

# QUALITY AND SHELF – LIFE ASSESSEMENT OF VARIOUSLY PROCESSED CATFISH AND TILAPIA STORED AT AMBIENT TEMPERATURE

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## INTRODUCTION

Among the food resources of the world, fish and fishery products are very important as sources of protein, especially in countries that are unsuitable for livestock production. Fish is a highly proteinous food consumed by a larger percentage of populace because of its availability and palatability (Foranet *al.*, 2005). However, quality of harvest is markedly affected by the ease of deterioration and spoilage in fresh fish. As such, processing provides a way out to avoid losses due to quality deterioration and spoilage.

Although fish is a good source of some essential nutrients, processing and processing practices could cause modifications in proximate composition, fatty acids and amino acids as well as changes in the nutritional quality of fish and trace metal composition (Castrillonet *al.*, 1997).

The study of mineral elements present in fish products is of biological importance; since many of such elements take part in metabolic processes and are known to be indispensable to all living things (Shul'man, 1974). A deficiency in these principal nutritional mineral elements induces a lot of malfunctioning; as it reduces productivity and causes diseases, such as inability of blood to clot, osteoporosis, anaemia etc. (Shul'man, 1974 and Mills, 1980). Also, the measurement of quality is often necessary to ensure that fresh and processed fish meets the requirements of food regulations and commercial specifications (Watermann, 2000).

Therefore, considering the possible health risks and the nutritional benefits associated with fish consumption; it has therefore become important that different processing methods be assessed in order to establish the acceptability and the of their products.

## MATERIALS AND METHODS

### Sample Collection

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

### **Fish Processing**

For the oven – drying treatment (OVD), fish samples were dried in an oven at an initial temperature of 45°C for two (2) hours, then at 105°C to a moisture content of  $15 \pm 5\%$ . For brining and oven - drying treatment (BOVD), 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°C for two (2) hours, then at 105°C to a moisture content of  $15 \pm 5\%$ . For smoking treatment, fish samples were drained of water and smoked in a neatly prepared traditional open drum. Iron mesh were placed 20cm from the top of the drum on which the samples were placed to be smoked. The drum was covered with aluminium foil to conserve heat and smoke. All samples cooled and exposed to ambient temperatures to air-dry. The samples were stored in perforated clean plastic containers at ambient temperature (25 – 32 °C) and labelled accordingly.

### **Determination of Freshness Quality**

#### **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 panel of assessors using a 15 point hedonic scale modified from Eyo (2001) and Nguyen (2005). Grades were allotted depending on their quality as follows:  $12 < S \leq 15$  = very fresh,  $9 < S \leq 12$  = fresh,  $6 < S \leq 9$  = poor,  $3 < S \leq 6$  = bad,  $S \leq 3$  = very bad.

#### **Total Viable Count**

1g 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  $25 \pm 5^\circ\text{C}$  for 24 hours. The total colonies were counted to represent the total number of bacterial cells (TVC) capable of forming colonies.

#### **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  $\text{NH}_4\text{SO}_4$  (0, 5, 10, 15, 20 and 25 ml of the 100  $\mu\text{g/ml}$   $\text{NH}_4^+$  -N) were prepared from  $\text{NH}_4\text{SO}_4$  and dried at 105°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 1 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.

### Trace Metal Analysis

1 g of processed samples was weighed and mixed with 20  $\text{cm}^3$  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  $\text{cm}^3$  with de-ionised distilled water. The digest were analysed for Zn, Fe, Cd and Pb using (AAS) Atomic Absorption Spectrophotometer.

## RESULTS AND DISCUSSION

### Organoleptic Assessment

The sensory scores of processed 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 higher 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 though 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). Also, in the BOVD samples, salt has the potential to accelerate fat oxidation (Eyo, 2006) accounting for the decrease in odour.

Based on sensory assessment, the processed 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. *Chrysichthys nigrodigitatus* decreased greatly in odour and flavour as the duration of storage increased compared with *Tilapia zillii*. Fatty fish species like *Chrysichthys nigrodigitatus* 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). Fish oil has been found to be more liable to spoilage than other oils due to their greater number of unsaturated fatty acids as shown by the lower specification number and higher iodine value (Eyo, 1983). The greater the degree of unsaturation, the greater would be the tendency for fat oxidation. This decrease may be attributed to lipid oxidation as the lipid content of fish contributes to spoilage processes

### **Total Viable Count**

The mean total viable count (TVC) of processed fish samples is presented in figs 4, 5 and 6. Results showed a significant ( $P < 0.05$ ) difference between the total viable count of BOVD, SMKD and OVD. BOVD had the lowest TVC out the processing methods studied. The introduction of heat during all the processing methods employed 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 destroy 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). Smoked samples also had relatively lower total microbial count when compared with oven dried samples as the duration of processing increased. This can be explained by the bactericidal effect of smoke constituents such as acids, aldehydes and phenols (Eyo, 2006). Olsen (1976) reported that the addition of the phenolic fraction of wood in the concentration of 45mg/kg resulted in inhibitory effects on *Staphylococcus aureus*. Yeast and moulds are however more resistant to the inhibitory effect influence of smoke even up to a concentration of 60 mg/kg.

While the microbial load of *Tilapia zillii* did not exceed the maximum bacterial count for good quality fish recommended by ICMSF (1986), fluffy woolly mat of moulds were noticed on the fish samples by the 7th week. However, by the 6th week, oven dried and smoked samples of *Chrysichthys nigrodigitatus* 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:  $5.39 \pm 0.09$  ( $\text{Log}_{10}\text{cfu/g}$ ) for *Tilapia zillii* and  $6.45 \pm 0.15$  ( $\text{Log}_{10}\text{cfu/g}$ ) for *Chrysichthys nigrodigitatus*.

### **Total Volatile Nitrogen**

Mean total volatile nitrogen (TVN) of processed 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 (Klomklaoet. al., (2010) thereby reducing protein breakdown. The highest total volatile nitrogen content was recorded at the 8th week in oven dried samples:  $24.89 \pm 0.01$  mg/100g for *Tilapia zillii* and  $27.94 \pm 0.14$  mg/100g for *Chrysichthys nigrodigitatus*. 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).

### **Trace metal content**

Mean metal concentrations in fish samples are expressed in table 1. Method of processing had no 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 processing process. This is in line with the observation of Essuman (2000) who suggested that salt and other materials used during processing may be sources of heavy metals in fish. The higher concentration of Fe and Zn in the fish samples analysed can be due to the natural abundance of these metals in Nigerian soils and since the source of metal depositories are aquatic systems (Adefemiet. al., 2000). The Cd content of the fish samples was lower than Fe and Zn with the highest concentration of  $0.081 \pm 0.004$  mg/Kg in smoked *Chrysichthys nigrodigitatus*. A possible explanation to this could be due to the fact that Cd is easier to leach from fish muscle than Fe and Zn (Hanamaka, 1981). Pb was below 0.05 mg/Kg in both fresh and processed samples of all fish species. This corresponds with the observation of Bebbintonet. al., 1977 and is much lower than the World Health Organisation (2000) recommended limit of 2.0 mg/Kg.

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.

## CONCLUSION

In conclusion, fish samples processed 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. *Clarias gariepinus* deteriorated faster in odour and flavour than *Tilapia zillidue* to its high fat content which makes it susceptible to fat oxidation. The optimum storage period of the processed fish species is 4-5 weeks. Therefore, in spite of being physically firm, caution should be exercised in consuming processed 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 processed 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 processed fish

|      | <i>T. zillii</i> |             |             |        | <i>C.nigrodigitatus</i> |             |             |        |
|------|------------------|-------------|-------------|--------|-------------------------|-------------|-------------|--------|
|      | Fe               | Zn          | Cd          | Pb     | Fe                      | Zn          | Cd          | Pb     |
| OVD  | 3.712±0.003      | 7.214±0.002 | 0.023±0.002 | < 0.05 | 4.640±0.000             | 5.161±0.000 | 0.079±0.000 | < 0.05 |
| BOVD | 3.713±0.002      | 7.221±0.002 | 0.024±0.003 | < 0.05 | 4.652±0.003             | 5.162±0.004 | 0.079±0.000 | < 0.05 |
| SMKD | 3.714±0.006      | 7.246±0.013 | 0.024±0.002 | < 0.05 | 4.713±0.001             | 5.164±0.002 | 0.081±0.004 | < 0.05 |

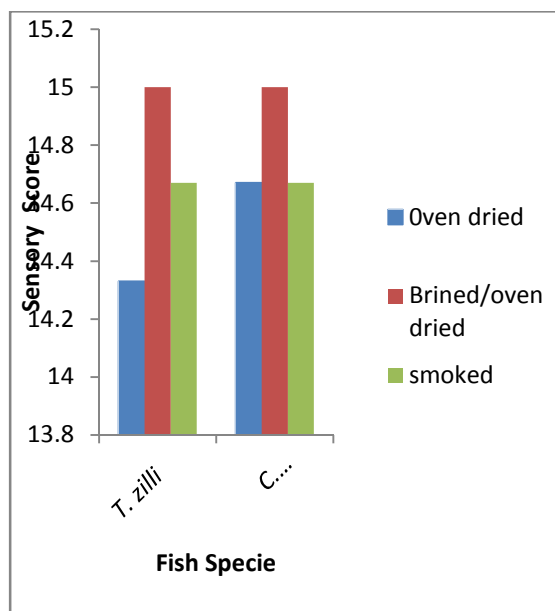
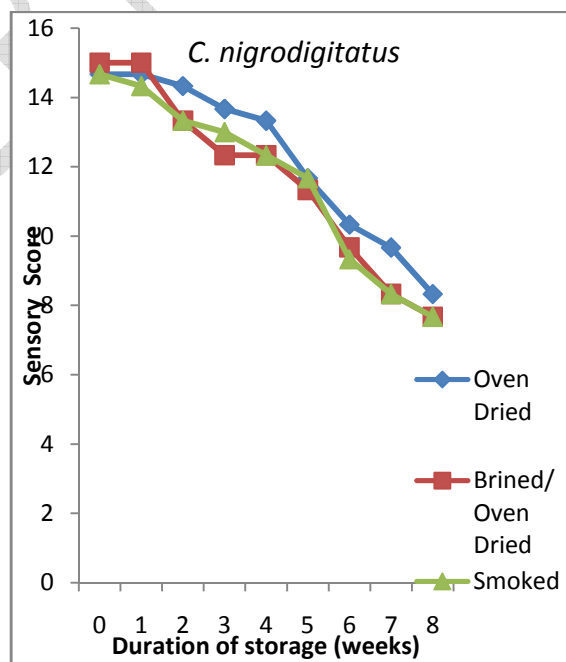
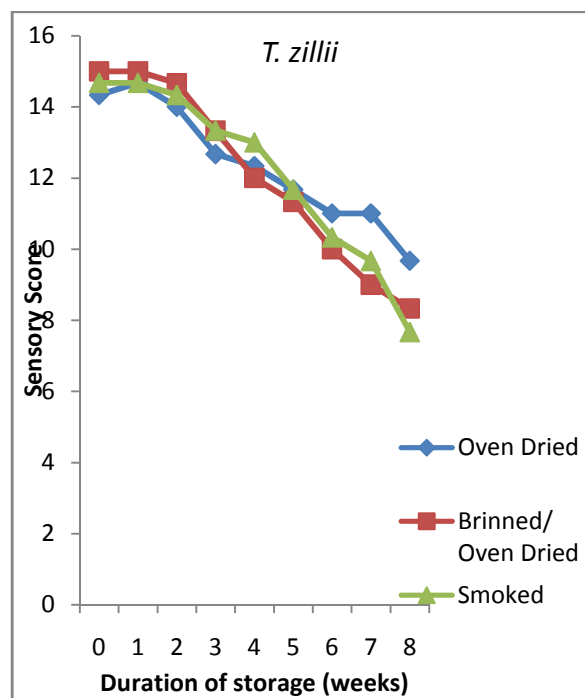


Fig 1: Effect of processing method on sensory score of freshly processed fish samples.



Figs 2 & 3: Effect of duration of storage on the sensory score of processed fish.

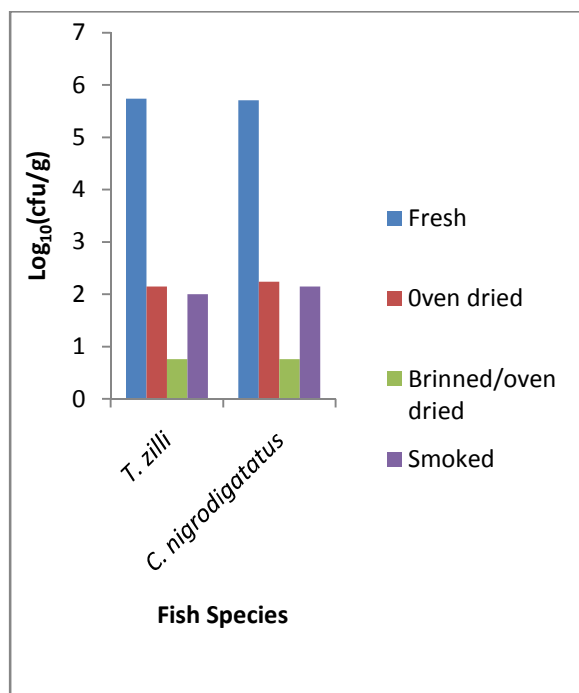
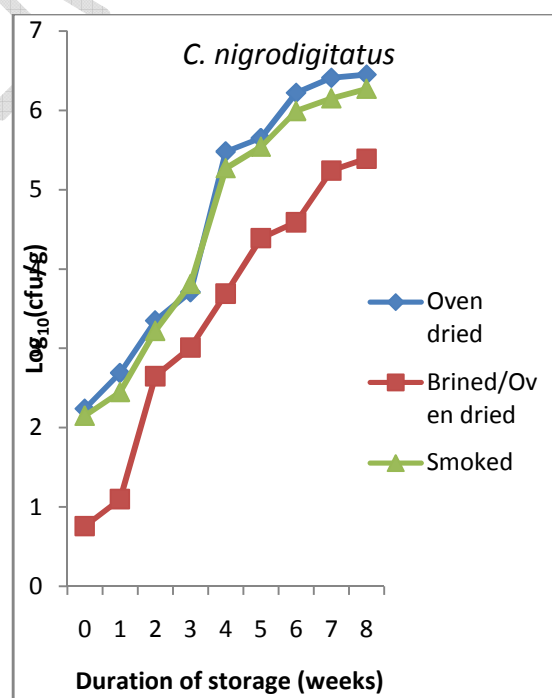
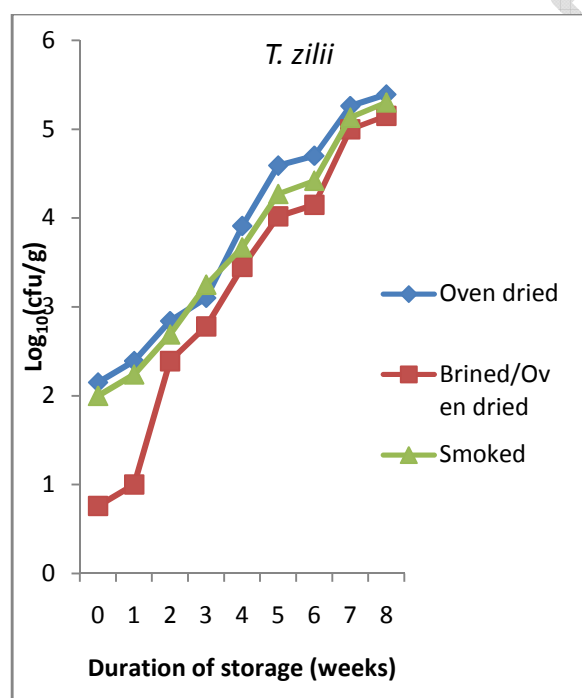


Fig 4: Effect of processing method on the total viable count ( $\text{Log}_{10}(\text{cfu/g})$ ) of freshly processed fish.



Figs 5 & 6: Effect of duration of storage on the total viable count ( $\text{Log}_{10}(\text{cfu/g})$ ) of fish

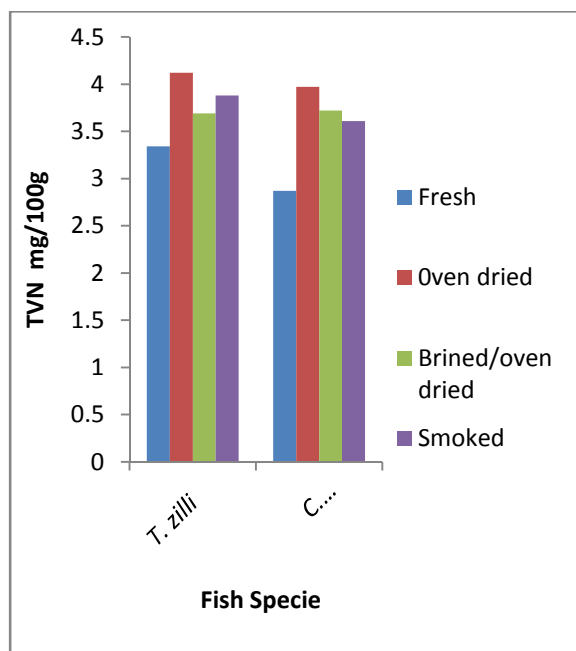
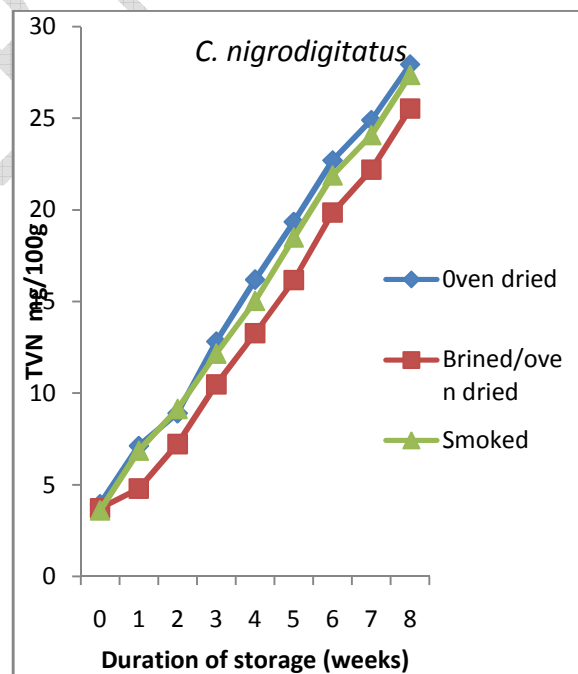
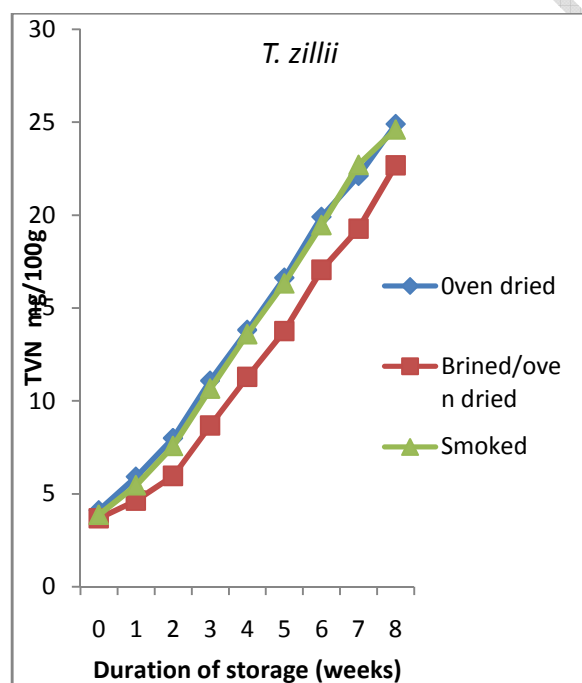


Fig7: Effect of processing methods total volatile nitrogen content (TVN) mg/100g of freshly processed fish.



Figs 8 & 9: Effect of duration of processing on the total volatile nitrogen mg/100g of fish.

UNDER PEER REVIEW