Original article

Nutritional and Microbial Quality of Dried Nile Bulti [*Oreochromis niloticus* (Trewavas)]

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Abstract

The aim of this study was to investigate the effect of sun drying in combination with salting using different salt concentrations on the nutritive value and microbiological quality of the Nile Bulti [*Oreochromis niloticus* (Trewavas)] products. The study was carried out during March–May 2012. Fresh fish specimens of *Oreochromis niloticus* obtained from (Al Mowrada) fish market in Omdurman - were subjected to drying and salting treatments. Fish proximate composition: moisture, ash, oil and protein contents were evaluated then out of these results; fat: protein ratio and caloric values were calculated. In addition, total bacterial counts and identification of some bacterial species was used to compare the effect of sun drying in combination with salting using two different salt concentrations (20 % and 30 % wt/ vol) on the nutritive value of fish. The statistical analysis of data showed clear significant differences in moisture, ash, protein contents and energy value of *Oreochromis niloticus* among the different treatments ($P<0.05$). However, no significant difference was detected in fat content and fat: protein ratio ($P>0.05$). Microbiological examination results showed that fresh and salted dried products of *Oreochromis niloticus* were within the acceptable ranges of the specified microbiological limits recommended by international agencies for fish and fishery products. Fish drying in combination with salting was proved to maintain good nutritional and microbial quality of dried *Oreochromis niloticus* products.

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Introduction

Fish is a very important food stuff in developing countries, due to its protein content and nutritional value (Jain and Pathare, 2007), in addition to some vitamins and minerals required by humans (Ojutiku *et al*., 2009 and Marimuthu *et al*., 2012). Its harvesting, handling, processing and distribution provide livelihood for millions of people as well as providing foreign exchange earnings for many countries (Al-Jufaili and Opara, 2006). Fish is an extremely perishable food item (Agbo *et al*., 2002 and Ahmed, 2008). Quality loss can occur very rapidly after catch (Khan and Khan, 2001;

Musa *et al*., 2010 and Dewi *et al*., 2011). Spoilage affects the odor, flavor, texture, color and chemical composition of fish (Agbabiaka *et al.,* 2012) and these in turn affect the nutritional quality, consumer acceptability and commercial value of fish (Daramola *et al*., 2007). In order to reduce wastage and spoilage of fish, and to enhance long storage, it is necessary to adopt appropriate as well as affordable fish processing and preservation techniques especially in the artisanal fishermen's environment (Oparaku and Ojike 2013). Several methods are followed worldwide for preserving fish to extend its shelf-life, including drying, salting and smoking (Abolagba and Melle, 2008).

According to Pandey and Shukla (2005), fish processing is a very important part of commercial fisheries for it helps to extend the storage life of fish. In addition, it gives the product a form which is attractive to consumers (Tawari and Abowei, 2011). Preservation techniques are designed to inhibit the activity of spoilage bacteria and metabolic changes to prevent fish spoilage and prolong shelf life. Some of these preservation techniques are affected through the control of temperature (e. g. by chilling or freezing), reduction of water activity (drying, salting and smoking) and use of preservatives (Abolagba and Nuntah, 2011).

Drying dehydrates the fish and inhibits enzymatic actions but during storage, nutritional quality may deteriorate as a result of lipid oxidation and microbial growth (Kumolu-Johnson and Ndimele, 2011). It also reduces or completely eliminates physiological, microbial and enzymatic degradation of biological materials (Shitanda and Wanjala, 2006). Wet salting reduces fish lipid oxidation, probably due to the restriction of oxygen access by immersion, retarding the rancidity reaction (Horner, 1997; Yanar *et al*., 2006 and Chaijan, 2011); it reduces micro-organisms counts on dry fish (Kiaye, 2004); Sodium chloride has traditionally been used in curing and preservation of meat and fish due to its capacity to improve the water holding capacity of proteins (Kituu, *et al*., 2008).

Oreochromis niloticus is an economically important cultured species in several areas of the world (El-Husseny *et al*., 2007 and El-Saidy and Gaber, 2005). In Sudan, the fish is considered amongst the top twenty species of inland water resources that are found in abundance all the year round. According to Karrar, (2007), the fish is an important dietary item and is consumed as fresh or treated products. The objective of this study was to determine the influence of salting in combination with sun drying on the nutritive value and microbiological quality of *Oreochromis niloticus*.

Materials and Methods

33.4 kilograms comprising 84 fresh specimens of *Oreochromis niloticus* (Nile Bulti) were obtained from Al Mowrada fish market in Omdurman, Khartoum State, Sudan. The study was carried out during March – May 2012. Fish specimens were washed, descaled, gutted, eviscerated and washed again. Five eviscerated fish specimens weighing 2.3 kilograms were taken randomly from the pooled sample to be analyzed and represent the control fresh sample. Then the remaining fish sample was divided into three sub samples. The first one consists of 27 fish weighing 10142.31 g, was subjected to direct sun drying without any predrying treatment. The second consists of 26 fish weighing 10649.84 g and third consists of 26 fish weighing 10280.80 g sub samples were brined in (20% and 30% wt/vol) sodium chloride solutions respectively, for 3hours.

The samples were then dried under direct sun and the weight of the three samples was measured daily until a constant weight was reached which indicates completion of the drying process, drying was achieved in 7 days period for all treatments. Dried samples were then transformed into powder for lab analysis. Fresh and dried fish were analyzed to determine the crude protein, fat, moisture and ash contents.

1. Proximate analysis

1.1. Moisture content

The moisture content was calculated by determining the difference in weight before and after drying one gram of the sample in a drying oven adjusted at 100 – 105 C°, as described by AOAC (2000). Then the moisture content was calculated using the following formula:

Moisture % = (Wet weight – dry weight)/ Wet weight X 100

1.2. Protein content

Protein content was determined by the Micro – Kjeldahl method, which involves digestion, distillation and titration and applying the factor 6.25 to the nitrogen content of the sample, as described by AOAC (2000). The protein percentage was given by the following formula:

Protein % = ((V2 – V1) X N X 14 X 100 X 6.25)/ 1000 X Wt.

Where:

V1 = Volume of HCl used in titration.

V2 = Volume of HCl used in blank titration.

N = Normality of HCL used in titration.

14/1000 = Conversion ratio from ammonium sulphate to nitrogen.

Wt. = Weight of sample. 6.25 = Conversion factor from nitrogen to protein.

1.3. Oil content

Fat content was determined by extracting 1 gm of sample with petroleum ether (boiling point 60 – 80 Cº) for six hours in Soxhelt apparatus. The extract was then dried in an oven at 100 – 105 Cº for removal of extra ether traces, following the method described by AOAC (2000). The fat content was given by the following formula:

Oil % = (Weight of ether extracted fat)/ Weight of sample X 100

1.4 Ash content

Ash content was determined after incineration of 2 gm of sample in a Muffle furnace at 450 -550 Cº for 5 hours, as described by Pearson (1976) and AOAC (2000), the ash percentage was given by the following formula:

Ash % = (Weight of ash)/ Weigh of sample X 100

2. Fat: protein ratio

Fat to protein ratio was calculated from the fat and protein contents of each individual sample.

3. Energy value

The energy value was calculated from the fat and protein contents of samples using the values 9.02 Kcal. /gm for fat content and 4.27 Kcal. / gm. for protein content as recommended by FAO (1989).

4. Microbiological analysis

Total viable bacterial count in the control and dried samples was determined using poured plate count technique as described by (FAO, 1992). Serial dilutions from 10-1–10-5 were plated on plate count agar (PCA) and incubated at 37Cº for 48 hours.

Multiple tubes method according to (FAO, 1992) was used for Escherichia coli detection; 1ml of each of the three first dilutions was inoculated aseptically in triplicates of 9 ml sterilized Lauryl Tryptose Broth test tubes and incubated at 37 Cº for 24 hours. Positive tubes were inoculated into Brilliant Green Bile (2 %) Lactose Broth and incubated at 44Cº for 24 hours. The positive tubes were streaked on Eosin Methylene Blue (EMB) Broth and then incubated at 37 Cº for 24 hours.

Detection of salmonella was performed as described by (FAO, 1992); 10 ml of neat solution (10-1) were transferred aseptically into sterilized 90 ml of pre – enrichment Nutrient Broth (NB) and incubated at 37Cº for 24 hours. 10 ml of incubated (NB) were transferred aseptically into sterilized Selenite Cystine Broth and incubated at 37Cº for 24 hours. 10 ml of incubated (SB) were streak – plated on Bismuth Sulphite Agar surface and incubated at 37Cº for 24 hours.

5. Climatic factors

During the fish drying process, daily records of the climatic factors; temperature, wind speed and relative humidity were measured using thermometer, wind speed meter and hygrometer respectively.

6. Statistical analysis

One way analysis of variance (ANOVA) and Duncan multiple range tests with significant level (0.05) were carried out for the data obtained throughout the course of this study.

Results and discussion

Dry and dry salted fish are used as a substitute when there is scarcity of fresh fish in many countries (Bille and Shemkai, 2006, Oyero *et al.*, 2007 and Chukwu and Shaba, 2009). The results of the present study focused mainly on the effect of salting using two different concentrations of sodium chloride solution (20% and 30% wt/vol) in combination with sun drying on the nutritive value of *Oreochromis niloticus*.

The chemical composition of fish is an important aspect in fish processing as it influences the keeping quality and the technological characteristics of the fish. According to Huss (1988), this is directly related to the moisture, protein, fat and ash contents of the muscles. These parameters were taken in consideration during the comparative study of nutritive values of fresh and salted dried fish products.

The study was carried out during the summer season, the average recorded climatic factors at then were: 40.28 ± 1.110 C, 29.71 ± 2.93 % and 1.73 ± 0.09 m/sec for temperature, relative humidity and wind speed. Our results have shown that all the different treatments followed the same pattern in weight loss during the drying process that started sharply during the first two days, and slowed down gradually till a constant weight was maintained. (Figure 1).

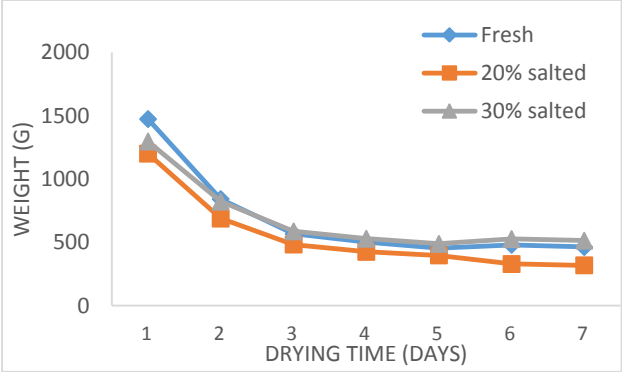

Figure 1: Daily weight loss during sun drying of fresh and salted *Oreochromis niloticus*.

The initial quality of raw fish material strongly influences subsequent performance in processing and storage. This is true not only for fish but also for all food stuffs. The final quality of the product is the most perfect indicator of the sum of chemical and biochemical changes, which have occurred between the sea and our table. Fish freshness and related quality control problems were studied by many authors: Bligh (1971), Jackson (1971), Connell (1975), Osuji (1975), Huss (1988) and Isono (1990). Table (1), illustrated the proximate chemical composition of fresh and dried *Oreochromis niloticus* products. The results of fresh *Oreochromis niloticus* chemical composition coincides with the results reported by Mahmoud (1977), Omer (1984), Awouda (1988) and Karrar (1997).

Table (1): Effect of sun drying and salting on the proximate composition of dry matter of *Oreochromis niloticus*

Chemical constituent	Control	Fresh dried	20% salted dried	30% salted dried	Sig.
Moisture %	71.2 b ± 2.51	4.35 a ± 0.51	2.97 a ± 0.53	2.74 a ± 0.71	0.000
Ash %	10.87 a ± 0.80	13.92 b ± 1.36	16.35c ± 2.21	18.64d ± 1.58	0.000
protein %	71.66 b ± 2.85	64.61a ± 3.18	67.79 a ± 2.75	67.43 a ± 2.96	0.005
Fat %	13.84 ± 1.87	15.31 ± 2.34	13.54 ± 1.34	12.47 ± 1.94	0.072
Fat: Protein Ratio	0.20 ± 0.03	0.24 ± 0.05	0.20 ± 0.02	0.19 ± 0.03	0.054
Energy Value Kcal/100gm	415.75 b ± 9.80	398.25 a ± 12.48	395.14 a ±16.10	383.97 a ±16.71	0.010

* Means with similar superscript (in a row) are not statistically significantly different (P > 0.05); those with different superscript are statistically significantly different (P < 0.05).

The moisture content of fresh *Oreochromis niloticus* was 71.2 ± 2.51 % of the total weight, this result was in the same range recorded by Yanar *et al.* (2006), Chaijan (2011) and Jim *et al.* (2017) and differ from the findings of Fonseca *et al.* (2013).

Results showed clear reduction in moisture content in comparison with control sample (P< 0.05) due to drying process. In contrast, no significant variation in moisture content was found among the three drying treatments, whereas slight decrease was observed with the increase in the brine concentration (Figure 2), similar observation were reported by Mujaffar and Sankat (2006), Sereno *et al.* (2006) and *Kituu et al.* (2008). These finding disagree with those of Graivier *et al.* (2006), mentioned significant reduction in moisture content of salted fish which can be explained by the fact that since salt is hygroscopic; increase in its concentration will increase the amount of salt particles for absorbing water molecules from the fish. Thorarinsdottir (2004) stated that at higher salt concentration, proteins had probably denaturized, leading to less WHC and dehydration of the muscle

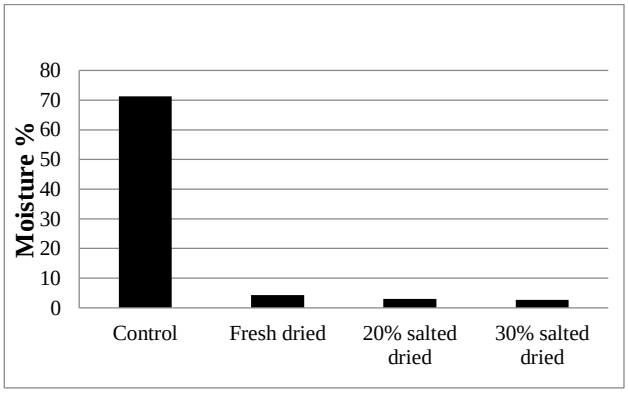

Figure 2: Moisture content of fresh and dried *Oreochromis niloticus*

Ash content of the control sample was10.87 ± 0.8 %, whereas the highest value of the dried products was 18.64 ± 1.58 % and the lowest was 13.92 ± 1.36 % for the 30 % dried products and fresh dried products respectively. Ash content shows clear significance differences among the different treatments (P< 0.05) (Figure 3). Increased values in salted dried samples could be attributed to high salt content which added more ash components to the products. These results were in accordance with Ahmed, 2006; Bakhiet and Khogalie, 2012; El-Bassir *et al*. 2015 and Farid *et al.*, (2016).

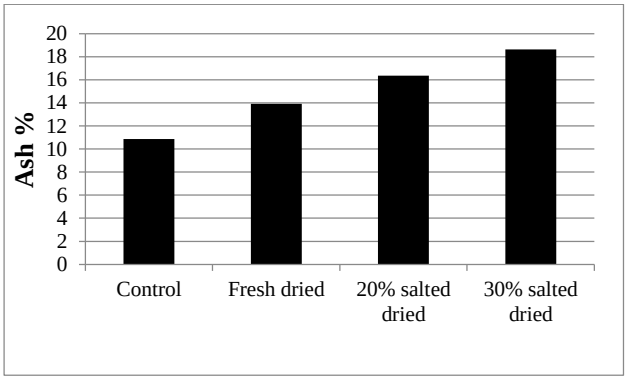

Figure 3: Ash content of fresh and dried *Oreochromis niloticus*

The nutritional importance of fish protein is due its characteristic amino acids content (Friedman, 1996 and Millward *et al*., 2008). Protein content (Figure 4) was highly significantly different among the different treatments (P<0.05). The recorded reduction in protein level in salted products could be attributed to the fact that the protein being dissolved in the brine (Clucas and Ward, 1996). These results coincide with the findings of Ufodike and Obureke (1989) and Arekemase *et al* (2012). However, they are in contrast with Mohamed (2008) who mentioned an increase in protein content of fish with the addition of salt. Nevertheless dried salted products retained a good proportion of protein ranging between 64.61 ± 3.185 % to 67.79 ± 2.75 % of fish dry matter (Longwe and Kapute, 2016).

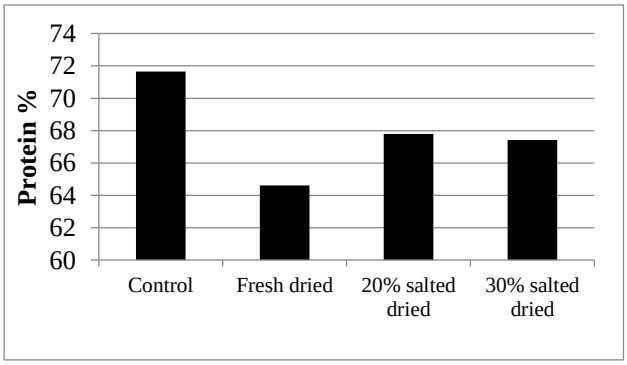

Figure (4) Protein content of fresh and dried *Oreochromis niloticus*

Fish oil is characterized by its distinguished polyunsaturated fatty acids which have acquired recent interest for their medicinal and nutritional properties (Razak, *et al*., 2001; Wang *et al*., 2006 and Amuamuta *et al*., 2014). The control sample fat content was 13.84 ± 1.87 % of the fish dry weight, the highest value of fat was15.31 ± 2.34 % and the lowest one was 12.47 ± 1.94 % for the fresh dried fish and 30 % salted dried fish respectively (Figure 5). Results of the study showed that fat content was not affected by the different treatments (P>0.05). This is in agreement with Hughes *et al*. (1980) and Shearer (1994) who stated that lipid content of fish varies only with seasonal and physiological factors.

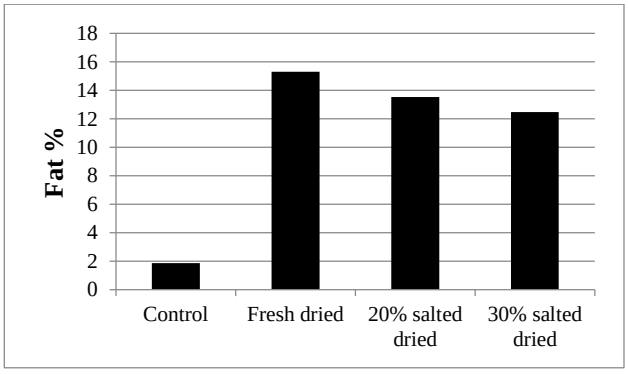

Figure (5) Fat content of fresh and dried *Oreochromis niloticus*

Bacterial growth is the main cause of fish spoilage; therefore it is logical to use bacterial counts as an index of fish quality. Beside the total viable bacterial count, the present study focused mainly on the detection of Escherichia coli and salmonella spp. because they are the most dangerous microorganisms that contaminate fish during harvest, processing and distribution owing to improper handling and storage Jay (2000) and Kim *et al*. (1999).

In this study, the total bacterial count (5×105 – 106 cfu\ g) for fresh and dried *Oreochromis niloticus* (Table 2) was within the accepted limits mentioned by Sudanese Standards and Metrology Organization (SSMO) (SDS 357) for fresh fish products. Also this count was in the normal range stated by Liston (1980) which was 102 – 107 cfu\ g of fish meat. Furthermore, there are reports e.g. Shewan, (1977) who suggested that bacterial flora on freshly caught fish depends on the environment rather than fish species, and this reflects a wide range of bacterial count in fish and fishery products. These results confirm the positive effect of salting process in inhibiting the growth of some bacterial species. Similar findings were reached by Yanar, *et al*, (2006).

Table (2) Total viable bacterial counts and presence of some dominant microbial species in dried *Oreochromis niloticus*

Treatment	Total Bacterial count cfu /g	Total Coliforms	*E. coli*	*Salmonella*.
Control	4.98 X 10^3	_	_	_
Fresh dried	6.14 X 10^3	+	+	_
20% salted dried	5.46 X 10^3	_	_	_
30% salted dried	5.04 X 10^3	_	_	_

+ ≡ present, _ ≡ *absent.*

Conclusions

* Sun drying is a simple, effective, and cheap method for fish preservation and affects the nutritional quality of dried *Oreochromis niloticus*. The process retains a suitable range of nutritional value of the dried products for the consumer.

*Salt application was much more effective with the sun drying process and gave significant results compared to fresh sun dried products especially prevention of microbial growth.

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