Research Journal of Food Science and Quality Control (RJFSQC) E-ISSN 2756-5483
P-ISSN 2695-2459 Vol 11. No. 1 2025 www.iiardjournals.org online version

Microbiological Assessment of Some Smoked Dried Fish Samples Sold in Open Markets in Port Harcourt Metropolis, Rivers State, Nigeria

Amachree D[1]., Akinrotimi O.A[2*] Orokotan O.O[3] and Ayaobu-Cookey, I.K[4]
[1]Department of Fisheries and Aquatic Environment, Faculty of Agriculture, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria
[2]Department of Mariculture, Nigerian Institute for Oceanography and Marine Research, Buguma, Rivers State, Nigeria
[3]Gabrovic Agric Nig. Ltd. Fishery Consultancy Services, RD Road, Rumuodara, Port Harcourt, Rivers State, Nigeria
[4]Department of Aquaculture, Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos, Nigeria
[*]Corresponding Author Email: ojoakinrotimi@gmail.com
DOI: 10.56201/rjfsqc.vol.11.no1.2025.pg105.114

Abstract
This study evaluated microbiological quality of smoked dried fish samples sold in some markets in Port Harcourt metropolis, Rivers State, Nigeria. Three replicates of four common species of smoked dried fish samples namely: Herring Clupea harengus (Sawa). Horse mackerel- Trachurus trachurus (Kote). Atlantic mackerel- Scomber scombrus (Titus), and Sphyraena barracuda (Panla) were obtained randomly from the retailers at different sales-point in Choba Junction, Rumuokoro, Mile 1, and Creek Road markets all located in Port Harcourt metropolis of Rivers State, Nigeria. Each sample was transported to the laboratory in a labelled and sterile polythene bags for analysis. Microbiological analysis which include: Total aerobic bacterial counts, Coliform counts and Salmonella counts were evaluated in each fish samples using standard laboratory methods. The results obtained indicated that the values of Total aerobic bacterial counts ranged from 0.64 x 10^4 cfu/g to 6.68 x 10^4 cfu/g, while Coliform counts ranged from 0.66 x 10^4 cfu/g to 4.44 x 10^4 cfu/g and Salmonella count ranged from 0.74 x 10^4 cfu/g to 1.93 x 10^4 cfu/g. Among the three bacteria under consideration, the Total aerobic bacteria count consistently recorded higher values in all the sampled fish species studied, this was closely followed by Coliform count, while Salmonella occurred the lowest in all the sampled fishes. The three microbes were moderately present in all the smoked fish samples. However, the lowest values were observed in the specie T.trachurus. Given the amounts of microbial load discovered in the fish samples examined, it is therefore recommended that consumers of smoked fish should cook it to an appropriate temperature in order to prevent food-borne diseases in the study area.

Keywords: *Microbial analysis, Fish products, Food safety, Markets*

INTRODUCTION

In human diet, fish is a significant source of protein, lipids, and minerals, particularly in tropical nations [1]. The world's population is growing, which is driving up demand for seafood. In contrast to meat protein, it is also comparatively inexpensive. Compared to meat, milk, and eggs, fish offers a higher grade of protein, which may help alleviate malnutrition [3]. Consuming fish has therapeutic benefits in managing illnesses like cancer, asthma, coronary heart disease, and arthritis due to the presence of omega-3 unsaturated fatty acids [4]. Because of their high water content and sensitive tissues, fish are particularly vulnerable to spoiling and microbial contamination [5]. Fish smoking is one of the classic processing techniques used to reduce or minimize postharvest losses because fish is a highly perishable commodity due to its high sensitivity to autolysis, oxidation, hydrolysis of lipids, and microbiological spoiling [6]. Furthermore, heat treatment eliminates water and stops bacterial and enzymatic activity in fish, according to Bankole *et al*. [7]. Following harvest, fish can be preserved by freezing (best done when conditioned to -10°C) and refrigerating (4°C). Additional popular methods include sun drying and smoking, both of which have been connected to a stronger germicidal effect as temperatures rise. Food inspectors, makers, and handlers must ensure that food is free of hazardous germs because eating has a direct impact on health, especially when it comes to fast food or other foods that are meant to be taken uncooked. Numerous bacteria have been shown to change the nutritional content of food, endangering the health of anyone who eats tainted food. Numerous locally sold food products have been shown to be highly contaminated with Staphylococcus, Bacillus, and other germs [8].

Microorganisms can cause foodborne illnesses and poisoning in humans. Some episodes of food poisoning may be caused by larger populations of bacteria that are physically present in the food that was consumed. In addition to bacterial infections, gastroenteritis, which includes low-grade fever, nausea, vomiting, diarrhea, abdominal pain, and paralysis, can also be caused by viral infections [9]. Recent estimates indicate that because beef is so expensive, people are eating less meat and more fish. Nigeria's demand for fish is expected to have grown by 25% in recent years. In fact, bacteria are naturally present in all of our foods, and during processing, they may have the opportunity to multiply and become more abundant as a result of contamination from the surroundings, tools, or clothing worn by workers [10]. Most chemicals that cause food poisoning only cause symptoms when taken in large quantities after food multiplication. One of the most prevalent health problems and a significant cause of decreased economic production is contamination-related disease [11]. Fish and fish products are not only tasty and satisfying, but they are also typically less expensive than other forms of animal protein. They are also excellent sources of adequate levels of food-based nutrients, including proteins, fats, lipids, vitamins, and minerals. [12].

Around the world, people have taken notice of the unhygienic conditions in which fish are left after being caught but before being served [13]. Furthermore, the microbial contamination of fish is likely caused by a lack of proper hygiene measures. Fish contamination by microorganisms is a serious issue for the environment, public health, and safety [14]. In Nigeria and other countries, eating fish contaminated with diseases has led to major health issues and has been connected to multiple recorded fatalities [15]. Because of their characteristics, fish are a perfect environment for bacteria to survive and grow. Because the main causes of food-borne illnesses are bacteria like E. coli and Vibrio spp. their presence in fish has caused scientists great concern [16]. In Nigeria, smoked fish products may contain bacteria from market centres and processing facilities before they are consumed by consumers. This is

because many hawkers and processors typically exhibit their products in an open manner, which may act as a possible source of microbial contamination [17]. Because of this, the study evaluated the potential microorganisms linked to smoked fish in order to determine the extent of their implications for public health in the study area. Thus, the purpose of this study was to evaluate the microbiological quality of smoked fish consumed in the vicinity of Port Harcourt Rivers State, Nigeria, in order to determine the fish's safety for consumption.

MATERIALS AND METHODS

Study Area

The study was carried out in four daily markets namely: Choba Junction, Rumuokoro, Mile One, and Creek Road markets located in Port Harcourt metropolis of Rivers State, Nigeria

Samples Collection

Three (3) replicates of four common species of smoked fish samples namely: Herring *Clupea harengus* (Sawa). Horse mackerel-*Trachurus trachurus (*Kote). Atlantic mackerel- *Scomber scombrus* (Titus), and *Sphyraena barracuda* (Panla) were obtained randomly from the retailers at different sales-point in Choba Junction, Rumuokoro, Mile One, and Creek Road markets located in Port Harcourt metropolis of Rivers State, Nigeria. Each sample was transported to the laboratory in a labelled and sterile polythene bags for analysis.

Preparation of Media

The media used are Nutrient agar (NA.), Salmonella Shigella Agar (SSA), and Eosin Methylene Blue Agar (EMB). All media used were prepared according to the manufacturers' instructions. The mean counts of bacteria and mould in colony forming units per gram (cfu/g) of samples were determined [18].

Preparation of Cultures

The samples were serially diluted after maceration under aseptic conditions. The appropriate dilutions were inoculated on the different agar media. All cultures were incubated in duplicate at 37ºC for 24 – 48 hours. The bacteria were inoculated on Nutrient Agar for 24- 48 hours, Salmonella - Shigella Agar (SSA) for 24 hours, and coliform on Eosin Methylene Blue (EMB) agar for 24 hours. Colonies on plates containing 30 - 306 colonies were counted and multiplied by the dilution factor [19].

Preparation of Samples and Enumeration of Microorganisms

The fish samples were surface sterilized separately in 3.5% sodium hypochlorite solution (w/v) with constant 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 muscles and of the fish samples were pulverized separately using a blender (maker). Five milliliters were taken from each sample into a sterile bottle containing 450 ml of sterile peptone physiological saline to form a stock culture [20]. 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. Aerobic mesophilic bacteria were enumerated on plate count agar (PCA, Oxoid) at 37°C for 24 hours. Colliform count were enumerated on de Man, Rogosa and Sharpe Agar (Merck) and incubated anaerobically at 30°C for 48 hours. Presumptive LAB was confirmed by oxidase and catalase tests, and confirmed counts were reported as lactic acid bacteria (LAB). Salmonella were enumerated on Violet Red Bile Glucose at 37°C for 24 hours while Staphylococci were counted on mannitol salt agar (Oxoid) at 30°C for 48 hours [21].

Identification of Bacteria

The isolates were identified using a number of characteristics. Their cultural and morphological characteristics were of vital importance in this process and were thus observed. Motility tests

as well as biochemical test were also carried out. Inocula were aseptically transferred from each slide into plates of respective media using a streak plate technique. The isolates were purified by repeated streaking on their respective media. Bacterial plates were incubated at 37°C for 24 hours while fungal plates at 25°C for 72 hours. A 24 hour old culture was prepared from each plate for identification purposes. Bacteria isolates were identified based on their cultural characteristics, Gram staining reaction and various identification tests. Isolates were identified according to the methods described by AOAC [22].

RESULTS

Microbiological Evaluations of some Smoked Fish Species Sampled from Some Markets in Port Harcourt Metropolis

The Total aerobic bacteria count (cfu/g) of selected smoked fish samples from some markets in Port Harcourt metropolis are presented in Table 1. The results revealed that the highest values of Total aerobic bacteria count (cfu/g) value of $6.68x10^3$ was observed in the specie *S.scrombus* sampled from Rumuokoro r market. While the lowest value of $0.64x10^3$ was observed in the specie *T. trachurus* from mile 1 market. However, the average values of 4.32 $x10^3$, 5.26 $x10^3$, 3.52 $x10^3$ and 0.98 $x10^3$ were observed in *C.harengus*, *S. scrombus*, *S.barracuda* and *T. trachurus* respectively. The Coliform count (cfu/g) of selected smoked fish samples from some markets in Port Harcourt metropolis is shown in Table 2. The results showed that the highest values of Coliform count (cfu/g) value of $4.44x10^3$ was observed in the specie *S. scrombus* sampled from Rumuokoro market. While the lowest value of $0.66x10^3$ was observed in the specie *T. trachurus* from Creek road market. However, the average values of 2.65 $x10^3$, 3,57 $x10^3$, 2.34 $x10^3$ and 0.89 $x10^3$ were observed in *C. harengus*, *S. scrombus*, *S. barracuda* and *T. trachurus* respectively. The Salmonella count (cfu/g) in selected smoked fish samples from some markets in Port Harcourt metropolis are presented in Table 3. The results revealed that that the highest values of Salmonella count (cfu/g) value of $1,93x10^3$ was observed in the specie *C.harengus* sampled from Rumuokoro. While the lowest value of $0.74x10^3$ was observed in the specie *T. trachurus* from Choba market. However, the average values of 1.20 $x10^3$, 1.16 $x10^3$, 1.45 $x10^3$ and 0.87 $x10^3$ were observed in *C. harengus*, *S. scrombus*, *S. barracuda* and *T.trachurus* respectively.

Microbial Occurrence in some Smoked Fish Species Sampled from Some Markets in Port Harcourt Metropolis

The microbial occurrence in some smoked fish species sampled from some markets in Port Harcourt metropolis are presented in Figure 1. Among the three bacteria under consideration, the total aerobic bacteria count consistently recorded higher values in all the sampled fish species under consideration, this was closely followed by Coliform count, while Salmonella occurred the lowest in all the sampled fishes. The three microbes were moderately present in all the smoked fish samples. However, lower values were observed in the specie *T.trachurus*.

Table 1: Total Aerobic Bacteria Count (cfu/g) in Selected Smoked Fish Samples from Some Markets in Port Harcourt Metropolis

Markets	Smoked Fish Species			
	C.harengus	**S.scrombus**	***S.barracuda***	***T.trachurus***
Choba	$4.22x10^4$	$5.34x10^4$	$2.23x10^4$	$1.75x10^4$
Rumuokoro	$5.51x10^4$	$6.68x10^4$	$3.64x10^4$	$0.65\ x10^4$
Mile one	$3.33x10^4$	$3.69x10^4$	$1.45x10^4$	$0.64x10^4$

Creek Road	$4.23x10^4$	$5.32 x10^4$	$6.74 x10^4$	$0.87 x10^4$
Mean	**$4.32 x10^4$**	**$5.26 x10^4$**	**$3.52 x10^4$**	**$0.98 x10^4$**

Table 2: Coliform Count (cfu/g) of Selected Smoked Fish Samples from Some Markets in Port Harcourt Metropolis

Markets	***Smoked Fish Species***			
	C.harengus	***S.scrombus***	***S.barracuda***	***T.trachurus***
Choba	$3.05x10^4$	$3.53x10^4$	$1.54x10^4$	$1.04x10^4$
Rumuokoro	$3.76x10^4$	$4.44x10^4$	$3.88x10^4$	$0.89x10^4$
Mile one	$1.74x10^4$	$3.76x10^4$	$1.05x10^4$	$0.97x10^4$
Creek Road	$2.05 x10^4$	$2.54 x10^4$	$2.90 x10^4$	$0.66 x10^4$
Average	**$2.65 x10^4$**	**$3.57 x10^4$**	**$2.34 x10^4$**	**$0.89 x10^4$**

Table 3: Salmonella Count (cfu/g) of Selected Smoked Fish Samples from Some Markets in Port Harcourt Metropolis

Markets	**Smoked Fish Species**			
	C.harengus	**S.scrombus**	***S.barracuda***	***T.trachurus***
Choba	$0.75x10^4$	$1.08x10^4$	$1.09x10^4$	$0.99x10^4$
Rumuokoro	$1.93x10^4$	$1.69x10^4$	$1.84x10^4$	$0.74x10^4$
Mile one	$1.01x10^4$	$0.98x10^4$	$1.65x10^4$	$0.86x10^4$
Creek Road	$1.12 x10^4$	$0.88 x10^4$	$1.23 x10^4$	$0.89 x10^4$
Average	**$1.20 x10^4$**	**$1.16x10^4$**	**$1.45 x10^4$**	**$0.87 x10^4$**

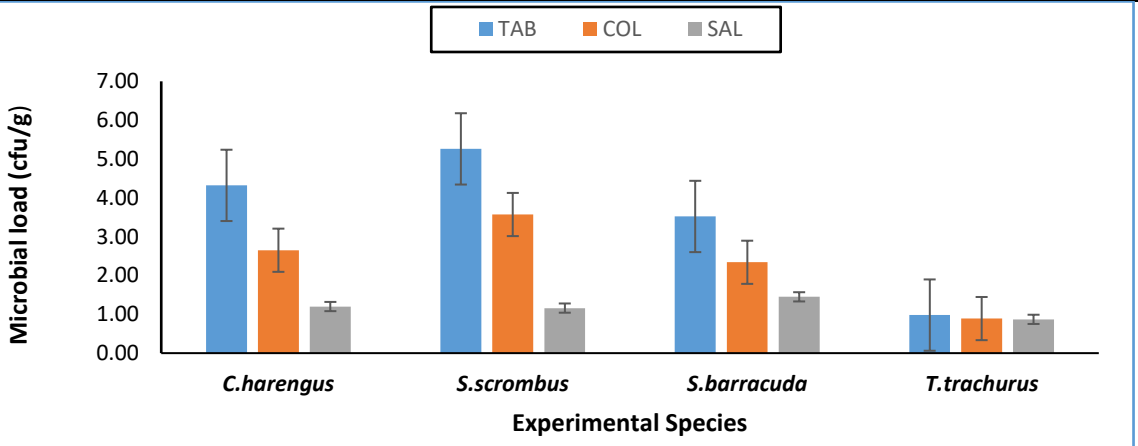

Figure 1: Microbial Occurrence in some smoked fish species from selected markets in Port Harcourt metropolis

Key: TAB- The Total aerobic bacteria count (cfu/g); COL- Coliform Count (cfu/g)
SAL- Salmonella Count (cfu/g)

DISCUSSION

Findings from the current study about the higher microbial load levels in fish sampled from the study area are in line with those of Abolagba *et al*. [23], who noted a similar pattern in smoked fish from a few Benin City markets. The handling procedures used after processing may have contributed significantly to the contamination of the fish products, as evidenced by the higher microbial load seen. Additionally, observations at the processing environment raise the

possibility that post-processing contaminations may start there and spread to the retail market. Processing staff usually did not wash their hands before taking the smoked fish out of the oven [24]. Other processors helped remove the fish from the oven, but they failed to change their clothes or wash their hands. Additionally, there may be a higher chance of post-smoking microbial contamination if smoked fish are placed on trays close to exposed ground. In addition to posing a physical risk to the fish, physical hazards like sand may also encourage the growth of soil microbes. Food safety is an issue because the fish are not given any serious attention before presenting it for sale, including washing, sorting, and packing [25].

Fish samples from Rumuokoro market are more contaminated than those from other areas. Among the sampled species, *S.scrombus* has the highest bacterial count and was found in the samples obtained from Rumuokoro market while the lowest count was observed in the *T.trachurus* gotten from mile 1 market. Additionally, the majority of the organisms identified in this study may have entered these foods through contaminated open market conditions, utensil and wrapping material water, improper product storage, handling conditions that were not hygienic, and other sources. The high bacterial count from Rumuokoro market may be due to the environmental condition and also due to the influx of dust resulting from the heavy traffic from which the fishes may be contaminated {26]. The diversity of microorganisms associated with these smoked fishes could be attributed to some features such as exposure at marketplace as the tissues of fish is capable of reabsorbing moisture from the atmosphere. This is corroborated by the report of Eyo [27] who stated that smoked fish samples may have a relatively high water activity level which is a prerequisite for microbial growth. Secondly, is the introduction of the organisms into foods from water used for washing, utensil or wrapping materials. This is supported by the observation of Eklund *et al*. [28], who stated that any handling of fish and the associated sanitary practice from the point of harvesting can potentially contribute to the micro flora on the final product.

The colony counts obtained are higher than the maximum count of 1 x 10 cfu/g of fish, indicating satisfactory bacteriological quality. The high moisture level of the fish samples encourages the growth of these micro organisms. The relatively high amount of coliform may be the result of food handlers' disdain for basic hygiene practices. The smoked fish, which include: Herring *Clupea harengus* (Sawa). Horse mackerel-*Trachurus trachurus (*Kote). Atlantic mackerel- *Scomber scombrus* (Titus), and *Sphyraena barracuda* (Panla) from different places, had high amounts of bacteria. This result is in line with a study by Okonko *et al.* [29], who observed a similar pattern in a some market areas in Ibadan metropolis. This might be as a result of the comparatively high moisture content in these foods with an intermediate moisture level. One kind of indicator organism that points to a possible fecal contamination is coliform organisms [30]. Although there is more coliform present, the permissible limit of bacterial contamination is 1000 cfu/g [31]. According to the results presented, some foods can lead to gastrointestinal issues and diarrhea in both adults and children. Most of these foods are kept for long periods of time at room temperature, which can encourage the growth of dangerous germs and result in food intoxication [32].

The presence of Salmonella in the sampled fish is of public health significance as no Salmonella is expected to be present in food meant for consumption. Though, Agu *et al.* [33] reported a higher prevalence of 20% in Benin, Nigeria while Raufu *et al.* [34] reported a prevalence of 11.5% in Catfish reared in Maiduguri, in northern part of Nigeria. The isolation of Salmonella from fish in this study may either be introduced through handling post-harvest,

or contamination via the water used. Also, environmental contamination may have contributed to the isolation of these organisms. Likewise, materials used for the preparation or the holding time may have contributed to these contaminations [35]. In this study, bigger fish were observed to have lower or no Salmonella as compared to smaller ones. This may be because microbial contamination may cover more of the entire surface area of a smaller organism faster than a larger organism and since it was not the entire fish that was processed, one can likely miss out some contaminated part more easily in a bigger fish than in a smaller one. This also applies in the case of lengthier fish as compared to smaller ones. This could also be due to the sampling method as small and shorter fish were sampled. This finding seems to be in contrast to the report of Emere and Egbe [36] and Omeji *et al*. [37] on parasite eggs and oocysts in fish whereby it was more in bigger and lengthier ones compared to smaller ones.

CONCLUSION AND RECOMMENDATIONS

The findings of this investigation demonstrate that smoked fish samples from all of the markets had bacterial counts over the recommended limits on bacterial contamination in food set by the international microbiological standard, rendering them microbiologically unacceptable." The study's findings showed that while smoking can help limit the activities of microorganisms, improper smoking still allows microbial growth and activity to continue, which degrades the fish. The pre-smoked fish from each of the four marketplaces that were examined had high levels of microorganisms. Therefore, it is best to wait until the fish is completely smoked before eating it. Given the results of the study, the following recommendations are made: Regular hygiene practices must be followed in order to stop these bacteria from infecting food products. As a result, greater focus should always be placed on the roadside market's microbiological standards. Because there are so many health concerns involved with direct human consumption, food handlers must adhere to basic sanitary rules when handling smoked fish. Salmonella has been found in fish, according to this study. Despite the low incidence, it is nonetheless important for public health. Therefore, smoked fish should be properly cooked before consumption, so as to reduce the incidence of food borne disease.

REFERENCES

1. Adebayo-Tayo BC, Onilude AA & Patrick UG (2008). Mycoflora of Smoke-Dried Fishes Sold in Uyo, Eastern Nigeria. *World Journal of Agricultural Science*, 4(3): 346-350
2. Akise OG, Abolagba OJ & Eyong MM. (2013). Mycoflora of three fish species smoke-dried using rubber wood (*Hevea brassillensis*) in Nigeria. *Greener Journal of Agricultural Sciences*, 3(5): 396-402.
3. Ogbonna IO, Danladi M.S, Akinwusire O & Odu CE (2012). Microbiological safety and proximate composition of suya street store at ambient temperature for six hours from Maiduguri; Northern Nigeria. *Internet Journal of Food Safety*, 14(1): 11-16.
4. Soltan MM, Taremi L, Gachkar S, Moderresi M & Sanaei R (2009). Characterization of antibiotic resistant patterns of Salmonella serotypes isolated from beef and chicken samples in Tehran. Jundishapur. *Journal of Microbiology*, 2(4): 124-131.
5. Heintz M.L & Johnson J. M. (1998). The incidence of Listeria spp., Samonella spp., and clostridium botulinum in smoked fish and shellfish. *Journal Food Protection*7 (4):177–181.

6. Al-jufaili, M. S.& Opara, I.U. (2016). Status of Fisheries Postharvest in the Sultanate of Oman: Part 1: handling and Marketing System of fresh fish. *Journal of Fisheries International* 1(2-4): 144- 149.
7. Bankole, M. O., Sangokoya, A. A. & Adeitan, O.A. (2014). The Microbiological analysis of spoilt canned foods sold and meant for sale in the markets. In :the book of Abstracts no. 67 of the 1st International Conference on Science and National Development, Organized by COLNAS, UNAAB, from 25-28th pp: 62.
8. Essuman, K. M., (2012). The role of inland fish in food consumption in West Africa: A case study in proceedings of the symposium on post harvest fish technology, Cairo Egypt; 21-22 October 1990. (Ed. Tentscher F.) pp: 22-34.
9. Jeyasanta K.I, Giftson H, Saritha K, Patterson J.(2015). Studies on the nutritional and microbiological quality of smoked Tuna Fish (*Auxis thazard*) in Tuticorin, South East coast of India. *International Journal of Food Quality and Safety*, 1:28-38
10. Dike-Ndudim J.N, Egbuobi R.C, Onyeneke E.N, Uduji H.I, Nwagbaraocha M.A, Ogamaka I.A, (2014). Microbial status of smoked fish, Scomber scombrus sold in Owerri, Imo State, Nigeria. *African Journal of Clinical and Experimental Microbiology*,15(1):35-39.
11. Kapute F, Likongwe J, Kangombe J, Kiiyukia C. (2013). Shelf life of whole fresh Lake Malawi tilapia (Oreochromis species – chambo) stored in ice. *African Journal of Food, Agriculture, Nutrition and Development.* 13(1):7138-7156
12. Abdullahi A. L, Agho M. O, Amos S, Gamaniel K. S, & Wambebe C. (2016).Antidiarrhoeal activity of the aqeous Extracts of Terminalia auicennoiodes roots. *Phytotherapy Research*, 15:431 -434
13. Ibrahim B.U, Baba J, & Sheshi M.S. (2014). Isolation and identification of bacteria associated with fresh and smoked fish (*Clarias gariepinus*) in Minna Metropolis, Niger State. Nigeria. *Journal of Applied and Environmental Microbiology*, 2(3):81-85.
14. Che , Y. B. & Ramadas, J. (2019). Effect of packaging environment on quality changes of smoked Spanish mackerel under refrigeration. *Journal of Food Quality*, 21, 167–174.
15. Eyabi G. D, and Ningo G. (2017). Composition, yield, characteristics. Edibility Efficiency of Fish, winkles and praws in south western Cameroons. The Effects of brine levels and types of packaging of the shelf-life of traditionally –smoked sardine. *Nigerian Food Journal*, 15:35-40
16. Odu N.N, and Imaku L.N. (2013).Assessment of the microbiological quality of street-vended ready-to-eat bole (roasted plantain) and fish (*Trachurus trachurus*) in PortHarcourt metropolis, Nigeria. *Researcher*; 5(3):9- 18
17. Aremu M.O, Namo B.S, Oko O.J, Adelagun R.O.A, and Yebpella G.G. (2014). Compositional evaluation of local smoked Nigerian mackerel (*Scomber scombrus*). *Food Science and Quality Management*. 2014; 24:42-50.
18. ICMSF (International Commission on Microbiological Specification for Foods) (1986).Microorganisms in Foods 2, Sampling for Microbiological Analysis. Principles and Specifications, 2nd edition. Oxford: Blackwell Science
19. Frank J.A, Reich C.I, Sharma S, Weisbaum J.S, Wilson B.A, Olsen G.J. (2008). Critical evaluation of two primers commonly used for amplification of bacterial 16S rRNA genes. *Applied and Environmental Microbiology*, 74:2461-2470

20. Adeyeye E.I, and Adamu A,S. (2005). Chemical composition and food properties of Gymnarchus niloticus (trunk fish). *Biosciences and Biotechnology Research*, Asia, 3(2):265-272
21. Cardinal, M., Gunnlaugsdottir, H., Bjoernevik, M., Ouisse, A., Vallet, J. L., & Leroi, F. (2014). Sensory characteristics of cold-smoked Atlantic Salmon (Salmo salar) from European market and relationships with chemical, physical, and microbiological measurements. *Food Research International*, 37: 181-193.
22. AOAC. (1990).Official Method of Analysis of the Association of the Analytical Chemist 15th Edition. Arlington Virginia, USA, 40-64.
23. Abolagba O. J, Adekunle AT, Dede A.P.O, & Omoigui G.O. (2020).Microbial assessment of smoked fish (Clarias spp) in Benin metropolis, Edo state Nigeria. *Nigeria Journal of Agriculture, Food and Environment*, 7(3).11-23.
24. Ashano M.O, and Ajayi O.E. (2008). Effect of processing and storage methods on the shelf life and incidence of insect pest on smoked Fish. *Global Journal of Pure and Applied Science*. 9(3):13-15
25. Mehemet C, John S, Kendendail AP & Gary CS (2003). Effect of acid adaptation on the inactivation of Salmonella during storage of beef jerky treated with maimaid. *International Journal of Food Microbiology*, 89(1): 51-65
26. Adebowale B. A, Dongo LN, & Orisajo S.B.(2018). Comparative quality assessment of fish (Clarias gariepinus) smoked with cocoa pod husk and three other different smoking materials. *Journal of Food Technology*, 6(1):5-8.
27. Eyo AA. Fish Processing Technology in the Tropics. National Institute for Freshwater Fisheries Research (NIFFR) New Bussa, Nigeria. 2001, 10-170
28. Eklund MW, Pebroy G, Poysky F, Paranjpye R, Lashbrook L, Peterson M. Guidelines for reduction and control of Listeria monocytogens on smoked fish. International Report on North West Fisheries Centre. 1993; 58:502-508
29. Okonko, I.O., OD. Adejoye, A.A. Ogun, A.A Ogunjobi, A.O. Nkang and B.C. Adebayo-Tayo, (2019). Hazards Analysis Critical Control Points (HACCP) and Microbiology qualities of sea-foods as affected by handler's hygiene in Ibadan and Lagos, Nigeria. *African Journal of Food Science*, 3(2): 035-050.
30. Akise OG, Abolagba OJ & Eyong MM. (2013). Mycoflora of three fish species smoke-dried using rubber wood (*Hevea brassillensis*) in Nigeria. Greener Journal of Agricultural Sciences, 3(5): 396-402.
31. Uzeh RE, Ohenhen RE & Adeniji OO (2006). Bacterial contamination of Tsire-Suya, Nigerian Meat Product. *Journal of Nutrition*, 5(5): 458-460
32. Ponce E, Khan AA, Cheng CM, Summage-West C & Cerniglia CE (2008). Prevalence and characterization of Salmonella enterica serovar Weltevreden from seafood. Journal of Food Microbiology, 25(1): 29-35.
33. Agu KC, Ukponmwan IO, Orji MU, Awah NS, Anaso CI & Udemezue OI (2013). Prevalence of pathogenic bacteria in smoked fish sold in major retail markets in Benin, Nigeria. *International Journal of Applied Sciences and Engineering*, 1(1): 1-4.
34. Raufu IA, Lawan FA, Bello HS, Musa AS, Ameh JA & Ambali AG (2014). Occurrence and antimicrobial susceptibility profiles of Salmonella serovars from fish in Maiduguri, sub-Saharah, Nigeria. *The Egyptian Journal of Aquatic Research*, 40(1): 59-63.

35. Mehemet C, John S, Kendendail AP & Gary CS (2003). Effect of acid adaptation on the inactivation of Salmonella during storage of beef jerky treated with maimaid. International *Journal of Food Microbiology*, 89(1): 51-65.
36. Emere MC & Egbe NEL (2006). Protozoan parasites of *Synodonits clarias* (a fresh water fish in river Kaduna). *Best Journal*, 3 (3): 58-64
37. Omeji S, Solomon SG & Idoga ES (2011). A Comparative study of the common protozoan parasites of *Clarias gariepinus* from the wild and cultured environments in Benue state, Nigeria. *Journal of Parasitology Research*, doi: 10.1155/2011/91648