PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
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Pakistan Journal of Nutrition 9 (5): 481-484, 2010
ISSN 1680-5194

Investigating the Quality Changes of Raw and Hot Smoked *Oreochromis niloticus* and *Clarias lazera*

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Abstract: This study deals with the effect of hot smoke curing by using two types of hard wood (*Acacia seyal* and *Citrus lemon*) on the proximate composition, microbial load and sensory evaluation of two species of fresh water fishes (*Oreochromis niloticus* and *Clarias lazera*). Highly significant differences ($p<0.05$) were observed on the proximate composition between the two species and the two types of wood, the percentage of total protein, lipid and ash contents increased, due to the decrease in the moisture content to the range 64,15±0.130 and 54.42±0.173%, respectively. The total viable counts of bacteria in fresh fish used as raw material (*Oreochromis niloticus* and *Clarias lazera*) were 281.5 x 10^3 and 183.7 x 10^3, respectively. After smoking the total viable counts of bacteria of *O. niloticus* reached 2 x 10^3, while of *Clarias lazera* was reduced to 6 x 10^3. The bacteria isolated before and after smoking was *Staphylococcus aureus*. With respect to the quality of the products related to colour, taste, texture and flavour, significant differences ($p<0.05$) in the parameters measured were observed, generally the products well accepted.

Key words: Hot smoke, hard wood, protein

INTRODUCTION

Fish is a very important food stuff, especially in developing countries, due to its high protein content and nutritional value of unsaturated fatty matter. However fish is greatly perishable, quality losses might occur very rapidly after catch, especially in hot climates and tropical areas where cold preservation techniques are often missing. Traditional fish processing, such as salting/brining, drying, smoking, allow better preservation and storage and increase fish availability to the consumers.

The waters of Sudan (100.000 km^2 fresh water and 750 km length of coastal marine waters on the Red Sea) have been fished for centuries by many generations. It has been estimated that 26000-29000 tons of fish have been taken from them annually (Yousif, 1988). This represents about 29% of the estimated annual potential i.e. 104,000 tons (Henderson, 1975). More recent estimates of production were in the range of 60,000 ton/year (Federal Fisheries Administration Department, Annual Reports). In the Sudan, nearly 70% of the total fish landings are consumed fresh; the rest is cured either by salting, fermentation or sun-drying. Some of the local fish supply is smoked in southern Sudan where smoked and very dry fermented fish products are very popular among the local community (FAO, 1992).

Smoking is the process of applying wood smoke to impart a smoky or smoked flavour and to partially dry a fish, or part of fish such as fillets, to produce a smoked fish product and also to extend the shelf life of the product under some conditions. In many parts of the world, preservation is still the main purpose of smoking. Any preservative effect of the smoke itself is probably largely due to the presence of a range of phenolic compounds, nitrites and formaldehyde.

The objective of this work is to carry out a comparative study on the use of two types of wood (*Acacia seyal* and *Citrus lemon*) to smoke two types of fish (*Oreochromis niloticus* and *Clarias lazera*) using one type of oven (steel), to conclude and recommend on better smoking of the fish.

MATERIALS AND METHODS

Sampling: Fresh fish of this study were purchased from Jebl-Aulia reservoir, 45 Km south of Khartoum. Fifteen samples of *Oreochromis niloticus* and ten samples of *Clarias lazera* were collected in polyethylene bags (Cold stored) and transported (early morning) to the Fisheries Research Center (Shagara), where fresh samples from raw material, for chemical and microbiological analyses were immediately prepared.

Processing: The pre-smoking process included washing of fresh fish, which was eviscerated; washed again and transferred to baskets to dry up while a thin cloth cover was placed in order to keep away insects. Then fishes were weighed to the nearest gram using a dial balance (KRUPS type 875).

Oreochromis niloticus and *Clarias lazera* were smoked using steel kiln whose fuel was composed of *Acacia*

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seyal and *Citrus lemon* weighing 14.6kg and 13.0kg respectively. Best quality products were obtained according to the following process regimes.

Brining in 10% brine for 15 min, drying phase for 30 min at 30°C; cooking phase 30 min at 60°C and the intensive smoking phase 30 min at 80°C, smoked samples were removed from the kiln and exposed to air to cool and dry.

Chemical analysis: Moisture, protein, fat, NaCl and ash contents were determined according to AOAC (1980).

Microbial examination: Microbial examination of the smoked fish was carried out by the following standard methods.

Total Viable Counts (TVC): Using Pour plate technique as described by Harrigan and MacCance (1976), dilution from 10^{-1} to 10^{-6}, in Nutrient agar and incubated at 37°C for 24 h. Colonies were counted by making the colony on the opposite side of the plate on its position in the colonies counter apparatus.

Isolation and identification of colonies: The samples of fish were first inoculated in nutrient Broth medium and incubated at 37°C for 24 h. In MacConkey's agar and blood agar were cultured from Broth medium by streaking method and incubation at 37°C for 24 h of the samples were done to isolate a single colony. The identification of purified isolates was carried out according to Cowan and Steel (1974).

Statistical analysis: The mean and standard deviation (mean ± SD) for the obtained results were calculated using SPSS soft ware (Version 10).

Organoleptic assessment: End products were submitted to 20 people test panel from Fisheries Research Center staff, fishermen and some students of Department of Fisheries, College of Natural Resources, University of Juba and judged in comparison of smoked fish. Comparison was carried out in terms of organoleptic characteristics, such as colour, flavour, taste and texture. The panel was requested to rate each organoleptic feature of the end products according to a 10 point scale (9 = excellent; 8-9 very good; 6.5-7.9 good; 5-6.4 fair; <5 bad), using the score method as reported by (Afolbi *et al*., 1984).

RESULTS AND DISCUSSION

Proximate composition of fresh fish: The proximate composition of *Oreochromis niloticus* and *Clarias lazera* are given in Table 1. In the two species studied, although *Oreochromis niloticus* showed higher average of moisture, ash content, protein and lower average of fat than *Clarias lazera* results revealed no significant differences ($p>0.05$). Similar results were obtained by various researchers, namely Thurston (1962) who worked on two subspecies of lake trout, Awouda (1984) on two species including *O. niloticus* and Mahmmoud *et al*. (1989) on *Eutropius niloticus*.

Table 1: Proximate composition (g/100 g) of two freshwater fish species

Fish species Parameters	*Oreochromis niloticus*	*Clarias lazera*
Moisture	75.1±2.740	70.0±0.740
Ash	2.1±0.358	1.8±0.10
Protein	19.8±0.10	15.0±0.368
Fat	1.5±0.10	2.1±0.10

Note: Values represent pooled means and standard deviations of triplicate determinations of wet weight

The high moisture contents recorded for the two species are comparable to that reported in other fresh water fish species such as *Alestes nurse, A macrolepidotus*, *Hydrocynus brevis* and *Hepsetus odoe* (Abdullahi, 2000a), *Labeo coubie, L senegalensis* and *Barbus occidentalis* (Abdullahi, 2000b).

The crude protein content was 19.8% and 15% on wet bases for *Oreochromis niloticus* and *Clarias lazera* respectively. This is probably due to the high moisture content. These results agree with those obtained by other investigators for common Nile fishes, (Mahmmoud, 1977; Iskander, 1982; Ssali, 1988).

Crude lipids contents were slightly higher in fresh *Clarias lazera* 2.1% than in *O. niloticus* 1.5% on wet basis. It can be seen that both species belong to the category of low fat classified by Ackman (1989) having fat content below 5%.

Ash content was slightly higher in fresh *O. niloticus* 1.8% than in *Clarias lazera*, 1.0%. These results are in accordance with those obtained by Mahmmoud (1977) and Ssali (1988).

Proximate composition of hot smoked cured products: Table 2 shows the percentage of proximate composition (w/w) of two species treated by two types of wood for smoking. In the corresponding smoked products, the percentage of total protein, lipid and ash contents increased due to water loss during smoking. Similar findings were reported by Aminullah Bhuiyan *et al.* (1986) in Atlantic mackerel and Unlusayin *et al*. (2001) in European eel, pike perch and rainbow trout. Industrial specifications for "smoked finished products" generally is recommended with water content in the fish flesh of less than 65% (Cardinal *et al*., 2001). Goulas and Kontominos (2005) reported that the moisture content of smoked chum Mackerel samples were 58.1 and 59%. Kolodziejska *et al*. (2002) also reported that moisture content of smoked Mackerel was 56.7%. This is in agreement with our result of 60.78% for *C. lazera* and 62.35% for *O. niloticus* moisture content.

Table 2: Proximate composition (g/100 g) of two smoked freshwater fish species treated by two types of wood

Fish species	*Oreochromis niloticus*		*Clarias lazera*	
Parameters	*Acacia seyal*	*Citrus lemon*	*Acacia seyal*	*Citrus lemon*
Moisture	62.3±0.183[b]	61.4±1.105[c]	54.42±0.173[d]	64.15±0.130[a]
Ash	8.58±0.222[c]	7.25±0.129[d]	9.74±0.149[b]	12.63±0.174[a]
Protein	22.15±0.129[c]	21.15±0.129[d]	23.15±0.129[a]	22.55±0.129[b]
Fat	5.23±1.296[d]	7.33±0.129[b]	6.23±0.136[c]	9.03±1.296[a]
NaCl	0.435±0.175[b]	0.658±1.296[a]	0.263±0.231[d]	0.375±0.231[c]

*Values represent pooled means and standard deviations of triplicate determinations of wet weight.
**Values with different superscript letters horizontally in rows are significantly different ($p<0.05$)

Table 3: Total viable counts (cfu/gm) and bacteria isolated from fresh and smoked fish sample

	Oreochromis niloticus		*Clarias lazera*		
Fish species	Fresh	Smoked	Fresh	Smoked	Bacteria species
Wood type	281.5 x 10^3	-	183.7 x 10^3	-	*Staphylococcus aureus*
Acacia seyal	-	-	-	6 x 10^3	*Staphylococcus aureus*
Citrus lemon	-	2 x 10^3	-	-	*Staphylococcus aureus*

Table 4: Means sensory scores of organoleptic tests of smoked fish using two types of wood

Fish species	*Oreochromis niloticus*		*Clarias lazera*	
Parameters	*Acacia seyal*	*Citrus lemon*	*Acacia seyal*	*Citrus lemon*
Colour	7.450±0.129[b]	7.150±0.129[b]	8.150±0.129[a]	8.135±0.175[a]
Texture	9.250±0.129[a]	8.950±0.129[a]	8.02±1.231[b]	8.150±0.129[b]
Flavour	7.435±0.358[b]	6.650±0.129[d]	7.850±0.407[a]	7.033±0.129[c]
Taste	7.250±0.129[d]	8.178±0.171[a]	7.950±0.129[c]	8.150±0.129[b]

*Values with different superscript letters horizontally in rows are significantly different ($p<0.05$)

Also from the result presented Table 2 shows that the increase in the crude protein was about 7.85% for *Clarias lazera* and 2.45% for *O. niloticus*. The variation of crude protein is highly significant in difference ($p<0.05$) between the two species. The impact of species is a highly effective factor, as both species were subjected to the same condition during processing, this means that the *Clarias lazera* muscle are susceptible to lose more water than the *O. niloticus* (Doe, 1998).

Salt content increased in the two species and significant differences ($p<0.05$) were recorded with respect to wood type as well as fish species.

The increase in ash content was correlated mostly with the increase in salt content during the smoking process. Ash content of *O. niloticus* and *C. lazera* was 2.1% and 1.0% (on wet basis), respectively, before processing, while after smoking, it increased to average 7.91% and 11.18% respectively. Karra (1978) found that ash content increased in dogfish from 1.19-4.75% after smoking.

Changes in the microbial load as affected by processing: The results presented in (Table 3) show the Total Viable Counts (TVC) as well as bacterial species. The results revealed that the flesh of the *O. niloticus* had a total microbial load reaching 2 x 10^3 and 6 x 10^3 per gram for *C. lazera*. Shewan (1952) reported that the effect of salt was due to the restriction of microbiological activity as a result of the decrease in water content of the tissues and to the direct action of NaCl on the putrefactive micro-organisms. Karra (1978) reported that smoking caused a decrease in total microbial count by an average of 94.7% of the original number in dogfish fillets.

Table 3 shows that no coliforms were detected in the two species before and after smoking, no pathogenic micro-organisms like *E. coli* and Salmonella were found. However, other microflora isolated was *Staphylococcus aureus*.

Sensory evaluation of smoked products: Sensory evaluation results of smoked products are presented in Table 4. The mean scores showed that all the characteristics of the products were moderately liked. Overall acceptability mean scores indicate that the products were generally well accepted. However, the *C. lazera* treated by *Citrus lemon* appeared to be more acceptable of all the products.

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