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Effect of Smoking Method on Quality Attributes of Traditional Smoked Silver Catfish (Chrysichthys Nigrodigitatus) from Lagos State, Nigeria

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Abstract
Effect of smoking methods on quality and safety of traditional smoked silver catfish from Lagos State, Nigeria was carried out with a focus on investigating the quality indices of traditional smoked silver catfish in twenty different fish processing centres. Fresh unsmoked silver catfish and smoked silver catfish samples were collected from different processing centres and and control samples were smoked with convectional smoke kiln. Proximate and quality analyses revealed that moisture content of fresh unsmoked silver catfish samples ranged from 71.66% – 74.92% and that of smoked silver catfish samples and control samples ranged from 11.18% - 14.77% and 8.48% – 10.43% respectively. Protein content of fresh unsmoked silver catfish samples ranged from 15.70% – 17.96% and that of smoked silver catfish samples and control samples ranged from 52.96% – 58.36% and 56.81% – 61.42%. Fat content of fresh unsmoked silver catfish samples ranged from 7.58% – 9.86% and that of smoked silver catfish samples and control samples ranged from 16.52% – 20.41% and 17.52% – 20.57%. The pH value of fresh unsmoked silver catfish samples ranged from 6.78 – 7.42 and that of smoked silver catfish samples and control samples ranged from 6.27 – 6.73 and 6.51 – 6.86. The TBA values of fresh unsmoked silver catfish samples ranged from 0.90 - 1.18mgMol/kg and that of smoked silver catfish samples and control samples ranged from 1.01 - 1.15mgMol/kg and 1.00 – 1.12 mgMol/kg. The TVB-N of fresh unsmoked silver catfish samples ranged from 13.15 - 15.40mgN/kg and that of smoked silver catfish samples and control samples ranged from 17.59 - 19.69mgN/kg and 15.63 - 17.86mgN/kg. The TMA **o**f fresh unsmoked silver catfish samples was 2.04 – 2.61mgN/kg and 2.36 – 2.96mgN/kg and 2.11 – 2.72mgN/kg for smoked silver catfish samples. This study revealed PV of 6.13 – 8.85 mgEq.peroxide/kg for fresh unsmoked silver catfish samples and 8.24 - 9.39mgEq.peroxide/kg and 7.13 - 8.67mgEq.peroxide/kg for smoked silver catfish samples. FFA of fresh unsmoked silver catfish samples was 1.00 – 1.16% while that of smoked silver catfish samples ranged from 1.03 – 1.26% and 1.00 – 1.24%. Convention smoke kiln (used for control samples) did not significantly affect pH and composition of smoked silver catfish. The study concluded that smoking method affect quality as convention smoke kiln significantly reduced the moisture content of smoked silver catfish and the quality indices such as FFA, TBA and PV.
Keywords: silver catfish, smoking, traditional, quality, smoking method

1.0 INTRODUCTION

Fish are widespread over the oceans and rivers of the world (da Silva, 2002). They are major source of food for humans providing a significant portion of the protein intake in the diets of a large proportion of the people, particularly so in the developing countries, where it represents about 14% of all animal protein on global basis (Afolabi *et al.,* 1984; Cluca and Ward, 1996, Eyo, 2001, da Silva, 2002, Abolagba and Melle, 2008). In many Asian countries, over 50 % of the animal protein intake comes from fish, while in Africa, the proportion is 17.5 % (Afolabi *et al.,* 1984; Abolagba and Melle, 2008). Fish provides between 30% and 80% of the total animal protein intake of the coastal people of West Africa (NCBI, 2012). (Nelson, 2006) In Nigeria, fish has an edge over meat because it is cheaper and relatively more abundant (Eyo, 2001) and constitutes about 40 % of the animal protein intake (Eyo, 2001; Abolagba and Melle, 2008). Fish is a cheap source of animal protein with little or no religious rejection of it, which gives it an advantage over pork or beef. Fish is a rich source of lysine suitable for supplementing high carbohydrate diet. It is also a valuable source of vitamin A, B and E, iodine and oils containing polyunsaturated fatty acids (Eyo, 2001, da Silva, 2002, Abolagba and Melle, 2008). In Nigeria, fish smoking is the most practiced preservation method. Practically all species of fish available in the country can be smoked and it has been estimated that 70 - 80 percent of the domestic marine and freshwater catch is consumed in smoked form(Akinyemi *et al.,* 2011). Smoked fish constitute a major source of animal protein for a vast majority of the population in Nigeria, particularly the rural population (Eyo, 1992).

Fish is also rich in unsaturated fat while the total fat content is relatively low (about 5%). It is high in polyunsaturated fatty acids that are important in lowering blood cholesterol level (Al-Jedah, *et al.,* 1999, Cluca and Ward, 1996, Eyo, 2001). Meats from most animals are rich in saturated fats, the fats that raise blood

cholesterol levels and cause clogging of blood vessel. Fish is also low in such saturated fats and rich in long chain omega-3 polyunsaturated fatty acids (PUFA), which includes alpha-linolenic acid (ALA, Cl8:3) and its longer-chain metabolites: eicosapentaenoic acid (EPA, C20:5) and docosahexaenoic acid (DHA, C22:6). Beneficial health effects of omega-3 PUFA, especially long chain EPA and DHA, are well demonstrated, mainly in the prevention of cardiovascular diseases (Brunner and Iso, 2008).

The unsaturated fats in fish, however, make it susceptible to oxidation after harvest. Other factors, such as reactions caused by the activities of the fish's own enzymes and the metabolic activities of micro-organisms, contribute to the spoilage of fish (Brunner and Iso, 2008). Because fish is highly perishable, a considerable effort has been directed to extend the shelf-life of fish using preservation and processing techniques, such as refrigeration, freezing, canning, smoking, salting, and drying. What's more, some of these techniques can also be used to enhance the value of fish. Smoking fish is one of them.

The smoking of fish from smouldering wood for its preservation dates back to civilization (Eyo, 2001). Wood has a highly complex molecular composition and contains wood smoke compounds that actually act as preservatives. Phenol and other phenolic compounds in wood smoke are both antioxidants, which slow rancidity of animal fats and antimicrobials, which slow bacterial growth. Other antimicrobials in wood smoke include formaldehyde, acetic acid, and other organic acids, which give wood smoke a low pH - about 2.5.

There is insufficient data on the quality attributes of traditional smoked wild fish from Nigeria despite the fact that it constitutes a substantial portion of fish available and a lot of Nigerians consume it. This study is embarked on to investigate the effect of smoking method on quality attributes of traditional smoked silver catfish from Lagos State.

2.0METHODOLOGY

2.1.0 Fish Used

Fresh fish samples were obtained from ten different fishing communities of Badagry and Epe Local Government Areas of Lagos State, Nigeria. The fresh silver catfish samples were freshly harvested. The samples were taken to the Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR) laboratory, Federal University of Agriculture, Abeokuta for smoking.

2.1.1 Chemicals

All chemicals used in this study were of the analytical grade unless stated otherwise.

2.2 Area of Study.

Using a current geopolitical map of Nigeria, Lagos State lies to the south-western part of Nigeria and has boundaries with Ogun State both in the north and east. It is bordered on the west by the Republic of Benin and in the south, stretches for 180 km. along the coast of the Atlantic Ocean. It therefore has 22.5% of Nigeria's coastline and occupies an area of 3,577 sq km land mass with about 786.94 sq. km. (22%) of it being lagoons and creeks. The state is endowed with marine, brackish and fresh water ecological zones with varying fish species that provide productive fishing opportunity for fishermen. Two local government areas (Badagry and Epe Local Government) were covered because they are highly densed fish processing centers. They were selected for the study and hazard analyses of the products.

2.3 Sampling Procedure

Fresh and smoked silver catfish samples were collected from 10 processing centres from each of the two local government areas, from the identified processing centres by purposive sampling in sterile containers (Ziploc).

All freshly harvested silver catfish samples were kept on ice during transportation to the laboratory and smoked on the same day. Smoked fish samples were analyzed immediately.

2.4 Fish Smoking Process

Smoked fish was prepared following the method (Fig.1.0) as described by Crapo (2011) with modifications. Fish were carefully cleaned to remove slime, blood and harmful bacteria. The fish were eviscerated, leaving the skin on the fish. The fish were cut into uniform pieces (fillet) so that no parts will get overheated.

The fish were smoked to 80°C internal temperature (with a thermometer) for 24hours. The kiln temperature was adjusted as needed throughout this smoking period to maintain the 80°C internal temperature. Hands, utensils and work surfaces were cleaned when transferring fish from smoker to oven to cool down to avoid cross-contamination. Smoking was done for 24 hours until the fish is fully dried.

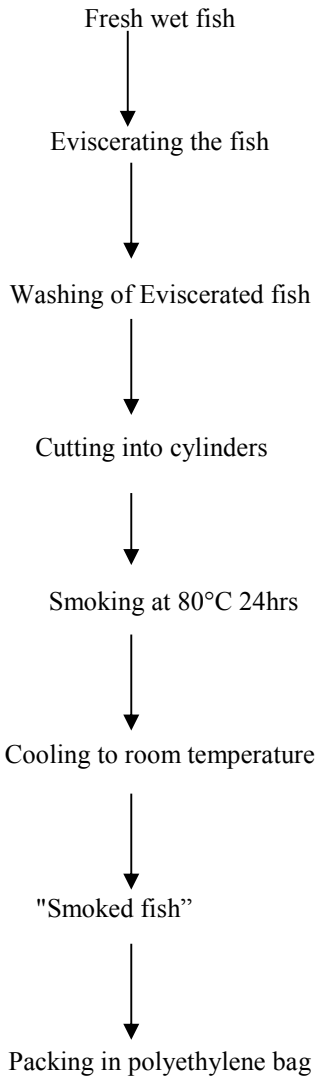

Figure 1.0: Flow chart for traditional fish smoking (Crapo, 2011))

2.5 Proximate analysis

The following proximate analyses were carried out on fresh silver catfish and the smoked silver catfish samples collected from the processing centres. The moisture content of the fresh silver catfish and smoked silver catfish were determined by the oven-drying method. Protein contents of the fresh silver catfish were extracted and fractionated by the method of AOAC (2000) method. The crude fat, crude fibre and ash content of the fresh silver catfish and smoked silver catfish were determined by AOAC (2000) method.

2.6 Physico-chemical analysis

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 10 g 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 fresh fish and smoked fish were determined by AOAC (2000) method.

2.7 Data Analysis

All data analyses were done in triplicates. The data obtained were subjected to descriptive statistics using IBM SPSS version 21.0 software and Microsoft office excel was used to generate tables and charts. One way analysis of variance (ANOVA) was done using Duncan's Multiple Range Test ($p<0.05$) to study the difference between means.

3.0 RESULTS AND DISCUSION

Moisture content of fresh unsmoked silver catfish samples ranged from 71.66% – 74.92% and that of smoked silver catfish samples obtained using local drum kiln and conventional smoke kiln ranged from 11.18% - 14.77% and 8.48% – 10.43%. In contrary to protein, fat, and ash, the moisture content of fresh silver catfish samples decreased sharply after the smoking process. This decrease was due to loss of water during smoking (Asiedu *et al.,* 1991). Moisture content of fish is of great importance as a number of biochemical reactions and physiological changes in fish depend on moisture content. Of greater significant is the effect of moisture on the stability and quality of fish. High moisture content also promotes microbial growth. In the present study, the protein content of fresh unsmoked silver catfish samples ranged from 15.70% – 17.96% and that of smoked fish samples ranged from 52.96% – 58.36% and 56.81% – 61.42%. There was an inverse relationship between the moisture and protein content in the smoked silver catfish (Goktepe, 1996 and da Silva, 2002). Fat content of fresh unsmoked fish samples ranged from 7.58% – 9.86% and that of smoked silver catfish samples ranged from 16.52% – 20.41% and 17.52% – 20.57%. Crude fibre content of fresh unsmoked silver catfish samples ranged from 0.18% – 0.24% and crude fibre content of smoked silver catfish samples ranged from 1.83% – 2.37% and 2.12% – 2.71%. Ash content of fresh unsmoked silver catfish samples ranged from 0.11% – 0.15% and ash content of smoked silver catfish samples ranged from 1.14% – 1.48% and 1.31% – 1.92%. The increase in mineral content, ash and crude fibre can be attributed to an increase in the dry matter content per unit weight following sample dehydration and during the smoking process (da Silva, 2002).. These results agreed with the work of Omojowo, *et al.,* 2008; Omojowo, *et al.,* 2009 and da Silva *et al.,* (2008). In this study carbohydrate content is given by difference that is the percentage of water, protein, fat and ash subtracted from 100. Carbohydrate content of fresh unsmoked silver catfish samples ranged from 0.90% – 1.10% and carbohydrate content of smoked silver catfish samples ranged from 8.49% – 15.78% and 7.12% – 10.63%. Carbohydrate content of smoked silver catfish samples is low because it is proteinous food. This result also agreed with the work of Idowu and Kue (1998).

Table 1: Proximate composition of fresh Silver catfish (*Chrysichthys nigrodigitatus*) samples from different processing centres

Locations	Moisture %	Protein %	Fat %	Crude fibre %	Ash %	Carbohydrate %
Agbalata	74.68a	15.70a	8.38abc	0.20a	0.13a	0.91a
Ajido	74.92a	16.16a	7.61a	0.22a	0.13a	0.96abcd
Asakpo	74.62a	15.81a	8.34abc	0.19a	0.14a	0.90a
Boguru	73.83a	16.91a	7.83ab	0.23a	0.13a	1.07cdef
Fvanoveh	72.91a	17.93a	7.84ab	0.23a	0.14a	0.95abc
Gberefun	74.87a	16.03a	7.81ab	0.19a	0.11a	0.99abcdef
Gbetrome	73.56a	17.24a	7.87ab	0.24a	0.12a	0.97abcde
Ilaje	72.88a	17.96a	7.79ab	0.21a	0.12a	1.04bcdef
Kofegameh	72.63a	16.62a	9.46ab	0.19a	0.14a	0.96abcd
Pako	73.58a	16.29a	8.73abc	0.18a	0.14a	1.08def
Afuye	72.85a	16.49a	9.36abc	0.22a	0.14a	0.94ab
BodinYawa	73.36a	16.12a	9.18abc	0.21a	0.14a	0.99abcdef
Idale	71.74a	16.97a	9.86c	0.19a	0.14a	1.10f
Igbodun	71.89a	17.91a	8.75abc	0.23a	0.13a	1.09ef
Ilogun	73.23a	16.64a	8.84abc	0.21a	0.13a	0.95abc
Mejona	74.57a	16.33a	7.68 ab	0.19a	0.13a	1.10f
Oluwo	72.84a	17.46a	8.42abc	0. 23a	0.14a	0.91a
Okorisan	74.62a	16.59a	7.58a	0.19a	0.12a	0.90a
Orita	73.68a	16.73a	8..32abc	0. 21a	0.14a	0.92ab
Orogoro	74.68a	17.32a	9.73c	0.20a	0.12a	0.97abcde

Data are means of 3 replicates

Data with the same subscript are not significantly different at $p<0.05$

Table 2: Proximate composition of smoked Silver catfish (*Chrysichthys nigrodigitatus*) from different processing centres using local drum kiln and conventional smoke kiln

Locations	Moisture %		Protein %		Fat %		Crude fibre %		Ash %		Carbohydrate %	
	Local	Convect	Local	Convect	Local	Convect	Local	Convect	Local	Convect	Local	Convect
Agbalata	11.86c	8.91d	54.80e	57.45c	19.32l	20.32l	2.04de	2.56ef	1.34de	1.62de	10.64bcd	9.14k
Ajido	14.32k	9.42fg	53.46b	58.78g	17.68f	18.68e	2.21gh	2.47cd	1.31cde	1.56cd	10.99bcd	9.09k
Asakpo	14.06j	10.12j	56.06h	59.13h	18.04g	19.04f	1.93bc	2.23b	1.42def	1.67ef	8.49bc	7.81c
Boguru	13.11g	9.47g	54.51de	57.74d	19.33l	20.13j	2.27hi	2.52def	1.36def	1.86ij	9.42bcd	8.08d
Fvanoveh	11.83c	8.79bc	58.13j	61.34l	16.54b	17.54a	2.16fg	2.43c	1.39efg	1.82hi	8.90bcd	8.28ef
Gberefun	14.91n	10.23k	54.03de	57.47c	18.11gh	19.11fg	1.89ab	2.13a	1.14a	1.56cd	9.92bcd	9.50m
Gbetrome	14.30k	9.56h	57.24i	60.63k	17.17c	18.17c	2.37j	2.59f	1.28bcd	1.61de	7.64ab	7.44b
Ilaje	12.73e	8.83c	58.36j	61.42m	16.52b	17.52a	2.14fg	2.48cde	1.16a	1.34a	9.09bcd	8.41h
Kofegameh	12.18d	8.74b	53.62b	57.89e	20.41o	20.41m	1.99cd	2.31b	1.41efg	1.74fgh	10.39bcd	8.91j
Pako	14.36l	10.43l	54.29cd	57.93e	18.23i	19.23h	1.83a	2.67g	1.45fg	1.81ghi	9.84bcd	8.23e
Afuye	13.73ij	9.92i	55.49g	58.78g	18.06g	20.06j	2.15fg	2.54def	1.36def	1.58d	9.21bcd	7.12a
Bodin Yawa	14.21k	10.43m	54.12c	57.45c	17.28d	20.28kl	2.12efg	2.43c	1.21abc	1.46b	11.06bcd	8.95j
Idale	11.18a	8.75b	54.47cde	57.73d	19.22k	20.22k	1.99cd	2.30b	1.48g	1.73fg	11.66cd	9.27l
Igbodun	11.47b	8.48a	58.11j	60.36j	16.05a	18.05b	2.33ij	2.71g	1.31cde	1.63de	10.73bcd	8.77i
Ilogun	13.19gh	9.34e	53.64b	56.92b	18.34j	19.34i	2.11ef	2.42c	1.37def	1.49bc	11.35bcd	10.49o
Mejona	15.23n	10.13j	54.33cd	57.66d	17.56e	18.56d	1.93bc	2.12a	1.33de	1.57cd	9.62bcd	9.96n
Oluwo	12.97f	9.98i	52.96a	56.81a	18.22i	19.22h	2.25hi	2.56ef	1.45fg	1.80ghi	12.15cd	10.63p
Okorisan	14.77m	10.18jk	54.29cd	59.53i	18.18hi	19.18gh	1.96bcd	2.24b	1.21abc	1.45b	9.59bcd	7.42b
Orita	13.27h	9.36ef	55.13f	58.64f	20.22n	18.22c	2.12efg	2.43c	1.40efg	1.92j	15.78e	9.43m
Orogoro	15.39o	10.06j	54.22cd	57.39c	19.57m	20.57n	2.04de	2.31b	1.18ab	1.31a	12.70de	8.36gh

Local = Local drum kiln Convect = Convectional smoke kiln
Data are means of 3 replicates
Data with the same subscript are not significantly different at p<0.05

The quality indices of the fresh and smoked silver catfish were studied. Fats undergo changes during storage which result in production of an unpleasant taste and odour which is commonly referred to as rancidity (FAO, 1992; da Silva, 2002; da Silva, *et al.,* 2008). The peroxide value (PV) results are similar in pattern to TBA. In this study PV of fresh unsmoked silver catfish samples was 6.13 – 8.85 mgEq.peroxide/kg and 8.24 – 9.39mgEq.peroxide/kg and 7.13 – 8.67mgEq.peroxide/kg for smoked silver catfish samples. These values are below the recommended value of between 20 and 40mgEq.peroxide/kg for rancid taste to begin. Free fatty acids values (FFA) of fresh unsmoked silver catfish samples was 1.00 – 1.16% while that of smoked fish samples ranged from 1.03 – 1.26% and 1.00 – 1.24%. These values are very low and below the threshold for rancidity detection in smoked fish. The thiobarbituric acid value (TBA) is used to assess the degree of fish spoilage especially in fatty fish. The TBA test measures a secondary product of lipid oxidation, malonaldehyde (da Silva, 2002). The TBA values of fresh unsmoked catfish samples ranged from 0.90 - 1.18mgMol/kg and thio-barbituric acid value (TBA) of smoked silver catfish samples ranged from 1.01 - 1.15mgMol/kg and 1.00 - 1.12mgMol/kg. The TBA (1.00 to 1.15 mg TBA/kg) did not exceed 1 to 2 mg TBA/kg which was well within acceptable limits. The sensory threshold level for detecting rancidity in fresh meat was reported to be between 1 and 2 TBA (Calhoun *et al.,* 1999). The increased TBA values in the smoked fish probably originated from the breakdown of oxidation products, mainly malonaldehyde, during smoking due to the high temperature (Goktepe and Moody, 1998).

Table 3: Quality indices of fresh Silver catfish (*Chrysichthys nigrodigitatus*) samples from different locations

Locations	Peroxide value (PV)(mEq. peroxide/kg)	Free fatty acid(FFA) %	Thiobarbituric acid (TBA) (mg Mol/kg)	Total volatile base-nitrogen (TVB-N) (mgN/kg)	Trimethyl amine value (TMA) (mgN/kg)	pH
Agbalata	6.32b	1.16a	0.90ab	14.63fg	2.17ab	6.96ab
Ajido	6.67d	1.01a	0.93abc	14.18e	2.32bcdef	7.04bcd
Asakpo	8.31i	1.04a	0.88a	3.50ab	2.26bcd	6.91ab
Boguru	8.63j	1.06a	0.94abc	15.37i	2.38cdefg	6.98ab
Fvanuveh	7.27e	1.02a	0.91ab	13.15a	2.23bc	7.01abc
Gberefun	8.14h	1.00a	1.00bcdef	13.43b	2.58ghi	7.13cdef
Gbetrome	6.35bc	1.03a	1.13gh	14.13e	2.51ghi	6.99ab
Ilaje	6.31b	1.07a	1.07fg	14.50f	2.43efgh	7.15def
Kofegameh	7.45f	1.13a	1.10fgh	13.71d	2.61hi	6.90a
Pako	8.63j	1.11a	1.05defg	13.36b	2.38cdefg	7.23f
Afuye	8.54j	1.03a	0.93abc	15.13h	2.41defg	7.18ef
BodinYawa	8.38i	1.05a	0.97abcd	13.61cd	2.46efghi	6.93ab
Idale	7.73g	1.01a	1.08fg	13.14a	2.53ghi	6.95ab
Igbodun	8.85k	1.10a	0.96abcd	15.40i	2.47fghi	7.24f
Ilogun	7.29e	1.02a	1.06efg	14.19e	2.52ghi	7.16def
Mejona	8.31i	1.11a	1.09fgh	14.67g	2.04a	6.94ab
Oluwo	6.13a	1.09a	1.13gh	15.38i	2.31bcde	7.12cdef
Okorisan	6.47c	1.07a	1.18h	15.12h	2.42efg	7.05bcde
Orita	7.62g	1.06a	1.01cdef	13.76d	2.63h	7.14def
Orogoro	8.29i	1.03a	0.94abc	13.34b	2.21b	6.99ab

Data are means of 3 replicates
Data with the same subscript are not significantly different at p<0.05

Beltran and Moral (1991) reported that high TBA values are correlated with the degree of oxidation of

fats in hot smoked sardines. Proteins are highly complex nitrogenous organic compounds which occur naturally in all living matter and form an important part of animal tissues. They are polymers of amino acids. TVB-N is related to protein breakdown and is an index of fish spoilage (da Silva, 2002). The legislative standard for TVB-N include: 20mgN/100g for fresh fish, 30 mgN/100g stale fish and 40 mgN/100g for fish that is unfit for human consumption but can be used for animal feed (FAO, 1992; da Silva, 2002). In this study, the total volatile base-nitrogen (TVB-N) of fresh unsmoked silver catfish samples ranged from 13.15 - 15.40mgN/kg and total volatile base- nitrogen (TVB-N) of smoked silver catfish samples ranged from 17.59 - 19.69mgN/kg and 15.63 - 17.86mgN/kg. These values are within the range of legislative standard for TVB-N which is 20mgN/100g for fresh fish. This suggests that the level of protein decomposition or breakdown in all the samples is low. The spoilage of fish is due to bacterial and enzyme action, which results in the production of various volatile compounds such as trimethylamine (TMA), dimethylamine (DMA), ammonia and volatile acids. Trimethylamine (TMA) is a reduction product of trimethylamine oxide during spoilage and ammonia is mainly formed as a product of protein breakdown. Trimethylamine (TMA) is one of the volatile amines plus ammonia which can be used as an index of spoilage (da Silva, 2002). In this study, the trimethylamine value (TMA) for fresh unsmoked silver catfish samples was 2.04 – 2.61mgN/kg and 2.36 – 2.96mgN/kg and 2.11 – 2.72mgN/kg for smoked silver catfish samples. The trimethylamine value (TMA) of 2.04 – 2.61mgN/kg for fresh fish samples and 2.36 – 2.96mgN/kg and 2.11 – 2.72mgN/kg for smoked silver catfish samples are within the range of < 3mgN/100g for fresh fish, >8mgN/100G for spoiled fish and ≥ 5mgN/100g for doubtful quality specified U.S.F.D.A (da Silva, *et al.,* 2008). pH is among the most critical factors affecting microbial growth and spoilage of foods. The pH value of fresh unsmoked silver catfish samples ranged from 6.90 – 7.24 and pH value of smoked silver catfish samples ranged from 6.27 – 6.86 and 6.5 – 6.86. The pH values of the fresh fish samples was high, this may be due to biochemical reactions and enzyme action as a result of delay in reaching the shore from the sea because most of the fishermen had no cooling system in their boats or canoes. However, the pH in fish tissues drops due to smoking (Doe, 1998; da Silva, 2002).

Table 4: Quality indices of smoked Silver catfish (*Chrysichthys nigrodigitatus*) from different locations using local drum kiln and conventional smoke kiln

Locations	Peroxide value (PV)(mEq,peroxide/kg)		Free fatty acid(FFA) %		Thiobarbituric acid (TBA) (mg Mol/kg)		Total volatile base-nitrogen (TVB-N) (mgN/100g)		Trimethyl amine value (TMA)(mgN/kg)		pH	
	Local	Convect	Local	Convect	Local	Local	Local	Convect	Local	Convect	Local	Convect
Agbalata	9.11efg	8.36gh	1.21de	1.13ef	1.10a	1.08b	19.69k	17.86i	2.52abc	2.36bcd	6.43abcde	6.51a
Ajido	9.19ghi	8.31efgh	1.13abcd	1.07abcdef	1.01a	0.99a	18.38c	16.61d	2.63abcd	2.41cde	6.48bcdef	6.73ef
Asakpo	9.24i	8.46i	1.11abcd	1.05abcdef	1.08a	1.06ab	18.56de	16.78e	2.58abcd	2.29b	6.67gh	6.62bcd
Boguru	9.17ghi	8.41hi	1.26e	1.23g	1.14a	1.12bc	19.27hi	17.36g	2.72a	2.53h	6.62fgh	6.66cdef
Fvanuveh	8.99cde	7.84d	1.12abcd	1.10bcdef	1.11a	1.08b	19.15gh	17.62h	2.56abcd	2.38bcd	6.54cdefg	6.61def
Gberefun	9.03def	8.23e	1.09abcd	1.04abcde	1.02a	1.00a	18.44cd	16.89f	2.91cd	2.67ij	6.41abcd	6.90g
Gbetrome	9.14fghi	8.67j	1.07abc	1.01a	1.03a	1.01a	19.13g	17.41g	2.84cd	2.62i	6.73h	6.68def
Ilaje	8.94cd	7.89d	1.18cde	1.13ef	1.06a	1.04a	18.53de	16.67de	2.74bcd	2.50efg	6.39abc	6.73ef
Kofegameh	9.08efg	8.26efg	1.20de	1.14f	1.15a	1.11bc	18.78f	16.34c	2.93cd	2.69ij	6.46bcdef	6.86g
Pako	9.21hi	8.34fgh	1.16bcde	1.11cdef	1.13a	1.06ab	19.31ij	17.64h	2.71bcd	2.43def	6.55cdefg	6.75f
Afuye	9.39j	8.63j	1.05ab	1.02abc	1.05a	1.01a	18.11b	16.32c	2.75bcd	2.48efg	6.42abcde	6.57abc
BodinYawa	9.08efg	8.25ef	1.09abcd	1.03abcd	1.01a	0.98a	17.63a	15.56a	2.79cd	2.51gh	6.57cdefgh	6.69cde
Idale	8.79b	7.91d	1.06ab	1.00a	1.02a	0.99a	18.18b	16.23c	2.84cd	2.63ij	6.43abcde	6.52a
Igbodun	9.15fghi	8.36gh	1.13abcd	1.11cdef	1.10a	1.07ab	19.43j	17.92i	2.78cd	2.52gh	6.41abcd	6.63cde
Ilogun	8.24a	7.13a	1.07abc	1.05abcdef	1.04a	1.02a	17.59a	15.67b	2.87cd	2.68ij	6.54cdefg	6.74f
Mejona	9.12fghi	8.32efgh	1.16bcde	1.12def	1.12a	1.10bc	19.15gh	17.32g	2.36ab	2.11a	6.60efgh	6.65cdef
Oluwo	8.69b	7.51c	1.04ab	1.02abc	1.10a	1.06ab	19.30ij	17.81i	2.63abcd	2.49efg	6.63fgh	6.53ab
Okorisan	8.26a	7.42b	1.02a	1.01ab	1.09a	1.07ab	18.19b	16.23c	2.72bcd	2.53h	6.58defgh	6.84g
Orita	8.91c	8.23e	1.03a	1.01ab	1.02a	1.00a	19.26ghi	17.53h	2.96cd	2.72j	6.27a	6.59abcd
Orogoro	9.16ghi	8.47i	1.12abcd	1.09abcdef	1.10a	1.05a	18.64ef	16.75e	2.54abcd	2.33bc	6.32ab	6.73ef

Local = Local drum kiln Convect = Convectional smoke kiln

Data are means of 3 replicates

Data with the same subscript are not significantly different at $p<0.05$

CONCLUSION

This research work revealed that moisture content of fish is of great importance as a number of biochemical reactions and physiological changes in fish depend on moisture content. In contrary to protein, fat, and ash, the moisture content of fresh fish samples decreased sharply after the smoking process. This decrease had been found to be due to loss of water during smoking. Protein content in smoked fish samples has been found to increase due to an increase in the dry matter content per unit weight following sample dehydration during smoking. There was an inverse relationship between the moisture and protein content in the smoked fish. The increase in mineral content, ash and crude fibre can be attributed to an increase in the dry matter content per unit weight following sample dehydration. The increased TBA values in the smoked fish probably originated from the breakdown of oxidation products during smoking due to the high temperature. The pH values of the fresh fish samples was found to be high, this may be due to biochemical reactions and enzyme actions as a result of delay in reaching the shore from the sea because most of the fishermen had no cooling system in their boats or canoes. However, the pH in fish tissues drops due to smoking. Convention smoke kiln did not significantly affect pH and composition of smoked fish. It, however, significantly reduced the moisture content of smoked fish and

the quality indices such as FFA, TBA and PV.

REFERENCES

Aberoumand, A. (2010). Estimation of Microbiological Variations in Minced Lean Fish Products. World Journal of Fish and Marine Sciences 2(3): 204 –207.

Abolagba, O.J. and Melle, O.O (2008). Chemical composition and keeping qualities of a Scaly Fish Tilapia (*Oreochromis niloticus*) Smoked with two Energy Sources. *African J. Gen. Agric*., KLOBEX, 4(2): 113-117.

Abolagba, O. J; Osifo S. J (2004) The effect of smoking on the chemical composityion and keeping qualities of cat fish **(***Heterobronchus bidosalis***)** using two energy sources. *J Agric Forestry Fish* 51: 27-30.

Adebayo-Tayo, B. C, A.A. Onilude and U.G. Patrick, (2008). Mycoflora of Smoke-dried Fishes Sold in Uyo, Eastern Nigeria. World J. Agric Sci. Pp23

Adenike OM (2014) The Effect of Different Processing Methods on the Nutritional Quality and Microbiological Status of Cat Fish (*Clarias lezera*). *J Food Process Technol* 5: 333. doi:10.4172/2157-7110.1000333

Afolabi OA, Arawomo OA. Oke, L.O. Quality changes of Nigerian Traditionally Processed freshwater fish species. I. Nutritive and organoleptic changes. Journal of Food Technology. 1984. 19, 333-340.

Al-Jedah J. H, Ali M. Z, Robinson R. K (1999). The nutritional importance to local communities of fish caught off the coast of Quatar. Nutr. Food Sci., 6: 288-294.

Akinyemi A. A., Adejola A. Q., Obasa S. O. and Ezeri G. N. O (2011) Aflatoxins in Smoked - dried Fish sold in Abeokuta, Ogun State, South - west Nigeria. Proceedings of the Environmental Management Conference, Federal University of Agriculture, Abeokuta, Nigeria, 2011pp476-486

AOAC (2005) Official Methods of Analysis, 15th Edition. Association of Analytical Chemists, Washington DC.

AOAC International. (2000) *Official Methods of Analysis*, 20th ed. AOAC International, Gaithersburg, MD.

Asiedu, M.S., Julshamn, K., and Lie, O. (1991) Effect of local processing methods (cooking, frying, and smoking) on three fish species from Ghana: Part I, Proximate composition, fatty acids, minerals, trace elements, and vitamins. Food Chem. 40:309-321.

Beltran, A. and Moral, A. (1991) Changes in fatty acid composition of fresh and frozen sardine (*Sardinella pilchardus*) during smoking. Food Chem. 42:99-109.

Burt J.R. (1988) Fish Smoking and Drying. The Effect of Smoking and Drying on the Nutritional Properties of Fish. Elsevier Applied Science. London and New York.

Calhoun, C.M., Gaebler, D.M., and Mandingo, R.W. (1999) Storage stability of ground pork containing meat from an advanced meat recovery system. *J. Food Sci., 64*: 69-75.

Clucks IJ, Ward AR. (1996) Post harvest Fisheries Development: A guide to handling, preservation, processing and quality. Chamita Maritime, Kent ME4 4TB, U.K.

Crapo, C (2011) Smoking Fish at Home. The University of Alaska, Fairbanks Cooperative Extension Service programs. Pp1- 4

da Silva, L. V. A (2002) Hazard Analysis Critical Control Point (HACCP), Microbial Safety, and Shelf Life of Smoked Blue Catfish *(Ictalurus furcatus*). A Master of Science in Food Science Thesis, the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College.

da Silva, L. V. A; Prinyawiwatkul, W; King, J. M ; No, H. K ; , Bankston, J. D Jr; Ge, B (2008) Effect of preservatives on microbial safety and quality of smoked blue catfish (Ictalurus furcatus) steaks during room-temperature storage. *Food Microbiol.* 2008 Dec;25(8):958-63

Doe, P. E. (1998). Fish Drying and Smoking Production and Quality, Pp.89–115. Lancaster, PA: Technomic Publishing Co., Inc.

Efiuvwevwere, B. J. O; Ajiboye, M. O (1996) Control of microbiological Quality and Shelf-life of Catfish (Clarias gariepinus) by Chemical preservatives and smoking. Journal of Applied Microbiology 80: 465-47

Eyo, A. A. (1992), Traditional and improved fish handling, preservation and processing techniques, NAERLS/NIFER national workshop on fish processing, storage, marketing and utilization, pp: 15

Eyo A. A., (2001) Fish processing technology in the tropics. University of Ilorin press, Nigeria. 403pp. ISSN 978 1770457

FAO (1984) Fish Processing in Africa. FAO, Fish .Rep. (329)

FDA, Department of Health and Human Services, (2001) Pathogen Growth & Toxin Formation as a Result of inadequate Drying. *In Fish & Fisheries Products Hazards & Controls Guidance*: Third Ed. Chapter 14, p. 191.

Goktepe, I. and Moody, M.W (1998) Effect of modified atmosphere package on the quality of smoked catfish. Journal of Muscle Foods, 9:375-389.

Hashimoto, K., Watanabe, S., Kono, M. and Shiro, K. (1979). Muscle protein composition of sardine and mackerel. Bulletin of the Japanese Society for the Science of Fish, 45, 1435–1441.

ICMSF (International Commission on Microbiological Specification for Foods) (1986) Microorganisms in Foods 2, Sampling for Microbiological Analysis. Principles and Specifications, 2nd edn. Oxford: Blackwell Science.

ISO (1993).International Organization for Standardisation ISO 8586–1993. Sensory Analysis. General Guidance for the Selection, Training and Monitoring of Assessors. Geneva: Switzerland.

ISO (1997). International Organization for Standaritation. ISO 5983–1997. Determination of nitrogen content and calculation of crudeprotein content-Kjeldahl method.

Nelson, J. S (2006) Fishes of the World. John Wiley & Sons, Inc. Canada.

Nickelson, R. and Finne, G. (1992) Fish, crustaceans, and precooked seafoods. In Compendium for the Microbiological Examination of Foods, American Public Health Association, 3rd ed., Ch. 47, Carl Vanderzant and Don Splittstoesser (Ed.), Washington, DC.

Sikoki, F. D. I (2013) "Fishes in Nigerian Waters: No Place to Hide". An Inaugural Lecture. Department of Animal and Environmental Biology, Faculty of Biological Sciences, College of Natural & Applied Sciences. University of Port Harcourt, Inaugural Lecture Series, No. 100. 31st January, 2013.

Simko, P. (1991) Changes of Benzo (a) Pyrene content in smoked fish during storage. *Food Chem.* 40:293-300.

Simko P (2002) Determination of polycyclic aromatic hydrocarbons in smoked meat products and smoke flavouring food additives. B: Analytical Technologies in the Biomedical and Life Sciences, *J. Chromatogra.*, 770: 3-18.

Woyewoda, A.D., Shaw, S.J., Ke, P.J., and Burns, B.G. (1986) Quality indices-lipid related. *In Recommended Laboratory Methods for Assessment of Fish Quality*. Canadian technical report of fisheries and aquatic science, Canada.

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