus, Horse mackerel: Trachurus trachurus) were obtained from fifteen (15) different processing sites in different locations in Ado-Ekiti. The study results showed the total heterotrophic bacteria count which ranges from  $0.30 \times 10^4$  –  $3.68 \times 10^4$  cfu/g, the highest colony count was examined from the panla (Blue whiting {Micromesistius poutassou}). The bacteria organisms isolated and identified in the smoked fish were Pseudomonas aeruginosa, Klebsiella pneumonia, Streptococcus sp, Bacillus subtilis, Escherichia coli, Proteus mirabilis and Staphylococcus aureus. The study showed that though smoking helps in inhibiting activities of bacteria, however, when not properly carried out, bacterial growth and activities still lead to the deterioration of the fish. Due to public health implication, the state of smoked fish should be paid proper attention by the processors and consumers for their safety through proper processing, storage and handling procedures.

**Keywords:** Smoking; smoked fish; processing; bacteria.

## 1. INTRODUCTION

“Fish and Fish product plays an important role in combating hunger and malnutrition. Fish is a source of proteins and healthy fats, but also a unique source of essential nutrients, including long-chain omega-3 fatty acids, iodine, vitamin D, and calcium. The numerous benefits of fatty fish high in omega-3s and small fish eaten whole containing nutrients in the skin and bones clearly illustrate seafood’s irreplaceable nutritional value. An increased focus on fish and nutrition aids both developing countries and the developed world. In many developing countries, fish is the main or only source of animal protein, and is essential for providing micronutrients to vulnerable populations. Fish can sometimes serve as a solution to existing health problems. For instance, goiter is found in areas where iodized salt is unavailable, but the consumption of fish and the natural iodine it contains could help reduce these cases. Dietary patterns are also shifting in developed and middle-income countries, and an increasing emphasis on coronary and overall health has led to an increased demand for fish” [1].

Fish smoking: either wet or dry smoking is one of the traditional processing methods aimed at preventing or reducing post-harvest and spoilage losses. Fish is a highly perishable product due to its high susceptibility to autolysis, oxidation and hydrolysis of fats and microbial spoilage. The post-harvest methods of preserving fish include refrigeration (4°C) and freezing which is effective when such fish is conditioned to a temperature of -10°C. Other methods frequently employed include sun drying and smoke drying all associated with increased germicidal action with increasing temperature. “Fish is one of the most important proteins available in the tropics and entire world at large, and it represents about 14% of all animal proteins in a global basis. In Nigeria, the demand for fish consumption is increasing due primarily to health benefits of eating fish and secondarily to increase in human population, high cost, disaster and drought bane which reduce the availability and affordability of red meat (cattle, sheep and goat)” [2].

Fish is extremely perishable immediately after catch and therefore requires immediate and proper handling and good preservation to retain its quality. The food eaten has a direct influence on health, it is therefore an important task that food inspectors, food manufacturers and food handlers keep food safe from pathogenic

microorganisms, especially when such foods are to be consumed without further processing, i.e. fast foods or “ready to eat” foods. Several types of microorganisms have been known to affect the quality of food, thereby constituting health hazards when food contaminated with these organisms are consumed. “A number of food items sold locally have been shown to be highly contaminated with *Bacillus species*, *Staphylococcus species*, and other bacteria species” (Oronsaye et al., [3].

“Bacterial component of fish microbial species and the occurrence of this pathogen is commonly related to its breeding, as well as to the industrialization environment, due to inefficient hygiene practices, equipment and inadequate food handling. Therefore, fish slaughterhouses must take special care in the handling, storage, preservation, transport and commercialization of these animals, since the quality of the final product depends on these factors.

The importance of these bacteria in fish have been assessed and evaluated, since records indicated that fish were responsible for the occurrence of 7% of total food borne outbreaks in Europe in 2016, with the majority of *Salmonella* infections in humans related to fish consumption caused by the *Typhimurium* and *Enteritidis serovars*” [4].

“In the United States, bacteria was responsible for 20,000 admissions and 380 deaths per year over a three-year period (Bae et al., [5]. In 2015, also in the US, a *Salmonella* outbreak was identified, with the recall of frozen raw tuna (*Thunnus alalunga*) from an Indonesian industry. This led to 65 people becoming infected with *Salmonella Paratyphi B* and *Salmonella Weltevreden* in 11 American states [6]. Another study, conducted on 11,3120 seafood samples imported from different countries over a 9-year period in which they were collected by the Food and Drug Administration (FDA) concluded that the overall incidence of *Salmonella* spp. in seafood was of 7.2%, and that incidence rates are higher in Central Pacific and African countries, or developing countries, compared to developed countries, such as countries in Europe, including Russia, and North America, that displayed a significantly lower incidence.” [7].

“*Salmonella* and *Listeria* have been reported to be more resistant to chlorine inactivation than

*Escherichia* strains in a system consisting of washing fresh products with hyperchlorinated

water. Thus, for inactivation of *Salmonella* in Panga fish (*Pangasius hypophthalmus*), a chlorine concentration of 10ppm was used for at least 30 seconds. Although, washing with hyper chlorinated water is often a control point, a critical control limit has not been validated” Thi et al. [8].

Microbial contamination cause infections that are responsible for various food borne illnesses and diseases. In uncontrolled conditions, these infections could cause major foodborne disease outbreaks in a community or population. Espejo-Hermes [9] has identified that infections caused by these microbes are more pronounced in developing countries, where there are improper practices in handling, storage, processing and distribution of food and food products.

## 2. AIMS AND OBJECTIVE IF THE STUDY

- I. To find out the occurrence of microorganism in fish sold at various processing points in Ado-Ekiti metropolis.
- II. To identify pathogenic organisms present in fish samples obtained from processing point using various biochemical tests.
- III. To compare the incidence of the bacteria at different processing point of the fish samples and to determine whether the various points have any significant effect on the prevalence of these pathogens in the fish.

## 3. MATERIALS AND METHODS

### 3.1 Materials

Petri-dishes, paper tape, distilled water, cotton wool, methylated spirit, microscope, hand glove, respiratory mask and distilled water.

### 3.2 Collection of Fish Sample

Fifty (50) samples of five (5) species of fish (Mackerel: *Somber scomber*, Herrings: *Clupea harengus*, Horse mackerel: *Trachurus trachurus*, Blue whiting: *Micromesistius poutassou*, Catfish: *Clarias gariepinus*) were obtained from fifteen (15) retailer shops selling at road side in different location in Ado-Ekiti. The samples were collected in a sterile foil paper and put inside ice cooler and transported to Microbiological laboratory in Federal Polytechnic Ado-Ekiti.

### 3.3 Preparation of Media

The preferred media was nutrient agar (NA), which were prepared according to manufacturer

instructions. The media was dissolved in adequate amount of distilled water. The media was homogenized and autoclaved at 121°C for 15minutes.

### 3.4 Isolation of Microorganisms

10grams of the fish sample were weight and macerated using mortar and pestle, 1g of the macerated sample was taken and dissolved inside 10ml of distilled water.

A series of test tubes were prepared for the isolation of bacteria and fungi. 9mL of sterile distilled water was put into each of the test tubes. To the first test tube, 1mL of the sample was added to give a dilution of  $10^{-1}$ . The contents were shaken properly and 1mL of the solution was taken and added to the next test tube containing 9mL of sterile distilled water to make a concentration of  $10^{-2}$ . The serial dilution was made up to  $10^{-6}$  dilution for the fish samples. 0.1ml of the  $10^{-3}$  and  $10^{-4}$  dilution was cultured on the agar plates using the pour plate technique (Fawole and Oso, 2001) labeled and incubated at 37°C for 24hours. Counting of the bacterial colony was done by using colony counter, distinct colonies were sub cultured picked by streaking on fresh nutrient agar plates. The pure culture was preserved on agar slants for further studies.

### 3.5 Biochemical Tests

#### 3.5.1 Gram staining technique

Smear of each bacterial isolate was prepared on a clean slide. In preparing the smear, a drop of sterile distilled water was placed in the middle of the slide. A sterilized inoculating needle was used to pick from the bacterial colony and rubbed on the slide containing a drop of sterile distilled water. The bacterial cells were spread into a thin smear, air dried and heat fixed.

#### 3.5.2 Catalase test

A thick emulsion of each test organism was prepared on a clean slide. Several drops of 3% hydrogen peroxide were added on each of the slides. A positive result was indicated by effervescence which was caused by the liberation of oxygen gas as a result of catalase production by the bacterium. There were no gas bubbles in the bacteria that do not produce catalase.

### 3.5.3 Coagulase test

A loopful of test isolates were picked from a young culture, emulsified with serum placed on a clean grease free slide and rocked for one minute. The presence of agglutination indicates a positive reaction

### 3.6 Motility Test

The hanging-drop method was used to determine the motility of the bacterial isolates. A little Vaseline was placed around the edge of the hallow of a clean cavity slide. A loopful of each isolate was transferred to the center of a clean coverslip laid on the bench. The cavity slide was carefully inverted over the coverslip and the slide was pressed down gently in order to seal the coverslip with the slide. The unit was then inverted in such a way that the loopful of the bacterial colony was in hanging position. The preparation was examined immediately under the X40 objective lens. The microscopy was done quickly in order to avoid excessive illumination, which could quickly cause the organism under study to lose motility.

Motile cells came in view and were seen moving rapidly in the field while non-motile were not moving.

### 3.7 Antibiotic Sensitivity Test

A broth culture of each organism was prepared and a sterile cotton swab was inserted into the broth culture to pick the isolates, then the inoculums on the swab stick were transferred into a fresh plate of nutrient agar. Each of the organisms was classified as either Gram positive or Gram negative and the sensitivity disc of each was placed on each plate containing the isolated organism. The plates were incubated invertedly at 37°C for 18-24hours.

## 4. RESULTS AND DISCUSSION

### Results

The study showed that pathogenic bacteria were present in fish sold at, Isato Isale, Falegan market, Ureje, Adehun, Irona, Ajebandele junction, Omisanjana, Egbewa, Okebola, Oke-ila and Adeike street in Ado-Ekiti. Table 1 shows the total heterotrophic bacteria count which ranges from  $0.30 \times 10^4$  –  $3.68 \times 10^4$  cfu/g the highest colony count was examined from the panla (Blue whiting {*Micromesistius poutassou*}) sample purchased from Owolabi street Ekute located in Ado-Ekiti, while Horse Mackerel: *Trachurus trachurus* purchase from Omisanjana opposite fountain junction has the lowest concentration of contamination.

**Table 1. Total heterotrophic count of bacteria present in smoke fish purchase from different processing site in Ado-Ekiti metropolis**

Sample code	Total Heterotrophic bacterial count ( $10^4$ cfu/g)
IIP	$3.08 \times 10^4$
FMP	$3.24 \times 10^4$
US	$0.88 \times 10^4$
UA	$0.52 \times 10^4$
AP	$1.44 \times 10^4$
IMA	$0.56 \times 10^4$
AJS	$3.04 \times 10^4$
OIS	$1.32 \times 10^4$
ERS	$1.04 \times 10^4$
OBSP	$2.04 \times 10^4$
ASAS	$1.08 \times 10^4$
OJS	$0.30 \times 10^4$
OAP	$0.84 \times 10^4$
OWSEP	$3.68 \times 10^4$
NRK	$3.14 \times 10^{-4}$
OAC	$3.40 \times 10^{-4}$

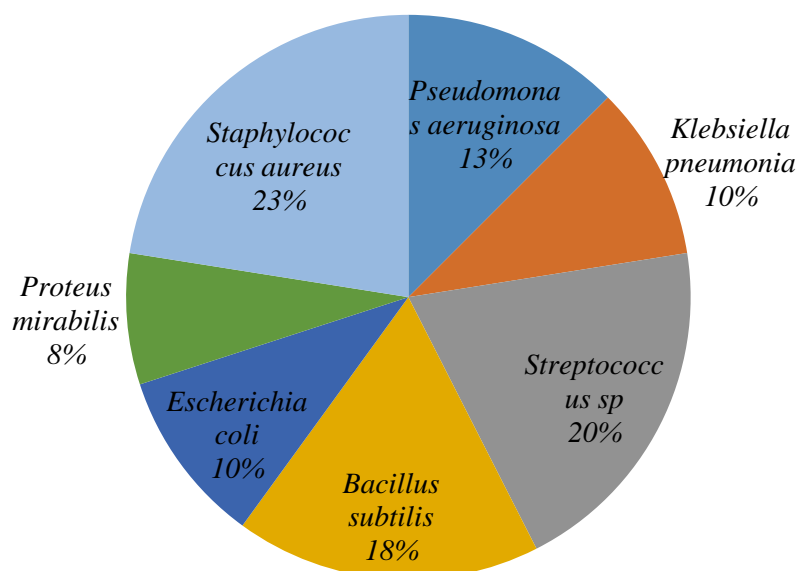
Key: IIP:- Isato Isale Panla, FMP:- Falegan Market Opposite Ikeja Avenue Panla, US:- Ureje Sawa, UA:- Ureje Alaran, AP:- Adehun Panla, IMA:- Irona Market alaran, AJS:- Ajebandele Junction Sawa, OIS: Oke-Ila Sawa, ERS:- Egbewa Road 6 Sawa, OSP:- Okebola Street Life Bible Church Panla, ASAS: No 19 Adeike Street Ajilosun Sawa, OJS: Omisanjana Opposite Fountain Junction Sawa, Ori-apata Panla, Owolabi street Ekute Panla, Nova road Kote and Odo-Ado Catfish

**Table 2. Colonial, cellular morphology and biochemical characteristics of the bacterial isolated from smoke fish sold in different processing point in Ado-Ekiti metropolis**

Sample	Detected Organisms													
	Colony pigmentation	Colony surface	Gram's Rtn	Colony shape	Catalase	Coagulase	Motility	Indole	Citrate	Oxidase	Spore staining	Methyred	V.P	
IIP	G	Smooth	-ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	-ve	-ve	-ve	<i>Pseudomonas aeruginosa</i>
	Y	Rough	+	Cocci in cluster	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Staphylococcus aureus</i>
	C	Rough	+ve	Cocci in chain	-ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Streptococcus sp</i>
FMP	C	Rough	+ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	<i>Bacillus subtilis</i>
	C	Rough	-ve	Rods	+ve	-ve	+ve	+ve	-ve	-ve	-ve	+ve	-ve	<i>Escherichia coli</i>
	C	Rough	+ve	Cocci in chain	-ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Streptococcus sp</i>
US	C	Rough	+ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	<i>Bacillus subtilis</i>
	Y	Rough	+	Cocci in cluster	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Staphylococcus aureus</i>
	G	Smooth	-ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	-ve	-ve	-ve	<i>Pseudomonas aeruginosa</i>
UA	C	Rough	-ve	Rods	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	+ve	<i>Klebsiella pneumonia</i>
	C	Rough	+ve	Cocci in chain	-ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Streptococcus sp</i>
	C	Rough	+ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	<i>Bacillus subtilis</i>
AP	C	Rough	-ve	Rods	+ve	-ve	+ve	+ve	-ve	-ve	-ve	+ve	-ve	<i>Escherichia coli</i>
	Y	Rough	+	Cocci in cluster	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Staphylococcus aureus</i>
	C	Rough	+ve	Cocci in chain	-ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Streptococcus sp</i>
IMA	Y	Smooth	-ve	Rods	+ve	-ve	+ve	-ve	+ve	-ve	-ve	+ve	-ve	<i>Proteus mirabilis</i>
	Y	Rough	+	Cocci in cluster	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Staphylococcus aureus</i>
	G	Smooth	-ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	-ve	-ve	-ve	<i>Pseudomonas aeruginosa</i>
AJS	C	Rough	-ve	Rods	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	+ve	<i>Klebsiella pneumonia</i>
	Y	Rough	+	Cocci in cluster	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Staphylococcus aureus</i>
OIS	C	Rough	+ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	<i>Bacillus subtilis</i>
	C	Rough	+ve	Cocci in chain	-ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Streptococcus sp</i>

Sample	Detected Organisms													
	Colony pigmentation	Colony surface	Gram's Rtn	Colony shape	Catalase	Coagulase	Motility	Indole	Citrate	Oxidase	Spore staining	Methyred	V.P	
ERS	Y	Rough	+	Cocci in cluster	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Staphylococcus aureus</i>
	G	Smooth	-ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	-ve	-ve	-ve	<i>Pseudomonas aeruginosa</i>
OBSP	C	Rough	-ve	Rods	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	+ve	<i>Klebsiella pneumonia</i>
	Y	Rough	+	Cocci in cluster	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Staphylococcus aureus</i>
ASAS	C	Rough	+ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	<i>Bacillus subtilis</i>
	C	Rough	-ve	Rods	+ve	-ve	+ve	+ve	-ve	-ve	-ve	+ve	-ve	<i>Escherichia coli</i>
OAP	C	Rough	+ve	Cocci in chain	-ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Streptococcus sp</i>
	Y	Smooth	-ve	Rods	+ve	-ve	+ve	-ve	+ve	-ve	-ve	+ve	-ve	<i>Proteus mirabilis</i>
OWSEP	Y	Smooth	-ve	Rods	+ve	-ve	+ve	-ve	+ve	-ve	-ve	+ve	-ve	<i>Proteus mirabilis</i>
	Y	Rough	+	Cocci in cluster	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Staphylococcus aureus</i>
	G	Smooth	-ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	-ve	-ve	-ve	<i>Pseudomonas aeruginosa</i>
NRK	C	Rough	-ve	Rods	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	+ve	<i>Klebsiella pneumonia</i>
	C	Rough	+ve	Cocci in chain	-ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Streptococcus sp</i>
OAS	C	Rough	+ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	<i>Bacillus subtilis</i>
	C	Rough	-ve	Rods	+ve	-ve	+ve	+ve	-ve	-ve	-ve	+ve	-ve	<i>Escherichia coli</i>
	Y	Rough	+	Cocci in cluster	+ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Staphylococcus aureus</i>
	C	Rough	+ve	Cocci in chain	-ve	+ve	-ve	-ve	+ve	-ve	-ve	+ve	+ve	<i>Streptococcus sp</i>
	C	Rough	+ve	Rods	+ve	-ve	+ve	-ve	+ve	+ve	+ve	-ve	+ve	<i>Bacillus subtilis</i>

Key: IIP:- Isato Isale Panla, FMP:- Falegan Market Opposite Ikeja Avenue Panla, US:- Ureje Sawa, UA:- Ureje Alaran, AP:- Adehun Panla, IMA:- Irona Market alaran, AJS:- Ajebandele Junction Sawa, OIS:- Oke-Ila Sawa, ERS:- Egbewa Road 6 Sawa, OSP:- Okebola Street Life Bible Church Panla, ASAS:- No 19 Adeike Street Ajilosun Sawa, OJS:- Omisanjana Opposite Fountain Junction Sawa, Ori-apata Panla, OWSEP: Owolabi street Ekute Panla, NRK:Nova road Kote andOdo-Ado Catfish



**Fig. 1. Frequency occurrence of bacteria isolated from smoke fish sold in Ado-Ekiti Metropolis**

**Positive = +ve , Negative = -ve, Y = Yellow, C = Cream, G= Green and S = Smooth**

Six (7) different bacteria genera were identified in smoked fish sold in Ado-Ekiti, Ekiti State these were *Pseudomonas aeruginosa*, , *Streptococcus sp*, *Escherichia coli*, *Proteus mirabilis* and *Staphylococcus aureus*, *Bacillus subtilis*, *Klebsiella pneumonia* Seven (7) different bacteria genera were identified in the smoked fish sold in Ado-Ekiti, Ekiti State, these were *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, *Streptococcus spp*, *Bacillus subtilis*, *Escherichia coli*, *Proteus mirabilis* and *Staphylococcus aureus* as shows in table 2 with different biochemical test. Moreover, most of the organisms isolated in this study might have been introduced into these foods from water used during processing, utensil and packaging materials, the exposures of the products to high temperature storage and unhygienic condition of handling, reheating of kept food and the market which are heavily affected by various microorganisms. The high microbial load may be due to the environmental condition and also due to the fact that the place is highly congested with traffic, which may create dust from which the fish may be contaminated.

Among these isolate *Staphylococcus aureus* is the more abundant (23%) followed by *Streptococcus*

(20%), *Bacillus subtilis* (17%), *Pseudomonas aeruginosa* (12%), *Klebsiella pneumonia* and *Escherichia coli* both has(10%) respectively while *Proteus mirabilis* is the least isolate that has less occurrence

Figure1 shows the frequency occurrence of bacteria isolates which *Staphylococcus aureus* has the highest cumulative frequency, this result agrees with that of Brown; Okonta and Ekelemu [10]. *Staphylococcus spp.* is said to be one of the predominant bacteria that the smoked fish samples were contaminated with, this agrees with the work of Okonta and Ekelemu [10] and Okonko et al., [11] who reported *Staphylococcus* as one of the predominant bacteria contaminating smoked fish and causing spoilage. Its evidence would be as a result of poor sanitary condition and lack of adequate packaging of the products as they are always exposed at the market. These bacteria would probably have contaminated the smoked fish then processing, air and soil. "The bacteria group of *Staphylococcus spp.* according to Herman et al. [12] reported that it was one of the most common causes of human disease and they are normally found on the human skin and mucous membrane without resulting in a diseased condition. This bacteria class may also cause infections such as boils, impetigo and folliculitis while more serious infections could be pneumonia, bacteremia and

other infections of the bones and wounds as reported by Adelaja et al., [13]. In addition the findings of Moshood et al., 2012 authenticate the findings in this study, since common bacteria such as *Staphylococcus aureus*, and *Bacillus subtilis* were also isolated during his studies. The presence of these organisms in the smoked fish samples of *Clarias gariepinus* might be due to increase in moisture content of the product during storage, and also increase in temperature that encourages the growth of these organisms.

*Bacillus* species were also found to be present in the smoked fish samples which agrees with a similar study carried out by Moshood and Tengku Haziyaamin [14], *Bacillus aureus*, *Staphylococcus aureus*, *Proteus mirabilis*, *Klebsiella spp.*, *Salmonella typhii* and *Streptococcus sp.* were all found to be associated with smoked fish. It is suspected that these organisms may have contaminated the smoked fish during processing of fish. The presence of these organisms might be due to increase in moisture content of the product during storage and also increase in temperature that favors the growth of these organisms. All these pathogens are of food and public health importance and hence hazardous and injurious to human health, if consumed. Microbial load on ready-to-eat foods should be considered, because, factors such as, processing, storage and display may influence the microbiological load of ready-to-eat foods at the point of sale. Although smoke-drying reduces water activity and kills bacteria through the agency of heat, yet poor post-processing contamination can and do occur especially during handling and transportation of processed foods to the point of sale.

The pathogenic state of species of *Streptococcus sp* is on the increase, thus this has become important disease agent in the aquaculture industrie. Efuntoye et. al., [15], reported that *Streptococcus spp* is the dominant etiological agent characterized by critical symptoms, such as chronic wasting syndrome, heamorrhagic septicaemia, exophtaimia and meningitis with abnormal swimming. *Streptococcal* diseases have been reported worldwide in wild and farmed populations of diverse fresh water and marine fish.

The public health importance of bacteria in smoked fish species have not been adequately defined due mainly to mode of food preparation in the tropics especially Nigeria, which involved cooking for considerable length of time. The heat

would have eliminated most, if not all the bacterial flora. It is noteworthy that sanitary condition under which fishes are handled, processed and stored be improved upon to reflect standard or good practices.

## 5. CONCLUSION

The study showed that though smoking helps in inhibiting activities of bacteria, however, when not properly carried out, bacterial growth and activities still lead to the deterioration of the fish. Due to public health implication, the state of smoked fish should be paid proper attention by the processors and consumers for their safety through proper processing, storage and handling procedures. It is noteworthy that sanitary condition under which fishes are handled, processed and stored be improved upon to reflect standard or good practices.

In conclusion, there is need to introduce routine sanitary measures to control of contamination of food products, high level of *Bacillus Spp*, Coliforms and other pathogenic bacteria in food should not be dismissed as mere contamination, since they are capable of causing chronic infections, food poisoning and detrimental to health.

## 6. RECOMMENDATION

This study recommends that the fish handlers should be educated on proper hand washing during fish processing. Public education of the fish processors on the need for proper environmental sanitation. Good hygienic practice aimed at minimizing the microbial load of fish must be ensured. Greater attention should therefore be paid to the microbiological standard of the activities of roadside market all the time. There must be good hygienic condition for food presented or market on the road side (smoked fish) such as using clean glass boxes, clean food wrappers to prevent excessive environmental contamination for smoked fish. The food handlers must observe basic sanitary rule on the smoked fish (food) as their direct consumption may pose a lot of health hazard to the life of man.

Standard organization should set standard/surveillance on the smoked fish. If these measures are put in place, they will go a long way to significantly reduce toxin and contaminants foods, thereby reducing the health hazards to man.



## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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