

Full Length Research Paper

The effects of smoking on the nutritional qualities and shelf-life of *Clarias gariepinus* (BURCHELL 1822)

C. A. Kumolu-Johnson¹, N. F. Aladetohun² and P. E. Ndimele^{1*}

¹Department of Fisheries, Faculty of Science, Lagos State University, Lagos, Nigeria.

²Federal College of Fisheries and Marine Technology, Wilmont Point, Victoria Island, Lagos, Nigeria.

Accepted 3 July, 2009

The effects of smoking on the chemical, microbiological and sensory qualities of a commercially important freshwater fish species, *Clarias gariepinus* stored at 4°C for 28 days were investigated. The fish samples were collected from a research pond of Lagos State University, Lagos, Nigeria and Badagry Market, Lagos, Nigeria. The chemical profiles of the fresh and smoked fish were analyzed while the microbiological and sensory assessments were carried out weekly for a period of 28 days. Highest protein content ($62.14 \pm 6.67\%$) was recorded in smoked fish obtained from the fish pond while the least ($14.23 \pm 4.13\%$) was observed in fresh fish samples also from the fish pond. Similar results were obtained for the fat and ash contents. The differences in the proximate composition of the smoked and fresh samples were significant ($p < 0.05$). The total coliform count (Log_{10} Cfu/g) of smoked fish ranged between 3.777 - 6.871 which increases with duration of storage. Sensory evaluation of smoked fish samples showed that the quality of the smoked fish decreases with duration of storage. Therefore, *C. gariepinus* should be stored for a short period after smoking to retain its unique taste and flavour.

Key words: *Clarias gariepinus*, smoking, microbiology, sensory parameters, chemical qualities.

INTRODUCTION

Poor post-harvest technology (handling, preservation and processing) have ability to cause unhealthy situation through massive spoilage. An estimate of 40% post-harvest losses of total fish landings have been reported in Nigeria (Akande, 1996). Mayboom (1974) similarly reported that 15% of the total fish catch in Kainji Lake is lost because of spoilage and breakage between the sources of supply and the consumers. Saliu (2008) also reported that fish spoilage in Nigeria is influenced to a large extent by high ambient temperatures, considerable distances of landing ports to points of utilization and poor as well as inadequate infrastructure for post-harvest processing and landing.

A number of processing techniques are in operation in Nigeria. These include chilling, freezing, salting, canning, drying and smoking. However, smoking is the most popular method of fish processing (Eyo, 2000) who reported that: smoking involves heat application to

remove water and inhibit bacterial and enzymatic action on fish. It imparts aroma, taste and colour on processed fish (Olley et al, 1988). Traditionally, fish is smoked in pits or on raised smoking "tables" where the control of heat is difficult and at times impossible (Afolabi, 1984).

Clarias gariepinus is a very important freshwater fish in Nigeria. It has enjoyed wide acceptability in most parts of the country because of its unique taste, flavour and good texture. It is widely distributed, extensively cultivated in ponds but under-priced. Aquaculturists have begun to smoke the fish to attract a better price from local and international markets. This research is thus aimed at studying the effects of smoking on the qualities and shelf-life of *C. gariepinus*.

MATERIALS AND METHODS

A total of 120 live African Catfish, *C. gariepinus* with average body weight and length of 455 ± 11.60 g and 42.16 ± 4.56 cm respectively, were obtained from two different places as follows: 1) research pond of Lagos State University, and 2) Badagry Market, Lagos, Nigeria. The fish were transported to the laboratory and were hot smoked in a locally made oven.

*Corresponding author. E-mail: drpendimele@yahoo.com. Tel: +234803-820-5109.

Table 1. Proximate composition of fresh and smoked *Clarias gariepinus* from a fish pond and market in Lagos, Nigeria.

Variable	LASU fish pond		Badagry market	
	Smoked	Fresh	Smoked	Fresh
Moisture content (%)	10.86 ± 2.33 ^a	81.03 ± 10.69 ^b	26.50 ± 5.68 ^c	77.90 ± 9.73 ^b
Ash content (%)	3.10 ± 0.53 ^a	1.30 ± 0.23 ^b	3.50 ± 0.64 ^c	0.20 ± 0.01 ^d
Crude protein content (%)	62.14 ± 6.67 ^a	14.23 ± 4.13 ^b	50.20 ± 6.15 ^c	14.50 ± 5.69 ^b
Fat content (%)	23.90 ± 7.51 ^a	3.44 ± 0.69 ^b	19.80 ± 4.49 ^c	7.40 ± 1.78 ^d

*Values in the same row and with the same superscript (alphabet) are not significantly different ($P > 0.05$).

Smoking process

The fish were gutted and washed thoroughly with clean water and the samples were then kept on racks and put in the oven. Smoking of the fishes was carried out for 4 h. The maximum temperature in the smoking chamber was 100°C. The smoke was produced by the burning of sawdust from different kinds of wood to simulate what is practised by local fish mongers (Salán et al., 2006). After smoking, the products were packed in transparent polyethylene bags, sealed with a sealing machine to reduce microbial infestation (Salán et al., 2006; Abolagba and Melle, 2008) and stored at a temperature of 4 ± 1°C (Bilgin et al., 2008) for 28 days. The sources of fish (LASU and BADAGRY) were the treatments.

Proximate analysis

The determination of the crude protein, moisture, ash and fat contents of the fresh and smoked fish were carried out in triplicate in accordance with the AOAC (1995). The protein content was obtained through the determination of total nitrogen by micro kjeldahl's method. The value of nitrogen obtained was then multiplied by 6.25 to get the crude protein value.

Moisture content of the samples were determined by the AOAC (1995) method in which 2 g of the samples (fish muscles) were oven-dried at 110 ± 1°C for 24 h to a constant weight. Loss in weight is equal to the moisture content of the original sample. The ash content was determined by heating the samples to a temperature of 550°C, the residue is equivalent to the ash content. The fat content was determined by extraction with hexane by soxhlet's method.

Microbiological analysis

The total coliform count was determined according to the method of Fawole and Oso (1995).

Sensory (organoleptic) analyses

Sensory evaluation was carried out by two panels according to the method of Poste et al. (1991). The first panel consisted of 10 staff of Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos, Nigeria. The other panel was made up of 10 students of Lagos State University, Lagos, Nigeria. The former panellists are trained fish quality analysts while the latter are untrained.

Questionnaires were used by both panels and scoring was done on a weekly basis. The questionnaires were prepared having hedonic of 2 - 10 [data were transformed into scale as follows: A (Excellent) = 10; B (Good) = 8; C (Fair) = 6; D (Unsatisfactory) = 4 and E (Unacceptable) = 2].

Qualitative descriptive analysis (QDA) was used to evaluate the sensory qualities of the smoked samples.

Statistical analyses

Statistical analyses were performed using SPSS V. 15.0 for Windows. Analysis of variance (ANOVA) was used and statistical significance was set at $p < 0.05$. Fisher's Least Significant Difference was used to separate differences in treatment means.

RESULTS AND DISCUSSION

Table 1 presents the proximate composition of fresh and smoked *C. gariepinus*. The highest moisture content (81.03 ± 10.69%) was recorded in fresh *C. gariepinus* obtained from a research pond of Lagos State University (LASU Fish pond) while the lowest (10.86 ± 2.33%) was found in smoked fish samples also from LASU Fish Pond. There was significant ($p < 0.05$) reduction in moisture content when the fish was hot smoked. This is due to loss in moisture during hot smoking. This observation is in agreement with the findings of Salán et al. (2006) and 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 addition of salt as well as reduction in moisture through sundrying or smoking. The percentage ash, crude protein and fat contents in smoked *C. gariepinus* were significantly ($p < 0.05$) higher than the values in the fresh samples for both treatments (LASU Fish Pond and Badagry Market).

The highest value of crude protein (62.14 ± 6.67%) and fat content (23.90 ± 7.51%) were recorded in smoked fish collected from LASU fish pond while the lowest values, 14.23 ± 4.13% (crude protein) and 3.44 ± 0.69% (fat content) were also observed in fish from LASU fish pond. Percentage ash content in *C. gariepinus* was maximum (3.50 ± 0.64%) in smoked fish bought from Badagry market while the minimum value (0.20 ± 0.01%) was recorded in fresh *C. gariepinus* also from Badagry market. Similar results for chemical composition of smoked fish have been reported in previous studies (Goulas and Kontominas, 2005; Bilgin et al., 2008). Salán et al. (2006) opined that the increase in ash content when fish are smoked is due to loss of humidity while Doe and

Table 2. Total coliform count (Log₁₀ cfu/g) of fresh and freshly smoked *Clarias gariepinus* from a fish pond and Badagry market in Lagos, Nigeria.

Fish	LASU fish pond	Badagry market
Fresh (skin)	4.312	4.593
Fresh (Gill)	4.255	4.428
Freshly smoked (zero day)	2.061	2.744

Table 3. Total coliform count (Log₁₀ cfu/g) of smoked *Clarias gariepinus* from a fish pond and Badagry market in Lagos, Nigeria during storage (4 °C).

Days	LASU fish pond	Badagry market
1 st Day	4.342	3.777
7 th Day	4.911	3.943
14 th Day	5.533	4.616
21 st Day	6.428	5.483
28 th Day	6.871	6.360

Table 4. Sensory evaluation of smoked *Clarias gariepinus* during storage (4 °C).

Parameter	Days				
	1	7	14	21	28
Flavour	8.15 ± 0.46 ^a	7.79 ± 0.31 ^a	7.53 ± 0.33 ^{ab}	6.68 ± 0.42 ^{bc}	6.10 ± 0.41 ^c
Texture	8.10 ± 0.49 ^a	7.65 ± 0.42 ^a	7.15 ± 0.47 ^{ab}	6.41 ± 0.51 ^{bc}	5.63 ± 0.28 ^c
Odour	7.86 ± 0.53 ^a	7.18 ± 0.41 ^a	7.12 ± 0.45 ^a	6.15 ± 0.37 ^b	5.75 ± 0.44 ^b
Appearance	8.42 ± 0.38 ^a	8.45 ± 0.34 ^a	7.13 ± 0.33 ^b	6.53 ± 0.43 ^{bc}	5.88 ± 0.49 ^c
General Taste	8.08 ± 0.34 ^a	7.89 ± 0.32 ^a	7.11 ± 0.23 ^b	6.26 ± 0.37 ^c	5.68 ± 0.31 ^d

*Values in the same row and with the same superscript (alphabet) are not significantly different (P > 0.05).

Oly (1983) reported that smoking resulted in concentration of nutrients like crude protein and fat.

Moisture, ash, crude protein and fat contents (Table 1) of smoked fish from LASU fish pond were significantly (p < 0.05) different from the values obtained from fish procured from Badagry market. Processing method, quality of feed given to the fish and storage are some of the factors responsible for difference in proximate compositions of smoked fish (Apendi et al., 1974; Ojewole et al., 2003). Since the fish from the two sources were subjected to the same processing method and storage, quality of the feed given to the fish may be responsible for the difference in nutrient quality of the smoked fish (Rizwan et al., 2000). While the fish from LASU fish pond were fed with high quality feed produced from conventional feed ingredients like fish meal, groundnut cake, and maize, the average farmer in the bid to reduce cost might include low quality non-conventional feedstuffs like blood meal, chicken offal and palm kernel cake which may be responsible for the low protein content of the fish from Badagry market (Omitoyin and Faturoti, 2000).

Table 2 shows a comparison between the microbial

loads in skin and gill of fresh samples of *C. gariepinus* and freshly smoked samples from LASU fish pond and Badagry market. The total coliform count (Log₁₀ Cfu/g) of skin (4.593) and gill (4.428) of fresh samples of *C. gariepinus* from Badagry market were higher than the values of 4.312 (skin) and 4.255 (gill) obtained from fish samples collected from LASU fish pond. However, the total coliform count (2.744) of freshly smoked *C. gariepinus* obtained from the Badagry market was higher than the value (2.061) recorded in the samples from LASU fish pond. Table 2 also shows a reduction in total coliform count after smoking. This result is in agreement with the work of Bilgin et al. (2008) in which there was significant decrease in the quantities of *Staphylococcus* and *Micrococcus* after smoking.

The weekly change in microbial loads of smoked *C. gariepinus* from LASU fish pond and Badagry market are presented in Table 3. Generally, there is an increase in the microbial load from the 1st day to the 28th day for the two treatments (LASU fish pond and Badagry market) due to growth and multiplication of the microbes (Çolakoğlu, 2004; Bilgin et al., 2008). This view is

supported by Clucas and Sutcliffe (1981). Hood et al. (1983) reported that microbial load increases with duration of storage and temperature. Salán et al. (2006) observed that smoking inhibits microbial growth in stored fish products. Thus, the relative increase in microbial load of smoked *C. gariepinus*, stored at 4°C is an important indicator of quality and influences the time for which smoked fish can be kept.

Some sensory (organoleptic) parameters like flavour, texture, appearance, odour and taste were examined on weekly basis and their results are presented in Table 4. The differences in the sensory parameters measured over a period of 28 days were significant ($P < 0.05$). However, there was no significant difference ($P > 0.05$) in these parameters within the first 7 days after smoking. This agrees with the findings of Bilgin et al. (2008). In all the sensory qualities examined, the smoked *C. gariepinus* scored above average, which indicates that they might still be acceptable 28 days after smoking.

REFERENCES

- Abolagba OJ, Melle OO (2008). Chemical composition and keeping qualities of a scaly fish tilapia, *Oreochromis niloticus* smoked with two energy sources. *Afr. J. Gen. Agric.* 4(2):113-117.
- Afolabi OA (1984). Quality changes in Nigeria Traditionally Processed Freshwater species. *J. Food Technol.* 18:17-29.
- Akande GR (1996). "Post-harvest processing in Fisheries". A paper presented at training for officers of UNDP assisted programme on artisanal fisheries development, Ogun State at Federal College of Fisheries and Marine Technology, Lagos. Jan. 15th - Feb. 5th, 1996:1-20.
- AOAC (1995). Official Methods of Analysis (16th Ed.). Association of Official Analytical Chemist, Arlington, VA, pp. 125 - 126, 132, 877 - 878.
- Apendi MD, Atmadilaga P, Bird HR (1974). Indonesian fish meals as poultry feed ingredients: Effects of species and spoilage. *World's Poul. Sci. J.* 30: 176-182.
- Bilgin S, Unlusayin M, Izci L, Gunlu A (2008). The determination of the shelf life and some nutritional components of gilthead seabream (*Sparus aurata* L., 1758) after cold and hot smoking. *Turk. J. Vet. Anim. Sci.* 32(1): 49-56.
- Clucas IJ, Sutcliffe PJ (1981). An Introduction to Fish Handling and Processing. (Part 2), Tropical Products Institute, 56/62 (LONDON) Gray's Inn Road, London. WCI & SLV Overseas Development Administration G. 143: 69-79.
- Dolakoğlu FA (2004). The effects of processing techniques on microflora of roach (*Rutilus rutilus*) and whitefish (*Coregonus* sp). *Turk. J. Vet. Anim. Sci.* 28: 239-247.
- Doe PE, Olley J (1983). Drying and Dried fish product. In: The production and storage of dried fish, FAO Fish Report No. 279: 56-62.
- Eyo AA (2000). Fish processing technology in the tropics. University of Ibadan Press. pp. 165-168.
- Fawole MO, Oso BO (1995). Laboratory Manual on Microbiology, 2nd edition. Spectrum Books Ltd. Ibadan, pp. 77-78.
- Goulas AE, Kontominas MG (2005). Effect of salting and smoking method on the keeping quality of chub mackerel (*Scomber japonicus*). *Biochem. and sensory attributes.* *Food Chem.* 95: 511-520.
- Hood MA, Ness GE, Rodrick GE, Blake NJ (1983). Effects of storage on microbial loads of two commercially important shellfish species, *Crassostrea virginica* and *Mercenaria campechiensis*. *Appl. Environ. Microbiol.* 45(4): 1221-1228.
- Kumolu-Johnson CA, Ndimele PE (2001). Effect of salting, brining and sundrying on the shelf-life of *Clarias gariepinus* (LACEPEDE). *J. Res. Rev. in Sci.* 2:21-25.
- Mayboom J (1974). Fish handling and processing in the Kainji Lake Basin and suggestions for improvement and future research. Kainji Lake Research Institute, New Bussa, Nigeria: pp. 34-45.
- Ojewole GS, Eburuaja AS, Okoye FC, Lawal AS, Akinmutimi AH (2003). Effect of inclusion of grass lopper meal on performance. Nutrient utilization and organ of broiler chicken. *J. Sustain. Agric. Environ.*, 5: 19-25.
- Olley J, Doe PE, Heruwati ES (1988). The influence of drying and smoking on the nutritional properties of fish. In Burth JR (ed); *An Introd. overview in fish smoking and drying.* Elsevier, London, pp. 1-14.
- Omitoyin BO (2007). Introduction to fish farming in Nigeria. Ibadan University Press. pp. 3-6.
- Omitoyin BO, Faturoti EO (2000). Effects of raw and parboiled chicken offal in the diet of *Clarias gariepinus*. *Aquabyte* 1: 20-25.
- Poste LM, Mackie DA, Butler G (1991). *Laboratory methods for sensory analysis of food.* Ottawa. Res. Branch Agric., Canada Publication. p. 90.
- Rizwan M, Akhtar M, Saima L, Munawar K, Sial MA (2000). Relationship between quality of animal protein sources and their gross and true metabolizable energy in cockrels. *Int. J. Agric. Biol.* 4: 316-317.
- Salán OE, Juliana AG, Marília O (2006). Use of smoking to add value to salmoned trout. *Braz. Arch. Biol. Technol.* 49(1): 57-62.
- Saliu JK (2008). Effect of smoking and frozen storage on the nutrient composition of some African fish. *Adv. Nat. Appl. Sci.* 2(1): 16-20.