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Full Length Research Paper

Chemical and microbiological qualities of smoked herring (*sardinella eba*,valenciennes 1847) in Odeda, Ogun state, Nigeria

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This study assessed the chemical and microbiological qualities of smoked herring (*Sardinella eba*) at three different locations in Odeda local government, Ogun state, Nigeria. The smoked fish samples were aseptically collected from different processors and then analysed for moisture, crude protein, fat, crude fiber and ash content. The pH, Peroxide Value (PV), Free Fatty Acid (FFA) and Thiobarbituric acid (TBA) were also determined as well as Total plate, fungal, Coliform, *Staphylococcal, Salmonella* spp, and *Listeria monocytogenes* counts using standard laboratory procedures. The moisture content ranged from 50.68 to 77.75%, ash 1.24 to 2.28%, fat 12.80 to 16.73%, crude fibre 0.18 to 0.30% and crude protein from 17.28 to 21.88%. There was significant difference (p <0.05) in the proximate composition of the smoked herring. The Total plate count (TPC) ranged from 1.26 x 10^6 to 3.00×10^7, fungal count from 0 to 3.50 x 10^3, *Staphylococci* from 2.50x10^2 to 2.90 x 10^3, coliform from 0 to 2.00×10^3 cfu/g, *Salmonella* had zero tolerance. The pH, PV, FFA and TBA of the smoked fish ranged from 5.92 to 6.57, 0.53 to 2.00 ml\kg, 0.05 to 0.06% and from 0.02 to 0.11 mg /kg, respectively. From this study, it showed that fish prepared under hygienic laboratory conditions had lower microbial load. While, smoked fish collected at Camp location had the highest microbial load and that from Alogi had the lowest microbial load.

Key words: *Sardinella eba*, proximate, fungal count, total plate count, microbial loads.

INTRODUCTION

Fish is a very important source of animal protein in the diets of man. Smoked fish is a traditional part of the diet of a large section of the world's population. However, the gap between the demand and supply of fish is widening due to increase in population, poor postharvest handling, lack of processing and storage facilities and utilization of unconventional fish species (FAO, 1999). In Nigeria, fish constitute 40% of the animal protein intake of the people, but 40% of the total fish catch in Nigeria are lost annually due to inadequate or poor preservation, processing and handling (Oladosun, Akande, & Tubor, 1996). Several methods are available for fish smoking and different smoked products have been developed in various parts of the world in relation to the properties of the locally available raw materials and the general level of technology (Olley, Doe, & Heruwati, 1988).Smoking is one of the traditional fish processing methods aimed at preventing or reducing post-harvest losses. Post-harvest losses in fish are represented by a net reduction in the amounts of nutrients potentially available to the consumer either by direct physical loss or nutritional loss. These factors have effect on consumer acceptability, commercial value and income of fish farmers/traders (Bostock, Walker, & Wood, 1987). Also, the health implication of consuming spoilt fish cannot be quantified. The short shelf life of dead fish is due to changes in the chemical constituents of fish after death. Smoking enhances flavour and increase utilization of the fish. Nonetheless, deterioration and spoilage still occur in smoked fish during storage. The rate of fish spoilage depends on handling during processing, acidity level, species of fish, weather condition, mode of storage and temperature during transportation (Clucas, 1982). Chemical breakdown of protein, fat and water contents contribute to quick spoilage of fish (Eyo,1993). Some pre-

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Table 1. Microbial Counts (cfu\g) of smoked herring (*Sardinella eba)*.

Fish Samples	Total Plate Count	Fungal Count	*Staphylococcus*	*Salmonella spp*	*Listeria Monocytogenes*	Coliform
Camp A	$3.00x10^7$	$2.90x10^3$	$2.50x10^3$	Nil	Nil	$2.00x10^3$
Camp B	$2.80x10^7$	$3.50x10^3$	$2.90x10^3$	Nil	Nil	$1.50x10^3$
Camp C	$2.00x10^7$	$2.10x10^3$	$1.80x10^3$	Nil	Nil	$2.00x10^2$
Osiele A	$2.00x10^7$	$1.90x10^3$	$2.70x10^3$	Nil	Nil	Nil
Osiele B	$2.30x10^6$	$3.50x10^2$	$2.90x10^3$	Nil	Nil	Nil
Osiele C	$2.70x10^6$	$2.30x10^3$	$2.80x10^3$	Nil	Nil	Nil
Alogi A	$2.60x10^6$	$3.00x10^2$	$3.00x10^2$	Nil	Nil	Nil
Alogi B	$2.80x10^7$	$2.00x10^3$	$1.30x10^3$	Nil	Nil	Nil
Alogi C	$2.30x10^7$	$2.30x10^3$	$1.60x10^3$	Nil	Nil	Nil
Control sample	$1.20x10^6$	Nil	$2.50x10^2$	Nil	Nil	Nil

servation techniques currently used in the tropics include chilling, freezing, drying, salting and smoking. However, in Nigeria the most affordable and widely used method of fish preservation is smoking. The smoking of fish from smouldering wood for its preservation dates back to civilization (Olokor, 2007). It is also noted that apart from giving the product a desirable taste and odour, smoking provides a longer shelf life through its anti-bacterial and oxidative effect, lowering of pH, imparting desirable colouration as well as accelerating the drying process and acting as antagonist to spoilage agents (Sengor *et al.,* 2004; Eyo, 2001). This study therefore aimed at assessing the chemical and microbiological composition of smoked Atlantic herring (*Sardinella eba*) purchased from different locations in Odeda Local Government, Ogun State, Nigeria.

MATERIALS

Smoked Atlantic herring (*Sardinella eba*) 3 replicates each (samples) were purchased from processors at the point of sale in 3 different locations in Odeda local government, Ogun state, Nigeria. The locations include Camp, Alogi and Osiele. The samples were collected aseptically using sterile plastic bags and transported to the laboratory for analysis immediately. The control sample was prepared in the Food processing laboratory, Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Nigeria.

ANALYTICAL PROCEDURE

The moisture, protein, ash, crude fibre and fat contents of the fish samples were determined using AOAC (2000) method. Glass wares sterilization and media preparation were carried out following standard methods Taylor *et al.,* (1998).One gram of smoked fish flesh were accurately weighed from the macerated fish portion and homogenized with 9 ml of distilled water in a McCartney bottle after crushing with a sterile pounder and dish. A six-fold serial dilution of sample homogenates was prepared. In this study, 1 ml aliquots from the fifth and sixth fish flesh dilution levels were plated in replicates of three per treatment (representing each locations) on Nutrient agar (for bacteria) and Potato Dextrose agar (for mould). Incubation of culture plates was for 24-48 hours. (Fawole, 2005; Cheesbrough, 2000) The pH, peroxide value (PV), free fatty acid and thiobarbituric acid were determined using AOAC (2000).

STATISTICAL ANALYSIS

All data were subjected to statistical analysis of variance (ANOVA) using SPSS Version 17 and means separated with Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Microbiological Quality of Smoked Herring (*Sardinella eba*) from different locations in Odeda local government of Ogun state, Nigeria

Table 1 shows the microbiological quality of smoked herring. The total plate count of smoked (*Sardinalla eba*) herring purchased from different markets ranged from $1.20x10^6$ to $3.00x10^7$ (cfu/g), with camp sample having the highest count while the control sample had the lowest count. Fungal count ranged from 0 to $3.50x10^3$(cfu/g), camp sample had the highest and the control sample had the lowest. The *Staphylococcoci* count ranged from $2.50x10^2$ to $2.90x10^3$(cfu/g) with camp location having the highest count and the control sample had the least count. For the *Listeria monocytogenes* and *Salmonella spp* there was zero tolerance for all location including the control sample. Coliform count ranged from 0 to 2.00 x 10^3(cfu/g). Control sample had zero tolerance while camp

Table 2. Proximate Composition of smoked herrings (*Sardinella eba)* (%).

Fish samples	Moisture	Ash	Fat	Crude fibre	Crude protein
Camp A	77.75[a]	1.28[d]	14.03[c]	0.30[a]	21.88[a]
Camp B	60.60[d]	2.28[a]	16.73[a]	0.30[a]	21.85[b]
Camp C	62.81 [c]	1.48[b]	15.93[b]	0.30[a]	20.86[c]
Alogi A	53.78[f]	1.42[c]	12.80[f]	0.19[b]	19.70[de]
Alogi B	60.97[d]	1.49[b]	13.01[e]	0.19[b]	19.99[d]
Alogi C	64.54[b]	1.42[bc]	13.20[d]	0.20[b]	20.88[c]
Oshiele A	51.51[g]	1.43[b]	13.00[e]	0.18[bc]	17.28[f]
Oshiele B	56.29[e]	1.44[ebc]	13.10[d]	0.19[b]	18.19[e]
Oshiele C	55.38[e]	1.44[bc]	13.10[d]	0.18[bc]	18.16[e]
Control sample	50.68[h]	1.24[d]	13.00[e]	0.20[b]	19.98[d]

Means values followed by different superscripts within a column are significantly different ($p<0.05$).

had the highest count. According to ICMSF (International Commission on Microbiological Specification for Food), the maximum recommended bacteria count for good quality fish products is 5.0×10^5 (5.0 cfu /g) and the maximum for marginally acceptable quality products is 10^7(7log cfu /g) and for *Listeria monocytogenes* and *Salmonella* spp, the level in the presence of organism is Zero tolerance. It was observed that smoked fish collected at Camp location had the highest microbial load while Alogi had the lowest microbial load. The high counts could be as a result of handling, frequent exposure and poor environmental and sanitary conditions. The variations in microbial counts of fish samples from different markets in which some have higher microbial counts may be due to lack of proper smoking on the side of the fish processor and improper hygiene and handling procedures adopted by the smoked fish sellers. This is in agreement with the findings of Abolagba & Melle (2008) who reported that lack of proper smoking and proper hygiene handling of smoked fish products would result in a very high microbial load. These differentials were linked with the higher human traffic and poor environmental sanitation of the locations used for this study. The Camp location is very congested, closed to motor pack and with poor sanitation compared to the Osiele location explaining the higher microbial activities and densities. It was also observed that the smoked products were constantly exposed to the effect of the humid environment, thus the possibility for an increase in the moisture content of the smoke-dried product was inevitable thereby enhancing the activity/proliferation of these microorganisms. This is corroborated by Eyo (2001) who stated that smoked fish samples may have a relatively high water activity level which is a prerequisite for microbial growth. The results obtained in this study indicated that fresh herring fish smoked by at the laboratory (control) had the lowest microbial load and thus would be safer for consumption as a result of the good sanitary measures adopted in the smoked fish processing chain.

The proximate composition of smoked herring (*Sardinella eba*)

Table 2 shows the proximate composition of smoked fish (*Sardinella eba*). The proximate composition were significantly different ($P<0.05$). The moisture content for smoked herring (*Sardinella eba*) ranged from 50.68 to 77.75% with Camp sample having the highest values and control sample had the least value. Ash content ranged from 1.24 to 2.28% with Camp sample having the highest values and control sample with the least value. Fat content ranged from 12.80 to 16.73%, while crude fibre ranged from 0.18 to 0.30%. Camp sample had the highest value and Osiele sample had the lowest. Crude protein ranged from 17.28 to 21.88% with Camp sample having the highest value and Osiele sample had the lowest. According to Motohiro (1989), the proximate composition of cold smoked Japanese herring, which was smoked at 30^{o}C for 15 days contained 36.50% moisture, 37.43% protein, 14.50% fat and 15.43% ash. Commercial smoked fish in Poland had moisture, protein, fat, and ash content ranging from 57.6-68.2, 19.5-23.3, 6.06-20.8 and from 2.24-4.56%, respectively (Usydus *et al*., 2009). Adebowale *et., al.*(2008) reported the range of moisture,

Table 3. Chemical composition of smoked herring (*Sardinella eba).*

Fish Samples	pH	FFA (%)	TBA (mg\kgs)	PV
Camp A	6.14	0.056	0.06	1.50
Camp B	6.33	0.056	0.06	1.35
Camp C	6.46	0.056	0.06	1.25
Alogi A	5.95	0.056	0.02	1.20
Alogi B	5.92	0.056	0.11	1.25
Alogi C	5.93	0.056	0.11	1.26
Osiele A	6.57	0.056	0.11	2.00
Osiele B	6.23	0.055	0.11	1.85
Osiele C	6.23	0.056	0.11	1.90
Control sample	5.92	0.028	0.02	0.53

protein, fat and ash content of Nigerian smoked catfish to be 7.16-10.71, 33.66-66.04, 1.58-6.09 and 9.21-12.16%, respectively. Hence, the proximate composition of smoked fish products will be different according to the producer country and fish type. The variation in proximate composition of smoked fish were caused by different factors, such as fish species, smoking methods (hot or cold), smoking time and salt concentration. Furthermore variations in the proximate composition of fish will affect its wholesomeness, safety and shelf life of the products.

The chemical composition of smoked herring (*Sardinella eba*)

Table 3 shows the chemical composition of smoked herring (*sardinella eba*). The pH ranged from 5.92 to 6.57 with Osiele sample having the highest value and the lowest was recorded by the control sample. PV ranged from 0.53 to 2.00 ml/kg and Osiele sample had the highest value and the lowest was recorded by the control sample. The FFA ranged from 0.05 to 0.06% with Camp sample having the highest value and the control sample had the lowest. TBA ranged from 0.02 to 0.11mg/kg with Alogi sample having the highest value and the control having the lowest. The pH increase could be associated with the production of basic components induced by the growth of bacteria (Aranilewa, Salawu, Sorungbe, & Ola-Salawu, 2005). According to Eyo (1993), pH is an indicator of the extent of microbial spoilage in fish and that some proteolytic microbes produce after decomposition of carbohydrate, thereby increasing the acid level of the medium. The pH value is also a reliable indicator of the degree of freshness or spoilage of fish. The free fatty acid is a tertiary product of rancidity and increased during storage. The FFA is a measure of hydrolytic rancidity and the extent of most lipid hydrolysis by lipase action. In most fish oils, rancidity is noticeable when the FFA (calculated as oleic acid) is between 0.5 and 1.5 (Eyo, 1993). The FFA values obtained in this study were lower than this hence, the level of rancidity in the fish samples can be said to still below. Fish sample may react directly with TBA but it is often distilled to eliminate interfering substances and then the distillate reacted with TBA (Pike, 1998). Beltran & Moral (1991) reported that high TBA values are correlated with the degree of oxidation of fats in hot smoked sardine. Goktepe and Moody (1998) also found that smoked catfish fillets stored in the air at 2 and 8^{o}C had a significant increase in TBA values (1.188 and 1.489 mg TBRS/kg, respectively) over time.Peroxides are the primary products of oxidation however, since they are relatively short lived, their usefulness as oxidation indicators is limited to an early stage of rancidity development. As oxidation proceeds, peroxides break down to aldehydes or combine with proteins (Woyewoda, Shaw, Ke, & Burns,, 1986)Based on the results, it showed that fishes prepared under laboratory and hygienic conditions had lower microbial load, therefore the control sample is of good quality and safe for human consumption compared to the fishes prepared in open market.

CONCLUSION

Microbial contamination of smoked fish has been found to be due to several factors such as poor smoking of fish products (i.e. inappropriate temperature control or application), poor personal hygiene of processors/seller, poor hygiene/sanitary practices relating to smoked fish products, smoke/workhouse, packaging and storage as well as the use of inadequate and inefficient traditional processing facilities. Poor environmental sanitation and high human/vehicular traffic are also implicated. The smoked fish obtained from the surveyed locations in Odeda local Government, Ogun State, Nigeria possessed marginally acceptable microbial quality based on the maximum recommended counts. Therefore, this study advocates the need for the adoption of good processing practices of smoked fish products (e.g. adequate smoking of fish products, proper hygiene practices, etc.) all involved in the processing and selling of smoked fish so as to ensure that safety standards are maintained and market worthiness of the final products (i.e. microbial load kept at minimum acceptable level) is preserved. Thus, the adoption of a good processing practice and the use of controlled temperature in processing and preserving of smoked fish product are highly recommended.

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