Nigerian Journal of Fisheries Vol. 23, No. 1; 2026
https://doi.org/10.65995/njf.2026.v2301.07

EFFECTS OF DIFFERENT SMOKE SOURCES ON THE PROXIMATE COMPOSITION AND SENSORY PROPERTIES OF AFRICAN CATFISH (*Clarias gariepinus*) USING NIOMR MODERN SMOKING KILN

[*1]OKEREKE, A. N., [2]O. A. ADENIYI and [3]J. S. EWUTANURE
[1]*Nigerian Institute for Oceanography and Marine Research of the African Regional Aquaculture Centre, Rivers State, Nigeria.*
[2]*Department of Animal Science, Faculty of Agriculture. Ajayi Crowther University, Oyo, Nigeria.*
[3]*Department of Fisheries and Aquaculture, Faculty of Environmental Management, Nigeria Maritime University, Okerenkoko, Delta State, Nigeria.*
**Correspondence: oa.adeniyiosas@acu.edu.ng*

Abstract
As a result of the likely high cost of appropriate smoking sources, up to one-third of fish is wasted and spoils within a few days, leading to the waste of fish and its scarcity. In this study, three samples of fresh African catfish (Clarias gariepinus) were smoked using sawdust, charcoal, and wood, with charcoal as a control. The fish samples were collected from the African Regional Aquaculture Centre pond. Results of the proximate composition showed that the charcoal-dried fish has the highest crude protein (60.1%) followed by fish samples dried with sawdust had (50.2%) while samples smoked with wood have 35.2% protein. The sample smoked with wood had the lowest moisture content (13.5 %) compared with the fish smoked with charcoal and sawdust (13.59%). The fat content and the crude fibre of the fish smoked with sawdust were higher (8.36% and 6.03%) than those of the fish smoked with charcoal and wood (3.20% and 4.24%). There were significant differences (p> 0.05) in the taste, flavor, and color of the fish smoked with firewood as a smoke source (4.04%, 2.22%, and 1.00%, respectively). There was no significant difference (p>0.05) in the taste, flavour, and color of the fish smoked with charcoal and sawdust. The general acceptability of the fish smoked with charcoal was highly significant.

Keywords: *Clarias gariepinus*, Smoke sources, Preservation, Proximate analyses, sensory.

INTRODUCTION

Food crisis is the challenge of the 21st century. The future global population is estimated growth is 9-10 billion people (FAO, 2012). Most resources are scarce and up to a third of food is wasted or gets spoilt within a few days due to the likely high cost of appropriate smoking source. Fish processing and preservation are an important part of food security. Food security is "a state of affairs where all people at all times have access to safe and nutritious food to maintain a healthy and active life". Currently, a global focus on connections between health and diet induces growth within the food industry and open number of commercial opportunities at various fronts.

Improving the quality of life in the rural areas and the level of poverty constitutes a major problem facing developing countries, especially Nigeria and Africa at a whole. The level of poverty is clearly manifested in the level of post –harvest loss. Post-harvest losses through widespread poor preservation and processing techniques have been identified as one of the prominent causes; this exacerbates the deficit in fish supply and the economy at large. Post-harvest losses in fish translate reduction in amounts of nutrients available to the consumer either by direct physical loss or nutritional loss. These factors influence consumer acceptability, commercial value, income of fish producers. Post-harvest losses are very high in artisanal fisheries because of lack of adequate processing, preservation and storage facilities. Hence fish preservation and processing become very important to economic development in Nigeria (Akinola *et al*., 2006). A good processing and preservation techniques requires a moderate use of raw material and production of value added products which is the main aim of profitability (Opara and Al-jufialli, 2006)

Africa is making appreciable progress in domestic fish essentially through fish farming and culture-based inland fish production to increase the protein intake of the populace. Nigeria produce over 300,000t/year from fish farming and catfish accounts for 90% of the total production (Eyo, 2001). Akinneye *et al*. (2007) and Davis *et al.* (2009) reported that the development of appropriate fishing machinery and techniques that employed effective production, handling, harvesting, processing and storage, cannot be over-emphasized especially in the age when aqua cultural development is gathering momentum in Nigeria. However, proximate composition of fish has been found to improve learning ability, prevent neural diseases and play a very important role in autogenesis (the origin and development of an organism). Hence, fish is a perishable food that is susceptible to autolysis, in order to prevent this, there is need for processing and preservation techniques such as smoking .This can be used to improve the value of all species of fish in Nigeria. It has been estimated that 70-80 per cent of the domestic marine and freshwater catch is consumed in smoked form (Akinyemi *et al*., 2011).However smoking becomes one of the oldest methods used to process and preserve fish (Fawole *et al.,* 2007; Hultmanna *et al*., 2004; Simko, 2002).Smoking can inhibit the formation of toxins in product, reduce the growth of bacteria, due to lower water activity in combination with salting and drying which creates a physical surface barrier (Swastawati *et al*., 2000).

Furthermore, processing and preservation of fish should

assure the best market quality, safety of product, reduce wastes to the nearest possible state. Fish production becomes a major industry in Nigeria. However, there is a limited exposure of fish to modern fish preservation technology. Fish being perishable food, smoking remains the best method of preventing spoilage thereby extending the shelf life of fish. This is often done with wood, sawdust, charcoal and other sources of energy. The design of kiln is a very important factors to consider for effective preservative methods .It also has effect of impacting a pleasant flavor to the product beside the preservatives effect of the smoke. Hence most researchers are concerned about the quality of the product .However; pretreatment of fish for smoking may widely differ depending on the equipment used .This will make the fish in the market to vary in their quality. It is important that the design of the kiln should be considered since the smoking process, operation and smoking source involved in smoking are different. Hence, smoked fish is a foreign exchange earner for Nigerians. Although, fish is a very perishable food. Smoking can be done on a commercial scale and remains the cheapest means of preventing spoilage. It can be done using different smoking source (FAO,2012). However, smoking preserves fish by drying and it deposit phenols and aldehydes which have powerful bactericidal action and prevent the growth of microorganism on the fish (Akinyemi *et al*., 2011) .The smoke determines the colour which is one of the attributes that attract consumers. This colour ranges from black, dark-brown, golden brown or light brown. This may be dependent on the smoking source. The determination of the proximate composition is very important to make sure they meet the requirement of food regulation and commercial specification

Nigerian Institute for Oceanography and Marine Research (NIOMR) modern smoking kiln used in this study is made from galvanized iron sheet. It is heavy and not cost effective. It has some advantages over traditional smoking kiln which are Smoke free, reduced health hazard to fish smokers, low risks of fire out breaks(Okerke*et al*., 2014). It has better overall product quality and longer shelf life, Temperature distribution is very good, uniform fish drying. The door with a locking system protects the fish against pilferage and attack by rodents. (Okerke*et al*., 2014)

Okereke *et al.,* (2016) reported that the various resources available for fish smoking include traditional smoking kiln such as cut drum oven ,choker oven ,gas oven .These resources can use gas or natural fuel such as fire wood, charcoal, wood and saw dust as smoking source . Fish preservation is based on the principle of keeping the fish at unfavorable temperature thereby reducing the water quality at the lowest level which will prevent the growth of microorganism. In 2009, fish accounted for 16.6 percent of the world population's intake of animal protein and 6.5 percent of all protein consumed (Okereke *et al.,* 2014). The development of appropriate fishing machinery and techniques that involve effective production, handling, harvesting, processing and storage cannot be overemphasized (Yola and Timothy, 2012). Drying using smoking kiln had a great influence on the nutritional quality of fish There is need for proper utilization of available sea food species and fish to ensure adequate nutrition for all. Food insecurity in sub Saharan Africa is characterized by widespread and chronic hunger and malnutrition as well as recurrent and acute food crises (Okerke *et al*., (2014) had also reported effects of different equipment such as NIOMR smoking kiln, oven, and local cut drum oven on the nutritional composition of *Clarias gariepinus* and the effect of the density of smoke, time and temperature of smoking on the spoilage of smoked products. Smoked fish has specific odor, taste and yellow colour (FAO, 2012). However, smoking contributed greatly to fish preservation by providing an effective bactericidal agent and antioxidant and a protective film on the smoked fish. The smoke compounds that worked as a bacteriostatic effect are the acids, aldehydes and phenolic compound (FAO, 2012. This also affect product quality. Davis *et al.(* 2009) reported nutritional losses from preservation process. The proximate composition of smoked catfish are very important to ascertain that they meet the requirements of food regulations and commercial specification (Aremu and Ekunode, 2008). However, the aim of smoking is not only for preservation, it also add flavor, and color to the product. It also retards the activities of bacteria, enzyme and chemicals as well as bacterial multiplication. However, smoked fish remains a delicacy in the dishes of Nigeria. In Nigeria, the smoked fish industry is dominated by peasant fish farmers who are presently having problem of underdevelopment, appropriate fishing machinery and techniques, different smoking source and methods. Smoked fish also has specific odour, taste and yellow colour (Okereke and Onukwuo, 2014; Bilgin *et al*., 2008).Hence there is need for a better understanding on the effect of different smoke source on the proximate composition of catfish and sensory properties to provide a successful marketing strategy that will improve sustainability of the country and industry. However, this will provide information on the effective utilization of smoked catfish in various food applications in Nigeria. This study therefore investigates effect of different smoke source on the proximate composition and sensory properties of catfish (*Clarias gariepinus)*.

MATERIALS AND METHODS

A modified Nigerian Institute for Oceanography and Marine Research (NIOMR) smoking kiln from African Regional Aquaculture Centre was used for the smoking operation. The smoke source of charcoal and firewood were bought from Choba market and the sawdust were bought from the timber market at Rumuosi market, Port Harcourt, River State. Ten (10kg) of African catfish (*Clarias gariepinus)* was obtained from the pond of African Regional Aquaculture Centre. Five kilo gramme of fish ,each weighing five hundred gram (500g) of fish smoked using charcoal as a smoke source were stunned with 6 g of salt for 5 minutes to inactivate the fish, degutted, washed thoroughly for 3 times to remove the slime. It was brine with 3 grams of salt for 15 to 20 minutes to improve the taste and also extend the shelf life. The fish were spiced with 6 g of pepper then allowed to drain

before smoking. The same was done with the other 2 samples using firewood and sawdust as a smoke source Hot smoking of the 3 samples were done at a temperature between 80^{0}C and 100^{0}C usingdigital thermometer for 4h. The cold smoking was done at a temperature of 30^{0}C to 40^{0}Cfor 48 h using thermometer, they were allowed to cool at room temperature for 24h (Okereke *et al*., 2014)

Proximate analysis
The method of (AOAC, 2010) was used for the proximate analysis. The carbohydrate content was calculated by difference (AOAC, 2010).

Sensory evaluation
The sensory evaluation of the products were carried out by 25 man panel, who rated each features on a 9 points hedonic scale as described by Iwe (2001). The parameter tested were colour, texture, taste and general acceptability

Statistical Analysis
The analyses were done in triplicate. Data were subjected to analysis of variance (ANOVA) Mean were separated using Duncans multiple range test and significance level accepted at(P≤ 0.05).The mean and standard deviation values were calculated . The statistical package used was IBM SPSS Inc. software (version 21.0).Mean values were compared using one-way ANOVA.

RESULTS
Table 1 shows sensory evaluation of fish (*Clarias gariepinus*) treated with different smoke sources using NIOMR modern smoking kiln. Taste of different fish samples ranged between 4.04 – 8.20 with the firewood smoked fish as the lowest and the charcoal treated as the highest. The flavor of fish smoked with charcoal had the highest value of (7.44) and it was reduced to (7.28) with the fish smoked with sawdust. The fish smoked with firewood had the least value of flavour (2.22); the colour of fish smoked with charcoal had the highest value of (7.76), the fish smoked with sawdust had (7.60) and the fish smoked with firewood as the lowest value (1.00). The appearance of different fish samples ranged between (1.13- 8.16) with the charcoal smoked fish as the highest and the fire wood as the lowest. The general acceptability of fish smoked with charcoal was the highest (7.89) compared to that of the fish samples smoked with sawdust. The fish sample smoked with firewood had the least value of general acceptability (2.97).

Table 1: Sensory properties of fish smoked with different smoke sources

Smoke Source	Taste	Flavor	Color	Appearance	General acceptability
Charcoal	8.20±0.01^a	7.44±0.001^a	7.76±0.01^a	8.16±0.001^a	7.89±0.01^a
Sawdust	7.72±0.01^a	7.28±0.01^a	7.60±0.01^a	7.84±0.001^a	7.61±0.01^a
Firewood	4.04±0.001^b	2.22±0.001^b	1.00±0.01^a	1.13±0.001^b	2.97±0.001^a

**Values are means ± standard deviation of duplicate determination. Means with different superscripts within the same column are significantly different (P<0.05).*

Table 2: Proximate Composition of Catfish Smoked with different smoke sources (%)

	Firewood	Charcoal	Sawdust
Moisture	13.5±0.01^b	4.20±0.01^a	3.59±0.01^b
Crude protein	48.20±0.005^a	59.53±0.01^a	50.10±0.01^b
Ash	5.32±0.001^a	0.25±0.01^a	6.02±0.01^a
Crude fibre	9.07±0.01^b	7.30±0.01^b	6.03±0.02^b
Fat	4.24±0.01^b	3.20±0.01^a	8.36±0.005^a
Carbohydrate	17.03± 0.01^b	13.70±0.01^a	14.00±0.005^a

*Mean values in the same row with different superscript differ significantly (P < 0.05)

Table 2 presents the effect of different smoke sources on the proximate composition of smoked fish using a modern smoking kiln. The highest moisture content was (13.5 %) forthe fish smoked with firewood, while the lowest moisture content was found in fish smoked with charcoal (4.20 %). The percentage crude protein in smoked catfish using charcoal as a smoking source was higher than that of the fish smoked with firewood and sawdust. The highest value of crude protein was (59.53%) in fish smoked with charcoal as a smoking source, and 50.10% with sawdust as a smoking source, while the lowest was (48.20%) with firewood as a smoking source. The highest value of fat (8.36%) were recorded in fish smoked with sawdust followed by the fish smoked with firewood (4.24%) while the lowest fat content (3.20%) were recorded in fish smoked with charcoal.

The highest value of ash (6.02±0.01) were recorded in smoked fish with sawdust next to the fish smoked with firewood (5.32%) while the lowest ash content was recorded for the fish smoked with charcoal (0.25%).
Fish smoked with firewood recorded the highest value of crude fibre (9.07%) next to fish smoked with charcoal (7.30%) while the fish smoked with sawdust had (6.03%).The carbohydrate content (17.03%) of the sample smoked with firewood was the highest. The ranged values of 1.26% to 2.54 are lower than that for some plants food.

DISCUSSION

The flavor of fish smoked with charcoal and sawdust were not significantly different (P≤0.05). The flavor of fish smoked with charcoal with the highest value of (7.44) was reduced to (7.28) with the fish smoked with sawdust.The fish smoked with firewood had the least value of flavour (2.22) and was significantly different (P<0.05) from the fish smoked with charcoal and sawdust.

The colour of fish smoked with firewood was significantly different (P<0.05) from the sample smoked with charcoal and sawdust. There was significant difference on the appearance of fish sample smoked with charcoal compared to the samples smoked with charcoal and sawdust. The general acceptability of fish smoked with charcoal was the highest (8.00) compared to that of the fish samples smoked with sawdust .The fish sample smoked with firewood had the least value of general acceptability (2.30) and is significantly different from the samples smoked with charcoal and sawdust.

There was no significant difference in the taste, flavor and color of the fish smoked with charcoal and sawdust (P>0.05). The general acceptability of the fish smoked with charcoal was highly significant with value of (8.00) (Okereke *et al.*, 2014; Yola and Timothy, 2012) also reported that different processing methods affects the general acceptability of a product. The range of color and taste of a food is very critical and a departure from an expected taste and color is a measure of quality defects. The colour of food often affects our perception and evaluation by other sense. This confirmed the work of Heinio *et al.,* (2016) and Okereke *et al.., (*2014) who reported that food colour helps to determine quality, degree of processing on spoilage. The utilization of smoked fish considering consumers preference would contribute to health, food security and sustainable food production.

The colour observed from the fish smoked with sawdust was in line with the work of Okereke *et al.* (2014) who reported that smoking of fish with soft wood materials added appreciable colour to the smoked product. Okereke *et al*., (2014) stated that smoked dried fish had the most attractive colour as against oven and sun dried samples. The design of the kiln and the smoking process could have effect on imparting pleasant flavor on the fish smoked using charcoal as a smoking source

In the result presented in Table 2, there was significant difference (P<0.05) on the moisture content of the fish smoked with charcoal as a smoke source than firewood and sawdust. The high content of the moisture content of fish smoked with sawdust is in tandem with the work of Aremu *et al*., (2013) who stated that fish sample smoked with saw dust had the highest moisture content of 4.46%. . The differences in nutrient content of smoked fish could be as a result of species and the differences in the efficiency of drying by different smoke sources. The 4.20% of fish smoked with charcoal in this study compares favourably with the one smoked with sawdust according to Aremu *et al.,* (2013) and 4.55% for C*aesalpina pulcherrima* (Aremu *et al.*, 2011) .The reduction in moisture content of smoked fish with charcoal as a smoking source could be as a result of hot smoking (Ogbonnaya and Ibrahim,2009) (Okereke *et al*.,2014). This is also in line with the findings of (Kumolu-Johnson and Ndimele, 2001) which reported that spoilage of fish resulting from the action of enzymes and bacteria can be slowed down by the reduction in moisture through smoking. This also contradicts the work of (Aremu *et al*.,2013) who stated that the fish sample smoked with sawdust had the highest moisture content of 4.46% .The percentage crude protein in smoked catfish using charcoal as a smoking source were significantly higher (P<0.05) than the fish smoked with firewood and sawdust. The highest value of crude protein (59.53%) in fish smoked with charcoal as a smoking sources and 50.10% with sawdust as a smoking source while the lowest was (48.20%) with firewood as a smoking source is in line with Okereke and Onunkwo (2014) which reported that there is an inverse relationship between the protein level and moisture content of food. The increase in protein contents may be due to product dehydration which concentrated the proteins during the heat treatment of the fish, thus increasing the nutritional value of the cat fish (Okereke *et al*., 2014) .The increase in protein is an added advantage as protein helps primarily to build and maintain body cells (Doe and Oily, 1983). Salen *et al*., (2006) also reported that smoking resulted in the increase in protein concentration and the increase could also be as a result of different smoke source. The major nutrients in fish are protein and fat. It is important to know that variation in the protein content could be as a result of species, different smoke source and types of smoking.

The highest value of fat recorded in smoked fish with sawdust as a smoking source is in agreement with the findings of Adebowale *et al.,* 2008 who reported significant difference of moisture, protein, fat and ash content of smoked catfish. Fat also supplies essential fatty acids needed in the body. Okereke *et al*., 2014 also stated that the increase in ash content when fish are smoked is due to loss of humidity. Smoking of fish using sawdust as a smoking source increased the fat content (8.36%).This is in contrast with the work of Okereke *et al*., (2014) who reported that the fat content of fresh catfish was 3.64% . This is however lower than the reported value of 19.80% to 23.90% for smoked *Clarias gariepinus* from Lagos State University (Nigeria) fish pond and Badagry market, respectively (Kumolu-Johnson and Ndimele, 2001).

The highest value of ash 6.02% for fish smoked with sawdust is in line with the work of (Aremu *et al*., (2013) who stated an increase in the fish smoked with sawdust as a smoking source. Okereke *et al.* (2014) reported that the ash content of fresh catfish was 0.68%.This means that smoking fish with sawdust as a smoking source increased the ash content. This contradict the work of Aremu *et al*. (2006) who reported lower ash content of catfish dried with electric oven . According to Okereke *et al*., (2014), ash is a non-organic compound containing food minerals and nutritionally, it aids in the metabolism of organic compounds such as fat and carbohydrates. The percent of

fat, protein and ash contents increased significantly because of loss of moisture and an increase in the dry matter content per unit of weight following sample dehydration.

There were significant differences ($P<0.05$) in the crude fiber content of fish smoked with firewood, charcoal and sawdust as a smoking source. This contradict the work of Ogbonnaya and Ibrahim (2009) who reported that the crude fiber content of 7.16% obtained for fish sample smoked with an electric oven is less than the values obtained for sawdust, rice bran and melon husk heat treatments, and ranged from7.16% to 15.63%

Conclusion

The quality of the smoked fish using charcoal and sawdust as smoked source improved the colour, taste and flavor of the fish. This will improve the knowledge of rural women in the use of appropriate smoke source,thereby providing processors better working conditions and alsoenable them to produce good quality and highly competitive smoked dried fish products for local and international market. The use of charcoal and sawdust as smoked source is therefore highly recommended based on the consumers preference.

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