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Effect of Processing and Storage on the Trace Metal Concentration and Freshness Quality of Catfish (Clarias gariepinus)

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Abstract

The freshness quality of fish is altered by enzymatic and microbial activities, necessitating the application of fish preservation technology. This study assessed trace metals concentration and freshness quality of Catfish (*Clarias gariepinus*) preserved by oven-drying, brining/oven drying and smoking. The fish were processed to average moisture contents of 15 ± 5 %. Processed fish samples were stored in perforated plastic containers for 11 successive weeks at room temperature and assessed weekly for levels of trace metals (Fe, Zn, Cd, Pb) and physical attributes of odour, flavour and texture. Microbial load was assessed by total viable count (TVC) and biochemical activity by total volatile nitrogen (TVN). The freshness quality of processed fish decreased with increasing storage time and all samples preserved using the three preservation methods contained levels of trace metals below the recommended limits for trace metals in fish and are therefore safe for human consumption.

Keywords: Preservation, trace metals, freshness quality, total viable count, total volatile nitrogen

1. Introduction

Fish are important sources of protein to millions of people worldwide. It is known to be one of the cheapest sources of animal protein and other essential nutrients required in human diets (Sadiku and Oladimeji, 1991). In many Asian countries, over 50 % of the animal protein intake comes from fish, while in Africa, the proportion is 17.5 % (Williams et al., 1988). In Nigeria, fish has an edge over meat because it is cheaper and relatively more abundant in Nigeria (Eyo, 1983) and constitutes about 40 % of the animal protein intake (Olatunde, 1998).

Among the food resources of the world, Fish and Fishery products are very important as sources of protein especially in some countries that are unsuitable for live stock production. However, quality of harvest is markedly affected by the ease of deterioration and spoilage in fresh fish. At present there are numerous problems confronting the wide field of fisheries and some of which seems to be related to the keeping quality of the fish (Okoro et al, 2010). Fish is a very perishable food and its high perishability has been the main obstacle in its preservation. As such, preservation provides a way out to avoid losses due to quality deterioration and spoilage. The successful application of preservation technology results in the conservation of desirable qualities in stabilized fish products. Such fish products permit their widespread distribution to meet the needs of people (Desrosier and Desrosier, 1977).

There are two main methods of assessing fish quality to determine its freshness and shelf life and these are sensory and non-sensory methods. Sensory methods rely mostly on appearance, odour, texture and taste of the Fish while non-sensory methods use physical, biochemical, chemical and microbiological means (Huss, 1995).

2. Materials and methods

2.1 Sample collection

Life fish samples were obtained from fishermen at Ibaro village along the Oyan Lake. The fish samples were stunned immediately after capture, carefully gutted and washed with clean water. They were packed in ice packs and transported to the laboratory.

2.2 Fish preservation

a. Drying: Fish samples were dried in an oven at an initial temperature of 45 ^{o}C for two (2) hours. Further drying at 105 ^{o}C was done.

b. Brining and Oven Drying: Fish samples were soaked in a 36% salt solution (Eyo, 2001) for 30 minutes. The samples were drained on white cardboard sheets in the laboratory and dried in an oven at an initial temperature of 45 ^{0}C for two (2) hours. Further drying at 105 ^{0}C was done.

c. Smoking: Fish samples were drained of water and smoked in a neatly prepared traditional smoking kiln constructed of an open drum. The drum was covered with aluminium foil to conserve heat and smoke.

All samples were processed to a moisture content of 15 ± 5 %.The Samples were cooled and exposed to ambient temperatures to air-dry. The samples were stored in perforated clean plastic containers at ambient temperature (25 -32 ^{o}C) and labelled accordingly.

2.3 Determination of freshness quality

a. Organoleptic assessment

Processed fish samples were placed in transparent polyethylene bags and sample coded. Consumer acceptance of odour, flavour, and texture of processed fish samples were assessed by a four-man panel using a 15 point scale modified from Eyo (2001) and Nguyen (2005). Grades were allotted depending on their quality: $12 < S \leq 15$ = very fresh, $12 < S \leq 9$ = fresh, $6 < S \leq 9$ = poor, $3 < S \leq 6$ = bad, ≤ 3 = very bad.

b. Total viable count

1 g of fish muscles was weighed aseptically and homogenised in 10 ml sterile peptone water. Serial dilutions of the mixture were prepared and 0.1 ml of diluent was spread on already prepared plates of nutrient agar. Duplicate plates were incubated at 25 ± 5 ^{0}C for 24 hours. The total colonies were counted to represent the total number of bacterial cells (TVC) capable of forming colonies.

c. Total volatile nitrogen

Total volatile nitrogen was determined using the colorimetric method (Anderson and Ingram, 1993).

0.5 g of fish muscle was digested using 30 ml Sulphuric acid and Selenium tablet. The digests were made up to 100 ml in clean volumetric flasks. 100 ml standard solutions of NH_4SO_4 (0, 5, 10, 15, 20 and 25 ml of the 100 µg/ml NH_4^+ -N) were prepared from NH_4SO_4 dried at 105^{o}C for two hours.

0.1 ml each of the standards and samples were measured using pipette into clean test-tubes and 5.0 ml of reagent N1 was added to each test tube, mixed well and left for 15 minutes. Then 5.0 ml of reagent N2 was added to each test tube, mixed well and left for l hr for full colour development. The absorbance of standards and samples were read at 655 nm using a UV spectrophotometer. Calibration curve of absorbance against standard concentration was plotted and the TVN concentrations determined from the curve. Reagents were prepared at least 24 hours before analysis.

d. Trace metal analysis

1g of processed samples was weighed and mixed with 20 cm^3 of the digestion mixture (Nitric acid/Hydrogen peroxide - 3:1). The mixture was heated until fuming ceased. The resulting digest was filtered using Whatman filter paper No. 42 and made up to 100 cm^3 with de-ionised distilled water. The digest were analysed for Zn, Fe, Cd and Pb using (AAS) Atomic Absorption Spectrophotometer.

3. Results and discussion

a. Organoleptic assessment

The sensory scores of preserved fish samples are presented in figs 1 and 2. . There was a general decline in the physical attributes of processed fish samples such as odour, taste and texture of fish as the weeks progressed in the order : Brined/Oven dried > Smoked > Oven dried (i.e. BOVD > SMKD > OVD). The reduction in the sensory qualities with increase in the storage period of processed fish could be attributed to activities of the spoilage agents. Similar trend was observed by Daramola *et. al.,* (*2007*) who observed a reduction in the physico-chemical qualities of smoked fish with increasing storage period. According to Llobreda *et. al.*, (1986), the storage of crustaceans (Oyster and Shrimps) revealed quality loss during storage both at ambient temperature and chilling.

Among the three processing methods, BOVD samples which were the most organoleptically accepted, reduced the most in texture and odour as the duration of storage increased. Hence, it can be assumed that BOVD samples absorbed moisture the most from the surrounding air. Reduction in texture could be due to the possibility of magnesium chloride impurities in the salt used for processing. Magnesium chloride is hygroscopic and if present in salted fish makes it damp paving way for bacterial and mould spoilage (Eyo, 2006). The reduction in odour is most likely due to rancidity as fatty fish species like *Clarias gariepinus* with fat content higher than 0.9% (Love

1988) are mostly affected by rancidity than lean fishes like *Tilapia zillii* with fat content of 0.1-0.9% (Love 1988). Also, in the BOVD samples, salt has the potential to accelerate fat oxidation (Eyo, 2006).

Based on the assessment of the taste, the preserved fish samples were unacceptable by the end of the 6th week. Fluffy woolly mat of moulds was noticed on fish samples from the 6th week of storage. There was also a significant colour change in all three groups as from the 7th week.

b. Total viable count

The mean total viable count (TVC) of preserved fish samples is presented in figs 3 and 4. Results showed a significant ($P<0.05$) difference between the total viable count of BOVD, SMKD and OVD. BOVD had the lowest TVC out of the processing methods studied. The introduction of heat during all the processing methods tested would not only kill microorganisms but will also reduce the moisture content of the fish muscles making the environment less favourable for microbial growth. However, heating does not destroys all organisms as thermophiles may survive in dried fish after heating, accounting for the higher microbial count of oven dried samples. The inclusion of salt (in case of BOVD samples) and smoke (SMKD samples) along with heating usually provides a more efficient method of processing, accounting for the lower microbial count in brined/oven dried and smoked samples(Fernandez *et. al*.,1997).

TVC of fish muscles increased significantly ($P<0.01$) with increase in the duration of storage. As the duration of storage increase, processed fish samples may absorb small amounts of moisture from surrounding atmosphere providing enabling environment for microbial growth (Eyo, 2006). By the 6th week, oven dried and smoked samples of *Clarias gariepinus* had total viable counts exceeding 5.7 (Log_{10} cfu/g). The highest total viable count was recorded at the 8th week in oven dried samples: 6.59 ± 0.11 (Log_{10} cfu/g).

c. Total volatile nitrogen

Mean total volatile nitrogen (TVN) of preserved fish samples are presented in figs 5 and 6. The method of processing has a significant ($P<0.05$) effect on the total volatile nitrogen content, with brined/oven dried fish samples having the least total volatile nitrogen content out of the three processing methods used. The variation in total volatile nitrogen content is partly related to the microbial load of the processed samples analysed each week. The viable count of processed fish samples was in the order: BOVD < SMKD < OVD. As such, the microbial breakdown of fish protein is expected to be of same trend.

The lower TVN content in BOVD can also be due to the presence of salt which apart from reducing microbial growth also reduces autolytic enzyme activities (Klomklao *et. al*., (2010) thereby reducing protein breakdown. The highest TVN content was recorded at the 8th week in oven dried samples: 27.67 ± 0.07 mg/100g. TVC had a strong positive correlation ($P<0.01$) with the TVN of fish samples, e.g. ($r = 0.973$ OVD, $r = 0.926$ for BOVD and $r = 0.985$ for SMK).

d. Trace metal content

Mean metal concentrations in fish samples are expressed in table1. Method of processing had a significant ($P<0.05$) effect on the trace metal content of fish samples. Among the three processing methods studied, SMKD samples had the highest trace metal content. The slightly higher concentration of concentrations in SMKD can be due to weighing error or the possibility of contamination from smoke particles used for the preservation process. This is in line with the observation of Essuman (2000) who suggested that salt and other materials used during preservation may be sources of heavy metals in fish. The high concentration of Fe and Zn in the fish samples analysed can be due to the natural abundance of the metals in Nigerian soils, and since the source of metal depositories are aquatic systems (Adefemi *et. al.*, 2000). The content of all Fe, Zn and Cd in all processed fish samples were lower than the maximum allowable limit set by the World Health Organisation (2008) and the Nigerian Federal Environmental Protection Agency (2003). The concentrations of Fe, Zn and Cd had no correlation with the duration of storage and remained almost constant throughout the period of study.

4. Conclusion

In conclusion, fish samples preserved by the methods of oven drying, brining/oven drying and smoking underwent loss in quality with duration of storage. However, brined/oven dried samples were most organoleptically accepted and deteriorated the least. The optimum storage period of the preserved fish is 4-5weeks due to its high fat content which makes it susceptible to fat oxidation. Also, in spite of being physically firm, caution should be exercised in consuming preserved fish stored on open shelf for very long weeks as they may contain higher amounts of microbial cells.

Results of this study also showed that consumption of smoked and brined/oven dried fish is safe with respect to Fe, Zn and Cd concentrations. However, since metal concentration of preserved fish muscle is dependent on fresh

content of fish, regular monitoring of fish is required to detect sudden changes in trace metal concentration of fresh fish muscle.

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Table 1: Trace metal concentration (mg/kg) of preserved catfish (*Clarias gariepinus*)

	Pb	**Fe**	**Zn**	**Cd**
OVD	< 0.05	5.242±0.003[a]	5.512±0.001[a]	0.067±0.001[a]
BOVD	< 0.05	5.350±0.008[b]	5.535±0.002[b]	0.068±0.003[b]
SMKD	< 0.05	5.561±0.002[c]	5.672±0.003[c]	0.078±0.000[b]

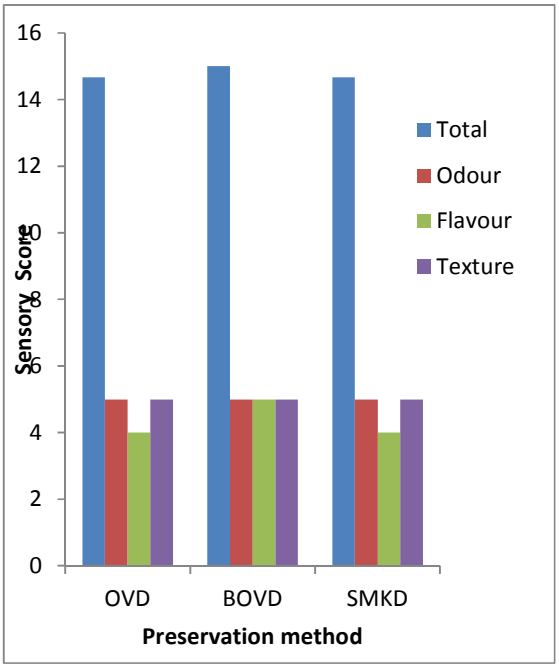

Fig 1: Effect of preservation method on sensory score of freshly preserved fish samples.

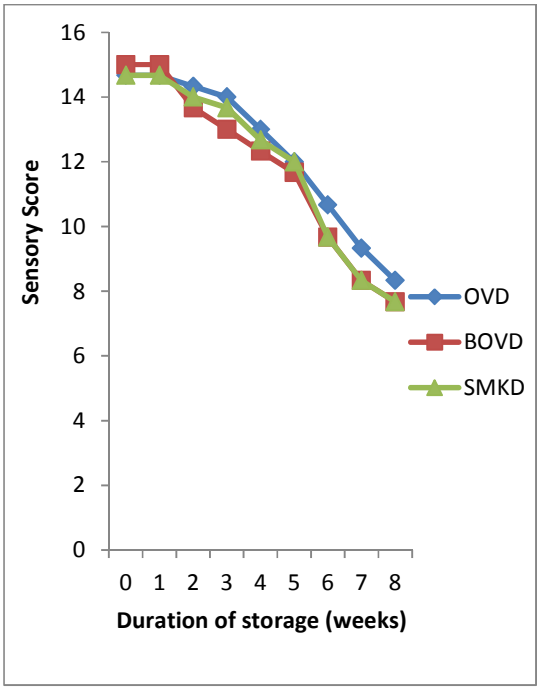

Fig 2: Effect of duration of storage on the sensory score of preserved fish.

OVD: Oven dried samples
BOVD: Brined/Oven dried samples
SMKD: Smoked samples

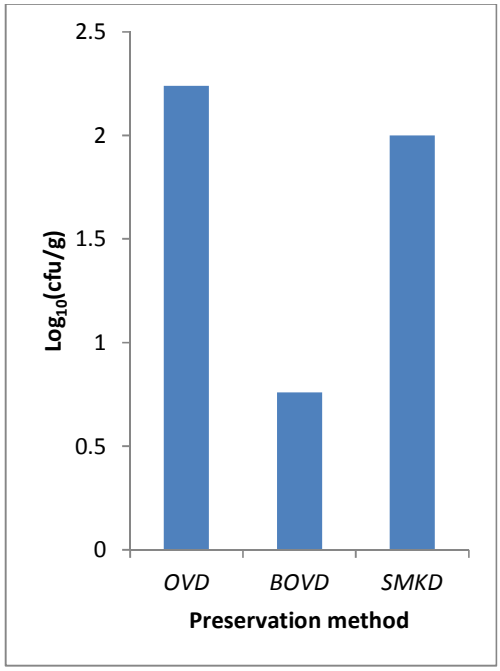

Fig 3: Effect of preservation method on the total viable count (Log_{10}(cfu/g) of freshly preserved fish.

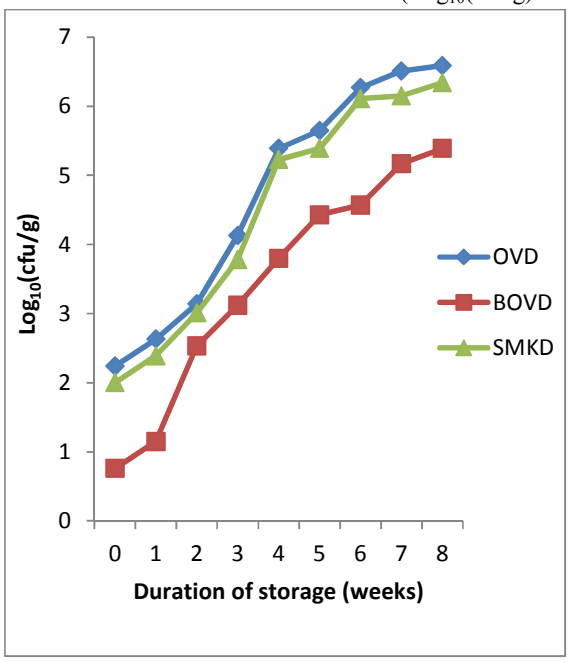

Fig 4: Effect of duration of storage on the total viable count (Log_{10}(cfu/g) of fish.

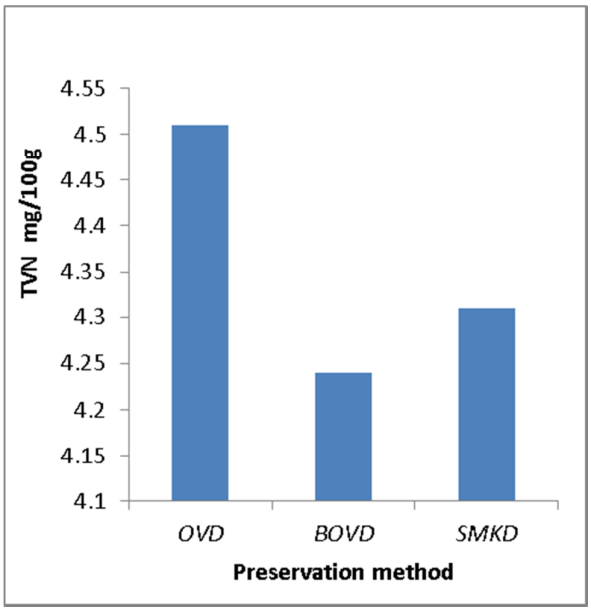

Fig 5: Effect of preservation methods total volatile nitrogen content (TVN) mg/100g of freshly preserved fish.

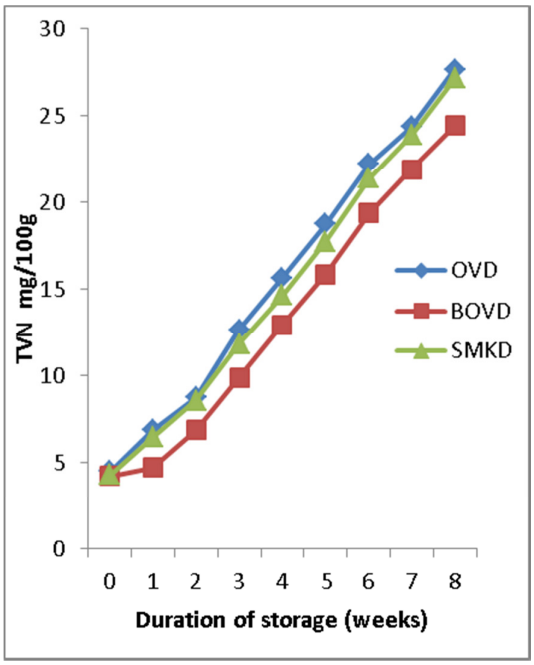

Fig6: Effect of duration of preservation on the total volatile nitrogen mg/100g of fish.