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EFFECTS OF SAWDUST SMOKE ON THE PROXIMATE COMPOSITION AND SENSORY ATTRIBUTES OF SMOKED FISH

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Abstract

The effects of cassava (Akpu) and Gmelina sawdust smoke on quality of smoked fish (Scomber scombrus and Trachurus trachurus) was investigated. Two varieties of frozen fresh fishes were obtained from Abakpa meat market in Abakaliki, Ebonyi State. The fishes were independently smoked with different sawdust to dryness and their proximate composition and sensory attributes were evaluated using standard methods. The results showed that moisture content ranged from 16.80 to 21.10 %, protein 51.19 to 60.05 %, fat 13.90 to 15.50 %, fibre 0.75 to 1.50 %, total ash 4.0 to 5.40 %, and carbohydrate 1.23 to 7.66 %. The results obtained showed that proximate composition of fish smoked with "Akpu" or Gmelina sawdust is in agreement with previous literatures. The organoleptic properties for smoked Scomber scombrus and Trachurus trachurus were evaluated by 20 trained panellists and they showed their preference for Scombia smoked with Akpu sawdust in terms of taste, colour, flavour, and general acceptability. The study shows that sawdust type did not significantly affect ($p< 0.05$) the nutritional quality of the smoked fishes, but however scombia smoked with "akpu" is most preferred by consumers.

Keywords: Akpu, Gmelina, *Scomber scombrus, Trachurus trachurus*

INTRODUCTION

Fish is a highly nutritious food that contains low fats and high quality protein that provides range of health benefits. Fish is currently being used as a good tool for food protein energy malnutrition (Ojutiku *et al.,* 2009). However, fish is highly perishable because it provides favourable medium for the growth of microorganisms after death (Oparaku and Mgbenka, 2012). It has become increasingly important to ensure that fish once caught is fully and efficiently utilized to avoid deterioration (Ojutiku *et al.,* 2009).

In a healthy live fish, all the complex biochemical reactions are balanced and the fish flesh is sterile (Adeyeye, 2016). After death however, irreversible change that results in fish spoilage begins to occur, the resultant effect is the decomposition of the fish (Akinola *et al.,* 2006). Fish quality also depends on the handling and the preservation practice after capture and this affects the degree of spoilage of the fish (Akinneye *et al.,* 2007) because Fish is highly susceptible to deterioration without any preservative or processing measures (Okonta and Ekelemu, 2005).

Mackerel is considered one of the healthiest fish because it is rich in omega-3 fatty acids and an excellent source of selenium, niacin, and vitamins B_6 and B_{12} (NOAA, 2014). Icelandic Ministry of Fisheries (2014) also reported that mackerel is a valuable pelagic fish and most of the catch is for human consumption. Mackerel is a fatty fish, and the fat and water content vary with season. The fat content is about 6-23%, water content is 56-74% and protein content are 18-20 % throughout the year (FAO, 2015). Fresh mackerel is very perishable because of its high fat and oil and protein content.

Akinola *et al*. (2006) reported different types of fish preservation methods; sun drying, smoking, freezing, chilling and brining. But the most prominent fish preservation method in Nigeria is smoke drying (Ikenweiwe *et al.,* 2010). This could be adduced to the fact that most of the fish communities have no access to electricity to freeze their products. Therefore, electricity itself is fast becoming a less reliable source of energy for fish processing and preservation (Ahmed *et al.,* 2011). Smoking is one of the oldest methods used to process and preserve fish (Bilgin *et al.,* 2008; Hultmanna *et al.,* 2004).

Smoking can inhibit the formation of toxins in products, by reducing the growth of bacteria, due to lower water activity which creates a physical surface barrier (Rorvik, 2000; Swastawati *et al.,*

2000). The spoilage and pathogenic micro flora of smoked products are affected by density of smoke, concentration of active components of the smoke in combination with the salt content, and the time and temperature of smoking (Kolodziejska *et al.,* 2002). Fuel wood is the main source of energy for fish smoking. Although many wood types may be used as fuel for fish smoking, among the many factors influencing the choice of wood, which is used depends on local availability (Abolagba*et al.,* 2002)

Smoking is one of the oldest traditional method used to process and preserve fish (Bilgin *et al.*, 2008; Hultmanna *et al.,* 2004).Smoking is the process of flavouring, cooking, or preserving food by exposing it to smoke from burning or smoldering material, most often wood. Smoking can inhibit the formation of toxins in products (University of Florida, 2004), reduce the growth of bacteria, due to lower water activity by smoking in combination with salting and drying which creates a physical surface barrier (Rorvik, 2000; Swastawati *et al.,* 2000).

MATERIALS AND METHODS

Sample Collection and Processing

Ten (10) pieces each of the two fresh fish samples, Horse mackerel (*Trachurus trachurus*) locally called Titus and Atlantic mackerel (*Scomber scombrus*) locally called Scombia were purchased from a market in Abakaliki, Ebonyi State. Gmelina and Akpu sawdust were sourced from timber shade at Nkwagu Abakaliki.The fishes were washed and allowed to drip dry. The two fish samples were divided into two portions each, and weighed using a Mettler balance. One portion of each sample was smoked with Gmelina and the other with "*Akpu"* sawdust using a locally fabricated smoke drum kiln in the Processing Laboratory of the Department of Food Science and Technology Ebonyi State University. The smoking kiln was stuffed with 4.5kg each of sawdust and smoking was done according to the method described by Adebowale *et al.* (2008). After smoking, the fish samples were allowed to cool at room temperature, and later packed in a transparent polyethylene bags, sealed and stored in a refrigerator prior to further analysis. The proximate, chemical and sensory analysis were carried out on all the smoked samples.

Determination of Proximate Composition

The determination of the proximate and chemical composition of the smoked fishes samples viz: moisture content, ash content, protein content, fat content, crude fiber and content were determined by methods described by AOAC (2005). Carbohydrate was calculated by difference. The smoked fishes samples were coded and presented to twenty (20) trained panelist to evaluate the sensory qualities: colour, flavor, taste and general acceptability using a nine(9) point hedonic scale, where 9 indicates extremely like and 1 extremely dislike.

Statistical analysis. All analysis was done in three replicates and the means determined. Analysis of variance was performed to determine significant differences between the means. Duncan multiple range was used to separate the means.

RESULTS AND DISCUSSION

Table 1.1: **Proximate composition of (*Scomber scombrus and Trachurus trachurus*) fish smoked with Gmelina and Akpu sawdust.**

Parameter	T. F	S. F	T. A	S. A	T. G	S. G
Moisture (%)	21.10^{a}	20.60^{a}	18.30^{b}	16.80^{c}	18.10^{b}	18.50^{b}
Protein (%)	51.19^{d}	52.28^{c}	58.78^{b}	58.55^{b}	60.05^{a}	60.05^{a}
Fat (%)	13.90^{c}	14.90^{ab}	15.50^{a}	15.30^{a}	14.40^{bc}	15.40^{a}
Fibre (%)	0.75^{c}	0.75^{c}	1.50^{a}	1.25^{ab}	1.50^{a}	1.0^{bc}
Ash (%)	5.40^{a}	5.10^{a}	4.70^{a}	4.70^{ab}	4.20^{b}	4.0^{b}
Carbohydrate (%)	7.66^{a}	6.36^{b}	1.23^{d}	2.47^{c}	1.68^{cd}	1.05^{d}

Values are means of triplicate samples, values with different superscripts along a row are significantly different ($P \leq 0.05$).
T.F = Titus fresh; S.F = Scombia fresh; T.A = Titus smoked with Akpu sawdust; S.A = Scombia smoked with Akpu sawdust; T.G = Titus smoked with Gmelina sawdust; S.G = Scombia smoked with Gmelina sawdust.

The moisture content results for fish samples are as shown in Table 1.1. The values range between 16.80 to 21.10%. The results show that the fresh *Trachurus trachurus* locally called Titus has the highest moisture content of 21.10% followed by fresh *Scomber scombrus* locally called Scombia 20.60%. The moisture content of fish smoked with both Akpu and Gmelina sawdust range between 16.80 to 18.50%.

The statistical analysis of the result shows that the fresh fish samples did not differ significantly from each other but they differed quite significantly from their smoked counterparts at ($p<0.05$). Both Titus smoked with Akpu and Gmelina had no significant difference from Scombia smoked with Gmelina sawdust. However, Scombia smoked with Akpu sawdust had the least moisture content 16.80%, and it differed quite significantly from other samples ($p<0.05$). The moisture content of the fresh frozen fishes was in range with the value 19.80 and 21% reported for fresh Tilapia and Catfish investigated by Ande *et al.* (2012), and was lower than the value 52.76% reported for fresh *Trachurus trachurus* by Adeyemi *et al.* (2013).

The observed low moisture content could be due to the dry weather of the time the research was carried out. The moisture content of the smoked Titus and Scombia with both sawdust are in range with value 18.20, 19.21 and 19.35% respectively reported for smoked *Synodontisclarias*, *Trachurustrecae* and *Clariasgariepinus*by (Oparaku, *et al.*, 2013; Obande et al., 2012). However the moisture content of the smoked fishes were high than the values 7.42, 8.46 and 8.62%reported for smoked *Clariasgariepinus, L. niloticus and S.membranaceus* respectively investigated by (Effiong and Fakunle, 2012; Adam and Sidahmed, 2012). This variation in moisture contents as shown could be due to method of processing, smoking aids and differences in species of fish used.

Egbal *et al*., (2013) reported that the moisture content of fish and food products give an indication of the available dry matter as well as plays a major role in determining the propensity of the food to spoilage. The result has shown that there is a reduction in moisture content of the both fish after smoking which is due to the application of heat and that Scombia smoked with Akpu sawdust has the lowest moisture content therefore can store well than other samples.

The protein content results for fish samples in Table 1.1 shows their values range between 51.19

to 60.05%.The results show that the protein contents of the fresh fishes are in range of 51.19 to 52.28%, and that the fresh fishes had the least protein content, while Titus and Scombia smoked with Gmelina had the highest protein content of 60.05%, however the protein contents of the smoked fishes from both Akpu and Gmelina sawdust ranged between 58.55 to 60.05%.

The statistical analysis of the result shows that the both fishes smoked with Gmelina sawdust had no significant difference ($p<0.05$) but differed significantly from other samples, similarly the fresh fishes differed significantly from each other and also from their smoked counterparts at ($p<0.05$).The values of protein content of smoked Scombia and Titus in this report are higher than results 28% reported for smoked rainbow trout fish by Pinar and Simay, (2013) and the value 20, 30 and 38% reported for *Trachurus Mediterraneus, Merlangiusmerlanguseuxinus* and *Spicarasmaris* respectively by Hunkar *et al.,* (2013), and had the same with the protein content of Scombia smoked with sawdust as investigated by (Matthew *et al.,*2014**;**Adam and Sidahmed, 2012), and the in same range with the values 52.38 to 62.04% reported for smoked *Clarasgenepinus* and *Clupeaharengus* by Adeyemi et al., 2015; Salihu et al, (2013) respectively. From the result it was observed that there was an increase in the protein content of the both fishes after smoking and this suggest that smoked fish is a good source of protein. The result is expected because fish is a major source of protein, and as water is removed during drying the protein concentration increases. The differences in the results obtained from the literature cited may as well be linked to differences in species of fish.

The fat content results for fish samples are as shown in Table 1.1.Their values range between 13.90 to 15.50%.The result shows that the fresh fishes had the least fat content range between 13.90 to 14.90%, whereas Titus smoked with Gmelina and Akpu range between 14.40 to 15.50%, Scombia smoked with Akpu and Gmelina sawdust range between 15.30 to 15.40%, Titus smoked wit Akpu sawdust had the highest fat content of 15.50% and statistically had no significant difference from fresh Scombia and Scombia smoked with Akpu and Gmelina sawdust, but differs significantly from fresh Titus and Titus smoked with Gmelina sawdust.

However fresh Titus had no significant difference from fresh Scombia and Titus smoked with Gmelina. The results agree with the value 13.44 to 16.44% reported for smoked *Clariasgariepinus* investigated by Aremu et al., (2013) and the value of 5.90 to 15.67 reported for *Scomber scombrus, Trachurus trachurus and Sardina pilchard* by USDA, (2010) and lower than the value of 25.83 to 28.33% reported for smoked Tilapia and catfish investigated by Ande *et al.,* (2012) also lower than the values of 20.19 to 25.46% reported for *Clariasgariepinus* smoked with different wood source by Agbabiaka *et al.,* (2012).

Although the values are higher than the result of 7.4 to 9.14% reported for *Scomber scombrus* smoked with different wood source by Matthew *et al.,* (2014) also higher than the values 7.43, 9.46 and 9.94% reported for *Scomber scombrus, Trachurus trachurus and Sardina pilchard* respectively by Paul and Vivian (2011). Therefore, it can be observed from the result that the fat content of the smoked fish probably must have been influenced by the duration of smoking and initial fat content of the fish.

The fibre content results for fish samples are as shown in Table 1.1. Their values range between 0.75 to 1.50%. Results shows that the fresh fishes had same fibre content and also had the least values of 0.75%, whereas Titus smoked with both sawdust had the same value and were the highest with 1.5%, while Scombia smoked with Gmelina and Akpu sawdust range from 1 to 1.25% respectively. The statistical analysis of the result shows that there was no significant difference ($p<0.05$) between Titus smoked with Akpu and Gmelina sawdust from Scombia smoked with Akpu sawdust, similarly the fresh fishes did not differ significantly from Scombia smoked with Gmelina sawdust but slightly differs from other samples. The fibre content of both fishes are the same with the values of 0.6 to 1.85% reported for smoked *L. niloticus, C.gariepinus* and *S.membranaceus*by (Effiong and Fakunle, 2012; Adeyemi *et al., 2015*) and are lower than the values of 3.4 to 10% reported for smoked *Clariasgariepinus* investigated by (Aremu *et al.,* 2013; Obande *et al.,* 2012). The variations from the cited works are due to types of fishes or method of analysis, though the result suggests that smoked fish is not a good source of fibre.

The ash content result for fish samples are as shown in Table 1.1. Their values range between 4 to 5.4%. Results show that the ash contents of the fresh fish samples which are in range of 5.1 to 5.4% where higher than those of smoked fishes.

The smoked fish samples from both the Akpu and Gmelina where in range of 4 to 4.7%, Scombia and Titus smoked with Akpu had the highest ash and Scombia smoked with Gmelina had least ash content 4.7 and 4% respectively, that of Gmelina range between 4 to 4.2%. Statistically there was no significant difference ($p<0.05$) between the ash content of the fresh fishes from both fishes smoked with Akpu sawdust, however the ash content of the both fishes smoked with Gmelina which had no significant difference slightly differs from the ash content for both fishes smoked with Akpu sawdust.

The ash content of the fresh fishes is in range with the values of 4 to 6% for smoked Red fish reported by Holma and Maalekuu, (2013), while the smoked fishes has the same ash content with values of 2.63 to 5.7% reported for smoked Catfish by (Obande*et al.*, 2012; Matthew *et al.*, 2014; Adeyemi*et al.*, 2015). The ash contents are lower than values of 6.8 to 8.7% reported for smoked Catfish by (Adam and Sidahmed 2012; Peter, 2015) and higher than the values of 0.87 to 2.8% reported for *Synodontisclarias*, *Trachurustrecae* and *Clariasgariepinus* by (Oparaku, *et al.*, 2013; Hunkar, *et al.*, 2013; Fronthea,*et al.*, 2012). The difference may be caused by method of analysis or species of fish.

The carbohydrate content result for the fish samples are as shown in Table 1.1. The values range between 1.05 to 7.66%. Results show that the carbohydrate contents of the fresh fish samples which are in the range of 6.36 to 7.66% where higher than those of smoked fishes. The smoked fish samples from both the Akpu and Gmelina where in range of 1.23 to 2.47%. Scombia smoked with Akpu had the highest carbohydrate and titus had the least carbohydrate content 2.47 and 1.23% respectively, that of Gmelina range between 1.05 to 1.68%.

The statistical analysis of the result shows that the fresh fishes' carbohydrate content differed quite significantly from their smoked counterparts at ($p<0.05$). Scombia smoked with Akpu did not differ significantly from Titus smoked with Gmelina. The result further shows that Titus smoked with Gmelina did not differ from Titus smoked with Akpu and Scombia smoked with Gmelina. However, the carbohydrate content of the fresh fishes was lower than the value 21.9% for fresh Catfish investigated by (Felix, 2014). While the carbohydrate content of the smoked fishes agrees with the value 1.70% reported for smoked Catfish by Obande *et al.*, (2012), values of 1.13 to 1.84% reported for smoked Catfish by Agbabiaka,*et al.*, (2012) and value of 1.26 to 2.5% reported for Catfish smoked with both sawdust and rice husk by Aremu *et al.*, (2013).

The carbohydrate content are lower than the value of 4.7% reported for smoked Red fish by Holma and Maalekuu, (2013), values of 15% reported for Smoked *Clariasgariepinus* by Peter, (2015), also lower than the value of 4 to 44% reported for smoked *Bonga*spp., *Sardinella*spp and *Heterotisniloticus* by Akinneye*et al.*, (2010). The differences in the cited works may be due to species of fish used for the analysis. The results suggest that fish is not a good carbohydrate source.

Table 1.2: Acid insoluble ash and Water-soluble ash of fish (Scomber Scombrus and Trachurustrachurus) smoked with Gmelina and Akpu sawdust.

Parameter	T.F	S.F	T.A	S.A	T.G	S.G
Acid insoluble ash (%)	1.20^{b}	1.30^{ab}	1.50^{a}	1.45^{a}	1.45^{a}	1.60^{a}
Water soluble ash (%)	2.70^{cd}	2.60^{d}	2.95^{ab}	3.09^{a}	2.85^{bc}	2.80^{bc}

Values are means of triplicate samples, values with different superscripts along a row are significantly different ($P \leq 0.05$).
T.F = Titus fresh; S.F = Scombia fresh; T.A = Titus smoked with Akpu sawdust; S.A = Scombia smoked with Akpu sawdust; T.G = Titus smoked with Gmelina sawdust; S.G = Scombia smoked with Gmelina sawdust.

The acid insoluble ash content results for fish samples are as shown in Table 1.2.The values range between 1.20 to 1.60%, the result show that Scombia smoked with Gmelina had the highest value of 1.60% followed by Titus smoked with Akpu sawdust 1.50%, the fresh fishes range between 1.20 to 1.30% and had the least value. Titus smoked with Gmelina and Akpu range between 1.45 to 1.50% respectively.

The statistical analysis of the result shows that there was no significant difference between the smoked fish samples and from the fresh Scombia, however fresh Titus differed significantly ($p<0.05$) from fresh Titus and the smoked samples. The result of the Acid insoluble ash agrees with the values 0.88 and 1.77% reported for smoked Mackerel and catfish respectively as investigated by Vijayan, *et al.* (2012).

The water soluble ash content results for fish samples are as shown in Table 1.2.The values range between 2.60 to 3.09%, the result show that the water soluble content of the fresh fishes is in range of 2.60 to 2.70%, while the smoked sample range between 2.80 to 3.09%, Scombia smoked with Akpu sawdust had the highest value of 3.09% whereas fresh Scombia had the least water soluble ash content of 2.60%.

The statistical analysis of the result shows that the fresh samples had no significant difference ($p<0.05$) from each other. Titus smoked with Akpu did not differ from Scombia smoked with Akpu, similarly Titus smoked with Gmelina also did not differ from scombia smoked with Gmelina. The result is lower than the value 4.8 and 4.4% reported for smoked *Oreochromisnoliticus* and *Clariasgariepinus* as investigated by (Emurotu, *et al.*, 2014) the differences may be due to the method of analysis or type of fish used.

Table 1.3: Sensory Evaluation of fish (*Scomber scombrus and Trachurustrachurus)* smoked with Gmelina and Akpu sawdust.

Parameter	**T. A**	**S. A**	**T. G**	**S. G**
Colour	6.45^{bc}	7.55^{a}	6.25^{c}	7.35^{ab}
Taste	6.80^{b}	8.05^{a}	6.85^{b}	7.65^{ab}
Flavour	7.45^{a}	7.90^{a}	7.20^{a}	7.65^{a}
General-Acceptability	6.95^{c}	8.0^{a}	6.65^{d}	7.50^{b}

Values are means of triplicate samples, values with different superscripts along a row are significantly different ($P \leq 0.05$).

T.F = Titus fresh; S.F = Scombia fresh; T.A = Titus smoked with Akpu sawdust; S.A = Scombia smoked with Akpu sawdust; T.G = Titus smoked with Gmelina sawdust; S.G = Scombia smoked with Gmelina sawdust.

The mean hedonic scores obtained for colour, taste, flavor and general acceptability of the four different samples are presented in Table 1.3 and Scombia smoked with Akpu had the best colour rating score of 7.55, followed by Scombia smoked with Akpu sawdust with hedonic score of 7.35, whereas Titus smoked with Gmelina sawdust had least hedonic score of 6.25.

There was no significant difference between the colour of both Scombia smoked with both Akpu and Gmelina sawdust, whereas significant difference exist between the colour of Scombia and Titus smoked with both sawdust, statistically no significant difference exist between the colour Titus smoked with both Akpu and Gmelina sawdust.

The taste of Scombia smoked with both Akpu and Gmelina sawdust had no significant differences, but there were significant differences ($p<0.05$) among the taste of Scombia smoked with both sawdust from the taste of Titus smoked with both sawdust, similarly no significant difference exist between Titus smoked with both sawdust, however Scombia smoked with Akpu sawdust had the best taste with hedonic score of 8.05, followed by Scombia smoked with Gmelina with hedonic score of7.65 while Titus smoked with Akpu sawdust had the least taste with hedonic score of 6.80. Scombia smoked with Akpu sawdust had the highest flavor with hedonic score of 7.90, followed by Scombia smoked with Gmelina sawdust with hedonic score of 7.65, whereas Titus smoked with Gmelina had the least flavor with hedonic score of 7.20, statistically there was no significant difference between the flavor of both fishes smoked with both Akpu and Gmelina sawdust.

Scombia smoked with Akpu sawdust had the highest hedonic score general acceptability with hedonic score of 8.0, which means it was the best sample generally accepted followed by Scombia smoked with Gmelina sawdust with hedonic score of 7.50, while Titus smoked with Gmelina sawdust had least hedonic score of 6.65, but statistically both Scombia and Titus smoked with both Akpu and Gmelina sawdust differs significantly. Generally brownish colour was observed on the four samples with glossy oily appearance and all the samples had a charred skin (skin damage).

CONCLUSION AND RECOMMENDATION

The results obtained showed that proximate composition of fish smoked with "Akpu" or Gmelina sawdust is in agreement with previous literatures. The sensory evaluation indicated that the smoked fish were generally acceptable even though the panelist preferred smoked *Scombia* to *Titus.* The use of sawdust waste for smoking is a cheaper fuel for smoking, and yield products that are of desirable quality.

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