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Assessment of the Microbial and Sensory Qualities of Smoked African Catfish (*Clarias gariepinus*)

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Abstract

This study was carried out to assess the microbial and sensory qualities of smoked catfish (*Clarias gariepinus*) treated with sodium chloride during a 6-week storage at room temperature. Raw catfish steaks were subjected to the following salt treatments (5%, 7.5%, 10%, 12.5% and 15%) for 15 minutes prior to smoking. The non-treated (without salt) catfish served as the control. The fresh fish, control and the treated samples showed diverse microbial loads. After smoke treatment, the microbial loads were reduced and this was maintained during the weeks of storage. The result from this study revealed that the smoked catfish are shelf stable for between three to five weeks under ambient storage condition, before the action and effects of spoilage microorganisms become significant. Smoked fish treated with 12.5% and 15% salt proved best in terms of reduced microbial loads but organoleptically, smoked fish treated at 5% salt was the most acceptable to the panelists.

Keywords: smoked, catfish, sodium chloride, microbial

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Introduction

Fish is a major source of proteins of high digestibility and are rich source of lysine and sulphur containing amino acids. In Africa, over 17.5% of the animal protein comes from fish while in Nigeria. Fish constitutes 40% of the animal protein intake of the people (Olatunde, 1989).

Its harvesting, handling, processing and distribution provide livelihood for millions of people as well as foreign exchange earning to many countries (Al-Jufaili and Opara, 2006). *Clarias gariepinus* (Catfish) is a very important fresh water fish in Nigeria (Idodo–Umeh, 2003) and enjoys wide acceptability in most part of the country because of its unique taste, flavor and texture.

Fresh fish is sterile but it is susceptible to spoilage as soon as fish is caught. Fish deterioration starts as soon as the fish dies and progresses until the fish is entirely destroyed. According to Eyabi-Eyabi (1996), the limited shelf life of dead fish i.e. 16-20 hours in Southern part of Nigeria and 20-36 hours under conditions in the Northern part are basically due to biochemical changes after death. The speed with which fish spoils depends on hygienic conditions, storage temperature, acidity and the structure of the muscular tissue (Clucas, 1990). Chemical breakdown of protein content, fat content (agent of rancidity and off-flavour) and the water content/water activity contribute to quick spoilage of fish (Daramola *et al.,* 2007). Similarly, Hood *et al*., (1983) also reported that microbial load increases with increasing temperatures and results in rapid fish spoilage. Microbial activity is responsible for spoilage of most fresh and of several lightly preserved seafoods (Lund *et al.,* 2000). However, the extent of fish damage depends on the processing techniques, the type of fish being processed, weather and mode of storage during transportation (Eyo, 1993).

Tobor (1992) estimated fish loss due to poor preservation to be between 35-40% of the landed weight of fish from the artisanal fishery sector in Nigeria. Post-harvest losses in fish are represented by a net reduction in the amounts of nutrients potentially available to the consumer. This is either by direct physical loss or nutritional loss which is the overall reduction in the value of their chemical components. These factors have effect on consumer acceptability, commercial value and income of fish farmers/traders i.e. economic loss (Bostock *et al.,* 1987).

However, there are different methods or ways of prolonging the shelf-life of fish. These include chilling, freezing, canning, drying, salting and smoking. Smoking of fish and/or meat products is one of the most ancient processing technologies. About 60-65% of fish caught in Nigeria inland waters are preserved by smoke curing (Eyo, 1993). It has been for centuries used for preservation, and is still widely used for this purpose among several tropical communities where up to 70% of the catch is smoked for preservation (Ward, 1995). The preservative effect of salt has been recognised as being due to a decrease in water activity, less availability to microbial attack and enhancement of functional properties, leading to an increase of the shelf-life time (Hall and Tall, 1994). Meanwhile, smoked fish and shellfish products have been reported to be a source of microbial hazards including *Listeria monocytogenes,Salmonella* spp.and *Clostridium botulinum* (Heintz and Johnson, 1998). Outbreaks of botulism, listeriosis, and salmonellosis resulting from smoked fish have been reported for over 30 years (CDC, 1979; Heinitz and Johnson 1998; Heinitz *et. al.*, 2000). Also, Omojowo *et. al.* (2009) reported that smoked fish samples from four local Markets in Kainji Lake area of Nigeria were dominated by gram-positive bacteria, potential pathogens, coagulase-positive *Staphylococcus* and *Escherichia coli*. Therefore, the broad objective is to study the microbiological and sensory qualities of smoked African catfish, *Clarias gariepinus* samples stored under ambient condition for a period of six weeks.

Materials and Method

Fresh *Clarias gariepinus* of relative the same age and size was purchased from a fish farm within Sango-Ota metropolis. The fishes were sorted into eight parts, put in separate sterile polythene bags and transported in ice. A part of the sorted batch of fish was moved to the Microbiology laboratory of the Bells University of Technology, Ota, Ogun State for analyses of fresh samples. While a batch of the fresh *Clarias gariepinus* was not salted before smoking, others were neatly prepared, soaked in 5%, 7.5%, 10%, 12.5% and 15% saline solution (using sodium chloride) separately for 15 minutes. Thereafter, the fish was drained and smoked on traditional smoking kiln constructed with an open drum at Bells Junction. The drum was covered with aluminium foil to conserve heat and smoke. All samples were processed and smoked for 10 hours each. The samples were cooled and exposed to ambient temperatures to air-dry.

The samples were stored at ambient temperature (25 to 32°C) and labeled accordingly in covered perforated plastic containers lined with clean sheets of Newspaper. These batches were smoked while microbiological and sensory analyses were carried out weekly on them. All experimental trials were conducted in replicates, except sensory analysis which was conducted with a panel of ten persons.

Microbial Analysis

For the microbial analysis of the samples of fresh, unsalted-smoked and salted-smoked *Clarias gariepinus,* the method as described by Slaby *et al.*, (1981) was adopted. Morphological characteristics of the various bacterial isolates were noted in the agar plates after Gram staining reactions and series of biochemical procedures, individual microbial species were identified. The microbial parameters determined were: Total viable count (TVC), Total coliform count, fungi, presence of *Escherichia coli*, *Staphylococcus aureus*, *Shigella* and *Salmonella* species were also determined.

Sensory Evaluation was also carried out on the fish samples by 10–man panel which consists of five staff and five students. The following sensory attributes of the smoked fish was assessed for changes during the storage period: colour, taste, salinity, odour and texture, the results were recorded inside the questionnaire given to them. Procedure for sensory assessment was strictly followed with reference to Bostock *et al* (1987) and Eyo (2001).

The evaluation keys were: 5 = Excellent, 4 = Good, 3 = Fair, 2 = Poor, 1 = Bad

Statistical design and analysis

Completely Randomised Design (CRD) was adopted in carrying out the experiment. Experimental trials were conducted in triplicates. One-way analysis of variance (ANOVA) where $P < 0.05$ was applied to the different sample values obtained. The differences among the means was characterised by the Duncan Multiple Range Test (DMRT). Statistical package for Social Science (SPSS) 16.0 software was used in the data analysis.

Results

In this study, Table 1 shows the microbial populations in smoked and salted fish samples with various degrees of microbial counts in different salt concentrations. The total viable count (TVC), coliform, staphylococci and fungi count in CFU/g of fresh and smoked samples plated on selective and non-selective media are shown in Tables 1. The total viable count (TVC) of the fresh non-treated (control) catfish was too numerous to count, also after the sample has been smoked the (TVC) was $7.2x10^6$ CFU/g. However, after the samples were subjected to treatments with table salt the TVC reduction was highest in 15% with $1.7x10^6$ CFU/g and least in 5% with $2.7x10^6$CFU/g. Similarly, coliform count was reduced from $4.6x10^6$ CFU/g in the control to $0.98x10^6$ CFU/g in 15% and least was $3.0x10^6$ CFU/g in 5% salt concentration. In the same vein, Staphylococci count was reduced from $5.0x10^6$CFU/g in the control to $1.2x10^6$ CFU/g in 15% and least in 5% ($3.0x10^6$CFU/g). In addition, fungi count was reduced from $5.1x10^6$ CFU/g (control) to $1.20x10^6$ CFU/g in 25% and least in 5% ($2.50x10^6$ CFU/g. Smoking sharply reduced the total viable count in all samples but the sample treated with 15% concentration had the best reduction of $1.7x10^6$ and $3.90x10^6$ CFU/g on day 0 and at the end of fifth week of storage.

Figure 1 shows the weekly increase in bacterial load of the fish samples, with 5% salt concentration having the highest microbial load compared to the other concentrations as used in this study.

Figure 2 shows the weekly increase in fungi load of the fish samples, the microbial load of 5% salt concentration was higher than the other concentrations. Figures 4 - 8 shows the organoleptic assessment of the fish samples smoked without treatment and the fish samples smoked with treatment (salt).

Table 1: Microbial Load of Catfish Treated With Sodium Chloride (10^6 Cfu/G)

	Microbial Group	Control	5%	7.5%	10%	12.5%	15%
Before Smoking	TVC	TNTC	N/A	N/A	N/A	N/A	N/A
After smoking	TVC	7.2	2.7	2.5	2.2	1.9	1.7
1st week	TVC	10.0	3.3	3.0	2.7	2.4	2.1
2nd week	TVC	12.0	4.0	3.8	3.2	2.7	2.4
3rd week	TVC	14.5	4.5	4.3	3.8	3.4	2.9
4th week	TVC	17.0	5.1	4.8	4.3	3.9	3.3
5th week	TVC	20.0	5.7	5.3	4.9	4.4	3.9
Before Smoking	Coliform	TNTC	N/A	N/A	N/A	N/A	N/A
After smoking	Coliform	4.6	3.0	2.0	1.0	1.0	0.9
1st week	Coliform	5.2	3.2	2.8	1.9	1.4	1.2
2nd week	Coliform	5.5	3.4	3.2	2.9	2.2	1.9
3rd week	Coliform	5.9	3.7	3.6	3.3	2.9	2.2
4th week	Coliform	6.2	4.2	4.0	3.8	3.4	2.9
5th week	Coliform	6.5	4.3	4.2	3.9	3.7	3.2
Before Smoking	Staph.	TNTC	N/A	N/A	N/A	N/A	N/A
After smoking	Staph.	5.0	3.0	2.9	2.6	1.7	1.2
1st week	Staph.	5.6	3.3	2.9	2.8	2.2	1.8
2nd week	Staph.	5.7	3.7	3.2	3.0	2.8	2.2
3rd week	Staph.	5.9	3.9	3.5	3.2	2.9	2.5
4th week	Staph.	6.3	4.1	3.9	3.6	3.2	3.1
5th week	Staph.	6.8	4.2	4.1	3.9	3.5	2.2
Before Smoking	*E. coli*	TNTC	N/A	N/A	N/A	N/A	N/A
After smoking	*E. coli*	-	1.0	-	-	-	-
1st week	*E. coli*	-	-	-	-	-	-
2nd week	*E. coli*	-	-	-	-	-	1.0
3rd week	*E. coli*	-	-	-	-	-	-
4th week	*E. coli*	-	-	-	-	-	-
5th week	*E. coli*	-	-	-	1.0	1.0	1.0
Before smoking	Fungi	TNTC	N/A	N/A	N/A	N/A	N/A
After smoking	Fungi	5.1	2.5	2.3	1.8	1.5	1.2
1st week	Fungi	6.9	3.1	2.7	2.5	1.9	1.6
2nd week	Fungi	7.4	3.6	3.3	2.9	2.4	2.2
3rd week	Fungi	8.1	4.2	3.9	3.6	3.1	2.9
4th week	Fungi	9.6	4.8	4.6	4.3	3.9	3.3
5th week	Fungi	10.5	5.3	5.1	4.9	4.4	3.9

Key: TNTC-Too numerous to count, N/A-Not applicable, - No growth, TVC- Total viable count

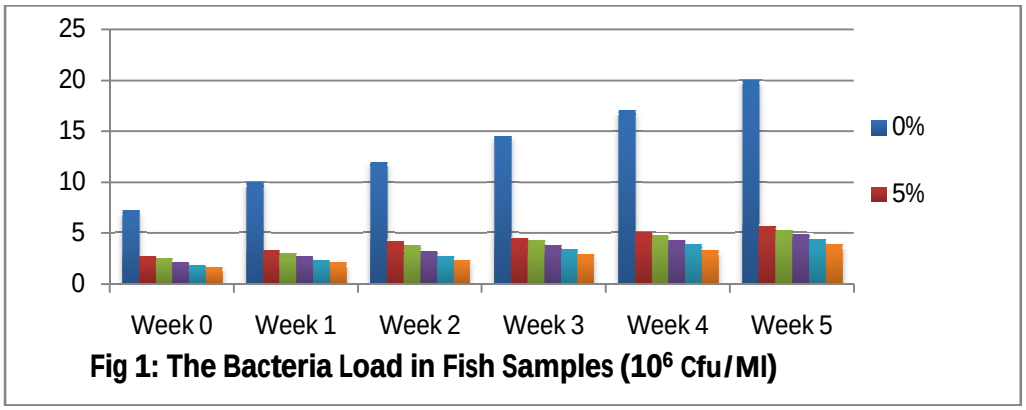

Fig 1: The Bacteria Load in Fish Samples (10^6 Cfu/Ml)

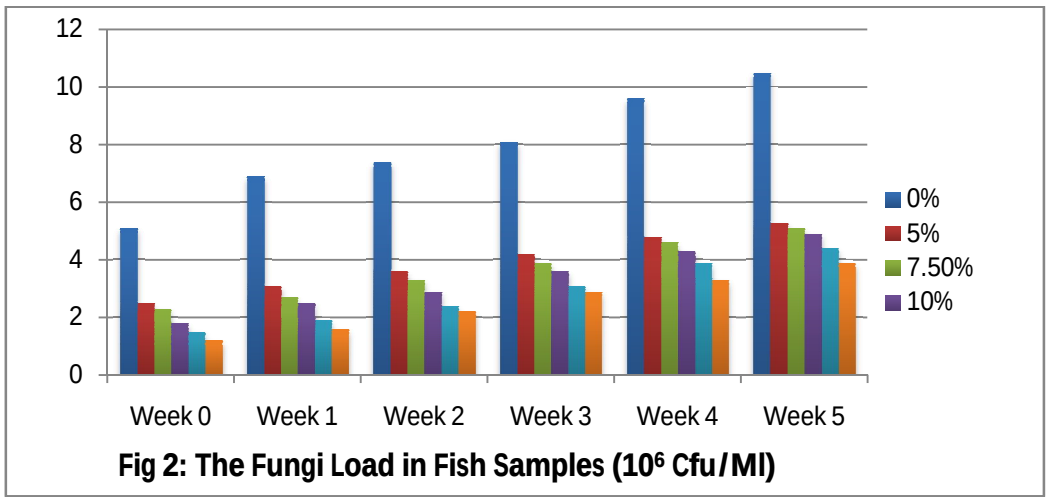

Fig 2: The Fungi Load in Fish Samples (10^6 Cfu/Ml)

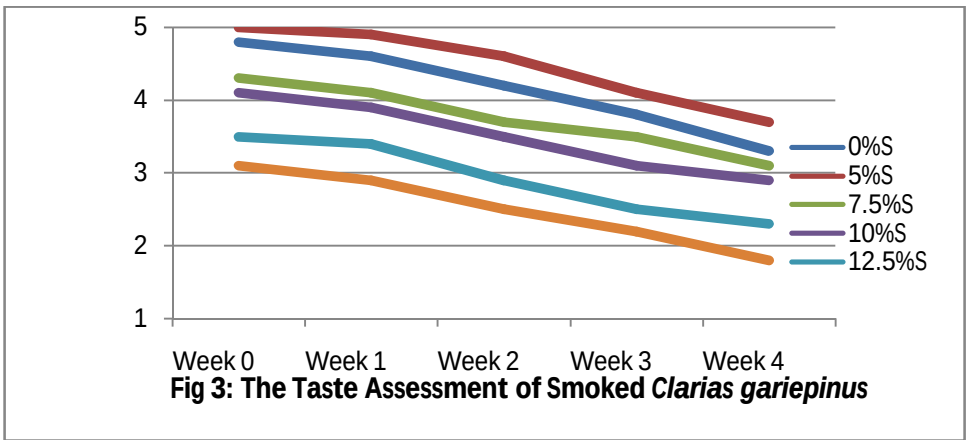

Fig 3: The Taste Assessment of Smoked *Clarias gariepinus*

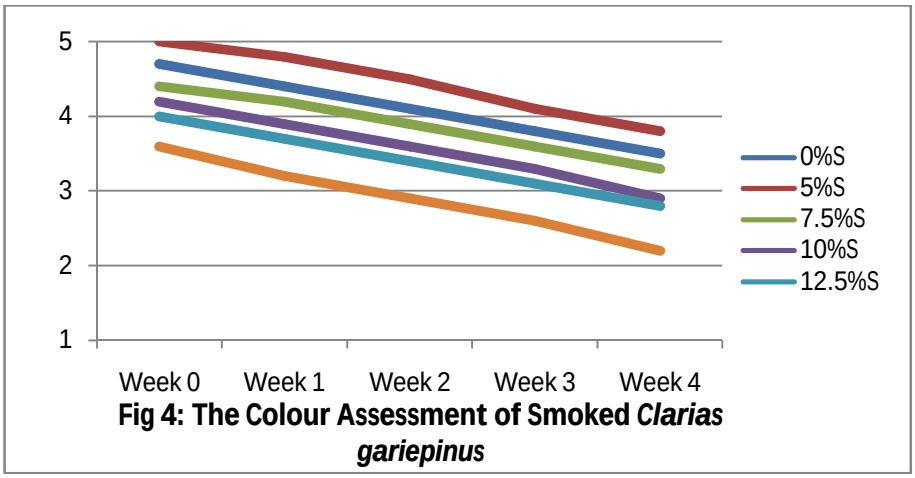

Fig 4: The Colour Assessment of Smoked *Clarias gariepinus*

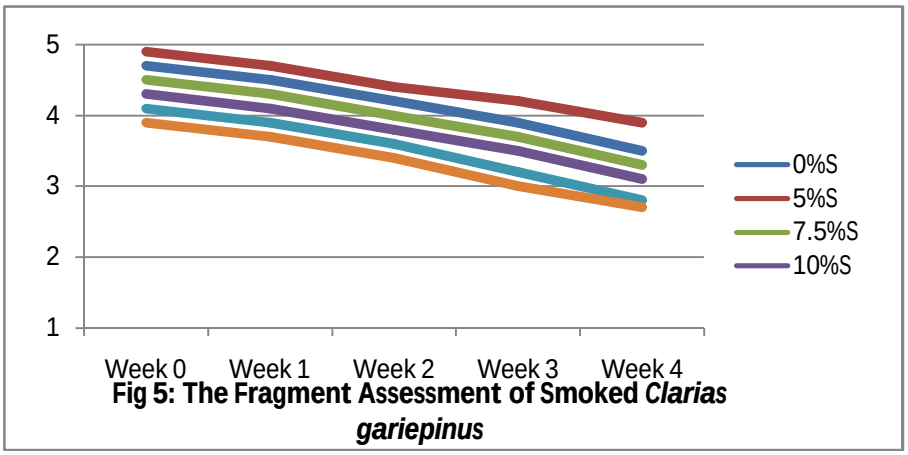

Fig 5: The Fragment Assessment of Smoked *Clarias gariepinus*

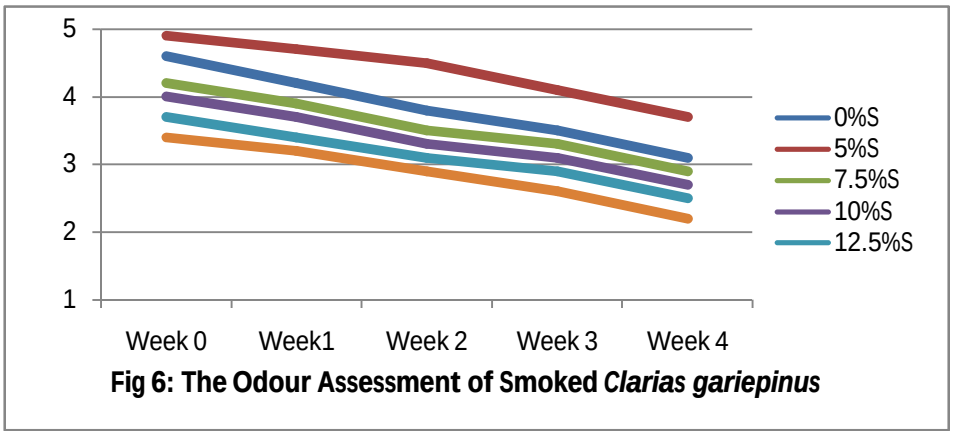

Fig 6: The Odour Assessment of Smoked *Clarias gariepinus*

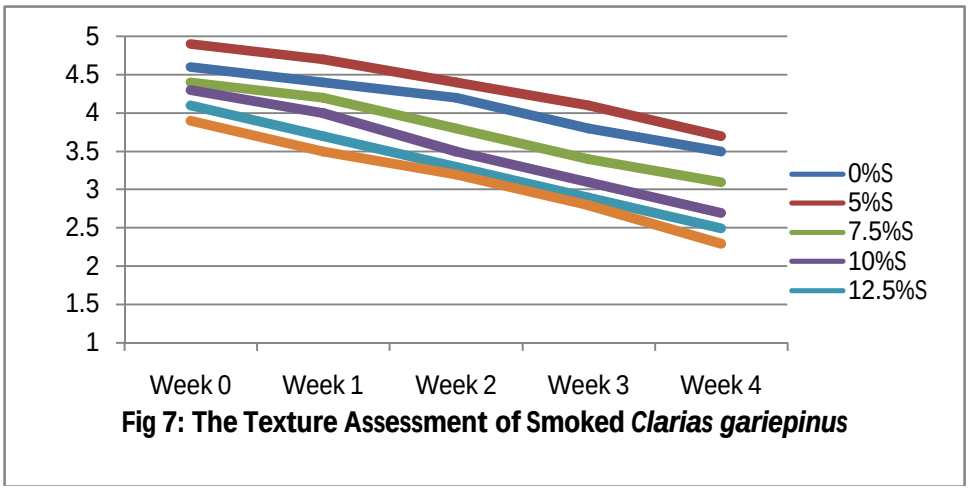

Fig 7: The Texture Assessment of Smoked *Clarias gariepinus*

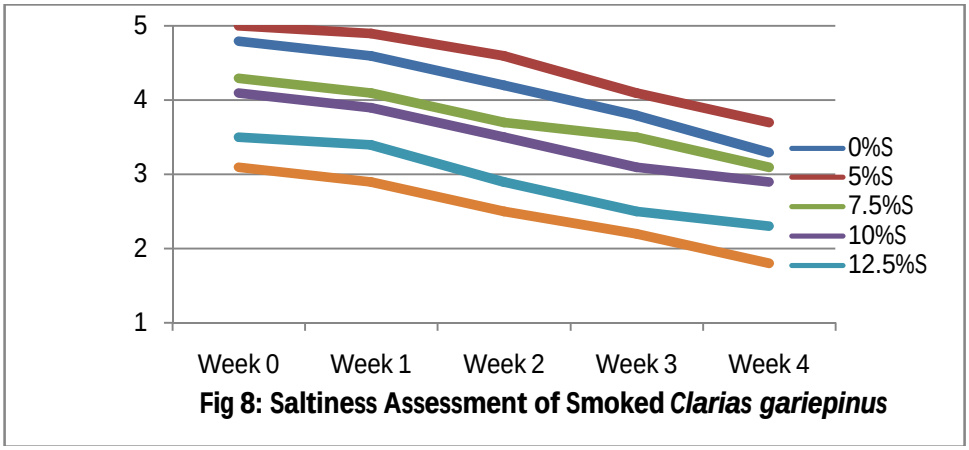

Fig 8: Saltiness Assessment of Smoked *Clarias gariepinus*

Discussion

In this study, evaluation of microbial qualities of the smoked and salted-smoked fish were carried out to determine proliferation of the target food borne pathogens such as *Salmonella*, *Staphylococcus aureus*, and *Escherichia coli*. The TVC of smoked control (untreated) samples were the highest throughout the period of storage and the sample were even completely covered by mould after the fifth week of storage. The results obtained were similar to those reported by Goktepe and Moody (1998) where aerobic plate counts in raw catfish fillets were 4.03 log CFU/g prior to brining and 3.61 log CFU/g after brining. Similar to TVC, the coliform count of the smoked samples treated with 15% sodium chloride was the most shelf stable in terms of the lowest microbial load of $0.9x10^6$ CFU/g on day 0.

This result is comparable with the effect of synthetic antimicrobial agents like potassium sorbate, citric acid and sodium metabisulphite as reported by Omojowo *et. al.* (2009).

Significant increases in coliform population of all samples occurred after 4 weeks of storage. Coliform count of all treated samples was less than $5.0x10^6$CFU/g throughout the 5-week storage. In the control samples, the coliform population of the control sample showed $6.5x10^6$CFU/g on the 5th week while the sample was completely covered by mould on the 6th week of storage. This result was similar to that reported by Da Silva (2002) where the Coliform in the control sample showed $2.6x10^6$CFU/g on the 4th week and the sample was completely covered by mould on the 6th week of storage hence the sample was not analyzed on the 6th week. The high coliform count recorded in this report may be due to contamination from the animal manure used in fertilizing the ponds at one time or the other. The control however, has TVC higher than $1.0x10^7$ CFU/g in the 1st week which is higher than the recommended limit $7.0x10^6$CFU/g (ICMSF, 1986). In addition the Coliform count already exceeded 10^3 even immediately after smoking. This finding is of concern as a result of the associated public health implications. For example, generally, hot smoked fish are consumed in the tropics with little or no further processing/cooking; thus, they fall into the high-risk category of foods (ICMSF, 1986). Hence there is a need for the use of appropriate percentage of choice antimicrobial agent.

The population of the fungi reduced in all the treatments and at the end of the 5-week storage time interval. However, the control samples were high throughout the period of storage and were even completely covered by mould at the end of the 5-week storage. It is of interest to observe that in spite of the slightly reduction in moisture contents (from 2nd to 5th week) in almost all the samples, the microbial load still increases exponentially. This indicates that many factors may be responsible for different microbial changes as reported by Omojowo *et. al.* (2009).

The organoleptic properties of the smoked *Clarias gariepinus* were also assessed. The fish sample that had the highest result was the fish smoked and treated and the score increased according to the effect of salt on the fish samples, the untreated smoked fish had the lowest score in all the assessments, probably due to the absence of salt on them. The fish salted with 5% salt concentration had the best overall assessment, while the fish salted with 15% salt concentration had the lowest score in the taste assessment, probably due to the high concentration of salt.

At the end of the 4th week 5% concentration fish sample was preferred above 10% salt fish sample. This 5% concentration was able to keep fish to ICMSF (1986) standard of good quality till the 4th week by reducing the TVC from $2.0.0x10^7$ CFU/g in the control to $5.7x10^6$CFU/g. It also reduced the fungi from $1.1 x10^7$ CFU/g in the control to $5.3 x10^6$ CFU/g. Also in the coliform count the reduction is from $6.5 x10^6$CFU/g in control to $4.3x10^6$CFU/g. Also in the *Staphylococcus* count it reduced from $6.8x10^6$ CFU/g in the control to $4.24x10^6$ CFU/g. The control samples were covered with mould on the 6th week, therefore no further analysis was carried out on it. In conlusion, 5% sodium chloride (salt) may be used as a preservative in smoked fish without adversely affecting quality in terms of colour, taste and other organoleptic properties for at most a period of 4 weeks.

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