EFFECTS OF SMOKING PROCESS AND CONDITIONS ON THE PROXIMATE COMPOSITION OF CATFISH (*CLARIAS GARIEPINUS*)

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Abstract
The effects of smoking process and conditions on the proximate composition of Catfish (Clarias gariepinus) was investigated and analyzed using the AOAC, 2001 methods. The analysis was carried out at the laboratory of the University of Ilorin, Kwara State Nigeria. The objective of this work is to determine the effects of smoking process and conditioning on some quality attributes of smoked Catfish. The proximate composition parameters that were investigated include: Protein, Fat, Ash and Moisture content. Two different smoking processes were considered. These are: the traditional smoking process, and smoking process carried out with the use of a smoking kiln developed at the National Center for Agricultural Mechanization (NCAM) Ilorin, kwara State, Nigeria.
The preparation of the fishes before smoking was carried out in two batches, with one batch salted and the other set unsalted. The results obtained from the two processes were compared and it showed that there was a marked effect of the smoking process on the moisture content (MC) which dropped from 71 % MC to 24 – 30% MC range, the ash content rose slightly from 3% to a maximum value of 6%, protein content of about 19% rose to 52%, and fat content of about 14% also rose to 21%. There was a marked increase in the ash, protein and fat contents while there was a noticeable decrease in moisture content of the different samples under consideration.
Statistically analyzed data reveals that there is significant difference between the effect of smoking method and conditions on moisture, ash and protein content of Catfish at $P < 0.05$ while there is no significant difference at $P < 0.05$ in respect of fat content. The smoking of Catfish using NCAM smoking kiln resulted to significantly lower moisture content, higher ash and protein content compared to the traditional smoking method with no significant effects on the proximate parameters studied. The unsalted, smoked Catfish processed by using NCAM's smoking kiln has better quality attributes than the samples smoked by using the traditional method. It is therefore recommended that, NCAM's smoking kiln and the procedures should be adopted for the production of high quality smoked Catfish.

Keywords: Catfish, Smoking, NCAM Smoking kiln, Salting, smoking process

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1. INTRODUCTION

Fish is a very important source of animal protein, whose importance has been recognized by man from the distant past. The flesh of fish is rich in minerals like Calcium, Phosphorus and Iron (H. H. Huss, 1988). It forms an important component in the diets of most Nigerians. According to statistical information from FAO (1999), the world's fish production (from captured fisheries and aquaculture) reached 121 million tons in 1996, which is 3.7 million tons more than what was obtained in 1995. A lot of pressure is also being mounted on the world wild fish population, in order to reach the high demand from the teeming human population which has hit 6.0 billion marks as at the year, 2000 A.D. This demand is higher in the tropics where the human population is rising increasingly. A decline in fish availability will have a detrimental effect on the nutritional status of the citizenry particularly in places like Nigeria where fish contributes significantly (about 40%) to the protein intake of the people (A. A. Eyo, 1981).
Therefore, since aquatic resources are finite although renewable, every effort should be geared towards increased fish population through improved resource management, resource conservation and intensive aquaculture practices (A. A. Eyo, 2001). This should therefore be matched with post-harvest fish handling, preservation and processing to prevent spoilage and subsequent loss of fish.
Fish smoking is predominant in most communities of Nigeria, despite modern fish

preservative techniques such as drying, canning, use of additives, freezing, refrigeration, aseptic packaging and pasteurization, which are sometimes expensive. Fish is highly susceptible to deterioration when it is without any processing or preservative measures. According to A.
Eves and R. Brown (1993), the preservative effect of the smoking process is due to drying, and the deposition of natural wood smoke chemicals in the product. During smoking, the smoke from the burning wood/charcoal containing a number of compounds inhibits bacterial growth, while the heat from the fire causes drying, however when the temperature is high enough, the flesh will be cooked, preventing bacteria, fungal growth and enzyme activity (UNIFEM., 1988, A. E. Goulas and M. G. Kontominas, 2005).
Since food is generally dried to preserve it for a longer period as high moisture content results in microbial degradation in food items. The dried product can then be put into use in periods of scarcity. This phenomena is also applicable to fish when dried for preservation due to its high perishability. The smoked fish owes its storage life primarily to the drying and cooking process, rather than the preservative value of the wood smoke chemicals (M. Cardinal et. al., 2001).
According to A. A. Eyo (2001), there are over 330 chemical compounds in wood smoke with more than 45 phenols, 70 carbonyls, 20 acids, 11 furans, 13 alcohols and esters, 13 lactones and 27 polynuclear aromatic hydrocarbons in smoke.
Many of these compounds are important in chemical reactions leading to the production of the flavor (a combination of odour and taste), colour, antioxidative, bacteriostatic and preservative properties of smoked fish (A. A. Eyo, 2001).
The specific objective of this work was to determine the effect of smoking processes (NCAM smoking Kiln and traditional smoking) and conditions (salted and unsalted) on some quality attributes (Moisture Content, Ash, Protein, and Fat) of smoked Catfish.

2. MATERIALS AND METHODS

The materials used for the study basically were sourced from the local fish market in Ilorin, Kwara State, while the fish kiln was developed and constructed by the National Centre for Agricultural Mechanization, (NCAM), Ilorin, Kwara State, Nigeria.
The fish used in the analysis was Catfish (*Clarias gariepinus*), which was purchased from the fish market at Ajasse Ipo, Ilorin, Kwara State. Nigeria.

2.1. Fish samples preparation

Two conditions for fish samples were used in this study. These are the salted and the unsalted conditions. The fish sample was prepared in batches of 5 kg of salted and unsalted, making a total of four (4) batches. The fish sample that was salted was treated with brine solution after been washed clean with water, while the unsalted batches were washed in clean water. The treatment stated above was carried out after the cleaning of the inside of the fishes by slitting the belly part, removing all the intestines and cleaning with clean water (eviscerating or gutting). Brining was done on the fish to check if it has any contribution to the proximate composition of the fish.
Usually, the slime on the fish is generally removed using wood ash, lime stone or lime; this was however not done in this study.

2.2. Brining process

Two sets of 5 kg batches of fish were brined in a salt solution of 40% strength (Salt). The fish were immersed in the brine solution for 10-15min in order to inhibit the growth of any food poisoning organisms present, particularly *Clostridium botulinum* and also to be certain that the salt in the solution is adequately absorbed into the flesh of the fish. Brining is believed to give the smoked its taste, appearance (attractive gloss), texture and improves its shelf life. The brine solution is continually stirred during the process to obtain an even salt content in the product. The brine strength was checked regularly with a Salinometer (brinometer) and maintained at the

30% level by the addition of solid salt as the brine strength decreases due to dilution by the water extracted from the fish tissue and the absorption of salt by fish tissues.
The percentage salt concentration in the solution was calculated using the equation below:

Percentage salt concentration = x 100 (1)

After brining, the whole fish were arranged on a rack to allow water to drip out.

2.3. Smoking process

The cleaned and treated Catfish samples were smoked using the following methods:
1.Smoking using the traditional process (Fig. 1)
2.Smoking using the NCAM developed fish smoking kiln (Fig. 7).

Fig. 1. Smoking using traditional method

2.4. Fish smoking by the traditional process

The prepared fish (brined and un-brined) were placed over a fire which is controlled so that, smoke instead of flames is produced. Fish are placed on the meshed wire placed across the local smoking arrangement (Fig. 2). Sometimes fresh leaves are placed over the fish to ensure proper circulation of smoke.
The fish are smoked for about 6 hours, and then allowed to cool. The initial temperature of the fish was measured. Charcoal was used as sources of heat. During smoking process, the process was monitored at 30mins intervals to prevent the fish from burning. Figure 1 shows the products obtained from the traditional smoking process.

2.5. Smoking using the ncam smoking kiln

The prepared fish (brined and un-brined) were placed inside the NCAM developed fish smoking kiln (Fig. 5). The heat source located at the bottom of the kiln is charcoal. Fish are placed on the meshed wire inside the developed smoking kiln. The door is closed tight so that there is no smoke escape except through the chimney to ensure proper circulation of smoke.

Fig. 2. Traditional fish smoking device

The fish are smoked for about 6 hours, and then allowed to cool the initial temperature of the kiln was measured. During smoking process, the process was monitored at 30mins intervals to prevent the fish from burning. Figure 7 shows the arrangement of Catfish inside NCAM smoking kiln.

2.6. Description of the traditional smoking process

The traditional smoking kiln is constructed with clay. It is circular with an opening for the heat material. The kiln is completely open at the top. The fish to be smoked are placed on a mesh above the heat source.

2.7. Description of NCAM developed kiln

The NCAM fish smoking kiln is a rectangular box like structure with a triangular cover housing the chimney for directing the smoke out of the kiln (Fig. 6). The basic features of this kiln are the cover, smoking chamber,

heating unit, chimney, collection base (for fat deposit) and trays arranged in layers inside the smoking unit. The machine has an overall dimension of 63cm x 102cm x 134cm. The housing is made up of lagged mild steel to serve as heat resistant preventing possible heat loss.

2.8. Quality evaluation

The smoked fish analyses were carried out using methods described in AOAC (2001), at the University of Ilorin laboratory. The parameters that were investigated include: Protein, Fat, Ash and Moisture content.

Fig. 3. Fresh cat fish

Fig. 4. Smoked cat fish

Fig. 5. NCAM fish smoking kiln

Fig. 6. Tray arrangement in Kiln

Fig. 7. Catfish inside NCAM Smoking Kiln

3. RESULTS AND DISCUSSION

The proximate composition of fresh Catfish, salted and unsalted Catfish smoked using both NCAM's smoking kiln and the traditional method are presented in Table 1. The result in Table 1 fundamentally shows that the corresponding effect of both NCAM's smoking kiln and traditional smoking method on samples of catfish, salted and unsalted. Each value in Table 1 is a mean value of a proximate parameter expressed in percentage. The statistically analyzed data shows that the smoking process generally has a significant effect on the proximate composition of fish. On the whole, the proximate compositions of Catfish processed using NCAM's smoking kiln have significant difference from samples processed by the traditional smoking method. In the respective smoking methods, the effect of fish conditions did not show significant difference.

Table 1. Proximate compositions of raw and smoked catfish

Smoking method			NCAN Developed Smoking Kiln		Traditional Smoking Method	
Sample	Proximate Composition (%)	Fresh fish	Smoked-Salted fish	Smoked–Unsalted fish	Smoked-Salted fish	Smoked–Unsalted fish
Cat fish	Moisture Ash Protein Fat	71.92 3.06 19.51 14.28	25.89 6.89 52.86 21.34	28.92 6.92 53.10 21.26	30.23 3.15 45.35 19.65	30.231 3.05 47.35 20.65

Table 2. Estimated Marginal Means of Moisture Content

Smoking Method	Fish Condition	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	Salted	76.307	0.487	75.338	77.275
	Unsalted	76.307	0.487	75.338	77.275
NCAM Kiln	Salted	27.557	0.487	26.589	28.526
	Unsalted	27.507	0.487	26.539	28.476
Traditional method	Salted	30.672	0.487	29.704	31.640
	Unsalted	30.753	0.487	29.784	31.721

Table 3. New Duncan Multiple Range Test for Fish Moisture Content

Smoking	Moisture Content
Control	76.31[a]
NCAM Kiln	27.53[b]
Traditional method	30.71[c]
Fish Condition	Moisture Content
Salted	44.84[a]
Unsalted	*44.85[b]*

Mean with the same alphabet are not significantly different from each other

Table 4. Estimated Marginal Means of Ash Content

Smoking Method	Fish Condition	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	Salted	3.112	0.114	2.884	3.340
	Unsalted	3.112	0.114	2.884	3.340
NCAM Kiln	Salted	6.614	0.114	6.386	6.842
	Unsalted	6.789	0.114	6.562	7.017
Traditional method	Salted	3.204	0.114	2.976	3.432
	Unsalted	3.081	0.114	2.862	3.300

Proximate compositions of the raw and smoked catfish are represented in Table 1. Table 2 shows the effect of smoking process and conditions on the moisture content of processed Catfish. It presents the marginal mean of moisture content for each smoking process and the conditions adopted. The mean moisture content under NCAM's smoking kiln: salted is 27.557 and unsalted is 27.507 while, under traditional smoking method: salted is 30.672 and 30.753. The smoked Catfish processed in NCAM's smoking kiln has the lowest moisture

content of 27.507. However, the traditional smoking method produced a product with the highest moisture content of 30.753.

The New Duncan Multiple Range Test in Table 3 reveals that there is significant difference between the moisture content of the smoked Catfish due to the different smoking methods, while the conditions did not cause significant difference.

Smoked fish with low moisture content inhibits food deterioration agents which results to long shelf life.

Smoked Catfish with the lowest moisture content was produced by using NCAM's smoking kiln. The effectiveness of the kiln may be due to controlled heating, adequate smoke accumulation and distribution within it.

Table 4 shows the effect of smoking process and conditions on the ash content of processed Catfish in form of the marginal means of ash content for each adopted smoking process and conditions. The marginal mean of ash content under NCAM's smoking kiln: salted is 6.614 and unsalted is 6.789 while, under traditional smoking method: salted is 3.204 and unsalted is 3.811. The highest value of ash content of about 6.789 is in unsalted Catfish smoked in the NCAM's smoking kiln. However, the lowest value of about 3.204 is of the salted Catfish smoked by the traditional smoking method.

In Table 5, the New Duncan Multiple Range Test reveals that there is significant difference between the ash content of the smoked Catfish resulting from the different smoking methods, while the conditions did not cause significant difference. According to M. A. Ndakuta, J. O. Oyero and A. M. Mamsa (2011), ash content is used as an index for the presence of minerals in fish. Minerals contribute essentially to metabolic process he opined. The highest amount of ash was observed in the unsalted samples processed in the smoking kiln negating the postulation of M. A. Ndakuta et. al. (2011). Controlled heat distribution in the kiln may be responsible for the high level of ash, since the uncontrolled heating in the traditional method could denature the minerals.

Table 6 depicts the effect of smoking process and conditions on the protein content of the processed Catfish. The marginal means of protein content for each adopted smoking process and conditions is shown clearly in the table.

Table 5. New Duncan Multiple Range Test for Fish Ash Content

Smoking	Ash Content
Control	3.1120[a]
NCAM Kiln	6.7017[b]
Traditional method	17.0077[c]
Fish Condition	Ash Content
Salted	4.31[a]
Unsalted	13.53[b]

Mean with the same alphabet are not significantly different from each other

Table 6. Estimated Marginal Means of Protein Content

Smoking Method	Fish Condition	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	Salted	19.069	0.189	18.693	19.446
	Unsalted	19.069	0.189	18.693	19.446
NCAM Kiln	Salted	52.596	0.189	52.220	52.972
	Unsalted	52.902	0.189	52.526	53.278
Traditional method	Salted	45.183	0.189	44.807	45.560
	Unsalted	47.125	0.189	46.749	47.502

Table 7. New Duncan Multiple Range Test for Fish Protein Content

Smoking	Protein Content
Control	19.0693[a]
NCAM Kiln	52.7490[b]
Traditional method	46.1543[c]
Fish Condition	Protein Content
Salted	38.95[a]
Unsalted	39.70[b]

Table 8. Estimated Marginal Means of Fat Content

Smoking Method	Fish Condition	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Control	Salted	14.305	0.102	14.101	14.508
	Unsalted	14.305	0.102	14.101	14.508
NCAM Kiln	Salted	21.537	0.102	21.334	21.741
	Unsalted	21.525	0.102	21.321	21.728
Traditional method	Salted	21.521	0.102	21.318	21.725
	Unsalted	19.822	0.102	19.618	20.026

Table 9. New Duncan Multiple Range Test for Fish Fat Content

Smoking	Fat Content
Control	14.3047[a]
NCAM Kiln	21.5310[b]
Traditional method	20.6717[a]
Fish Condition	Fat Content
Salted	19.121[a]
Unsalted	18.55[b]

Mean with the same alphabet are not significantly different from each other.

The marginal mean of protein content under NCAM's smoking kiln: salted is 52.596 and unsalted is 52.902 while, under traditional smoking method: salted is 45.183 and unsalted is 47.125. The highest recorded value of protein content of about 52.902 is in unsalted Catfish, smoked in the NCAM's smoking kiln. However, the lowest value of about 45.183 is of the salted Catfish, smoked by the traditional smoking method.

The New Duncan Multiple Range Test in Table 7 shows that there is significant difference between the protein content of the smoked Catfish resulting from the different smoking methods, while there is no significant difference between the conditions of the fish.

The result of the proximate composition of smoked Catfish samples by the kiln smoking method showed higher protein content than those samples smoked by the other method. This result is in agreement with the finding of P. E. Doe, and J. Olley (1983) and A. K. M. Aminullah Bhuiyan et. al. (1986) where it was also explained that smoking concentrates nutrients due to low residual moisture levels in smoked food products. Since protein is the major nutrient factor contributed by animals to human diet of which fish is a major supplier of high class of quality protein compared to other animal protein sources, smoking of Catfish by using NCAM's smoking kiln can be used to preserve both the intrinsic and extrinsic qualities of fish soon after harvest.

Table 8 presents the effect of smoking process and conditions on the fat content of processed Catfish. The marginal mean of fat content for each adopted smoking process and conditions is shown clearly in this table. The marginal mean of fat content under NCAM's smoking kiln: salted is 21.537 and unsalted is 21.525

while, under traditional smoking method: salted is 21.521 and unsalted is 19.822. The highest recorded value of fat content of about 21.537 is in the salted Catfish, smoked in the NCAM's smoking kiln. However, the lowest value of about 19.822 is of the unsalted Catfish, smoked by the traditional smoking method.

The New Duncan Multiple Range Test in Table 9 reveals that there is significant difference between the fat content of the smoked Catfish due to the different smoking methods used, and also between fish conditions.

The entire smoked samples show a slight raise in fat content as also reported by A. Ahmed et.al. (2011). The observable increase in fat content of smoked fish was also reported by O. O. Fapohunda and M. Ogunkoya, (2006).

Concisely put, the moisture content decreased due to heat application while protein, fat, and ash contents increased due to nutrients concentration as a result of fish dehydration. The taste impact as well as the colour of smoked fish is the product of protein reaction with the smoke from the heat source.

4. CONCLUSIONS

In conclusion, the NCAM's smoking kiln performance on the quality attribute of smoked Catfish is more satisfactory than the traditional smoking method. The application of salt before smoking has no significant effect on the proximate composition of smoked Catfish. The NCAM's smoking kiln process is free from environmental contamination, super heat damage and high moisture content which is an assurance of extended shelf life of the product.

It is therefore recommended that NCAM's smoking kiln and the procedures should be adopted for the production of high quality smoked Catfish.

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