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Microbial Assessment and Nutritional Quality of Smoked Fish at Sales Point in Two Different Major Markets in Ibadan

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Abstract

As one of the common sources of protein available to man, fish is highly consumed due to its lower cholesterol content and price. Fish is a rich protein source for both poor and rich. As a part of checkmating the public health risks associated with this general dependence of the population on fish, the microbiological assessment of smoked fish sold in Ojoo and Bodija markets were investigated to determine the safety of fish consumed and to ascertain if the fish provided the expected nutritional value to the consumer. A total of 3 different smoked fish samples *Alaska pollock* (Panla fish) from Ojoo, Smoked *Clupea harengus* (Shawa fish) from Bodija and smoked *Scomber scombrus* (Smoked *Alaran* fish) were collected from Ojoo and Bodija markets and were analysed microbiologically for bacteria and fungi count. Twenty bacteria and ten fungi were isolated from smoked fish obtained from Bodija and Ojoo markets. The isolates were characterized and identified as *Staphylococcus aureus, Salmonella typhi, Shigella* spp, *Bacillus cereus, E. coli, Pseudomonas* spp, *Klebsiella* spp. and fungi such as *Aspergillus flavus, Aspergillus niger, Cladosporium* spp., *Mucor* spp., *Penicillium chrysogenum, Fusarium moniliforme* and *Penicillium viridicatum.* Sensory evaluation revealed that appearance, odor, and flavor of Sample A (Smoked *Clupea harengus* (Shawa fish from Ojoo market) were the most preferred. Sample A had the lowest moisture content (20.00%), better keeping quality and high percentage crude protein (40.22%). Physiochemical analysis (Total volatile base nitrogen, Thiobarbituric acid, Peroxide value and pH) was used to check the quality of the smoked fish. Only sample A (Smoked *Clupea harengus* (Shawa fish from Ojoo) had 20 mgN/100g of Total volatile base nitrogen that is within the TVBN acceptable range. Majority of the bacteria isolated in this research were multi drug resistant. However, some of the isolated bacteria were susceptible to Ciprofloxacin and Amoxicillin, which could be selected as drugs of choice to treat infection that emanate from smoked fish. High level of microbial contamination observed in these work can be traceable to handlers and environment to which this fish is exposed during smoking. Considering the danger smoked fish contamination portends to public health, food safety authorities should intensify their monitoring efforts towards controlling such contamination.

Keywords: *Smoked Fish; Microorganisms; Antibiotics; Microbiological Assessment and Sensory Evaluation*

Introduction

Food quality and safety had been a major public health concern as consumers need to purchase safe products that do not pose any kind of risk or danger to their well-being [1]. More so, assessment of food quality helps to ensure that all attributes that influence the quality of a product for the consumer are effectively checked [2] which includes spoilage, contamination with filth, discoloration, and off odors. Other attributes are the origin, color, flavor, texture and processing methods of the fish [3].

Fish serve as important source of protein which is consumed by a large number of people in Nigeria, it provides high quality protein and contains many vitamins and minerals, it has a relative 10% calories content which makes its role in nutrition known [4]. Nevertheless, the nutritional value of fish mostly depends on its freshness which are usually sterile, but the skin, gills and alimentary tracts all carry substantial number of bacteria [5]. However, putrefaction usually sets in which is considered by increase in the ambient temperature that triggers promising conditions for microorganisms to grow thus making the quality of fish to depreciate [6].

Fish will become unfit for human eating within about one day of capture, unless it is subjected to protection (preservation). Different types of processing and preservation methods have to be tracked as soon as possible after the catching to keep the freshness and nutritive value. According to [7] various food preservation techniques have been employed to improve the microbial safety and extend the shelf-life of fish in general including freezing, chemical preservation, salting, smoking and frying. However, smoking is the most popular method by fish farmers and consumers in Nigeria [8] which is more often desirable due to the ease of procedure, taste, flavour, texture and most times consumer's preference [9]. It reduces the moisture content of fish to a point that it impairs the activities of spoilage microbes, though, investigations had shown the presence of microbial contamination even on smoked fish [10]. This is caused due to improper handling during the processing of the smoked fish.

The microorganisms linked with smoked fish posture a great danger to the public as the transmission of the microorganisms attack the resistant ability of the buyer thus enhanced invasion of disease. However, unpreserved fish provides satisfactory medium for the growth of microorganisms after death [11] degradation of lipids in fatty fish produces sour odors. In addition, aquatic fish and some river fish contain trimethylamine oxide that is tainted by several decay bacteria to trim ethylamine (TMA), the compound responsible for fishy off odors. Iron is a preventive nutrient in fish and this favors growth of bacteria such as pseudomonads that produce siderophores that bind iron [12].

Putrefaction of fish is the result of a series of changes brought about in the dead fish mainly due to the actions of enzymes and bacterial action [12]. Fish has high dampness content and fat thereby making them liable to infective microorganisms and rot. Therefore, there is need to ascertain the quality of market sold smoked fish. Since raw smoked fish are generally eaten by many people with minimum or none processing before consumption as a rich source of protein in Nigeria, consequently if the smoked fish are contaminated with pathogenic microbes, they can cause fatal diseases in the human body. This study therefore centered on evaluating microbiological quality, safety and nutritional potential of the processed fish.

Materials and Methods

Sample collection

A total of 3 different smoked fish samples *Alaska pollock* (panla fish) from Ojoo (Smoked *Clupea harengus* (Shawa) fish from Bodija) and smoked (*Scomber scombrus* (Smoked *Alaran fish)* were collected at two different major markets (Bodija and Ojoo) in Ibadan metropolis. The samples were collected in clean polythene bags. The bag was closed tightly and labeled appropriately then immediately transferred to the laboratory in ice packs for immediate analysis.

Sensory analysis of the smoked fish

Sensory analysis was conducted on the smoked fish taking into consideration of taste, flavor, texture, appearance and palatability of the dried fish using [20] panel of judges that are familiar with the product and general acceptance on 1 to 9 points scale with score 9 having excellent attraction.

Preparation of fish samples for microbiological analysis

A sterilized knife was used to cut fish sample of about 10.0g. The fish were minced and suspended in 10ml normal saline to make a stock suspension after which serial dilution was made.

Sterilization/Enumeration of bacterial and fungal counts

The working tables were swabbed with 70% ethanol to disinfect the table top. All the glass wares were washed and air-dried after which they were sterilized in hot air oven at 160°C for 1 hour. The wire loop was sterilized by flaming in red-hot fire using a spirit lamp. Culture media were prepared according to manufacturers' specifications and distilled water used for serial dilution was sterilized in an autoclave at 121°C for 15 minutes before use. Ten (10g) of each fish sample were weighed aseptically and homogenized in 90 ml sterile peptone water. Then, serial dilutions were made by mixing 1.0 ml of the suspension in 9.0 ml sterile peptone water to obtain 10^{-1} dilution. The dilution was then made to 10^{-8}, then spread-plated on plates of Plate count agar (for total viable counts); Salmonella shigella agar (for *Salmonella* and *Shigella* count); Mannitol salt agar (for *Staphylococcus spp* count); Listeria agar base (for *Listeria monocytogenes* count); MacConkey agar (for *E. coli* and other enteric bacteria count), and Sabouraud Dextrose Agar (SDA) was used to enumerate fungal growths. Each of the samples was plated in triplicate and incubated at 37°C for 24 hours for bacteria and 3 to 5 days for fungi. Total number of cells per gram of samples was then estimated after counting the colonies on the plates. Colonies on the plates were then picked and sub-cultured on nutrient agar plates to ensure purity of cultures. The different pure cultures were then transferred to nutrient agar slopes for preservation and for further analysis [13].

Identification of bacteria and fungi isolates

The bacteria isolates were identified based on morphology and biochemical tests including Gram reaction, citrate, catalase, oxidase, indole, coagulase, motility and methyl red using the scheme of 14 and 15. The Gram positive cocci isolates was grown Blood Agar plate and incubated at 37°C for 24h. Growth showing haemolytic characteristics indicates the presence of *Streptococcus* spp. The scheme of 15 and Bergey's Manual of Determinative Bacteriology by 16 was used to compared resultant characteristics with those of known taxa. Total fungi identification was based on the macroscopic/colonial and microscopic characteristics. The microscopic morphology was determined using the scheme of Pepper and Gerba (2005). Lactophenol cotton blue stain was used for the identification of fungi. The resultant microscopic characteristics were compared with the scheme provided by [17] and [18].

Physico-chemical analysis of the fish

A Kent pH meter (Kent Ind. Measurement Ltd., survey) model 7020 equipped with a glass electrode was used to measure the pH of the flesh, employing 10g of fish homogenized in 10 ml of distilled water. Triplicate determinations were made in all cases. The pH meter was calibrated using pH 4.0 and pH 7.0 buffers. The total volatile base- nitrogen, trimethylamine value (TMA), thio-barbituric acid value, peroxide value and free fatty acid value of the smoked fish was determined by 19 methods.

Proximate analysis

Determination of crude protein by Kjeldahl method

The fish sample to be analyzed was digested with concentrated sulphuric acid in the presence of a small amount of copper sulphate, selenium and sufficient sodium or potassium sulphate with mercury (Hg) as a metal catalyst. Under these conditions, the organic matter

was oxidized and the protein nitrogen was converted to ammonium sulphate $(NH4)_2SO_4$. The digestion was followed by the addition of a strong base (NaOH) to liberate ammonia. The ammonia distilled; trapped in 0.5% boric acid indicator was then titrated with 0.01 ml HCl. Almost all organic forms of nitrogen were converted to ammonia by the conditions of the digestion. The result of Kjeldahl analysis is usually expressed as crude protein. The weight of nitrogen in a sample can be converted to protein using the appropriate factor based on the percentage of nitrogen in the protein sample. To convert gram of nitrogen to gram of protein, the common factors 6.25 was used. The nitrogen value was therefore multiplied by 6.25 to get the weight of protein [20].

Determination of moisture: Moisture was determined by the reduction in weight when the sample was dried to a constant weight in an oven. About 2g of fish sample was weighed into a silica dish which was previously dried and weighed; the sample was then dried again in an oven at 65°C for 36h, cooled in a desiccator and weighed. This process was continued until a constant weight was achieved [20]:

$$\% \text{ moisture} = \frac{\text{Weight of sample +dish before drying-weight of sample +dish after drying}}{\text{Weight of sample taken}} \times 100$$

Determination of crude fat: The ether extract of a fish represents the fat and oil in the smoked fish. Soxhlet apparatus is the equipment used for the determination of ether extract. It consists of 3 major components; an extractor: comprising the thimble which holds the sample, a condenser: for cooling and condensing the ether vapor and 250 ml flask. About 150 ml of an anhydrous diethyl ether (petroleum ether) of boiling point of 40 - 60°C was placed in the flask. 2 - 5g of the sample was weighed into a thimble and the thimble was plugged with cotton wool. The thimble with content was placed into the extractor; the ether in the flask was then heated. As the ether vapor reached the condenser through the side arm of the extractor, it condensed to liquid form and dropped back into the sample in the thimble; the other soluble substances were dissolved and 4h. The thimble was removed and most of the solvent was distilled from the flask into the extractor. The flask was then disconnected and placed in an oven at 65°C for 4h, cooled in a desiccator and weighed [20]:

$$\%\text{fat} = \frac{\text{Weight of extract-tare weight of flask\% of fat}}{\text{Weight of sample taken}} \times 100$$

Determination of crude ash: Ash is the inorganic residue obtained by burning off the organic matter of the samples at 400 - 600°C in a muffle furnace for 4h. 2g of the sample was weighed into a pre-heated crucible. The crucible was placed in muffle furnace at 400 - 600°C for 4h or until a whitish-grey ash was obtained; and then was placed in the desiccators and weighed [20]:

$$\% \text{ ash} = \frac{\text{Weight of fish}}{\text{Weight of sample taken}} \times 100$$

Results

Bacteria and fungi were isolated from smoked fish obtained at two selected markets in Ibadan metropolis. The microorganism was morphologically, physiologically and biochemically characterized. Cultural characteristics such as shape, size, margin, elevation, colour, surface and opacity of the isolated bacteria were observed, the isolates were also differentiated based on their carbohydrate fermentation pattern. Bacteria isolates were identified as *Staphylococcus aureus, Salmonella typhi, Shigella* species*, Bacillus cereus, E. coli, Pseudomonas* species, *Klebsiella* species and *Staphylococcus epidermis* with *Staphylococcus aureus* (25%) and *E. coli* (25%) having the highest frequency of occurrence while *Bacillus cereus* (5%) had the lowest. Fungi isolates were identified as *Aspergillus flavus, Aspergillus niger, Cladosporium* species*, Mucor* species*, Penicillium chrysogenum, Fusarium moniliforme* and *Penicillium viridicatum. Penicillium viridicatum* with *Aspergillus flavus* (28%) having the highest occurrence while *Mucor* species (7%) has the lowest.

Table 1 shows the sensory analysis of smoked fish from different sampling sites. Sample A (Smoked *Clupea harengus* (Shawa) fish from Ojoo) has high appearance value of 8.00 while Sample D (Smoked *Clupea harengus* (Shawa) fish from Bodija) has the lowest appearance value of 5.20. Sample A has the best texture (8.10) and the highest value of 9.00 for taste while Sample D having 5.60 has the lowest value for taste. Overall, the sensory qualities and consumer acceptability of Sample A was the most preferred out of the six different sources.

Sample	Appearance	Texture	Flavour	Taste
A	8.00 ± 1.89	8.10 ± 1.78	7.32 ± 0.82	9.00 ± 1.00
B	6.35 ± 1.20	7.20 ± 1.22	6.82 ± 0.79	6.86 ± 1.24
C	7.38 ± 1.48	7.50 ± 1.78	7.74 ± 1.12	7.80 ± 1.66
D	4.20 ± 1.46	6.60 ± 1.36	6.84 ± 1.20	5.60 ± 1.66
E	6.45 ± 1.33	7.40 ± 1.41	6.12 ± 1.30	6.23 ± 1.38
F	6.40 ± 1.52	7.20 ± 1.52	7.54 ± 1.52	7.20 ± 1.78

Table 1: *Sensory analysis of different smoked fish samples obtained from two selected Markets in Ibadan.*

Key: A = Smoked Clupea harengus (Shawa fish) from Ojoo, B = Smoked Alaska pollock (Panla fish) from Ojoo, C= Smoked Scomber scombrus (Alaran fish) from Ojoo. D= Smoked Clupea harengus (Shawa fish) from Bodija, E= Smoked Alaska pollock (Panla fish) from Bodija, F= Smoked Scomber scombrus (Alaran fish) from Bodija.

The microbial load of the different smoked fish in Bodija and Ojoo markets are shown in table 2. Smoked *Clupea harengus* (Shawa fish) obtained from Bodija market had higher bacteria count of 5.6 x 10^7 compared to the one at Ojoo market with bacteria count of 4.0 x 10^7 cfu/g. Smoked *Alaska pollock* (Panla fish) from Ojoo had the higher bacteria count of 6.2 x 10^7 cfu/g compared to smoked *Alaska pollock* (Panla fish) from Bodija having 5.8 x 10^7 cfu/g. Smoked *Scomber scombrus* (Alaran fish) from Bodija with 6.5 x 10^7 cfu/g bacteria count is higher than 6.3 x 10^7 bacteria count of smoked *Scomber scombrus* (Alaran fish) from Ojoo. Coliform count (2.6 x 10^7 cfu/g) in smoked *Clupea harengus* (Shawa fish) from Ojoo is lower compared to smoked *Clupea harengus* from Bodija market which was 3.0 x 10^7 cfu/g. Smoked *Alaska pollock* (Panla fish) from Ojoo and Bodija had the same coliform count of 3.6 x 10^7 cfu/g. Smoked *Scomber scombrus* (Alaran fish) from Ojoo had higher coliform count of 4.0 x 10^7 cfu/g compared to smoked *Scomber scombrus* (Alaran fish) from Bodija market having coliform count of 3.8 x 10^7 cfu/g.

Sample	Total bacteria count (CFU/g)	Total coliform count (CFU/g)	Total fungi count (CFU/g)
A	4.0×10^7	2.6×10^7	2.3×10^6
B	6.2×10^7	3.6×10^7	1.6×10^6
C	6.5×10^7	4.0×10^7	2.6×10^6
D	5.6×10^7	3.0×10^7	2.0×10^6
E	5.8×10^7	3.6×10^7	2.8×10^6
F	6.3×10^7	3.8×10^7	2.6×10^6

Table 2: *Microbial load in different fish samples obtained from two selected markets in Ibadan.*

Key: A = Smoked Clupea harengus (Shawa fish) from Ojoo, B = Smoked Alaska pollock (Panla fish) from Ojoo, C= Smoked Scomber scombrus (Alaran fish) from Ojoo. D= Smoked Clupea harengus (Shawa fish) from Bodija, E= Smoked Alaska pollock (Panla fish) from Bodija, F= Smoked Scomber scombrus (Alaran fish) from Bodija.

Total fungi count of smoked *Clupea harengus* (Shawa fish) from Ojoo market (2.3 x10^6 cfu/g) is higher than that of smoked *Clupea harengus* (Shawa fish) at Bodija market (2.0 x 10^6) while smoked *Alaska pollock* (Panla) from Bodija market hs higher fungi count of 2.8 x 10^6 cfu/g than that of Alask Pollock (Panla) from Ojoo. *Scomber scombrus* (Alaran fish) from Ojoo and Bodija market had the same fungi count of 2.6 x 10^6.

Physiochemical analysis (Total volatile base nitrogen, thiobarbituric, free fatty acid and pH) of smoked fish from Ojoo and Bodija markets are shown in table 3. Total volatile base nitrogen of the test samples ranges from 20 to 40 mgN/kg with Sample A (Smoked *Clupea harengus* (Shawa fish from Ojoo market) having the lowest value of 20 mgN/kg while samples C and E had the highest total volatile base nitrogen. The thiobarbituric acid content of smoked fish ranges from 1.204 to 2.340 ma/kg with sample A recorded the lowest thiobarbituric content of 1.204 ma/kg while sample F had the highest thiobarbituric acid content of 2.304 ma/kg. Samples B and C had 1.930 and 1.910 ma/kg thiobarbituric acid content respectively while sample D had 2.248 ma/kg. The free fatty acid content of the smoked fish obtained from two selected markets in Ibadan ranged between 0.20% to 0.84%. Sample D had the lowest content of free fatty acid while sample E had the highest content. Sample A and B recorded 0.79% and 0.65% respectively while sample F had 0.54% free fatty acid. The pH of the samples ranges from 6.47 to 6.85 however, 0.00 meq/kg peroxide value was recorded for all the samples.

Sample Code	Total volatile base nitrogen (TVB-N)	Thiobarbituric acid	Free fatty acid	Peroxide value	pH
A	20 mgN/100g	1.204 ma/kg	0.79%	0.00 meq/kg	6.47
B	35 mgN/100g	1.930 ma/kg	0.65%	0.00 meq/kg	6.75
C	40 mgN/100g	1.910 ma/kg	0.72%	0.00 meq/kg	6.60
D	33 mgN/100g	2.248 ma/kg	0.20%	0.00 meq/kg	6.80
E	40 mgN/100g	1.811 ma/kg	0.84%	0.00 meq/kg	6.85
F	34 mgN/100g	2.340 ma/kg	0.54%	0.00 meg/kg	6.52

Table 3: *Physiochemical properties of smoked fish obtained from Ojoo and Bodija markets in Ibadan.*

Key: A = Smoked Clupea harengus (Shawa fish) from Ojoo, B = Smoked Alaska pollock (Panla fish) from Ojoo, C= Smoked Scomber scombrus (Alaran fish) from Ojoo. D= Smoked Clupea haregus (Shawa fish) from Bodija, E= Smoked Alaska pollock (Panla fish) from Bodija, F= Smoked Scomber scombrus (Alaran fish) from Bodija.

The close and proximate analysis of smoked fish from different sampling sites are shown in table 4. The proximate composition of the smoked fish shows that the percentage of moisture range from 20.00 to 40.12%, Sample C (Smoked *Scomber Scombrus* (Alaran fish from ojoo market) has the highest percentage while sample A (Smoked *Clupea harengus* (Shawa fish from Ojoo market) has the lowest. Percentage of crude protein ranges from 40.22 to 51.25 with sample A (Smoked *Clupea harengus* (Shawa fish from Ojoo market) having the highest protein content. Percentage of fat content ranges from 10.06 to 13.13 with sample E (Smoked *Alaska pollock* (Panla fish from Bodija market) having the highest fat content. The percentage of ash ranges from 6.87 for sample D (Smoked *Clupea harengus* (*Shawa* fish from Bodija market 0 to 8.35 for sample F (Smoked *Scomber scombrus* (*Alaran* fish from Bodija market).

Discussion

The quality assessment of *Alaska pollock* (Panla fish), *Scomber scombrus* (Alaran fish) and *Clupea harengus* (Shawa fish) was based mainly on sensory, microbiological and chemical methods. The appearance of the fish skin, texture of the flesh, the gills and the development

Sample code	Protein content (%)	Moisture content (%)	Ash content (%)	Fat content (%)
A	51.25	20.00	7.00	10.06
B	30.22	26.80	8.00	10.12
C	37.48	40.12	7.20	10.86
D	40.22	30.00	6.87	12.17
E	40.12	30.33	5.34	13.13
F	40.22	30.20	8.35	11.14

Table 4: *Proximate analysis of different fish samples obtained from two selected markets in Ibadan.*

Key: A = Smoked Clupea harengus (Shawa fish) from Ojoo, B = Smoked Alaska pollock (Panla fish) from Ojoo, C= Smoked Scomber scombrus (Alaran fish) from Ojoo. D= Smoked Clupea harengus (Shawa fish) from Bodija, E= Smoked Alaska pollock (Panla fish) from Bodija, F= Smoked Scomber scombrus (Alaran fish) from Bodija.

of offensive odour were considered. The criteria for rejection was based on the development of strong offensive odours, softening of the tissues, discolouration of the skin and very high microbial counts of the fish tissue which correlated with high values of Total volatile bases (TVB-N) and change of the fish pH to alkalinity. Sensory qualities results showed that the appearance, odor, flavor and taste of sample A (Smoked *Clupea harengus* (Shawa fish) from Ojoo market were preferred by most panelists due to the nature and the quality of the product while Sample D (Smoked *Clupea harengus* (Shawa fish from Bodija market) had the lowest score due to poor handling of the fish, this was in line with the work of [21].

The proximate analyses showed that the moisture content in the smoked fish samples were greatly reduced, it was also observed that the protein content in the smoked fish samples were retained and this is in agreement with the work of [22] (1992) who reported that smoking demonstrated a better efficient method of fish processing in terms of protein retention and reduction in moisture content. The difference in the protein and fats contents in the proximate analysis of fish samples may be attributed majorly to environmental factors and the type of nutrients being fed to the fishes. All the different fish samples had no value for crude fibre which is not in agreement with the findings of [23] (2014) who reported low crude fibre value for smoked Catfish species.

The physiochemical parameter of smoked fish obtained from Ojoo and Bodija market showed that only sample A (Smoked *Clupea harengus* (Shawa fish) from Ojoo market had 20 mgN/100g of Total volatile base nitrogen that falls within [24] (1982) recommended acceptability limit of TVBN in fish (20 to 30 mgN/100g) making it a good quality fish while other samples had increased Total volatile base nitrogen. Increase in final values of TVB-N in this study is similar to the result of [25]. who reported that the TVB-N values of the dried fish products ranged from 30.64 mg/100g to 45.45 mg/100g. Thiobarbituric acid is used to monitor lipids oxidation in fish, an increase in lipid oxidation gives rise to off odour in fish. The maximum acceptable limit for thiobarbituric acid is 2MDA/kg, above it indicates fish of low quality. Most of the fish samples falls within the range of acceptable limit indicating that the fish are of less off odour except samples D and E having thiobarbituric acid values higher than the acceptable limit.

The bacterial isolates that were obtained from smoked fish in different sampling site (Ojoo and Bodija market) were *Staphylococcus aureus*, *Klebsiella* species, *Salmonella* species, *Shigella* species, *Pseudomonas aeruginosa* and *Escherichia coli*, this was in agreement with the work of researchers such as [26] who also isolated *Shigella* species, *Staphylococcus aureus*, *Salmonella* spp. and *Pseudomonas aeruginosa* from Catfish samples; while [27] (2010) isolated *Staphylococcus* sp. and *Salmonella* sp. from Tilapia fish. The fungi were majorly *Aspergillus niger*, *Aspergillus flavus*, *Fusarium* spp., *Penicillium chrysogenum* and *Cladosporium* spp.

The pathogenic microorganisms isolated from different smoked fish samples in the course of this research work are of public health importance; *Escherichia coli* have been known to cause kidney damage as well as uncomplicated community acquired Urinary Tract Infection while *Salmonella* sp. causes gastroenteritis and typhoid fever amongst others [28]. The presence of *Aspergillus* sp. could be an indicator factor to aflatoxin production, therefore, adequate processing and storage as well as thorough smoking should be done. Fish products which contains moulds should be discarded because most of the toxins are heat stable. The higher bacterial and fungal population in the commercially smoked fish could be attributed to poor handling, lack of hygiene, improper smoking and poor packaging methods.

Conclusion

The outcome of this study indicates that moisture contents of fish are of great importance, as most of the biochemical reactions and physiological changes in fish depend on moisture content. Biochemical and sensory evaluation revealed that smoked fish samples stored for sale at Ojoo and Bodija market in Ibadan are of low quality and are also heavily contaminated with food borne bacteria as well as some fungi. This study therefore recommended the need for the adoption of good processing practices and storage methods of smoked fish. Though fish inspection should be carry out in order to minimize the risk of disease transmission through fish consumption.

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