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Research Article

Effect of smoking, drying and the combination of smoking-drying on the nutritional and sensory attributes of catfish (*Clarias gariepinus*)

Akinsola, A.O[1,2*], Idowu, O.A[1], Akanbi, G.O[2]., Taiwo-Oshin, M.A[2]
Department of Food Technology, Federal Polytechnic, Offa, Kwara State, Nigeria
Department of Home Economics, Federal College of Education (Special), Oyo, Oyo State, Nigeria

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*Corresponding author (E-mail: akinsola4gold@gmail.com)

Abstract

Poor post harvesting technology such as handling, preservation and processing can lead to an unhealthy situation through massive spoilage and waste. This study assessed the effect of smoking, drying and the combination of smoking-drying on the nutritional and sensory attributes of catfish. Six kilograms of average fresh catfish were washed, eviscerated, drained, and divided into four portions of 1.5 kg each. Sample A served as control (fresh fish), while samples B, C, D were dried, smoked, dried and smoked fish respectively. Samples were analyzed using standard methods. The results of proximate analyses of samples showed that the moisture content ranged from 20.1 to 75.0 %, the protein content from 21.7 to 63.0 %, the fat content from 0.5 to 8.6 %, while the crude fibre ranged from 0.0 to 0.04 %. The total ash ranged from 1.1 to 4.9 %, while Carbohydrate (NFE) ranged from 0.1 to 3.5 %. Significant difference ($p>0.05$) was observed in the free fatty acids and pH of sample C compared to other samples. The total plate count ranged from 2.4 to 4.3×10^{-5} CFU/g. The sensory attributes result showed that sample D was the most preferred and acceptable. The study showed that dried-smoked fish had a better quality and was more preferred for consumption than singly dried or smoked catfish.

Keywords: Dried and smoked fish, fresh catfish, free fatty acids, smoking, total plated count

Introduction

Fish is an extremely perishable food item (Agbon *et al.*, 2002), highly susceptible to deterioration without any preservative or processing measures (Okonta and Ekelemu, 2005). Soon after death, fish begins to spoil. The handling and the preservation practice after capture affects the degree of spoilage of the fish (Akinneye *et al.*, 2007). Immediately after the death of the fish, a number of physiological and microbial deterioration set in and thereby degrade the fish (Tawari and Abowei, 2011). Aquaculture business is fast gathering momentum in Nigeria, therefore there is need for adequate and effective processing and storage facilities to be put in place in order to prevent or reduce postharvest losses of fish caught. Akinola *et al*. (2006) reported different types of preservation methods; drying, smoking, freezing, chilling and brining. Fish drying and smoking are important activities in developing countries, especially in areas where cold preservation techniques are not easily obtained. Fish consumption constitutes about 60 % of the total protein intake in adults especially in the rural area of Nigeria (Ime-Ibanga and Fakunle, 2008; Foline *et al*., 2011).

Smoking, a unit operation, involves heat application from kiln or firewood smoke to remove water, inhibit bacteria, and enzymatic action on fish, while drying of fish is a process of extracting water from fresh/frozen fish by sun-drying or oven-drying in order to enhance it's quality. Akande *et al*. (1998) reported that there are 40 % postharvest losses of total fish caught in Nigeria in 1997; 15 % of the total fish caught at Kanji Lake were lost because of the spoilage and handling between the sources of supply and consumptions. About 25-30 % of the world fish catch is consumed in the dried, smoked form or the combination of these processing methods. According to Eyo (2001), fish smoking primarily reduced water activity to less than 30% and enhanced the storage period of dry fish by preventing mould and bacterial infestation on the fish. Popularity of smoked fish consumption is increasing, because of the incessant power outage that made cold storage non-realistic in this part of the world (Ogbona and Ibrahim, 2009), and traditionally smoking process is done without the addition of preservatives (Ime-Ibanga and Fakunle, 2008). Some of these processes though important for preservation have various effects on the physical and nutritional composition of fish (Foline *et al*., 2011).

Nutritive and organoleptic changes of traditionally processed fresh water fish species were studied by Ime-Ibanga and Fakunle (2008). The study reported that different processing and drying methods have different effects on the organoleptic parameters and on the nutritional composition of fish due to heating and a high concentration of salt (Nelson, 2006), which changes the chemical and physical concentration leading to an increase in digestibility and protein denaturation. Fresh fish in Nigeria were usually under prized, hence, aqua culturists have begun to dry or smoke the fish to attract a better price from the local and international markets (Tobor, 2004; Ali *et al*., 2011). Hence, there is a need to determine the nutritional and sensory attributes of catfish subjected to drying, smoking and the smoking-drying methods before commercial cottage production could be embarked upon. The objective of this study was to determine the effect of drying, smoking and the combination of smoking-drying on the nutritional and sensory attributes of catfish.

Materials and Methods

Six kilograms of freshly caught *Clarias gariepinus* fish was obtained from a private fishpond at Fola-tyre area, Oyo town, Oyo State, while dried firewood (*Hevea brasilensis*) used was purchased from Akeesan (local) market, Oyo town, Oyo State, Nigeria.

Pre-processing method

All the catfish were killed, eviscerated and thoroughly rinsed with clean water and let to thaw for 30 min. All the pre-processed catfish was equally divided into four portions of 1.2 kg each after thawed. A portion of this sample served as control (sample A) and was kept at 18 ºC for further use.

Drying method

A portion of the pre-processed catfish was placed on a stainless-tray and put into an air oven (model: DC 500; serial number: 12B154) for drying at 90 ± 5 ºC for 36 hr. The fish was turned at every 2 hr to prevent hardening. It was then let to cool at ambient temperature (28 ± 2 ºC), packaged and stored in transparent air-tight polyethene bags as sample B for further use.

Smoking method

Another portion of the pre-processed catfish was smoked by lighten hardwood and prevented from catching fire, which has a higher hemicelluloses content compared to the softwood (Akande *et al*., 1998) using the traditional semi-circular mud kiln in an open space commonly used by the villagers. The maximum smoking duration was eight hours and the fish were periodically turned at a certain interval to prevent charring and the fire intensity was very low. The catfish samples were turned at every 15 min to prevent hardening. It was then allowed to cool to ambient temperature (28 ± 2 ºC) and packed as sample C. The packed sample was stored as described for sample B.

Smoking and drying method

The last portion of pre-processed catfish was first smoked using the method of Akande *et al*. (1998) method and further oven-dried (model: DC 500; serial number: 12B154)) at 90 ± 5 ºC for 36 hr. It was then allowed to cool at ambient temperature (28 ± 2 ºC) and packaged as sample D. The packed sample was stored as described for sample B.

Analyses of Catfish

Proximate composition

The proximate analyses (moisture content, protein content, ash content, fat content and crude fiber) of the samples were analyzed according the official methods of analysis described by the Association of Official Analytical Chemists (2005), while carbohydrate was calculated by differences.

Determination of microbiological quality and safety

The method of Harrigan and MacCance (1982) was used to determine the total plate count of the composite flour samples. The samples were serially decimal and spread plated one milliliter aliquots on the nutrient agar and incubated at 37 ºC for 48 hr. The total plate count value is expressed in logarithm colony forming unit per gram (log cfu/g).

The presumptive coliform count was determined by plating 1 ml of the serially diluted composite flour samples on MacConkey's agar and incubated at 37 ºC for 24 hr according to Hartman (1985) method. Rose pink, non-mucoid colonies measured 0.5 mm or more uncrowded plate colonies were counted. Confirmation was done by fermenting on lactose and indole at 44 ºC after 24 hr incubation. Coliform counts value is expressed in logarithm colony forming unit per gramme (log cfu/g).

The method of AOAC (2005) was used to determine the *Salmonella-Shigella* quality of the composite flour samples. The samples were first pre-enriched by preparing and dispensing 90 ml of buffered peptone water into bottle, sterilized and then allowed to cool before incubation. Ten gramme of the sample was inoculated into the bottles and incubated at 37 ºC for 24 hr. After 24 hr of incubation, 1 ml of the inoculum was poured into 9 ml of sterile cooled buffered peptone water and tenfold serial dilutions were made by transferring 1 ml to the next tube shaking and mixing thoroughly with the help of a vortex mixer until dilution was completed. One milliliter of inoculum from the dilution (10^{-5}) was dispensed into petri-plate and about 15 ml sterile cooled 40 ºC *Salmonella-Shigella* agar (SSA) was poured into it. The petri-plate was allowed to gel and cool. Then, it was transferred to the incubator at 37 ºC for another 24 hr. After 24 hr, counting was done using an UV light box and results are tabulated. The *Salmonella-Shigella* counts are expressed in logarithm colony forming unit per gramme (log cfu/g).

Determination of lipid profile

Fat saponification, peroxide value, free fatty acid, and pH of each sample were determined using the method described by AOAC (2005).

Sensory attributes of the catfish

Samples produced were presented to 20 semi-trained panelists using 9 hedonic scale were asked to assess the coded samples in order of like and dislike based on colour, flavour, texture, crispiness, taste and overall acceptability as described by Iwe (2002). Scoring was done on the 9-point Hedonic scale where 9 = like extremely and 1 = dislike extremely.

Statistical analysis

Results are expressed as a mean of triplicate analyses. One-way analysis of variance and Duncan's test were used to establish the significance of differences among the mean values at the 0.05 significance level. The statistical analyses were performed using SPSS 17.0 software (Systat statistical program version 21 Inc., USA).

Results and Discussion

Proximate composition of the samples

Table 1 shows the proximate composition of the samples. Statistical differences ($p<0.05$) were observed in all the samples. The moisture content of the samples ranged from 20.70 to 74.98% with sample A having the highest value, while sample D had the lowest value. However, samples B, C and D showed a lower moisture content compared to sample A. This might be due to the loss of water during drying, smoking and the combination of smoking-drying. A study on the influence of the traditional smoking and/or drying on the quality of catfish by Ali *et al*. (2011) showed that the percentage moisture content was low

Table 1: Proximate composition of the samples

Parameter	Sample A	Sample B	Sample C	Sample D
Moisture %	74.98±0.21	26.60±0.17	25.92±0.25	20.70±0.32
Crude protein %	21.71±0.01	60.69±0.11	60.46±0.06	63.00±0.16
Crude fat %	0.50±0.14	8.57±0.00	7.47±0.08	8.46±0.03
Crude fibre %	0.00±0.00	0.02±0.00	0.04±0.01	0.01±0.00
Total Ash %	1.13±0.13	4.52±0.14	4.89±0.19	4.70±0.07
NFE %	1.69±0.16	0.05±0.01	1.26±0.08	3.15±0.12

Mean values in the same column with different superscript are significantly different (p< 0.05).
NFE: carbohydrate; sample A: Control sample B: Dried fish; sample C: Smoked fish; sample D: Smoked-dried fish.

Table 2: Lipid analysis of catfish

Parameter	Sample A	Sample B	Sample C	Sample D
Saponification value (mg/kg)	214.35±3.17	200.21±4.11	189.76±2.28	198.30±1.86
Peroxide value (mg/kg)	3.54±0.14	4.57±0.21	4.39±0.00	5.00±0.45
Free fatty Acid (%)	1.02±0.23	2.20±0.19	2.27±0.43	2.77±0.00
pH value	6.50±0.11	6.25±0.37	6.10±0.15	5.73±0.05

Mean values in the same column with different superscript are significantly different (p< 0.05).
Sample A: Control sample B: Dried fish; sample C: Smoked fish; sample D: Smoked-dried fish.

Table 3: Microbiological quality and safety analysis

Microbial Count (x 10^5log cfu/g)	Sample A	Sample B	Sample C	Sample D
Total Plate Count	3.34±0.14	5.92±0.30	4.30±0.04	2.41±0.02
Coliform Count	2.01±0.08	0.16±0.00	0.22±0.13	0.40±0.15
Salmonella-Shigella	0.92±0.16	0.77±0.11	0.50±0.28	0.89±0.26

Mean values in the same column with different superscript are significantly different (p< 0.05).
Sample A: Control sample B: Dried fish; sample C: Smoked fish; sample D: Smoked-dried fish.

in smoked-dried catfish compared to other samples. The moisture content results agreed with the work of Cardinal *et al*. (2001) and Abolagba and Osifo (2004). They reported that fish weight loss is due to the dehydration during smoking. The protein content of samples A, B, C and D ranged from 21.71 to 63.00%, with sample D having the highest value, while sample A has the least value. The increase observed in the protein content of the processed catfish could be attributed to the loss of water which lead to an increase in the dry matter content per unit of weight of the sample (Ikeme and Gugnani, 1988; Ime-Ibanga and Fakunle, 2008). The crude fiber of the catfish ranged from 0.00 – 0.04 % with sample A having the least, while sample B has the highest value.

The fat content of the sample A to D ranged from 0.50 to 8.57%, with sample B having the highest value, while sample A has the lowest value. The ash content of the catfish ranged from 1.13 to 4.89% with sample A having the least value, while sample B has the highest value. There is a correlation between percentage crude fiber and percentage total ash. This is an indication that total amount of minerals available in sample C is greater than other samples including the control.

Lipid profile of the samples

Lipid profile of the samples is shown in Table 2. Statistical differences (p<0.05) were observed in all the samples, except in free fatty acid and pH value. The saponification value ranged from 189.76 to 214.35 mg/NaOH/kg with sample B having the least value of 189.76 mg/NaOH/kg, while sample A has the highest value with 214.35 mg/NaOH/g. The results showed that dried, smoked and the combination of smoking-drying had significant effect (p<0.05) on the saponification value of processed catfish compared to fresh fish. The result indicated that the lower the moisture content of a fish, its level of sodium hydroxide reaction with fatty acids will be low. Its keeping qualities in terms of off-flavour, taste and rancidity were significantly (p<0.05) improved after processing.

The peroxide value ranged from 3.54 to 5.00 mg peroxide/kg, with sample A having the least value of 3.54, while sample D has the highest value. The amount of peroxide value of fat indicates the degree of primary oxidation and rancidity. Unsaturated free fatty acids react with oxygen in the presence of heat and light to form peroxides, which determine a series of chain reaction that generate the production of volatile substances (Ikeme and Gugnani, 1988). A lower number of peroxides indicated the good quality of oil and enhance fish preservation. Free Fatty Acid content of the samples ranged from 1.02 to 2.77 % with sample A having the least value (1.02 %), while sample D has the highest value (2.77 %). The pH ranged from 5.73 to 6.50 with sample D as the most acidic among the catfish products. The high acid content of sample D may be due to the combined method of smoking and drying (Ikeme and Gugnani, 1988). Sample D may have a better shelf life compared to sample A – C.

Microbiological quality of the samples

Table 3 shows the microbiological quality of the samples. Statistical differences (p<0.05) were observed in all the samples Sample D had the lowest total plate count, while sample B had the highest total plate count. This may be due to the combined processing method used. The aggregate *Salmonella-Shigella* count ranged from 0.50 x 10^{-5} CFU/g to 0.92 x 10^{-5} CFU/g with sample A having the highest value, while sample C had the least value.

Sensory attributes of the samples

Table 4 showed the results obtained for the sensory attributes of the processed catfish. Mean values obtained for appearance ranged from 7.4 for sample B to 8.6 for sample D, while that of colour ranged from 7.1 for sample B to 8.5

Table 4: Sensory attributes of the samples

Sample	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
Sample A (Raw)	N.D	N.D	N.D	N.D	N.D	N.D
Sample B	7.4±0.01	7.1±0.21	7.2±0.14	6.2±0.11	7.3±0.03	7.1 ±0.13
Sample C	8.0±0.22	8.2±0.14	8.2±0.21	7.3±0.02	7.8±0.01	8.3±0.09
Sample D	8.6±0.16	8.5±0,07	8.6±0.00	8.2±0.03	8.3±0.17	8.6±0.06

Mean values in the same column with different superscript are significantly different ($p < 0.05$).
N.D: Not determined; Sample A: Control sample B: Dried fish; sample C: Smoked fish; sample D: Smoked-dried fish.

for sample D. The result showed that there is no significant difference ($p<0.05$) between the samples in terms of appearance and colour. All the panelists did not show total dislike for any of the samples appearance and colour. The mean scores obtained for the flavour ranged from 7.2 for sample B to 8.6 for sample D, while that of taste ranged from 6.2 for sample B to 8.2 for sample D. Texture mean scores ranged from 7.3 for sample B to 8.3 for sample D. Flavour plays an important factor in consumers preferences and products, hence sample D would be most preferred than other two samples. Overall acceptability of the catfish products ranged from 7.1 to 8.6, which indicated that all the catfish products were accepted by the panelists based on a mean scores obtained, which is greater than 5.0. Sample D, smoked-dried catfish was the most preferred and accepted one by the panelists as shown in Table 4.

Conclusion

Based on the study findings, smoking and drying of catfish increased proximate composition than singly dried or smoked catfish. Microbial loads and especially coliform incidence which is an indication of fecal contamination that can be reduced significantly using the combined processing method of smoking and drying than singly processing method of smoking or drying. This study showed that the combined processing of smoking and drying will not only enhance the proximate composition, reduce microbial loads, but also enhance the general acceptability of catfish products.

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