



## THE EFFECT OF VARIOUS SMOKING METHODS ON THE QUALITY OF DIFFERENTLY SALTED *Oreochromis niloticus*

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### ABSTRACT

A study was carried out to assess the effect of various smoking methods on the quality of *O. niloticus* unsalted and salted at different levels. Sensory, biochemical and storage evaluations were carried out on the unsalted and salted fish after smoking. The acceptability, of salted and unsalted fish differed significantly ( $P < 0.05$ ). The moisture, protein lipid and ash contents differed significantly ( $P < 0.05$ ). The mineral composition showed that Sodium, Magnesium, and Calcium and Potassium content differed significantly ( $P < 0.05$ ). The storage evaluation showed that the Free Fatty Acid (FFA), Iodine Number (IN) and Total Viable Count (TVC) differed significantly ( $P < 0.05$ ).

**KEYWORDS:** smoking, unsalted, salted, *O. niloticus*

### INTRODUCTION

In fish, two types of smoking processes are in common use. The 'cold' smoking process in which the temperature does not exceed 30°C and hot smoking during which the fish is properly cooked with the temperature reaching 120°C or so while the centre of the fish may be at 60°C (Eyo, 2001). Hot smoking is the traditional method of fish smoking in the tropics. Fish is smoked until cooked in order to obtain a product with extended shelf life. Fish smoking in the tropics is conducted in smokehouses and smoking ovens or kilns. The design of smoking equipment varies from place to place. However, these designs tend to solve problems associated with the existing ones in order to obtain better-smoked fish products in terms of cost effectiveness and the ease to construct. In addition, the portability, fuel efficiency, ease to operate and maintain, the uniformity and acceptability of the smoked product, high carrying capacity, durability, less labour intensiveness to operate and safety of the product emanating from the kiln for human consumption are considered. Methods of smoking of fish vary between different countries and within the same country depending on the species of fish used and the type of product desired. These variations make it difficult to arrive at general conclusions regarding processing effects of smoking on protein quality and the nutritional value of the final products. However, the impact of smoking on the nutritive quality of fish could be assessed from known effects of physical/chemical parameters employed in the production such as dehydration, temperature, time, added compounds and oxidation, but only tests on actual products can provide reliable data on their nutritive quality (Opstvedt, 1988). In line with the efforts to improve on the existing smoking kilns, three kilns namely, traditional smoking kiln (TS), firewood fuelled improved traditional smoking kiln (FFS), charcoal fuelled and improved traditional smoking kiln (CFS) were tested to ascertain their impact on the nutritive qualities of *O. niloticus*.

### MATERIALS & METHODS

#### Experimental Procedure

Sixty fresh *O. niloticus* (weight range, 80-100 g) were used for this study. The degree of freshness was based on the method of assessment described by Johnson and Clucas (1996). Immediately the fish were procured they were de-scaled, gutted, washed with clean portable water and kept in a deep freezer for 24hr to maintain the freshness till they were needed for processing

#### Smoking Procedure

Smoking was carried out in three different smoking kilns as classified by Eyo (2001) namely traditional smoking kiln (TS), Improved Traditional Smoking Kiln (ITS) - i. Firewood Fuelled and ii. Charcoal Fuelled. In each smoking kiln 60 pieces of fresh *O. niloticus* were smoked. The sixty *O. niloticus* were divided into five treatment groups of different levels of salting, namely, Unsalted the fish were not salted, 25% Brine (25) fish were immersed in 25% brine for one hour, 50% brine (50) fish were immersed in 50% for one hour, 75% Brine (75) fish were immersed in 75% brine for one hour and 100% Dry salted (Dry salted) fish were rubbed on the surface and inside of the fish with salt. Each treatment had twelve *O. niloticus*.

#### Sensory Evaluation

The sensory evaluation of the smoked fish samples were done weekly for four weeks by a trained panel of ten evaluators according to, (Doe and Olley, 1990).

#### Biochemical Evaluation

The proximate composition, free fatty acid and mineral contents of smoked *O. niloticus* were carried out using the methods of AOAC, (1990). The Iodine number was determined using Wijs' method (Pearson, 1976). The Total Viable Count (TVC) was determined using pour plate serial dilution method as described by Brown and Creedy (1970).

#### Statistical analysis

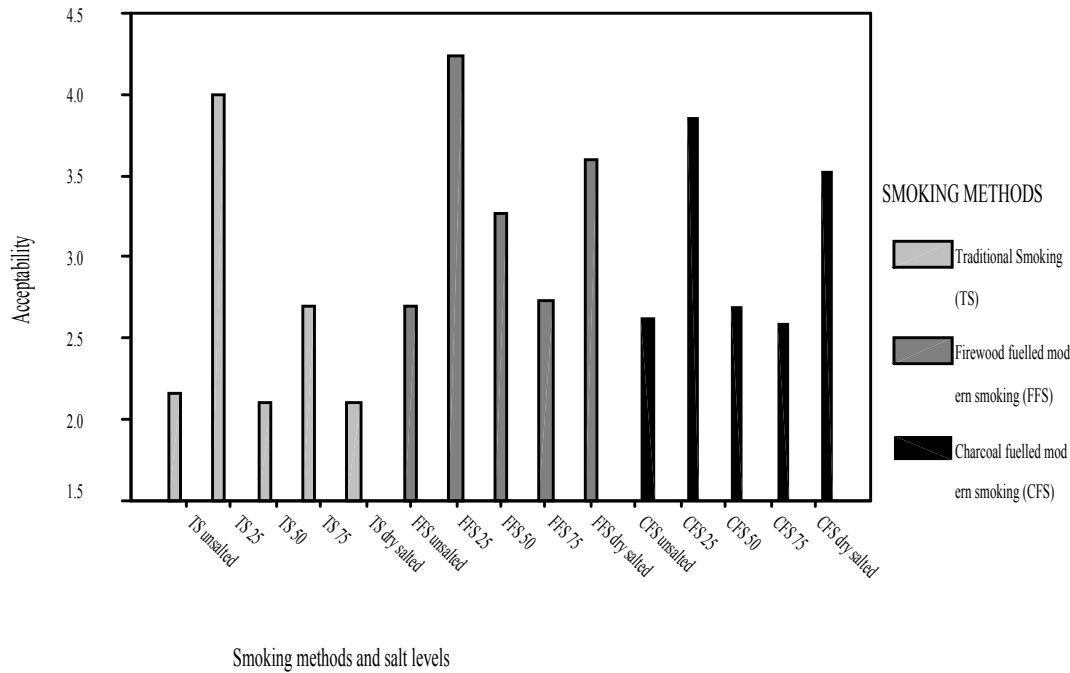
The experimental design was a completely randomized block design with three replicates. The sensory and

biochemical data were subjected to one way Analysis of variance (ANOVA) and mean comparison were done according to Duncan (1955). All the statistical analyses and graphical presentations of the results were done using (SPSS, 1998).

**RESULTS AND DISCUSSION**

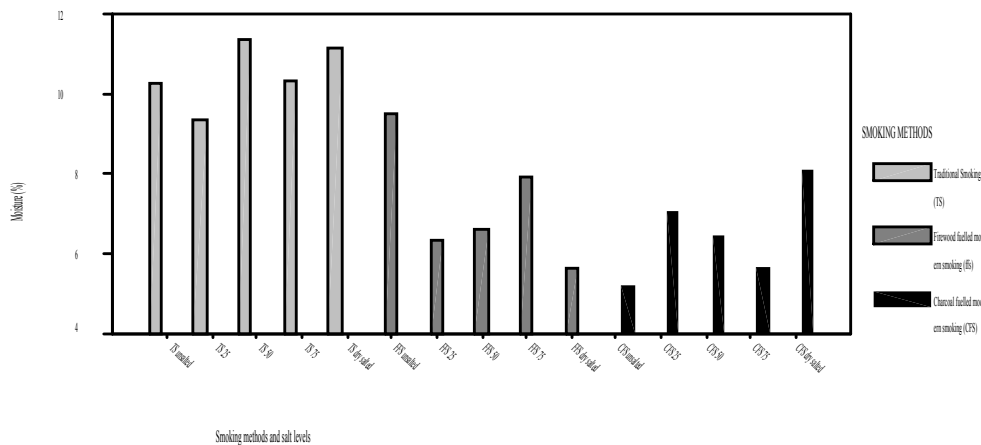
Fig. 1 shows the sensory evaluation of differently salted *O. niloticus* smoked using three different smoking kilns. TS50 product was the least accepted with a value of 2.10 while FFS25 product with a value of 4.23 was most

accepted. There was a significant difference ( $P < 0.05$ ) in the acceptability values of the smoked products. In the individual kilns namely TS, FFS and CFS the acceptability ranged as follow: - For TS the values were 2.10 (TS50 and TS Dry salted), 2.17 (TS Unsalted) 2.70 (TS 75) and 4.00 (TS 25). In the FFS the values ranged from 2.70 (FFS Unsalted) 2.73 (FFS 75) 3.27 (FFS 50), 3.60 (FFS Dry salted) and 4.23 (FFS 25). The results in CFS the values ranged from 2.60 (CFS 75) 2.63 (CFS Unsalted), 2.70 (CFS 50), 3.53 (CFS 100Dry salted) and 3.87 (CFS 25).

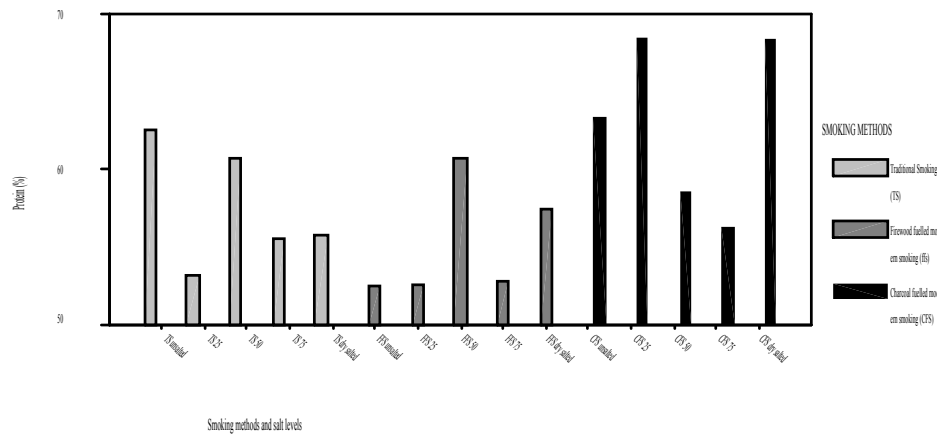


**FIGURE 1:** The mean acceptability of differently salted and smoked *O. niloticus*

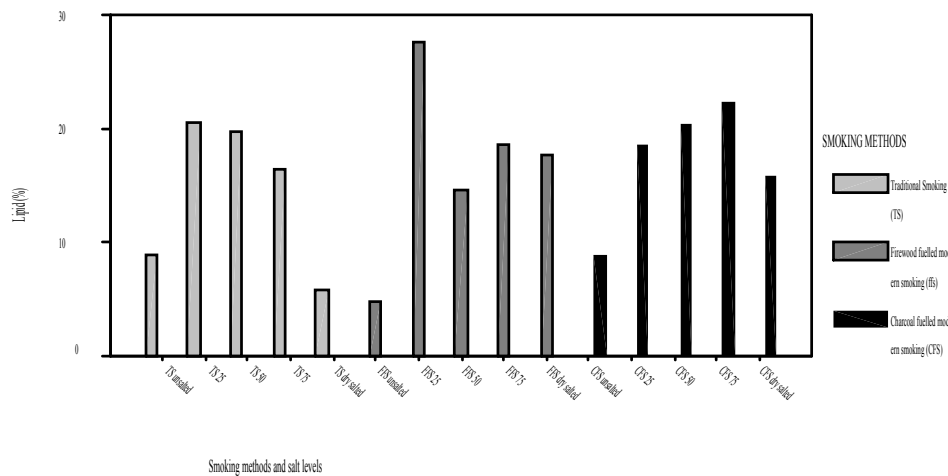
Figures 2-5 show the moisture, protein lipid and ash contents of differently salted *O. niloticus* dried using three different smoking kilns. The moisture contents differed significantly ( $P < 0.05$  and ranged from 5.23% in CFS Unsalted to 11.35% in TS 50).



**FIGURE 2:** The mean moisture content of differently salted and smoked *O. niloticus*  
The protein contents differed significantly ( $P < 0.05$  and ranged from 52.53 in FFS Unsalted to 68.49 in CFS 25).

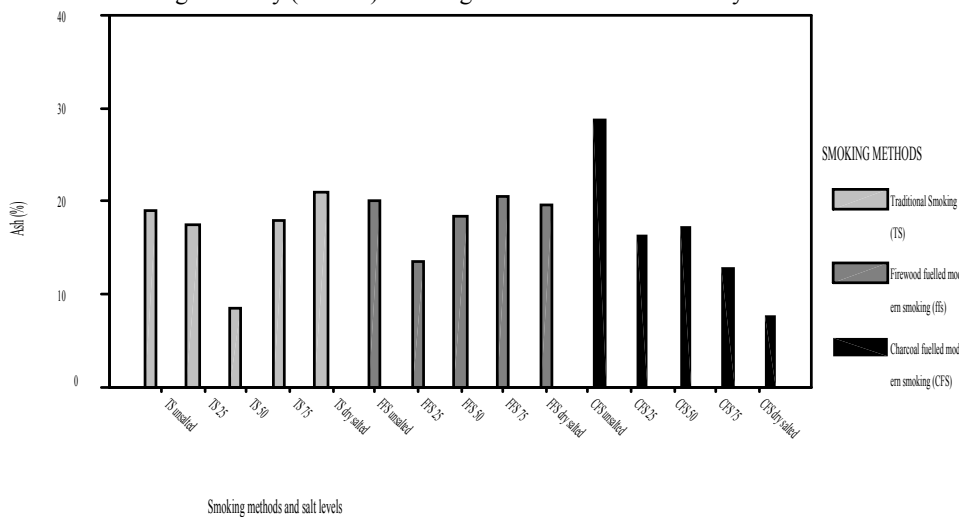


**FIGURE 3:** The mean protein content of differently salted and smoked *O. niloticus*. The lipid contents differed significantly ( $P < 0.05$ ) and ranged from 4.77% in FFS Unsalted to 27.65 FFS 25.



**FIGURE 4:** The mean lipid content of differently salted and smoked *O. niloticus*

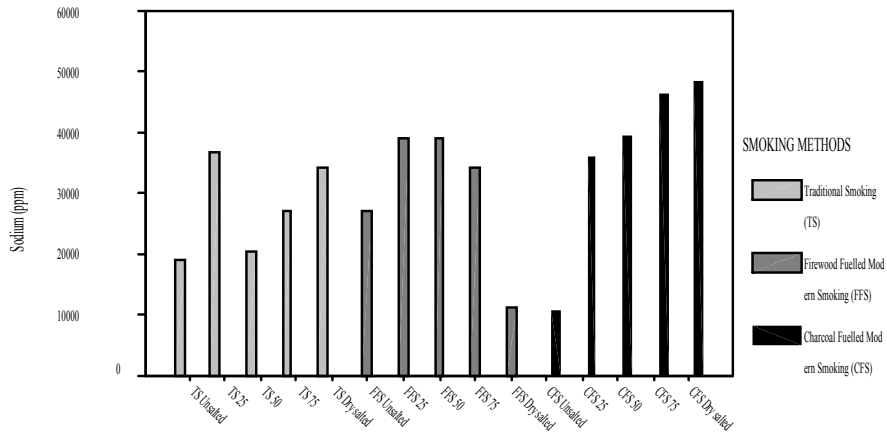
The Ash contents differed significantly ( $P < 0.05$ ) and ranged from 7.71% in CFS Dry salted to 28.90% In CFS Unsalted.



**FIGURE 5:** The mean ash content of differently salted and smoked *O. niloticus*

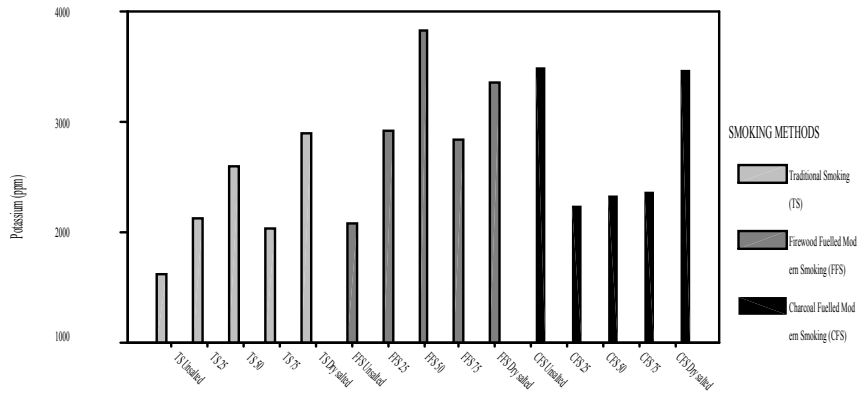
Figures 6 -9 show the Sodium, Magnesium, and Calcium and Potassium compositions of differently salted *O. niloticus* using three different smoking kilns. The Sodium differed significantly ( $P < 0.05$ ). The Sodium ranged from 10837 ppm for CFS unsalted to 48614 ppm for CFS dry salted.

Smoking methods on the salted *Oreochromis niloticus*



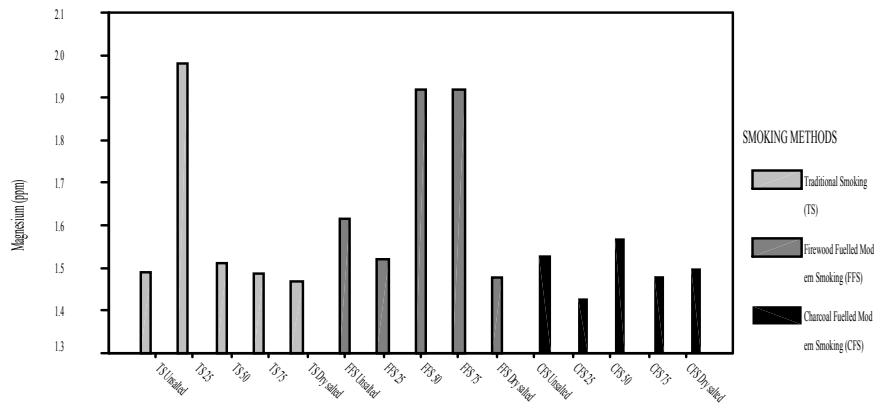
Smoking methods and salt levels

**FIGURE 6:** The mean Sodium content of differently salted and smoked *O. niloticus*. The Potassium differed significantly ( $P < 0.05$ ) and ranged from 1622 ppm for TS unsalted to 3828 ppm for FFS 50%.



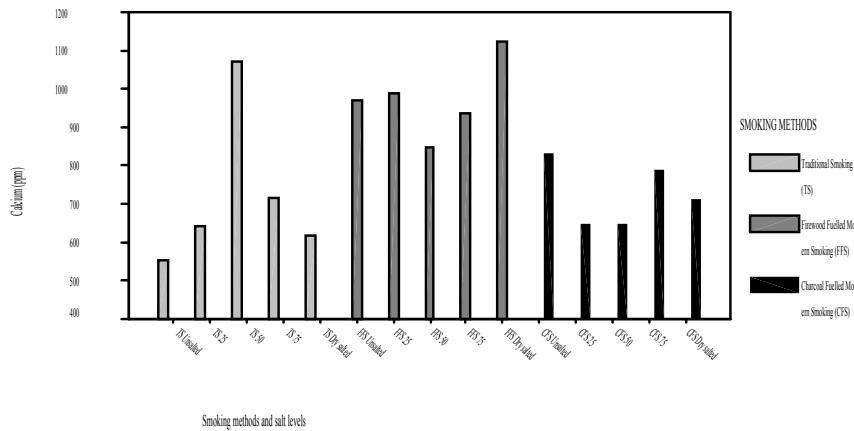
Smoking methods and salt levels

**FIGURE 7:** The mean Potassium content of differently salted and smoked *O. niloticus*. The Magnesium differed significantly ( $P < 0.05$ ) and ranged from 1.43 ppm for CFS 25% brined to 1.98 ppm for TS 25%.



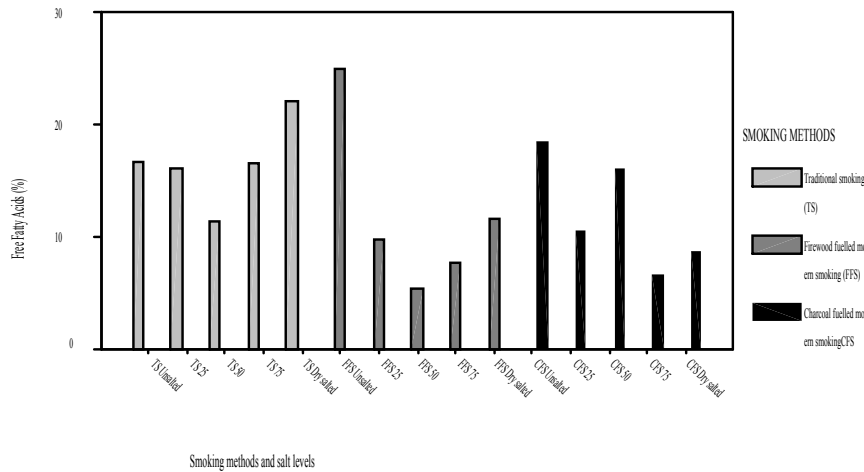
Smoking methods and salt levels

**FIGURE 8:** The mean Magnesium content of differently salted and smoked *O. niloticus*. The Calcium differed significantly ( $P < 0.05$ ) and ranged from 552.86 ppm for TS unsalted to 1122.27 for FFS dry salted.

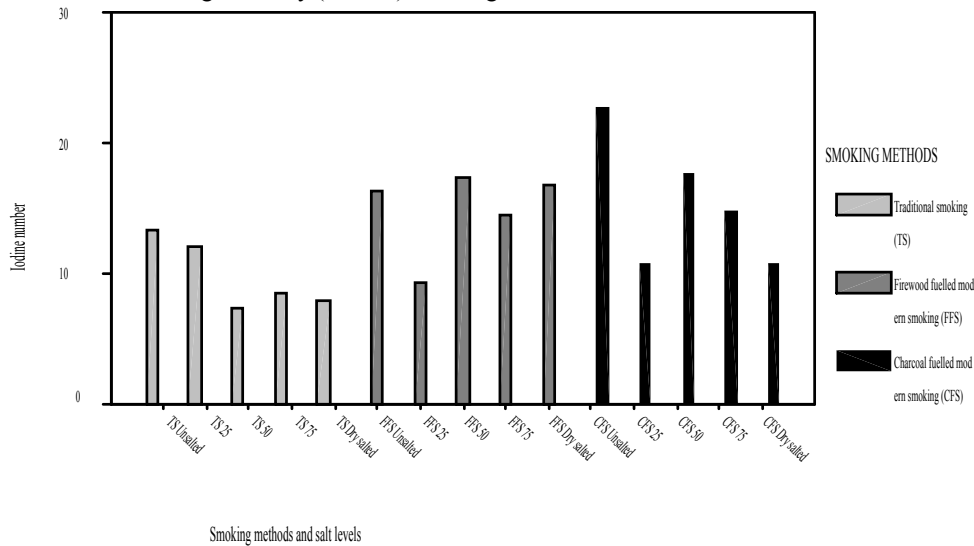


**FIGURE 9:** The mean Calcium content of differently salted and smoked *O. niloticus*

**FIGURES 9:** show the Free Fatty Acid (FFA), Iodine Value (IV) and Total Viable Count (TVC) of differently salted *O. niloticus* dried using three different smoking kilns. The FFA differed significantly ( $P < 0.05$ ) and ranged from 5.44% for FFS 50 to 24.37 FFS unsalted.



**FIGURE 10:** The mean Free Fatty Acid content of differently salted and smoked *O. niloticus*. The IV differed significantly ( $P < 0.05$ ) and ranged from 7.30 for TS 50% to 22.77 for CFS unsalted.



**FIGURE 11:** The mean Iodine value of differently salted and smoked *O. niloticus*. The TVC differed significantly ( $P < 0.05$ ) and ranged from  $0.52 \times 10^6$  for FFS 75% brined to  $67.67 \times 10^6$  for CFS 50% brined.

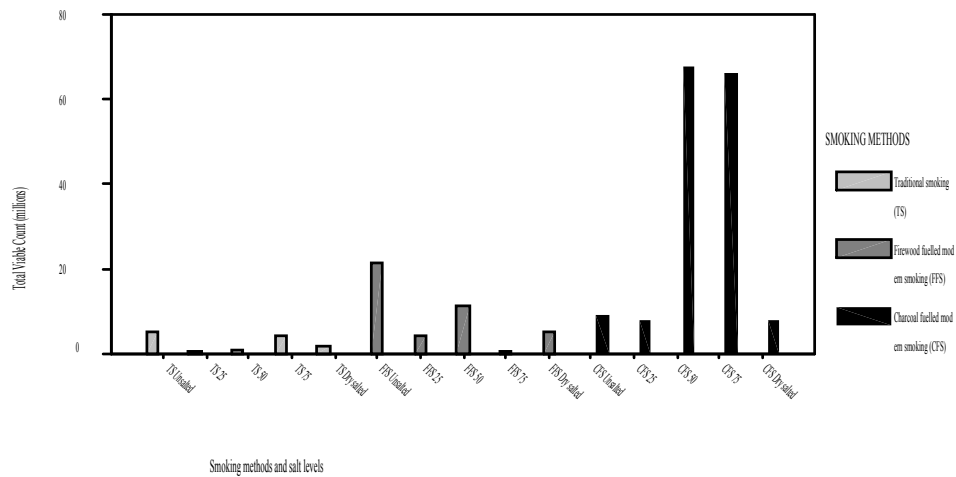


FIGURE 11: The mean Total Viable Count of differently salted and smoked *O. niloticus*

## DISCUSSION

The objectives of modern smoking procedures should be to impart the desired sensory characteristics to the product uniformly, without undue variation from batch to batch and to extend product shelf life. The results of the sensory evaluation showed that there were differences in the acceptability of the smoked *O. niloticus* from the different smoking kilns. However, the contributory factor was likely to be the different levels of salting. This was because against all expectation the smoked product TS 25% brined ranked second best. This was an indication that despite all demerits associated with traditional form of smoking, with the application of salt at the right level traditionally smoked fish can turn out to be good enough for acceptance and can keep better. From the results obtained the product that ranked best in each kiln was brined at 25% concentration. Other parameters of appearance, colour, odour, taste and texture evaluated showed a clear-cut preference trend for the products smoked at salt levels of 25% brined and 50% brined.

The results of the proximate analysis showed that the moisture contents of the smoked products in all the kilns had low moisture ranging from 5.22 % for CFS unsalted to 11.35 TS 50% brined. These levels of moisture signified that the products were well dried and indeed were stable in storage. The drying effect of the smoking process lowers the water activity and hence contributes to the stability of smoked products (Olley *et al.*, 1988). Salt is also a good ally in many respects to effective drying of smoked fish products. However high levels of salt are considered undesirable today and are linked to hypertension (Stibich, 2010). For the protein in the proximate analysis CFS 25% brined had the highest protein value of 68.49. This value might be due to the fact that there was no direct impact of the heat on the fish as the smoking chamber was separated from the fuel chamber and right combination of salt level. Most modern kilns like the CFS do not involve temperatures sufficiently high to reduce biological value and net protein utilization. It is known nevertheless, that smoke components react with amino acids and protein in the food. Carbonyls and phenols in particular, react with lysine, arginine, methionine and other sulphur containing amino acids. Even so, these losses are relatively minor.

As in the case of the lipid contents of the smoked products, all the products showed significant values. Apart from FFS unsalted TS dry salted CFS unsalted and TS unsalted that had below 10% all other products ranged from 14.63 for FFS 50% brined and 27.56% for FFS 25% brined. These showed that the products were rich in essential fatty acids and poly unsaturated fatty acids which are useful sources of omega ( $w3$  and  $w6$ ) series in human diet. Also, the smoked products showed significant levels of ash content thus signifying that the smoked products apart from CFS dry salted, had high levels of mineral matter. Eyo, 2001 stated that the ash content is the inorganic matter, which remains after the organic matter burnt. Determination of ash content indicates largely the mineral matter present in the fish.

The results of the mineral composition of the smoked products showed that all the products had appreciable level of  $Na^+$ . In the TS and FFS there was no particular trend in the levels of salting and  $Na^+$  content unlike what was observed in the CFS where the  $Na^+$  increased in relation to the level of salting. However, there were high levels of sodium in all the products. The high levels could be attributed to the fact that the salt used contained low calcium and magnesium salts as impurities because according to Desrosier and Desrosier (1987) calcium and magnesium salts and sulphates affect a retardation of the rate of penetration of sodium chloride into fish during the salting process. This retardation of the rate of salting permits more decomposition of the protein of the fish tissues during the process of salting. The potassium magnesium and calcium contents of the smoked products were very low. This showed a positive development. The high levels of these minerals would have signified that the common salt used in the treatment of the fish before smoking was impure. There low levels and the merit of were seen in the acceptability of the fish product. It could therefore be established that there is a relationship between sensory acceptability of smoked product and the level of potassium, magnesium and calcium contents present Desrosier and Desrosier (1987) stated that calcium and magnesium salts present as impurities in salt used for salting of fish affect the colour and firmness of the product to a remarkable extent. The presence of as small an

amount as 1% of calcium and magnesium in salt causes a remarkable whitening and stiffening of the flesh. Salts of both of these metals give a strong, bitter taste.

All the smoked products from the three kilns showed appreciable levels of lipid degradation in terms of free fatty acid (FFA). Eyo (2001) stated that most oil rancidity is noticeable when the FFA calculated as oleic acid is in the region of 0.5 – 15%. All the smoked products had values more than 1.5%. The values ranged from 5.44% to 24.97%. Heating according to Aitken and Connell (1979) undoubtedly causes oxidation of lipids in fish. In the case of iodine value (IV), which is a useful index of the degree of unsaturation of oil, the values in the smoking kilns showed a trend in relation to the levels of salting. It was observed that in each of the kilns products brined at 25% salt concentration showed the least value of iodine. This then signified that these products brined at 25% salt concentration were least un-saturated and the least tendency for their lipids to oxidize as the greater the degree of unsaturation and the higher the IV and the greater is the liability of the fat to oxidative rancidity. (Egwele *et al.*, 1986). Although the presence of salt accelerates the reaction of fat and oxygen giving rise to rancidity, high salt concentration is known to decrease the solubility of oxygen thereby retard fat oxidation in the milieu (Eyo 2001). The total viable counts of the smoked products were very low with the exception of CFS 50 brined and CFS 75 brined. This showed that the combination of salting and smoking retards the activities of bacteria. Salt retards the activities of bacteria by causing the bacteria cells to plasmolyse (Eyo, 2001). This applies to all bacteria except the cells of halophilic and haloduric types which can withstand high salt concentration.

### CONCLUSION

Acceptability of differently salted and smoked *O. niloticus* using various smoking kilns showed a clear-cut preference trend for the products smoked at salt levels of 25% brined and 50% brined. The smoked products showed appreciable levels of ash content thus signifying that the smoked products apart from CFS dry salted, had high levels of mineral matter. The results of the mineral composition of the smoked products showed that all the products had appreciable level of Na<sup>+</sup>. The potassium magnesium and calcium contents of the smoked products were very low. It could be established that there was a relationship between sensory acceptability of smoked product and the level of potassium, magnesium and calcium contents. All the smoked products from the three kilns showed appreciable levels of lipid degradation in terms of free fatty acid (FFA). The total viable counts of the smoked products were very low with the exception of CFS 50 brined and CFS 75 brined. This showed that the combination of salting and smoking retards the activities of bacteria. Based on the outcome of the smoke-dried products, it could be safely concluded and recommended that for effective smoke-drying of *O. niloticus* it should be

combined with brining at between 25% and 50% brine levels for one hour before the process of smoking.

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