

# Biochemical and Sensory Characteristics of the Smoked African Catfish (*Clarias gariepinus*) under Different Storage Conditions in the Coastal Region of Kenya

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## Abstract

Smoking is one of the oldest methods of drying food for purposes of preservation and flavouring. However, technologies are changing fast resulting in various smoking techniques to improve fish quality and shelf life. Different storage conditions have been used and others are still being tested to improve shelf life of smoked fish products. The aim of this study was to determine the changes in biochemical and sensory attributes of smoked African catfish (*Clarias gariepinus*) under different storage conditions. Samples were stored in open air, sealed polythene paper bags and vacuum sealed polythene paper bags for a period of 30 days. Storage in open air exhibited highest value at day 30 while vacuum package exhibited the least. Protein decreased with time to lowest value of 60.83% in the open air storage at day 30 while those of vacuum packaging exhibited insignificant change with time. Fat content showed no significant linear change with storage time except the one stored under normal packaging. Ash and moisture content exhibited linear change with time on open package samples only. Organoleptic responses remained constant until day 30 when there was a slight change in responses on taste and overall acceptability. In general, pronounced changes were exhibited on open air while vacuum packaging had the least changes.

**Key words:** Smoking, Shelf life, Organoleptic, Kilns, Packaging, Quality

## INTRODUCTION

One of the oldest methods of drying food for purposes of preservation and addition of flavour is smoking. It is estimated that 25% of the world's fish catch destined for human consumption is dried in some manner, combined with some salting, brining or smoking. The basic food process called drying, combined with effect of salt and smoke particulates results in smoked products (Pigott, 2002). Hot and cold smoking methods are the predominant ones as far as fish smoking is concerned. However, since the beginning of fish smoking, the general procedure has remained unchanged with methods applied depending on opinion. Basically, it depends on which type of wood to use and what temperature and time to do the smoking (Pigott, 2002). This has necessitated the emergence of various smoking technologies (Oyaro et al. 2012) to ensure quality products with improved shelf life in order to satisfy market requirements. However, due to diverse consumer needs, new innovations are still required to further improve the quality of smoked products as well as their shelf life. The African catfish is one of the fishes caught in Lake Kenyatta (oxbow lake of River Tana) in Lamu County coast of Kenya. It is mainly sold as smoked products (tonzi) with a wide distribution in Kenya. However, the quality of the product during storage has been of concern. This follows the understanding that fish is classified as a highly perishable food commodity with shelf life dependent on the initial quality, processing technology and storage conditions. In this study therefore, an improved smoking Kiln was designed with enhanced smoking features for quality products with better characteristics. Biochemical and sensory methods were used in evaluating the characteristics of the smoked products under different storage conditions with the aim of establishing the most appropriate conditions of storage that would improve the shelf life of the smoked fish for marketing purposes both locally and regionally. The packaging types used for storage was open air (as control), normal polythene packaging and vacuum packaging.

## MATERIALS AND METHODS

### Smoking Protocol

Smoked fish products were processed at Lake Kenyatta, Mpeketoni area of Lamu County. Eight improved smoking ovens have been constructed to smoke

fish products. Fish were purchased from fishermen in the area, gutted and cleaned thoroughly using potable water. The fish samples were then brined using 20% w/v of water for about one hour, removed and placed on the smoking trays to drain for 30 minutes. The smoking was done using a 4x8x3 feet double door smoking oven. About 3 kg of wood fuel was lit to burn completely till the flame was allowed to go off. Whole fish products were then transferred to the smoking ovens. The fish was then left to dry slowly in smoke and controlled heat (average 80°C). Small quantities of wood fuel were added slowly to the fire until the product dried to below 20% moisture content. The process took 32 hours net drying period to completion. The final products were wrapped in aluminium foil, packed in trays and transported to KMFRI laboratory where shelf life studies were conducted.

### Laboratory Analysis

Biochemical and sensory methods were used in the evaluation of quality changes with time. Samples for day 0 were analyzed immediately. About 30kg of the smoked products were used in shelf life study using different packaging methods separated in three lots. The first lot of 10 Kg samples were kept in open plastic containers (Open Air (OA)), the other 10 kg were packed in polythene papers and sealed (normal packaging (NP)) while the third lot were vacuum packed (VP). Subsequent biochemical and sensory analyses were carried out on day 15 and day 30.

$$\text{mg malonaldehyde/kg} = \text{abs} \times 7.8$$

Where

abs = corrected absorbance of supernatant

7.8 = a constant

## Biochemical and Sensory Determination

### Determination of thiobarbituric acid reactive substances (TBARS)

The thiobarbituric acid-reactive substances (TBARS) assay was performed as described by Buege & Aust (1978). Ground sample (0.5 g) was homogenised with 2.5 ml of a solution containing 0.375% thiobarbituric acid, 15% trichloroacetic acid and 0.25N HCl using homogenizer. The mixture was heated in a boiling water bath (95–100 °C) for 10 min to develop a pink colour, cooled with running tap water and centrifuged at 3600g at 25°C for 20 min using a centrifuge. The absorbance of the supernatant was measured at 532nm. TBARS was calculated and expressed as mg malonaldehyde/kg sample as below.

### Total Volatile Bases-Nitrogen (TVB-N)

The total volatile basic -nitrogen (TVB-N) was determined according to Kirk & Sawyer (1991). Approximately 5g of whole ground shrimp sample was homogenized with 15ml of 4% Trichloroacetic acid (TCA) (w/v) and centrifuged at 3000g for 3 minutes then filtered through filter paper (125mm diameter). A 5ml aliquot was removed and mixed with 5ml of 2M NaOH. The mixture was then poured into a semi-micro-distillation tube and steam distilled. The distillate was collected in a beaker containing 15 ml of 0.01M HCl standard to a final volume of 50 ml. Rosolic acid 1% in 10 ml (v/v) ethanol was used as indicator. The TVB-N was calculated using the following formula:

$$\text{TVB-N (mg/100g sample)} = \frac{\text{Ml. of titrant} \times 0.14 \times 2 \times 100}{\text{Sample Wt.}}$$

### Determination of Proximate Composition

#### Protein analysis

Protein content in shrimp meat was determined based on Kjeldahl method (AOAC, 1990). A sample of 5 g was digested in Sulphuric acid (H<sub>2</sub>SO<sub>4</sub>) in the presence of copper sulphate as a catalyst. Thereafter, the sample was placed in the distillation unit, 2400 Kjeltac Auto Sample System. The acid solution was made alkaline by sodium hydroxide solution. Ammonia was then steam distilled in boric acid having indicators. The boric acid was then simultaneously titrated with 0.01M H<sub>2</sub>SO<sub>4</sub>. The nitrogen content was then multiplied by a factor of 6.25 to get the ratio of crude protein.

#### Determination of Fat Content

The fat content in shrimp flesh was determined using AOCS (1997) official method of analysis. The sample was extracted using petroleum ether, with a boiling range of 40-60°C. The extract was recovered using a Rotary evaporator. The extract was weighed and the fat content calculated as follows;

$$\% \text{ fat content} = \frac{(\text{weight of fat} + \text{container}) - (\text{weight of container})}{\text{weight of sample}} \times 100$$

### Determination of Moisture Content

Moisture content was determined according to AOCS (1997) official method of analysis. In a pre-weighed aluminium foil, 5 g of crushed whole shrimp was dried for 24 hours in an oven at 105°C and cooled in a desiccator to room temperature. The same was weighed and recorded accordingly. The moisture content was calculated as follows:

$$\text{Moisture content x (\%wb)} = \frac{\text{initial Wt} - \text{Final wt}}{\text{initial Wt.}} \times 100$$

### Determination of Ash Content

The ash content was determined according to AOCS (1997) official method of analysis. 5g of shrimp flesh was dried for 24 hours in an oven at 105°C and cooled in a desiccator to room temperature. The same was weighed and recorded accordingly. In a known weight of aluminium foil, the samples were placed in the micro furnace at 450°C for six hours to ash completely. The ash content was calculated as follows:

$$\% \text{ Ash content} = \frac{\text{initial weight before ashing} - \text{Final weight after ashing}}{\text{initial weight before ashing}} \times 100$$

### Determination of Water Activity

Water activity was measured using the water activity meter (Decagon).

### Temperature Measurements

Temperature humidity logger was used to measure the temperature.

### Determination of Sensory Attributes

10 trained taste panellists were used to determine the sensory attributes using a 0-5 score range (5= best score and 0 = worst score). The scores were added together and the average of all the four attributes (taste, appearance, texture and general appearance) used to determine its acceptability.

## RESULTS AND DISCUSSION

### Biochemical

There were appreciable changes in TVB-N for open and normal packaged products with no noticeable changes in the vacuum packaged ones. Open packaged samples had the highest result of 0.0046 ± 0.0003 mgN/100g on day 30. However, a different trend was seen in the TBARS results where only open packaging had an appreciable increase with the highest value being 5.7681±0.2300mg malonaldehyde/Kg on day 30 (Fig1&2).

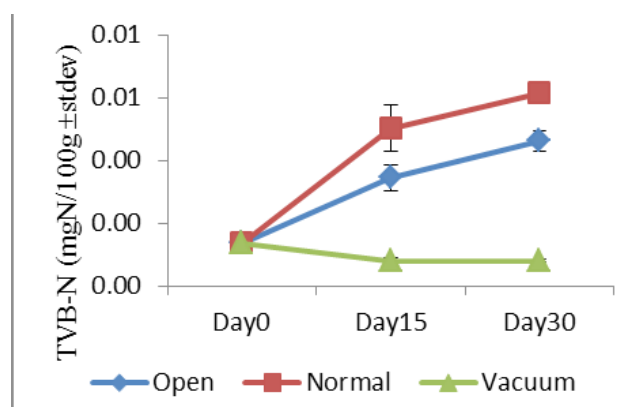


Fig 1: Changes in TBV-N during storage

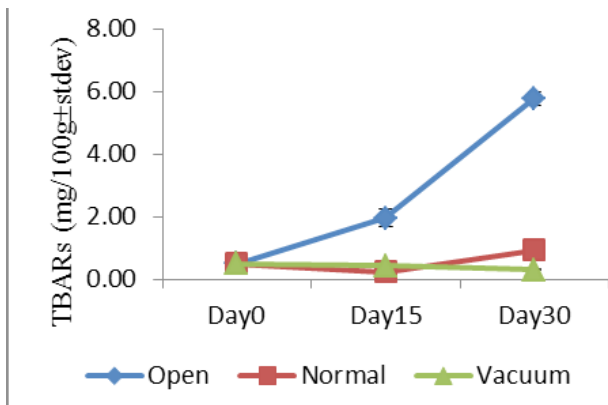


Fig 2: Changes in TBARs during storage

### Proximate Composition

Percentage content of protein, fat, ash and moisture were determined for proximate composition during the 30 days period. Changes were noticeable in Open and Normal packaging with percentage of fat appreciably decreasing from  $5.8169 \pm 0.1956$  on day 0 to  $4.9742 \pm 0.1582$  and  $5.8169 \pm 0.1956$  to  $3.9754 \pm 0.1735$  on day 30. There was not much change noticed in percentage of ash content during the 30 days storage period. However, moisture content for open packaging increased from  $18.7084 \pm 0.6191$  to  $24.9475 \pm 0.9362$  during the storage period while protein behaved in the reverse by decreasing from  $72.996 \pm 1.2976$  to  $60.8362 \pm 2.1406$  for the open package. No major changes were noticed on protein and moisture content for the 30 days storage period (Figs 5 & 6).

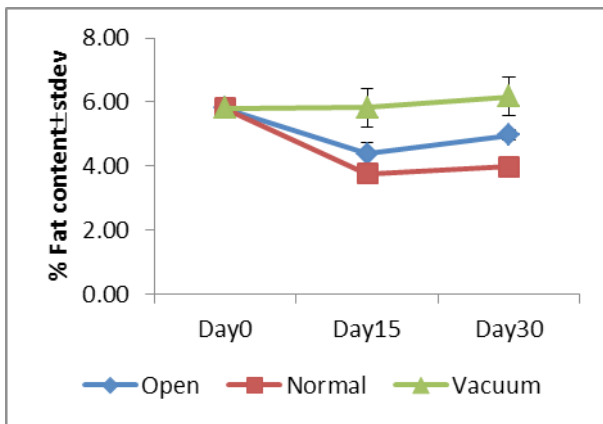


Fig 3: Changes in percentage fat content during storage

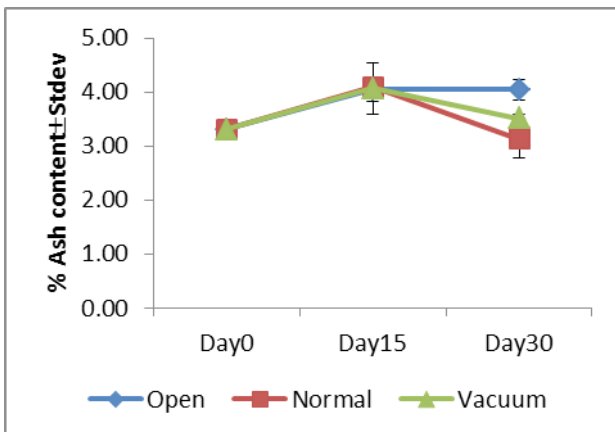


Fig 4: Changes in percentage ash content during storage

Fig 5: Changes in moisture during storage

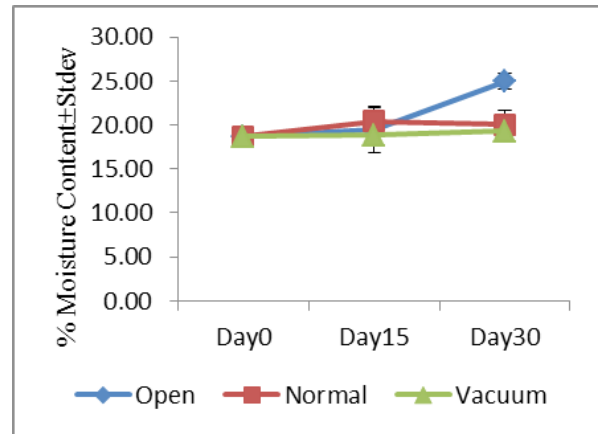
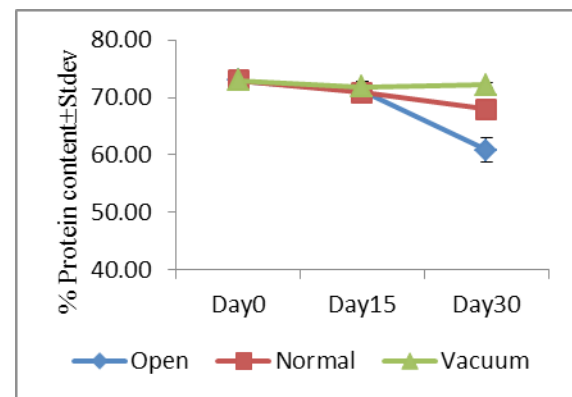


Fig 6: Changes in protein content during storage



### Linear Regression Results

A multi linear regression analysis was performed on the biochemical and proximate composition parameters to establish the relationship between storage period with changes in parameter levels. TVB-N showed significant linear relationship in all the packaging conditions hence affected directly with storage period under all conditions. However, under vacuum packaging the effect is appreciably reduced ( $r=0.83$ ) compared to open ( $r=0.97$ ) and normal packaging ( $r=0.94$ ). This could be attributed to reduced chances of samples being in contact with open air exposed to microorganism activities. TBARs showed strong linear changes with time in both open ( $r=0.96$ ) and vacuum packaging ( $r=0.86$ ). However, under normal packaging there was no significant linear relationship with storage period. Ash and moisture content results showed no linear relationship with storage period except for the open packaged samples. This could be associated with reduced chances of being in contact with atmospheric moisture due to sealed packaging. Protein content results had significant linear reduction with storage on both open ( $r=0.90$ ;  $p<0.05$ ) and Normal packaging ( $r=0.86$ ;  $p<0.005$ ). This could be associated with continued microorganism activity on the free amino acids to protein products due to air contact with the samples even after packaging. Fat content did not show significant linear relationship in open and vacuum packaging except on the normal packaging where there was a relationship ( $r=0.86$ ;  $p<0.05$ ). This could be attributed to continued lipid oxidation due to air in the package emitting non fatty acid products.

**Table 1: Multi-linear regression of biochemical and proximate composition of the products during the storage period under different packaging conditions**

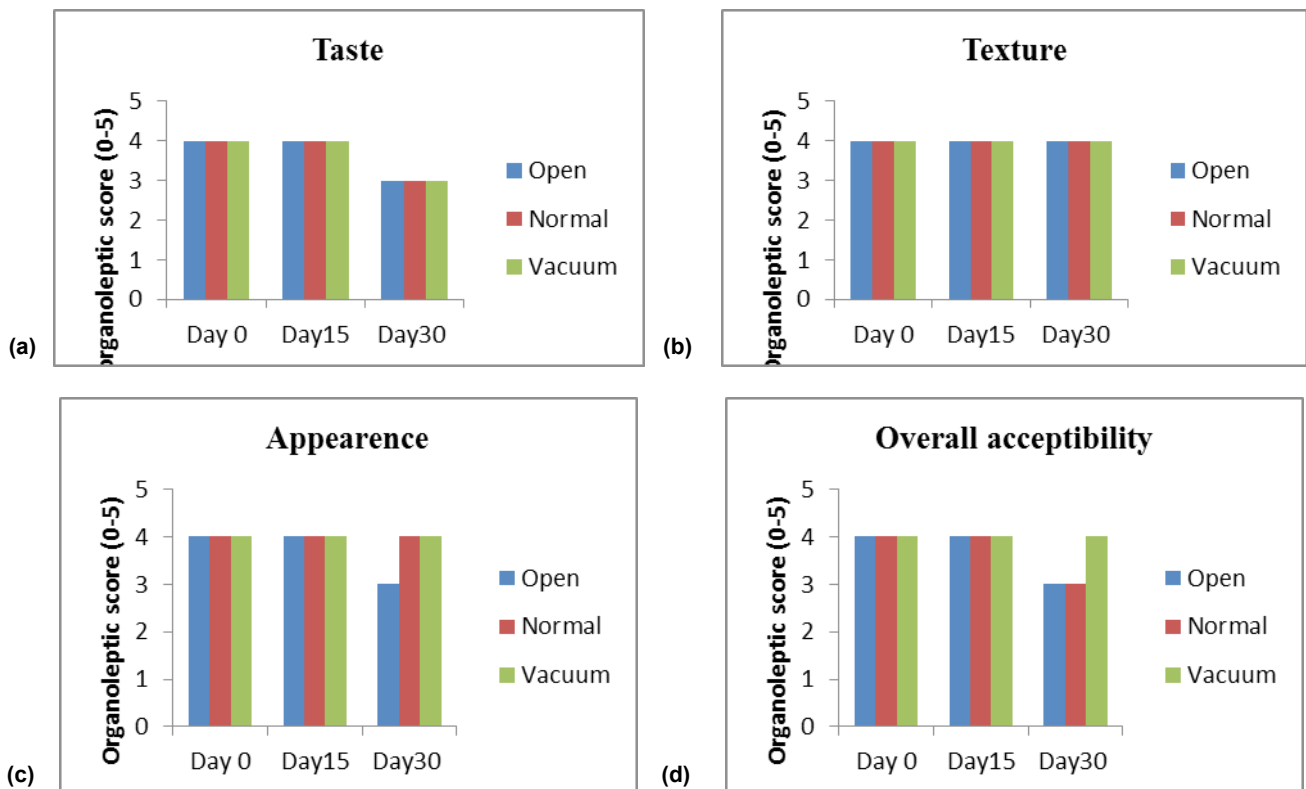
Parameter	Storage condition	Day 0	Day15	Day 30	R	P
TVB-NmgN/100g	Open	0.0013 . 0.0001	0.0034 . 0.0004	0.0046 . 0.0003	0.9704	0.0000
	Normal	0.0013 . 0.0001	0.0050 . 0.0007	0.0061 . 0.0003	0.9404	0.0002
	Vacuum	0.0013 . 0.0001	0.0008 . 0.0001	0.0008 . 0.0000	0.8354	0.0051
TBARs mg/Kg	Open	0.4940 .0.0596	1.9559 .0.2833	5.7681 .0.2300	0.9655	0.0000
	Normal	0.4940 .0.0596	0.2366 .0.0162	0.9277 .0.0753	0.6129	0.0792
	Vacuum	0.4940 .0.0596	0.4143 .0.0821	0.2897 .0.0201	0.8583	0.0031
% Protein(N)	Open	72.996.1.2976	71.0556.1.6716	60.8362.2.1406	0.8993	0.0010
	Normal	72.996.0.9739	70.8531.1.0251	67.9204.1.6917	0.8618	0.0028
	Vacuum	72.996.1.2976	71.8136.0.9263	72.1527.0.3865	0.3745	0.3207
% Fat	Open	5.8169 .0.1956	4.3810 .0.3626	4.9742 .0.1582	0.6315	0.0681
	Normal	5.8169 .0.1956	3.7566 .0.2176	3.9754 .0.1735	0.8016	0.0094
	Vacuum	5.8169 .0.1956	5.8178.0.6068	6.1766.0.6096	0.3271	0.3902
% Ash	Open	3.3121 .0.1611	4.0430 .0.2230	4.0468 .0.1879	0.7904	0.0112
	Normal	3.3121 .0.1611	4.0911 .0.1091	3.1262 .0.3446	0.1658	0.6700
	Vacuum	3.3121 .0.1611	4.0651 .0.4821	3.5106 .0.0719	0.20225	0.6013
% MC	Open	18.7084 .0.6191	19.4351.2.6517	24.9475.0.9362	0.8220	0.0066
	Normal	18.7084 .0.6191	20.4197.1.4887	20.0137 .1.5901	0.1847	0.6342
	Vacuum	18.7084.0.6191	18.8803.0.9267	19.3138.0.4053	0.4023	0.2830

The values in bold show significant linear relationship with storage time

## Sensory Evaluation

Sensory evaluation method was used to determine the level of acceptability by the consumers during the storage period. Taste, texture, appearance and overall acceptability were scored at a scale of 0-5 and the averages used as indicators of acceptability of the products.

**Fig. 7: Changes of sensory attributes with time during storage period**



All the sensory attributes did not show any significant different in panellists' response with all panellists scoring 4 out of 5 indicating higher acceptability of the product. However, day 30 had a slight drop (score 3) in taste and appearance.

## Water Activity and Temperature

The water activity (Wa) and temperature were stable throughout the storage period. However, the vacuum packaged samples showed higher values with storage period. Temperatures were stable throughout with insignificant changes during the period (Fig. 8 & 9).

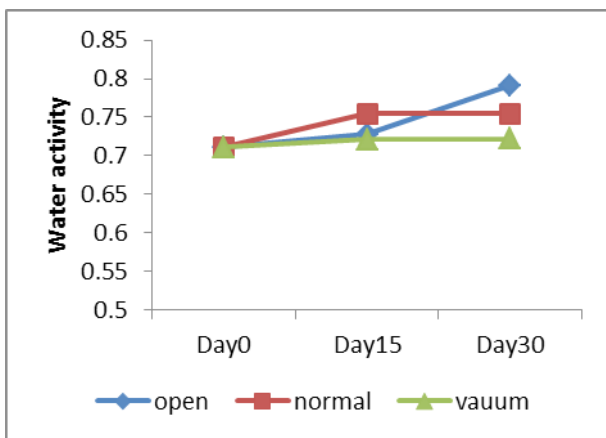


Fig 8: Water activity during storage period

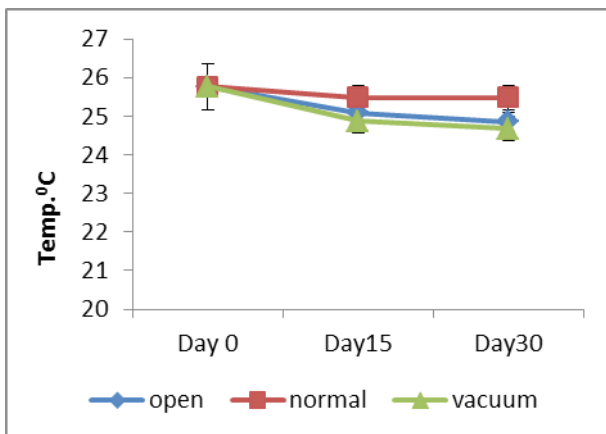


Fig 9: Temperature during storage period

## CONCLUSION AND RECOMMENDATION

### Biochemical Evaluation

All biochemical parameters showed significant changes for open storage conditions. This means that open packaging reduces the shelf life significantly as all parameter showed significant linear relationship with time. Normal and vacuum packaged samples had the least effect during storage period although the vacuum was the best in maintaining quality. It was observed that using vacuum packaging would extend the shelf life of smoked products significantly. However none of the stored samples exhibited critical levels. Sensory results showed that all the samples within acceptable levels. Amongst the proximate composition parameters, samples stored under open packaging are affected most as all showed linear changes with time. Therefore, samples are affected most under open packaging.

Vacuum packaging is recommended for packaging of smoked fish samples. However, storage trials should be done for longer period than 30 days in order to establish the critical storage limits at which the parameters reach the unacceptable levels. Development of smoked fish product needs to be tested in the market using vacuum packaging.

## ACKNOWLEDGMENT

Our acknowledgement goes to the Kenya Coastal Development Project (KCDP) for having funded this study for the entire period. We also appreciate KMFRI for having supported this work by providing workspace. Our gratitude also goes to the technical staff of the Kenya Marine and Fisheries Research Institute (KM-FRI), various Beach Management Units (BMUs) and all those who assisted in one way or the other to make this work a reality.

## REFERENCES

- AOAC. (1990). Official methods of analysis of the association of official analytical chemists Arlington. Association of Official Analytical Chemists Inc, (5(1):), p 771.
- AOCS. (1997). Sampling and analysis of oil seed by-products. (with modification according to application note tecator no AN 301). Official Method, pp3-38.
- Buege, J., & Aust, S. (1978). Methods Enzymol, (52), 302-310.
- Chaijan, M. (2011). Physicochemical changes of tilapia (*Oreochromis niloticus*) muscle during salting. Food Chemistry, 129(3), 1201-1210.
- Kirk, S., & Sawyer, R. (1991). Pearson's composition and analysis of foods. Longman Group Ltd.
- Oyero, J. O., Sadiku, S. O. E., & Eyo, A. A. (2012). The effect of various smoking methods on the quality of differently salted *Oreochromis niloticus*. International Journal of Advanced Biological Research, 2(4), 717-723.
- Piggott, G. M. (2002). Smoking of fish, special considerations. Institute for Food Science and Technology University of Washington.