Research in
ISSN : P-2409-0603, E-2409-9325
AGRICULTURE, LIVESTOCK and FISHERIES
An Open Access Peer Reviewed Journal

Open Access **Res. Agric. Livest. Fish.**
Research Article **Vol. 5, No. 2, August 2018 : 241-248.**

EFFECT OF ONION TOP LEAVES EXTRACT ON THE QUALITY OF SMOKED *Heterotis niloticus* (Cuvier, 1829)

Ibrahim Shehu Jega[1,3*], Philomina Michael[1] and Ibrahim Mohammed Ribah[2]

[1]Department of Forestry and Fisheries, Kebbi State University of Science and Technology, Aliero, Nigeria; [2]Department of Animal Science, Kebbi State University of Science and Technology, Aliero, Nigeria; and [3]Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

***Corresponding author:** Ibrahim Shehu Jega; E-mail: ibrahimshehu77@yahoo.com

ARTICLE INFO

Received
05 July, 2018

Accepted
14 August, 2018

Online
30 August, 2018

Key words
Preservation
Onion tops
Chemical analysis
sensory analysis

ABSTRACT

Food preservation techniques to improve the oxidative stability of fish-based foods are gaining renewed research interest in natural compounds of vegetable origin as valid alternatives to synthetic preservatives. This study was designed to determine the effect of Onion Top Leaves Extract (OTLE) on the chemical and sensory qualities of smoked *Heterotis niloticus* using four concentrations (0, 0.25, 0.5 and 0.75% w/w) and three storage periods replicated four times in a Completely Randomized Design (CRD). A total of 48 fresh samples of *H. niloticus* were treated with the different concentrations of OTLE, sundried for three hours and smoked using a modified portable drum kiln designed in the laboratory. The treated smoked samples were packaged in paper envelopes and stored at room temperature for a period of three weeks. The results indicated that OTLE concentration had significantly affected ($P<0.05$) moisture content, crude protein, crude fibre, nitrogen and total volatile base – nitrogen (TVB-N). The storage period was significantly affected ($P<0.05$) by OTLE for all tested chemical parameters except carbohydrates, ($P>0.05$). The results for sensory qualities indicated that after three weeks of storage, OTLE exerted a significant effect ($P<0.05$) on all sensory qualities tested in the study except general acceptability. The results for merit analysis showed that the samples treated with OTLE concentration of 0.25% ranked better followed by 0.5% while 0.75% recorded the lowest performance. For better optimisation of shelf life, chemical and sensory qualities of smoked *H. niloticus,* the product can be preserved in 0.25% w/w OTLE and stored for one week at room temperature in paper envelopes.

To cite this article: Jega IS, P Michael and IM Ribah, 2018. Effect of onion top leaves extract on the quality of smoked *Heterotis niloticus* (Cuvier, 1829). Res. Agric. Livest. Fish. 5 (2): 241-248.

This is an open access article licensed under the terms of the Creative Commons Attribution 4.0 International License

INTRODUCTION

Fish is highly nutritious, tasty and easily digested. It is much sought after by a broad cross-section of the world's population, particularly in developing countries. It is estimated that around 60 percent of people in many developing countries depend on fish for over 30 percent of their animal protein supplies, while almost 80 percent in most developed countries obtain less than 20 percent of their animal protein from fish (Shiman, 1991). Technological development in food processing and packaging is ongoing in many countries, with increases in efficient, effective and lucrative utilization of raw materials, and innovation in product diversification (FAO, 2016). Fish products are comparable to meat and dairy products in nutritional quality, depending on the methods used in preservation and preparation. The protein content of most fish averages 15 to 20 percent. Fish also contains significant amounts of all essential amino acids, particularly lysine in which cereals are relatively poor. Fish protein can be used therefore to complement the amino acid pattern and improve the overall protein quality of a mixed diet. Moreover, the sensory properties of an otherwise bland diet can be enhanced through fish products, thus facilitating and contributing to greater consumption (Balogun, 1992). Fish is greatly perishable but very important food stuff, especially in third world countries, due to its high protein content and nutritional value of unsaturated fatty matter and affordability by the masses when compared with beef (FAO, 1998; Olatunde, 1998). The rate of fish spoilage depends on handling during processing, acidity level, species of fish, weather, mode of storage and temperature during transportation (Oladosun et al., 1996). Chemical breakdown of protein, fat and water contents contribute to quick spoilage of fish. Quality losses might occur very rapidly after catch, especially in hot climates and tropical areas where cold preservation techniques are often missing.

The processes of smoking and drying are the affordable and most widely used methods for fish preservation in Nigeria that dates back to civilization (Oladosun, et al., 1996), and aimed at preventing or reducing post-harvest losses (Govindan, 1985). Smoking involves the application of wood smoke to impart a smoky or smoked flavour and to partially dry a fish, or part of fish such as fillets, to produce a smoked fish product and also to extend the shelf life of the product under some conditions. In many parts of the world, preservation is still the main purpose of smoking. Besides enhancing the taste and look, smoking increases the product's shelf life. It helps preserve the meat by slowing down the spoilage of fat and growth of bacteria. Components in the fuel (wood/charcoal) via pyrolysis are broken down in the process of burning to form smoke, which imparts on the fish a unique aroma, improves taste and color of fish (Afolabi, 1984), largely due to the presence of a range of phenolic compounds, nitrites and formaldehyde present in the smoke (IMPPFA, 2010). Since the use of synthetic antioxidants has been restricted because of their possible health risks and toxicity and consumers demand for additive-free or natural products, the development of effective natural anti-oxidants have been investigated in meat products and plant extracts with antioxidant and antimicrobial activities are being studied to prolong the shelf life of meat, fish, poultry, and their products.

Natural antioxidants are currently receiving considerable attention in human nutrition and good starting material is provided by secondary metabolites, such as the polyphenolic compounds present in plants that have been reported to have antioxidant properties. The scientific literature on food preservation techniques to improve the oxidative stability of fish-based foods reports renewed research interest in natural compounds of vegetable origin as valid alternatives to synthetic preservatives. Herbs and spices are traditionally used as food ingredients, as well as for their antioxidant properties. Spices are edible plant materials (leaf in onion and garlic, rhizomes in ginger) that have anti-oxidative, antiseptic and bacterio-statistic properties. They are added to food such as fish and meat to delay the onset of rancidity and reduce microbial proliferation (Eyo, 2001). Onion (*Allium cepa*), garlic (*Allium sativum*) leek (*Allium porrum*) and other edible allium are among the oldest cultivated plants, and all belong to family of Alliaceae. Onion is commonly used as spices in Nigeria especially in ground beef, meat ball, and to reduce pathogenic micro –organism. The essential oil from *A. cepa* may be a new potential source of natural anti-microbial and anti-oxidant agent applied in the food system (Ibrahim, 2010). Within Aliero community, Kebbi State, Nigeria, *H. niloticus* is not readily consumed or accepted in its fresh state. The four most popular methods of fish preservation are freezing, canning, smoking and pickling, the major preservation method being pickling or salting, which has been used for centuries. The aim of this study was to assess the effect of onion top leaves extract (OTLE) on the quality and shelf life of smoked *H. niloticus.*

MATERIALS AND METHODS

Study area

The study was conducted in the Fisheries Laboratory of the Kebbi State University of Science and Technology Aliero, Kebbi State located between Lat.12°16′42″N and Long. 4°27′6″E. Most of the people in Aliero are agrarian, with emphasis on onion and pepper. A good number of the people also engage in fishing activities because of the famous Sabiyel lake and the neighbouring Jega river. The town has the largest onion market in northwest Nigeria and is a major producer of onions in Nigeria.

Sample collection

Fresh fish samples of about the same weight (±10g) were bought from fish vendors in Aliero town. The fish were chilled in plastic containers and transported to the Fisheries Laboratory of the Faculty of Agriculture, Kebbi State University of Science and Technology, Aliero, Nigeria. Fresh onion tops were bought from Aliero onion market along Jega-Sokoto road. The onion top leaves were packed in polythene bags and transported to the Fisheries Laboratory. The fish samples were weighed before removing the viscerals and scales, washed thoroughly and dried under the sun.

Preparation of Onion Top Leaves Extract (OTLE)

The onion tops were washed with distilled water and blended using an electrical blender. Three portions (0.25kg, 0.5kg, and 0.75kg) of the blended onion tops were measured out separately and each portion was mixed with one litre of water, shaken vigorously and allowed to stay for 24 hours according to the method of Adu-Adjei *et al.* (2014). Each mixture was then filtered through filter paper to obtain 0.25kg/L, 0.5kg/L and 0.75kg/L of the filtrate (crude onion top leave extract), respectively, at room temperature (29^0C ±1). The extract was kept at ambient temperature.

Treatments and experimental procedure

The treatments consisted of OTLE applied at 0kg/L (control), 0.5kg/L, 0.25kg/L and 0.75kg/L of the fish. Each treatment was replicated four (4) times in a Completely Randomized Design (CRD). The onion top leaves extract was variously applied to each of the four (4) batches of the fish by immersing each batch into each of the solutions for 10 mins and then sun dried for three hours. The treated samples were then separately packaged in paper envelopes and stored at ambient temperature for three weeks according to the methods of Jega et al. (2013).

Procedure for fish smoking

A modified drum kiln was used for the smoking process. The smoking chamber was separated into 3 compartments using kitchen wire mesh. Firewood was set up in the combustion chamber and then lighted. The fish samples were placed on the mesh in the kiln after weighing and arranged according to treatments. The burning wood was adjusted continuously to maintain the required temperature and smoke in the chamber during the smoking period.

Proximate analysis

The proximate composition of the fish was determined according to the recommended methods of the Association of Official Analytical Chemists (AOAC, 2000) on weight basis.

Estimation of moisture

The initial weight of the samples was taken and the samples were dried in moisture dish in an oven at about 105ºC for about 10 hrs until a constant weight was reached and then cooled in a desiccator and weighed again. The percentage of moisture content was calculated using the following equation:

$$\% \text{ of moisture} = \frac{W_W - W_D}{Ww} \times 100$$

Where: Ww = weight of wet sample, Wd = weight of dry sample

Estimation of fat

This was obtained by exhaustively extracting 1.0 g of each sample in a Soxhlet apparatus using petroleum ethyl ether, with boiling point ranging from 40-60^{o}C, as the extractant. The percentage of fat content was calculated as:

% of fat = weight of extract / weight of the sample (g) x 100.

Estimation of protein

One gram of each replicate sample was weighed into digestion tube and one Kjehl tab CU3.5 (catalyst salt) was added into each tube. About 20ml of concentrated sulfuric acid (H_2SO_4) was carefully added into the tube and then shaken gently before the digestion procedure was carried out. The digested samples were cooled for 10-20 mins and then the distillation procedure was performed using distillation unit and distillate was titrated with 0.025g of sulfuric acid (H_2SO_4) until the end point changes from green to pink. The percentage of protein content was calculated according to the equation:

% of nitrogen = 0.14 x VD x N x 100 x TV / Weight of sample x AD
Where; VD = volume of digest, N = Normality of each acid, TV = titrate value, AD =Aliquot of digest

Estimation of ash

The ash content of a sample is the residue left after ashing in a muffle furnace (Gerhardt) at about 550-600^{o}C till the residue becomes white. The percentage of ash was calculated as follows:
% ash = weight of ash/ weight of sample x 100

Sensory analysis

Subjective evaluation of the product quality was carried out by a panel of four (4) judges. A coded sample accompanied by questionnaires was presented to the panelists. Quality attributes studied included taste, texture, colour, and general acceptability. The scoring scale used was a (7) seven point hedonic scale ranging from highly acceptable to highly unacceptable.

Determination of TVB-N

The Total Volatile Base Nitrogen (TVB-N) was determined by extracting the volatile nitrogenous bases from a sample by a solution of 0.6 M perchloric acid. After alkinisation, the extract was submitted to steam distillation and the volatile base components absorbed by an acid receiver. The TVB-N concentration was determined by titration of the absorbed bases.

Data analysis

The data collected was subjected to Analysis of Variance (ANOVA) using SPSS version 16.0 and Duncan's Multiple Range Test (DMRT) was used to separate means where there was significant difference.

RESULTS

Chemical qualities of smoked *H. niloticus*

Results for chemical qualities of smoked *H. niloticus* treated with onion top leaves extract (OTLE) according to concentration and storage period are presented in Table 1. The results indicated that OTLE concentration had a significant effect ($P<0.05$) on the chemical qualities of smoked *H. niloticus*. Concentration of the OTLE had significantly affected ($P<0.05$) moisture content, crude protein, crude fibre, nitrogen and total volatile base – nitrogen (TVBN). Lower moisture content (1.850%) was observed in 0.25% OTLE concentration which was not different from the control (1.883%). High moisture content was observed in 0.75 and 0.50% (2.200 and 2.333, respectively). High crude protein was observed in samples with low OTLE concentration having 29.433, 29.733, 29.742 and 28.417g for 0, 0.25, 0.5 and 0.75%, respectively. The storage period also significantly affected ($P<0.05$) all tested chemical parameters except carbohydrates. There was a significant interaction ($P<0.01$) between OTLE concentration and storage period on crude protein and TVBN.

Table 1. Chemical qualities of smoked *H. niloticus* treated with onion top leaves extract (OTLE) according to concentration and storage period

FACTORS	PARAMETERS							
	Moisture content (%)	**Crude protein (g/kg)**	**Lipid (g/kg)**	**Crude fat (g/kg)**	**Ash (g/kg)**	**Nitrogen (g/kg)**	**Carbohydr -ate (g/kg)**	**TVB-N (mg/100g)**
OTLE Concentration (%)								
0.00	1.883^{a}	29.433^{a}	2.932	1.517^{a}	5.500	4.633^{ab}	56.742	35.55^{a}
0.25	1.850^{a}	29.733^{a}	3.408	1.542^{a}	5.717	4.650^{ab}	56.658	35.55^{a}
0.50	2.333^{b}	29.742^{a}	3.082	1.875^{b}	5.458	4.733^{a}	56.617	10.64^{c}
0.75	2.200^{b}	28.417^{b}	3.207	1.958^{b}	5.267	4.558^{b}	57.308	13.02^{b}
SE	*0.075*	*0.167*	*0.179*	*0.110*	*.147*	*0.055*	*0.442*	*2.299*
Storage Period								
Week 1	1.575^{a}	28.700^{b}	0.825^{a}	1.825^{b}	1.894^{a}	4.712	57.144^{b}	
Week 2	2.688^{c}	29.475^{a}	3.834^{b}	1.500^{a}	6.938^{b}	4.631	57.469^{b}	
Week 3	1.937^{b}	29.819^{a}	4.813^{c}	1.844^{b}	7.625^{c}	4.587	55.881^{a}	
SE	*0.065*	*0.145*	*0.155*	*0.095*	*0.127*	*0.047*	*0.383*	
Interaction								
Coc × Period	Ns	**	Ns	Ns	Ns	Ns	Ns	**

a,b,c = Means with different superscripts along the same column for each factor differ significantly (P<0.05)
** = significant interaction (P<0.001)
NS = Not Significant

Table 2. Sensory qualities of smoked *H. niloticus* treated with onion top leaves extract (OTLE) according to concentration and storage period

FACTORS	PARAMETERS				
OTLE Concentration (%)	**Aroma**	**Texture**	**Colour**	**Acceptability**	**Taste**
0.00	5.500	5.917	5.250	5.583	5.417
0.25	5.167	5.500	5.583	5.750	5.667
0.50	5.250	5.583	5.250	5.250	5.667
0.75	5.333	5.250	5.750	5.417	5.667
SE	*0.311*	*0.303*	*0.337*	*0.398*	*0.341*
Storage Period					
Week 1	5.500^{ab}	6.437^{a}	5.875^{a}	5.688	5.938^{a}
Week 2	4.750^{b}	4.687^{c}	6.062^{a}	5.562	5.875^{a}
Week 3	5.688^{a}	5.562^{b}	4.437^{b}	5.250	5.000^{b}
SE	*0.269*	*0.263*	*0.292*	*0.345*	*0.295*
Interaction					
Conc × Period	Ns	Ns	Ns	Ns	Ns

a, b, c = Means with different superscripts along the same column differ significantly (P<0.05)
NS = Not Significant

Table 3. Merit analysis for chemical and sensory qualities of smoked *H. niloticus* treated with OTLE

Parameters	OTLE Concentration (%)				Storage Period (Weeks)		
	0	**0.25**	**0.5**	**0.75**	**1**	**2**	**3**
Moisture content	2	2	1	1	3	2	1
Crude protein	2	2	2	1	1	2	2
Lipids	0	0	0	0	3	2	1
Crude fibre	2	2	1	1	1	2	1
Ash	0	0	0	0	3	2	1
Nitrogen	1.5	1.5	2	1	0	0	0
Carbohydrates	0	0	0	0	1	1	2
TVB-N	2	1	2	2	1	3	2
Aroma	0	0	0	0	1.5	1	2
Texture	0	0	0	0	3	1	2
Colour	0	0	0	0	2	2	1
Acceptability	0	0	0	0	0	0	0
Taste	0	0	0	0	2	2	1
Total	**9.5**	**8.5**	**8.0**	**6.0**	**21.5**	**19.0**	**17.0**
Rank		**1st**	**2nd**	**3rd**	**1st**	**2nd**	**3rd**

Sensory qualities of smoked *H. niloticus*

Table 2 presents results for sensory qualities of smoked *H. niloticus* treated with onion top leaves extract according to concentration and storage period. The results indicated that OTLE concentration had no significant effect (P>0.05) on all the tested sensory qualities of smoked *H. niloticus*. On the other hand, after three weeks of storage, OTLE exerted a significant effect (P<0.05) on all sensory qualities tested in the study except general acceptability which was not significantly different (P>0.05) among the periods of storage. No significant interaction (P>0.01) was observed between OTLE concentration and storage period on all the tested sensory qualities of *H. niloticus.*

Merit analysis

Merit analysis conducted to evaluate the performance of each treatment based on significant parameters is presented in Table 3. The results showed that the samples treated with OTLE concentration of 0.25% ranked better followed by 0.5% while 0.75% recorded the lowest performance. In the case of storage period, samples stored for one week had a better performance for both chemical and sensory analysis followed by Week 2 while Week 3 recorded the lowest performance.

DISCUSSION

Related research (Peiretti *et al*., 2012; Ahmadi *et al.,* 2014) on preservation of fresh fish using plant extracts have shown that the extracts have impressively improved chemical qualities of fish. However, no available information was obtained on the use of OTLE. In the current study, OTLE concentration had significantly influenced the chemical qualities of smoked *H. niloticus*. Moisture content, crude protein, crude fibre, nitrogen and total volatile base – nitrogen (TVBN) significantly differ among the concentrations of OTLE but lipid, ash and carbohydrates were not significantly influenced by OTLE concentrations. It was observed that increase in OTLE concentration led to high moisture content which might be due to the high water content in the extract and which is detrimental to the shelf life of the product. The moisture content can be used as a pointer to the rate at which deterioration occurred in fish samples resulting in early decomposition (Nahid *et al*., 2014). Similarly, increasing OTLE concentration led to increase in crude fiber in the order of 1.517<1.542<1.875<1.958 for 0, 0.25, 0.5 and 0.75% concentration, respectively. TVBN, which is the measurement of shelf life, was better (13.02 mg/100g) at 0.75 % OTLE concentration. The TVB-N of fish is an indicator of the freshness of the raw material (Zhou *et al*., 2011). Higher TVBN value was recorded in 0.25% (35.55 mg/100g) which was not desirable. Kirk and Sawyer (1991) suggested a value of 30 to 40 mg N/100 g as the upper limit of acceptability of TVBN for fish.

The storage period was also significantly influenced by OTLE on all tested chemical parameters except carbohydrate. Week one recorded the least moisture (1.575), lipid (0.825) and ash (1.894) contents which are desirable qualities. Similarly, week two recorded the high crude protein (29.475) and low crude fiber (1.500) which is desirable qualities. Week three had the highest crude protein (29.819) and least carbohydrate content (55.881) which are also desirable qualities. Onion top leaves extract (OTLE) concentration had not significantly affected all the tested sensory qualities of smoked *H. niloticus*. On the other hand, after three weeks of storage OTLE exerted a significant influence on all sensory qualities tested in the study except general acceptability. On the seven point hedonic scale rating, week one of storage recorded better texture (6.437), colour (5.875) and taste (5.938). Week two also recorded good colour (6.062) and taste (5.875) while week three was better in aroma (5.688). Tiamiyu et a*l.* (2012) also reported the least value for colour for onion in their study of the sensory evaluation of smoked *H. niloticus* using locally available spices (onion, ginger, guinea pepper and garlic). Adu-Adjei et al*.* (2014) pointed out that aroma gives an indication of the degree of attraction or repulsion of consumers to food substance. However, all the samples were found to be acceptable.

Merit analysis conducted to evaluate the performance of each treatment based on the significant parameters showed that samples treated with 0.25% OTLE concentration ranked first among the treated samples for both chemical and sensory qualities. Similarly, treated samples stored for one week performed better and were ranked first than subsequent weeks suggesting that quality of the samples decreased as the storage period got longer. This was in agreement with Sarah et al. (2010) who reported that all the samples treated with onion juice extract developed off-flavour with increased storage time. Mercola (2014) further stressed that onion contain potent health-promoting flavonoids and phenolics that act as anticarcinogenic, antioxidant and anti-inflammatory agents.

CONCLUSIONS

The study revealed that onion top leaves extract (OTLE) concentration had significantly influenced the chemical qualities of smoked *H. niloticus* especially crude protein more than the control. After three weeks of storage, OTLE exerted a significant influence on all sensory qualities tested in the study except general acceptability and OTLE concentration of 0.25% ranked first among the treated samples for both chemical and sensory qualities. Similarly, treated samples stored for one week performed better and were ranked first than subsequent weeks suggesting that quality of the samples reduced as the storage period got longer.

COMPETING INTEREST

The authors declare that they have no competing interests.

REFERENCES

1. Adu-Adjei S, F Adzitey and GA Teye, 2014. The effect of 'prekese` (*Tetrapleura tetrapluera*) pod extract on the sensory and nutritional qualities of pork sausage. Global Journal of Animal Scientific Research, 2(1): 7p.
2. Afolabi OA, 1984. Quality Changes in Nigeria Traditionally Processed Fresh water Species. Journal of Food Science, 18: 17-29.
3. Ahmadi M, V Razavilar, AA Motallebi, R Esmailzadeh Kenari and AA Khanipour, 2014. Effects of Hydroalcoholic and Water Extracts of Nettle Leaf (*Urtica dioica* L.) Journal of Food Quality and Hazards Control, 1: 85-88.
4. AOAC, 2000. Official method of analysis. Association of Official Analytical Chemists, W. Horwtz (Editor) 12th ED. Washington.
5. Balogun AM, 1992. Fish handling and quality control. In: Aquaculture Development in Africa: Training and References Manual for Aquaculture Extensionists. (I.G. Cowx, Ed.) Published by Commonwealth Secretariat, London. Pp. 290-318.

6. Eyo EO, 2001. *Fish Processing Technology in the Tropics.* National Institute for Freshwater Fisheries Research, New Bussa, Nigeria, 97817-1770457, p 403.
7. FAO, 1988. Information, Fishery – Statistics, In Food and Agriculture Organization.
8. FAO, 2016. The State of World Fisheries and Aquaculture. Contributing to food security and nutrition for all. Rome. 200 pp.
9. Govindan TK, 1985. *Fish Processing Technology*. Oxford & IBH Pub Co. New Delhi, India 245.
10. Ibrahim ND, 2010. Growth and yield of onion (*Allium cepa* l.) in Sokoto, Nigeria. Agriculture and Biology Journal of North America. lSBN online 2151- 7525.
11. IMPPFA, 2010. *Ingredients in Meat Products*. Archives Immfa. Rar. Filmed at the IFT (Institute of Food Technology) Conference, CRC Press mian N. Riaz.
12. Jega IS, I Magawata, JK Ipinjolu and M Jibir, 2013. Quality evaluation of kilishi processed Bony Tongue (*Heterotis niloticus*, Cuvier) under different storage media. International Journal of Agriculture and Food Science Technology, 4(2): 83-93.
13. Kirk RS, R Sawyer, 1991. Pearson's Composition and Analysis of Foods, 9th ed. (student edition), England Addision Wesley Longman Ltd. pp. 33-36.
14. Mercola D, 2014. What is new and beneficial about onions? https://articles.mercola.com/sites/articles/archive/2014/04/12/onion-health-benefits.aspx.
15. Nahid MN, GA Latifa, FB Farid and M Begum, 2014. Evaluation of biochemical composition of salt and garlic treated smoke-dried chapila (*Gudusia chapra* Hamilton, 1822) and Kaika (*Xenentodon cancila*, Hamilton-Buchanan: 1822) stored at laboratory condition (26-31ºC). Journal of Agriculture and Veterinary Science, 9: 23-32.
16. Oladusun OH, GR Akande, GJ Tobor, 1996. Technology needs assessment in the conceptualization and design of Magbon-Alade fish smoking and drying equipmentNIOMR. *FAO Expert Consultant of Fish Technology in Africa;* Kisumu, Kenya.
17. Olatunde A, 1988. Approaches to the study of fisheries biology in Nigeria inland waters in: Ayen, M and *Decades of Research on Lake Kainji*, 1538 -1541.
18. Peiretti PG, G Francesco, O Marco, A Riccardo, and M Claudio, 2012. Effects of Rosemary Oil (*Rosmarinus officinalis*) on the shelf-life of minced Rainbow Trout (*Oncorhynchus mykiss*) during refrigerated storage. Foods, 1: 28-39.
19. Sarah HK, A Hadiseh, A Gholamhossein and S Baharch, 2010. Effect of green tea (*Camellia sinensis*) extract and onion (*Allium cepa*) juice on lipid degradation and sensory acceptance of Persian sturgeon (*Acipenser persicus*) fillets. International Food Research Journal, 17: 751-761.
20. Shiman GN, 1991. Post –harvest losses in inland fisheries in Nigeria with emphasis on Lake Chad and Lake Kainji. In: Proceedings of the symposium on post-harvest fish technology. Fisheries and Aquaculture Department, p. 1-10.
21. Tiamiyu LO, FG Ogbe and EO Okpall, 2012. Effect of locally available spices on the organoleptic and storage periods of *Heterotis niloticus*., In :19th Annual Conference of the Fisheries Society of Nigeria (FISON), 29th Nov- 3rd December, 2004, held in the University of Ilorin, Nigeria, pp.20-24
22. Zhou R, Y Liu, J Xie, X Wang, 2011. Effects of combined treatment of electrolyzed water and chitosan on the quality attributes and myofibril degradation in farmed obscure puffer fish (*Takifugu obscurus*) during refrigerated storage. Food Chemistry, 129 (4): 1660-1666.