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Assessment of the Quality of Smoked Fish Obtained From White Nile River

Abdel Moneim E. Sulieman[1+2] , Waleed A. Mustafa[3] and Sohair AM Shommo[4]
[1]Department of Biology, Faculty of Science, University of Hail, Kingdom of Saudi Arabia
[2]Department of Food Science and Technology, Faculty of Engineering and Technology, University of Gezira, Wad-Medani, Sudan
[3]Department of Food Science and Technology, Faculty of Agriculture, University of Bakht Al-Ruda, ElDueim, Sudan
[4]Family Science Department, Faculty of Education, University of Khartoum, Khartoum, Sudan

ABSTRACT
Smoking method is an important preservation process mostly imparts a desirable flavour and inhibit the growth of microbe. In the present study, smoking was carried out on fish samples collected from Eldueim coast of white Nile river. Quality of the processed samples was evaluated via chemical, microbiological and sensory methods.. The contents of moisture, protein, ash, fat, crude fibre and carbohydrates varied considerably between fresh fish types and ranged between 51.0-55.0 %, 18.5-21.5%, 12.9-14.2%, 7.7-8.9%, 0.9-1.8% and 2.6-6.2%, respectively. High microbial counts was found in raw fishes indicating poor hygienic practices during collection and handling. Smoking process increased the protein and carbohydrate values and reduced the fat contents of smoked fish samples. Smoking process resulted in decreasing the microbial load of the smoked fishes and freed them from pathogenic bacteria which contaminated the fresh fish samples. These products were highly accepted by the panelists.
Keywords: *Smoking, moisture, protein, fat, carbohydrates, salmonella, yeast.*

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INTRODUCTION

Antiquated techniques of preserving fish included drying, salting, pickling and smoking. All of these methods are as yet utilized today yet the more modern techniques of freezing and canning have taken on a large importance.

Processing of fish involves essentially the utilization of conservation procedures in order to retain quality and increase shelf life. It might likewise mean increasing the value to produce a wide assortment of products. Various techniques are utilized to preserve fish [20]. Most of these techniques based on temperature control, utilizing ice, refrigeration or freezing; others on the control of water activity that includes drying, salting, smoking and freeze-drying. The different types of deterioration and food poisoning caused by micro-organisms are preventable to a substantial degree by various preservation techniques, the majority of which act by averting or moderating microbial development. These include freezing, chilling, drying, curing, conserving, vacuum packing, modified atmosphere packing, acidifying, fermenting, and adding preservatives [10].

Smoking method mostly imparts a desirable flavour and inhibit the growth of microbe [21]. The utilization of smoking as curing technique is controlled by the accessibility of fuel and nearby custom, it is broadly practiced in Africa, that around 35% of aggregate arrivals in tropical Africa are being processed along these lines, yet it is a method of moderately minor significance in Asia and Latin America [8]. In this process, fish is smoked until cooked in order to obtain a product with extended shelf–life, since alternative preservation methods such as refrigeration are absent in remote fishing villages where most fish processing takes place [3].

Conventional smoking is generally-hot-smoking which cooks and in part dries the fish and in addition conferring a smoky flavour [9]. The fish might be salted and partially sun-dried before smoking, and further drying may happen after smoking, contingent upon the last moisture content required. Smoking

can be performed for whatever length of time that three days or for only one day. The open nature of numerous conventional fire pits implies that smoke densities and temperatures are roughly controlled by managing the fire itself, and the process requires a high level of supervision by an experienced administrator [9].

Fish processing and handling is carried out in Sudan by conventional techniques, so the amounts of the processed samples are moderately few with a short time span of usability and devoured locally. Therefore it is of prime significance to encourage upgrading of fish industry and to expand the interest in this sector, and to make utilization of stored fish monetarily through technique of preservation and processing and handling of fish [20]. The objective of this research was to evaluate the quality characteristics of smoked fish produced locally at Deuim area, central Sudan.

MATERIALS AND METHODS

Collection of samples

Fresh local fish samples, namely: *Garmout, Bolti, Kas, Kabarous, Kharsha and Amokoro* were collected from anglers at ElDueim coast (Central Sudan) on White Nile immediately after landing during summer months (2010). All samples were collected in sterile polyethylene bags, then transported in strict sterilization conditions to the laboratory pending analyses.

Preparation of samples

The fish samples received for analyses were cleaned manually to remove adhering matter. The smaller fishes were passed through the meat mincer in the intact form. However, in case of larger fishes, only meat was taken for analyses, and in this case, the head and fins were removed and the body was cut along the abdomen. All the viscera including the gonads, the backbone and the ribs were removed. Then the fish was cut along the back, then, the meat and fat were carefully cleaned of skin.

Processing of fish

Samples of the collected fish were processed into smoked fish products. Good hygienic conditions and good manufacturing practices were followed during the various processing steps.

The smoking process started by preparation of the fish in which: the fish samples were rinsed in fresh water, and all loose pieces and bones were removed properly. The skin was removed too. The fishes (all pieces) were completely submerged in brine solution (sodium chloride solution). The brining period was 3 hours at low temperature 7 ° C for the duration of the time of brining.

At the end of the brining period, fish samples were removed, then placed on elevated racks for drying before smoking. Then dried fish samples were placed in racks and hanged inside an earthenware container in which wood was burned in order to produce smoke. During smoking period (1-2 hours) earthenware container was covered with cloth.

Chemical methods

The proximate analysis was carried out in triplicates in all samples according to AOAC [3, 4], these analyses included: the contents of moisture, ash, protein, fat, crude fibre and carbohydrates.

Microbiological analysis

The microbiological analysis were carried out according to Harrigan and MacCance [11]. Serial dilutions of the fresh fish and smoked fish samples in 0.1 gm aliquots were spread on pre-poured plates of Plate count agar (PCA)for counting of total viable count, Mac Conkey agar for coliforms, Baird-Parker agar (BPA) for staphylococci *spp*. and Potato Dextrose Agar (PDA) for yeasts and moulds. After incubation, PCA plates were inoculated at 37^{o}C for 24-48 h, while PDA plates were incubated for 72 h at 25^{o}C. The Characteristic colonies were counted, multiplied by the dilution factor and expressed as colony forming units per ml c.f.u/g.

For Salmonella detection, ten grams of sample were weighted aseptically and mixed well with 100 ml sterile nutrient broth. This was incubated at 37ºC for 24 hours. Then 10 ml were drawn aseptically and added to 100 ml selenite broth. The broth was incubated at 37ºC for 24 hours. Then with a loopful streaking was done on dried Bismuth sulphite agar plates. The plates were then incubated at 37ºC for 72 hours. Black metallic sheen discrete colonies indicated the presence of salmonella. A confirmatory test was carried out by taking a discrete black sheen colony and subculturing it in a Triple sugar iron agar tubes. Production of a black colour at the bottom of the tube confirms the presence of salmonella.

Sensory evaluation

Smoked fish samples were subjected to panel tests. The performance of judges towards these products was tested using hedonic scale, whereby 15 panelists were selected each time. The samples were presented so that each sample had an equal chance to be tested first, second or last. The result obtained by the panelists was converted to scores ranging from like extremely (9) to dislike extremely (1) [14].

Statistical analysis

The data were subjected to statistical analysis using analysis of variance. Mean separation was done according to Duncan's Multiple Range Test at 5% level.

RESULTS AND DISCUSSION

The proximate chemical composition and pH values of the various fish types collected from anglers at El Duiem coast are presented in Figure (1) together with the smoked products prepared from these fish types. The contents of moisture, protein, ash, fat, crude fibre and carbohydrates varied considerably between fresh fish types and ranged between 51.0-55.0 %, 18.5-21.5%, 12.9-14.2%, 7.7-8.9%, 0.9-1.8% and 2.6-6.2%, respectively. All chemical components changed as a consequence of smoking. A substantial decrease occur in moisture contents of the smoked samples which ranged between 39.6 and 46.3%. The strength of smoking was its capacity to diminish the moisture content or water activity in an item hence expanding the time span of usability by hindering the growth of spoilage bacteria [2].

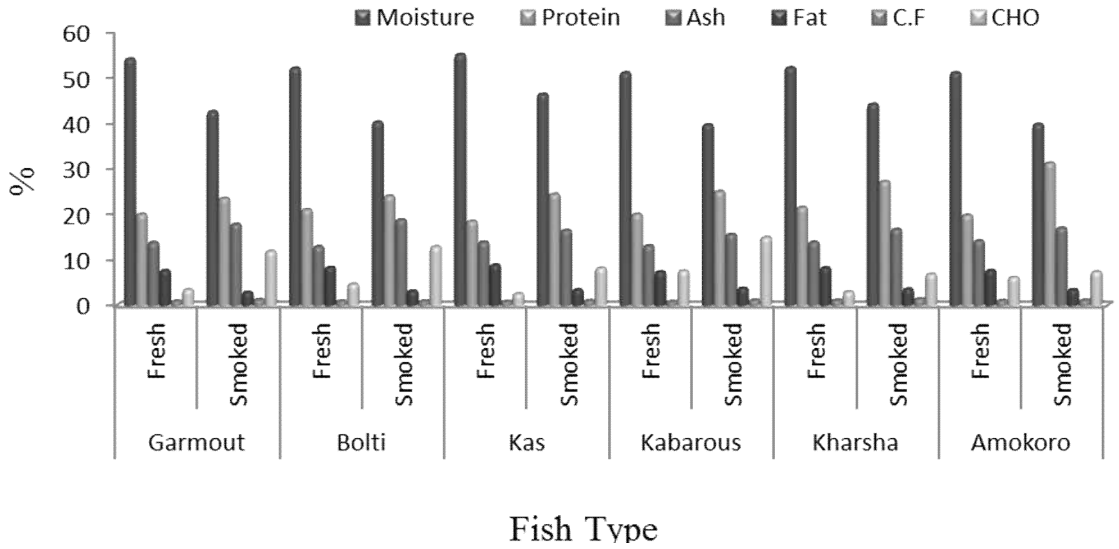

Fig.(1). Chemical composition of fish samples collected from anglers at EDuiem coast and smoked fishes

The protein contents of the smoked samples exceeded those of fresh samples and ranged between 22.9 and 31.2% . The obtained protein value was lower compared to those reported in the muscle of *Penaeus monodon*, *Metapenaeus monoceros* and *Macrobrachium scariculum* which were 63.22 %, 60.15 % [19] and 56.75 % [6]. The recorded high contents of proteins in the various smoked fish samples indicate that smoking processes will increase the contents of this important macronutrient component of food products. This agrees with that reported by Okerreke *et.al.,* [15] who attributed the protein content increase in his smoked catch fish (*Clarias gariepinus*) compared to fresh samples, to the product dehydration which concentrated the proteins during the heat treatment of the fish, thus increasing the nutritional value of the catchfish.

The ash contents ranged 15.6-18.8% which was also higher than that of fresh samples. The highest value obtained in the smoked fish samples was adduced to moisture loss [2]. Salán *et al.* [18] suggested that the increase in ash content of smoked fish is due to loss of humidity, while Doe and Olly [7] revealed that smoking resulted in concentration of nutrients like crude protein and fat.

The fat content ranged 2.9 - 4.4% was lower than that of fresh samples (7.7-8.9%). Presence of fat in different smokes fish samples gives advantages of the medium for the absorption of fat-soluble vitamins, contributing to the palatability of food and essential to legitimate improvement and survival during the early stages of life-embryonic development and early growth after birth, on through earliest stages and adolescence (FAO 2008). It is guessed that expanded fat levels in smoked and sundried specimens in the present investigation may have come about because of processed glycogen from cell wall of fishes. The crude fibre content ranged 1.0 - 1.5% and 6.8-10.2%, during summer and winter, respectively. It has been stated that heat processing methods lower the fibre values as a result of heat treatment which causes in the loss of cell wall of fish [2].

The carbohydrates content ranged between 6.9 - 14.9%. The carbohydrate content was lower than the value to the 5.08 % that reported by Snehalata and Sahu [19] in *Penaeus monodon.* These results indicate

that smoking processes will increase the contents of this vital macronutrient components of food products. It is instructive to note that most elevated dietary protein and carbohydrate levels by smoking procedure as indicated in the present study will be a an extremely valuable practice towards expanding access per unit serve of protein in places where the cost of animal protein is restrictive and dietary energy is required. Petricorena [17] reported that fish is the only protein source that contains all the essential amino acids and while lipids and proteins are the major components of fish food; the carbohydrates are usually detected at very low levels (<0.5 %).

It has been reported that chemical composition of fish varies greatly among species and from an individual fish to another, depending on age, sex, environment, and season [17]. The mix of smoke, salt, and drying is one of the most punctual recorded strategies of food preservation. These systems, inexactly known as "Smoking" or "Smoke Preservation," are effective in light of the fact that they kill food poisoning and spoilage bacteria or render them innocuous by modifying the chemistry of the environment these spoilage organisms need to grow [12].

Microbiological characteristics

The results of the microbiological analyses which included the load of bacteria, yeasts and moulds and pathogenic microorganisms in various fresh fish types and smoked fish samples, are shown in Tables 1 and 2, respectively. The highest total viable count of bacteria (5.1 x 10^6 cfu/g) was observed in *Garmout* and the lowest (2.3 x 10^5 cfu/g) in *Kas.* Yeast and mold count was highest (8.6.4×10^3) in *Kabarous* and the lowest (1.5 x 10^2 cfu/g) in *Kas* fish type (Table 2). However, the other fish types had almost similar results. Total coliform bacteria was detected in all the fish samples. It was found in a range of 80 to 240/g, but *Escherichia coli* was not detected in all examined fish samples. Highest staphylococci count was observed in *Kas* fish type (2.3×10^3 cfu/g), while the lowest (1.2×10^2 cfu/g). Salmonella was detected in about 33% of the fresh fish samples. High microbial load in raw fishes demonstrates that crude fish would deteriorate rapidly at surrounding temperature, and the presence of coliforms, staphylococci and Salmonella indicates the crude fish handling is not safe. Fish in this way a product that requires proper handling and processing in order to preserve nutrients and its functional components that promote good health.

Smoking process resulted in changing the microbial load of the smoked fish from the same types as in Table (2) which shows the microbiological characteristics of various samples of smoked fish. The highest total viable count was observed in smoked *bolti* (3.7×10^6 cfu/g), and the lowest (3.8×10^4cfu/g) in smoked *Kharsha* fish. All smoked fish products were free from coliform, staphylococci and salmonella**.** However, the yeasts and moulds counts ranged from 1.2×10^2 to 5.8×10^2 cfu/g.

The study pointed out that though smoking assists in inhibiting the activities of microorganisms, however, when not properly done, microbial growth and activities still continue, leading to the deterioration of the fish. Nonetheless, generally the smoked fish nevertheless recorded low existence of microorganisms because of the good sanitary conditions observed prior to and during the smoking process.

Okonta and Ekelemu [16] conducted a preparatory study on the microorganisms related with smoked fish and reported *E.coli* and *Staphylococcus aureus* as the dominating microorganisms infecting fish spoilage in Asaba area of Nigeria. The outcomes from their study indicated that smoked fish from the markets had the highest microbial load (bacteria and yeast and moulds) when compared with smoked fish. Generally, the smoked fish samples exhibited and the microbiological load fell within acceptable level stipulated by microbiological standards. This indicates that the samples were safe for consumption, this fact corresponded with that reported by Adenike [1] who concluded that using sodium citrate and black pepper singly and in combination have a potent antioxidant and antimicrobial effect more than smoking. Moreover, Kester *et.al*., [13] in his study of the effect cold smoking on microbiological quality of smoked fish, concluded that the cold-smoking Gadus morhua at 7.5 h will preserve the fish more and make it safe for consumers.

Table 1. The Microbiological Characteristic of fresh fish collected from anglers at ElDueim coast

Fish type	Total viable count of bacteria (cfu/g)	Coliform MPN per gram		Yeasts and moulds (cfu/g)	*Staphyloc-occi*	Detection of Salmonella
		Total	*E.Coli*			
Garmout	5.1 x 10^6	240	0	5.2 x 10^2	1.4×10^2	- ve
Bolti	2.7×10^6	240	0	5.5 x 10^2	1.2×10^2	+ve
Kas	2.3 x 10^5	240	0	1.5 x 10^2	2.3×10^3	-ve
Kabarous	3.3×10^5	120	0	8.6 x 10^2	4.7×10^2	+ve
Kharsha	8.5×10^5	100	0	5.0 x 10^1	3.3×10^3	-ve
Amokoro	7.2×10^5	240	0	5.4 x 10^2	4.5×10^2	-ve

Table 2. The Microbiological Characteristic of smoked fish samples

Smoked fish product	Total viable count of bacteria (cfu/g)	Coliform MPN per gram		Yeasts and moulds (cfu/g)	*Staphyloc-occi*	Detection of Salmonella
		Total	*E.coli*			
Garmout	2.4×10^{5}	0	0	5.8×10^{2}	ND	-ve
Bolti	3.7×10^{6}	0	0	4.6×10^{2}	ND	-ve
Kas	7.8×10^{4}	0	0	1.2×10^{2}	ND	-ve
Kabarous	9.0×10^{4}	0	0	3.3×10^{2}	ND	-ve
Kharsha	3.8×10^{4}	0	0	4.2×10^{2}	ND	-ve
Amokoro	2.9×10^{5}	0	0	3.6×10^{2}	ND	-ve

Sensory evaluation

Sensory evaluation is a vital important quality assessment method of fish and fish products. As the quality of these products deteriorates progressively, several off-odours can be noticed. Many different odour compounds can be perceived but some are having very low odour threshold values

The sensory evaluation results of the smoked fish products are shown in Table (3). The results show that there were insignificant differences in most of the sensory parameters of most of the smoked fish samples. All smoked fish products were highly accepted by the panelists who gave high scores for most of the products. The most accepted smoked fish product was salted *Kabarous* fish product which also had the most attractive appearance, while the least accepted one was smoked G*armout* fish product.

Table 3. Sensory evaluation* of some of smoked fish products

Smoked fish product	Appearance	Texture	Colour	Flavour	Overall acceptability
Garmout	6.8 b	6.9 b	6.2 b	6.4 b	6.7 b
Bolti	7.6 a	7.7 b	7.5 a	7.6 b	7.6 a
Kas	7.6 a	7.8 a	7.7 a	7.7 a	7.5 a
Kabarous	7.8 a	7.9 a	7.8 a	7.7 a	7.8 a
Kharsha	7.5 a	7.6 a	7.5 a	7.5 a	7.5 a
Amoroko	7.7 a	7.8 a	7.6 a	7.7 a	7.6 a

* Means followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test at 5% level

CONCLUSIONS

Since fish is very perishable, it is therefore, necessary to preserve fish if not consumed or disposed immediately. The chemical analyses indicated the similarity of most of the tested chemical components of the fresh and smoked fish products. They also showed that smoking increased protein and carbohydrate values and reduced fat contents.

Generally, microbiological analyses showed that collected fresh fish were not safe for consumption before processing since the same fish samples when subjected to smoking process, revealed lower microbial load and devoid of pathogenic bacteria beside. These products were highly accepted by the panelists. The higher microbial load of the fresh fish samples could be a result of unhygienic conditions during handling and marketing..

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