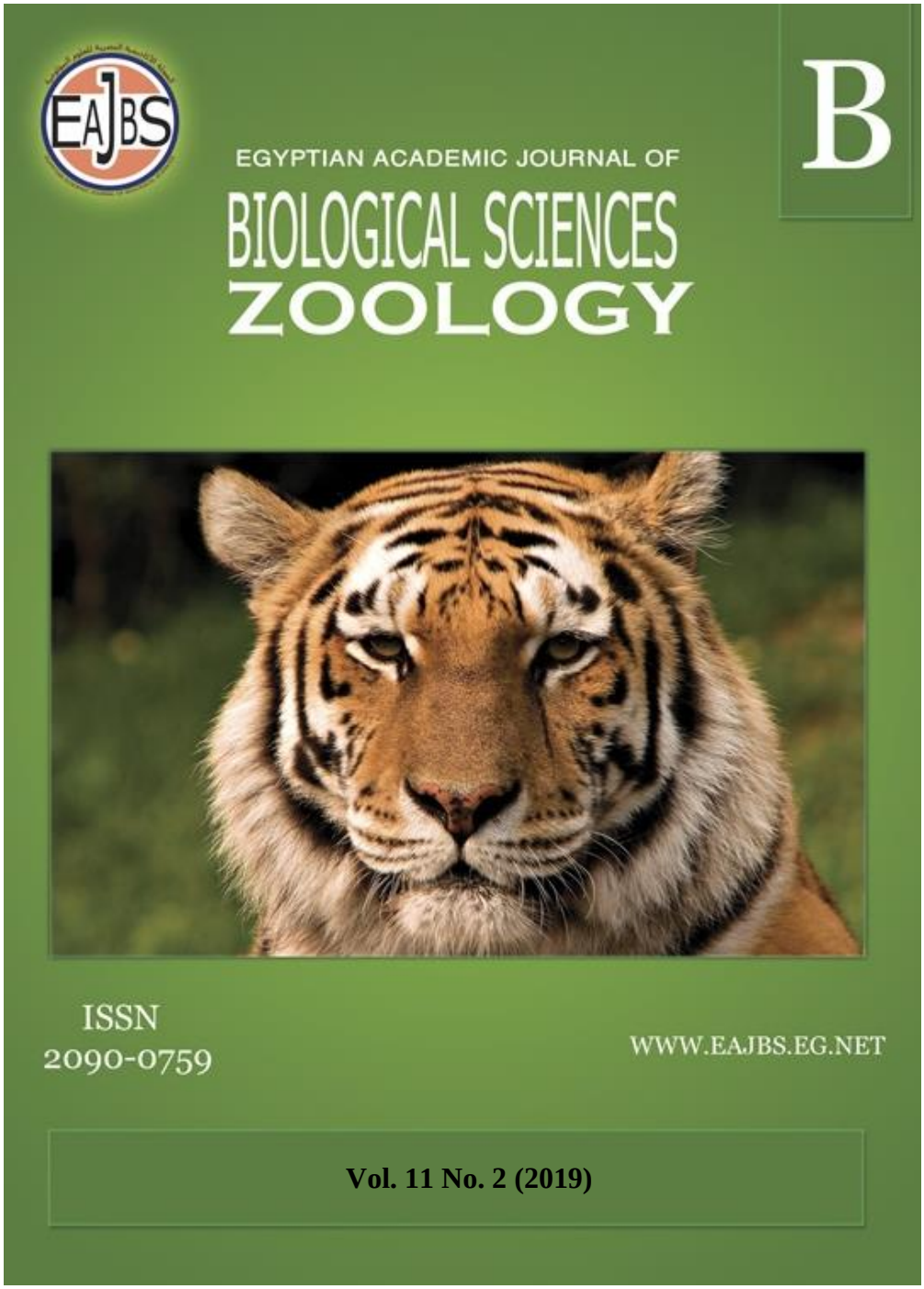

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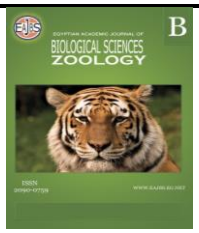

Drying Profiles and Quality Evaluation of Smoke-Dried Catfish (Burchell, 1822) Using Traditional and Ecologically Friendly Kilns in Lagos, Nigeria

Ogunbambo, Mutiat Mogbonjubola
Department of Marine Sciences, Faculty of Science, University of Lagos, Akoka-Yaba, Lagos State, Nigeria
E.Mail: mmogunbambo@gmail.com, mogunbambo@unilag.edu.ng

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ABSTRACT

Catfish processing by smoke-drying using Traditional Drum Kiln (TDK) is a major source of livelihood in Nigeria. Challenges of standardization of smoke-drying process and quality of smoke-dried fish product prompted the construction of Ecologically Friendly Kiln (EFK). TDK was built according to existing standards while EFK was built to have flame, drying and electronic chambers and smoke filters were also installed. Smoke-drying was carried out for an average of twenty-four hours at a stretch at a temperature range of 60 - 80 ^{0}C. Drying profiles were determined by calculating weight loss against time using both kilns while sensory and shelf-life parameters were ascertained with the use of a ten-man panel. EFK fitted with two layers of 0.3 cm smoke filters showed the least clogging and also had best drying profile while smoke-drying using TDK had to be stopped at eighteen hours because the smoke-dried catfish product was becoming very brittle. The sensory parameters of appearance, odour, taste, and flavour although were all scored high by the sensory panel, were significantly higher with the catfish samples smoke-dried using EFK. Mould growth was found to be significantly lower in samples smoke-dried using EFK. This study showed that maintaining smoke-drying temperature between 60 - 80 ^{0}C generally produced high-quality smoke-dried fish but smoke-drying using Ecologically Friendly Kiln produced fish with significantly higher sensory and shelf life quality.

INTRODUCTION

Fish is considered an important source of animal protein as it is generally low in total saturated fat, has high Long Chain Polyunsaturated Fatty acids (LCPUFAs) and provides nutrients such as amino acids, minerals and fatty acids (Fawole *et al*., 2007; Kabaherda *et al*., 2009; Oriakpono *et al*., 2013). African mudfish *Clarias gariepinus* (Burchell, 1822) is one of the most highly valued freshwater fishes in Africa and is presently the most successfully cultured fish in Nigeria because of its resilience, thus a prized food delicacy (Agbede *et al*.,, 2003; Adekoya and Miller, 2004; Osibona, 2011).

Over half of all harvested fish in Nigeria goes to waste on an annual basis due to poor post-harvest handling, preservation, and processing. This is because once fish dies, there is an inevitable natural deterioration that immediately commences (Adekoya and Miller, 2004; Akinneye *et al*., 2007; World Bank, 2012; NBS, 2013). In order to slow down this spoilage process, preservation or processing techniques are usually carried out. Preservation techniques such as freezing and icing are however not very common in Nigeria due to unstable power supply and thus processing with the use of Traditional Drum Kiln (TDK) is favoured because of its relatively low cost and ease of use (Eyo, 1992; Okonta and Ekelemu, 2005; Obodai *et al.*, 2009; Kumolu-Johnson *et al.*, 2010).

Traditional Drum Kiln is made from a large cylindrical drum with an aperture cut out at the base to accommodate burning fuel, oftentimes wood. The top is also cut off and one or more wire racks placed on top of the drum for hot smoke-drying between 60^0 to 120^0 C (Clucas, 1990; Abolagba and Melle, 2008). Major challenges often encountered with the use of TDK however is the lack of standardization of smoke-dried fish product because there are no regulated smoke-drying temperatures when processing; there is also the risk of TDK easily catching fire and thus negatively affecting the quality of the smoke-dried fish product because the fish being processed is placed directly above the source of heat for the smoke-drying process.

The aim of this study was to determine the drying profiles and assess the sensory and shelf-life attributes of smoke-dried catfish when stored at ambient and adjusted temperatures using Traditional Drum Kiln (TDK) and a new Ecologically Friendly Kiln (EFK).

MATERIALS AND METHODS

Both the Traditional Drum Kiln (TDK) and Ecologically Friendly Kiln (EFK) used for this study were constructed and assembled at the Instrumentation Unit of the Department of Physics, University of Lagos.

Construction of Traditional Drum Kiln (TDK):

TDK was constructed from a cylindrical metal drum as is often used in fishing villages where fish processing is done by smoke-drying. The metal drum had dimensions of 72 cm height, 187 cm circumference, and 55 cm diameter at the open top. A circular opening of diameter 36 cm was carved out at the bottom and served as the vent through which wood fuel was arranged and burned to supply heat. A circular wire rack with a diameter of 76.5 cm and mesh size 6 cm X 6 cm was placed on top of the traditional drum and served as the fish drying tray on which the fresh catfish was arranged for the smoke-drying process. The assembled kiln was then placed on a flat rectangular iron base with dimensions 106 cm X 57.2 cm X 1.8 cm for the smoke-drying process in order to protect the cemented floor from cracking from the heat generated when smoke-drying. The fully assembled traditional drum kiln is presented in Plate 1.

Plate 1: Fully Assembled Traditional Drum Kiln

Construction of Ecologically Friendly Kiln (EFK):
EFK was built with a carrying capacity of about 20 kg. Two smoke filters with diameters 0.1 cm and 0.3 cm (Plates 2a and b) were used in three combinations for this study namely 0.1 cm smoke filter in two layers, 0.3 cm smoke filters in two layers and 0.3 smoke filters in four layers. The EFK comprised three parts; the drying, the flame, and the electronic chambers.

Plate 2a: 0.1cm Smoke Filter Used in EFK **Plate 2b:** 0.3cm Smoke Filter Used in EFK0

The Drying Chamber**:** The drying chamber was constructed by fortifying a metal iron mesh with lagging material (refractory) made up of a composite mixture of clay, sawdust, and silicon carbide in the ratio 4:2:0.5. A fish drying stand with three layers was placed in the drying chamber for smoke-drying and a smoke outlet made out of a cylindrical rod of 18.9 cm length and 8.4 cm diameter was built on the side away from the smoke-processor. The drying chamber was fitted with a parabolic dome-shaped cover of diameter 68 cm with the convex side facing the inside. The outer side of the cover and the body of the drying chamber was then covered with a thick paste of lagging material, cemented and then allowed to dry naturally before use.

The Flame Chamber: The flame chamber was constructed by assembling red bricks in a staggered manner in order to give room for expansion when smoke-drying. The fortification was done with four iron rods with dimensions 93.2 cm length and 4.5 cm diameter inserted at the four corners of the flame chamber. The brick walls were then coated on the inside and outside with the refractory material to seal in most of the heat generated from the heat source and allowed to dry naturally and then cemented. An aperture with dimensions 29.6 cm X 16.8 cm was made at the front to serve as inlet for firewood which was the source of fuel. Smoke filter layers were placed at the back where the flame chamber joined with the drying chamber. The fully assembled flame chamber had dimensions of 93.1 cm X 77.5 cm X 85.2 cm. A flat iron plate 78.4 cm X 56.6 cm was placed on the flame chamber and twenty-one refractory bricks each with dimensions 23.4 cm X 11.3 cm X 5.1 cm were then placed on the flat iron plate placed

on the flame chamber to seal in most of the heat generated from the heat source. The Ecologically Friendly Kiln (EFK) as used for this study is presented in Plate. 3.

Plate 3: Constructed Ecologically Friendly Kiln (EFK)

The Electronic Components: The electronics of the Ecologically Friendly Kiln (EFK) entailed the building of an electronic control system to guide in the maintenance of an optimum temperature range of 60 - 85 ^{0}C within the drying chamber (Clucas, 1990). The electronics for this study composed of temperature sensor built as a small metal nub that transferred heat to an audio alarm that made no noise, a beeping sound or gave a loud alarm at less than 60, 60 - 80 and above 85 ^{0}C respectively, visual Light Emitting Diode (LED) indicators were powered by one 9V battery and consisted of red, blue and green lights which stayed off, blinked with a second interval or stayed on according to temperature range.

The following parameters were measured during the smoke-drying process: average smoke-drying temperature on an hourly basis, weight loss on an hourly basis, percentage weight loss during smoke-drying and the drying profile of each smoke-drying kiln.

Sample Collection, Preparation, and Smoke-drying Process:

Clarias gariepinus were obtained live from the Aquaculture Unit of the Department of Marine Sciences, University of Lagos, stunned with a wooden club, washed with clean pipe-borne water and then arranged on covered metal racks to drain. The freshly prepared fish was not seasoned in any way and were then arranged in both TDK and EFK before smoke-drying at a temperature range of 60 - 85 ^{0}C maintained with the aid of temperature alarm and Visual Light Emitting Diode. The fish were measured on an hourly basis until a fairly constant weight was achieved, lasting an average of 24 $\pm$ 3 hours using both kilns.

Drying Profile Determination:

The drying profiles of Traditional Drum Kiln (TDK) and Ecologically Friendly Kiln (EFK) was calculated by plotting the average weights of the smoke-drying catfish in both kilns against time. This was done on an hourly basis of the total time spent smoke-drying the catfish.

Sensory and Shelf Life Evaluation:

The smoke-dried *Clarias gariepinus* fish samples from each kiln were divided into two, one set was kept in wire cages and stored at ambient temperature of 28 ^{0}C in a laboratory while the other set was kept in a refrigerator adjusted to 14 ^{0}C with the aid of a Uniscope Mercury in Glass thermometer. There were thus four sets of samples labeled Traditional Drum Kiln Ambient Temperature (TDK1), Traditional Drum Kiln Adjusted Temperature (TDK2), Ecologically Friendly Kiln Ambient Temperature (EFK1) and Ecologically Friendly Kiln Adjusted Temperature (EFK2).

The sensory or organoleptic evaluation and the shelf life assessment of the four sets of smoke-dried samples were based on a 10-point hedonic scale with 10 = excellent, 8 = good, 6 = fair, 4 = poor and 2 = bad and collected with the use of questionnaires. The samples were physically assessed once each week on the same day and time by a 10-man panel. This was done for six months of rainy season and then again for six months in dry season in Lagos Nigeria (Eyo, 2001; Odekunle, 2004; Ikenweiwe *et al.*, 2010).

Statistical Analysis:

Data for weights of samples plotted against time were presented as averages while all data for sensory and shelf-life analyses were presented as means ± standard error (SE) while analysis of variance (ANOVA) was set at 0.05 level of significance while Duncan multiple-range test (DMRT) and T-test were carried out using Excel, PAST 3 and SPSS 20.0 software

RESULTS

Drying Profiles and Weight Loss of *Clarias Gariepinus* Smoke-Dried using Traditional Drum and Ecologically Friendly Kiln Fitted with Different Smoke Filters:

The smoke-dried catfish samples showed rapid weight loss of an average of 50 % in the first five (5) hours using both TDK and EFK as shown in Figures 1 and 2. The smoke-drying process, however, had to be stopped at eighteen hours using TDK as the catfish samples had become very brittle and were starting to disintegrate. The highest clogging of the smoke filters was found with EFK using combination of two layers of 0.1cm smoke filters and the least clogging was found in EFK using combination of two layers of 0.3cm smoke filters.

Sensory and Shelf Life Evaluation:

The results of the sensory and shelf life analyses of catfish samples stored at ambient and adjusted temperatures in wet and dry seasons using EFK and TDK are as presented in Table 1.

The 10-man panel rated the catfish samples smoke-dried using Ecologically Friendly Kiln higher than catfish samples smoke-dried using Traditional Drum Kiln when the processed samples were stored at ambient and adjusted temperatures in both wet and dry seasons. Lower mould growth values were however found in catfish samples smoke-dried using EFK as against TDK when the samples were stored at ambient and adjusted temperatures in both wet and dry seasons.

There was a significant difference in the appearance of the smoke-dried catfish when stored at ambient and adjusted temperatures in wet and dry season. There was also significant difference in the odour and taste of the catfish samples only in the dry season when stored at ambient and adjusted temperatures and no significant difference was observed in the mould growth of the catfish samples at both temperatures and during both wet and dry seasons.

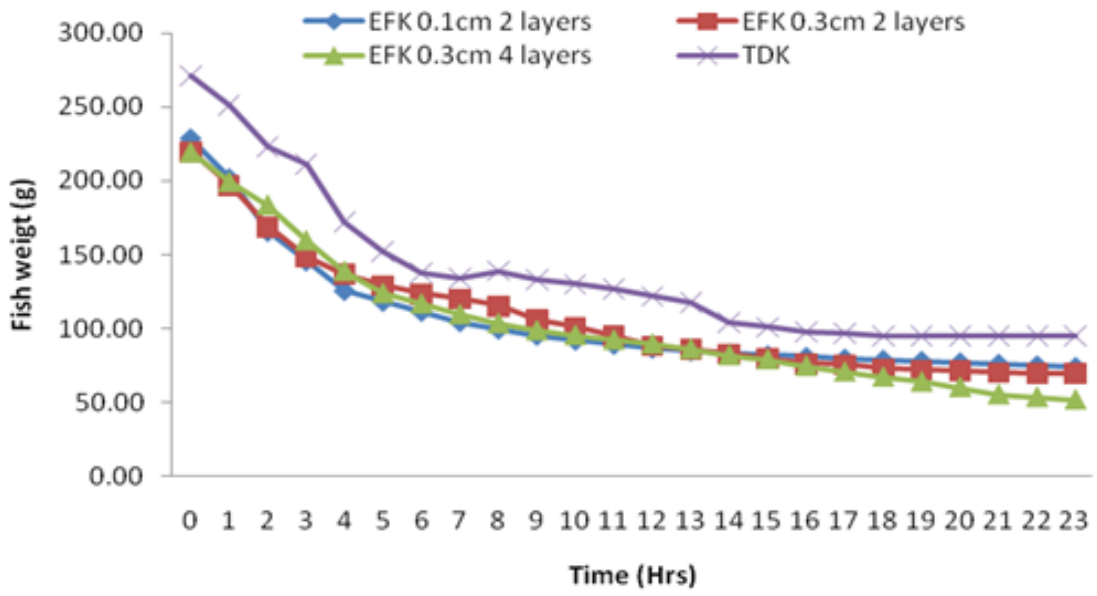

Fig. 1: Weight Loss of the Smoke-dried Catfish using Eco-Friendly and Traditional Smoke-drying Kilns

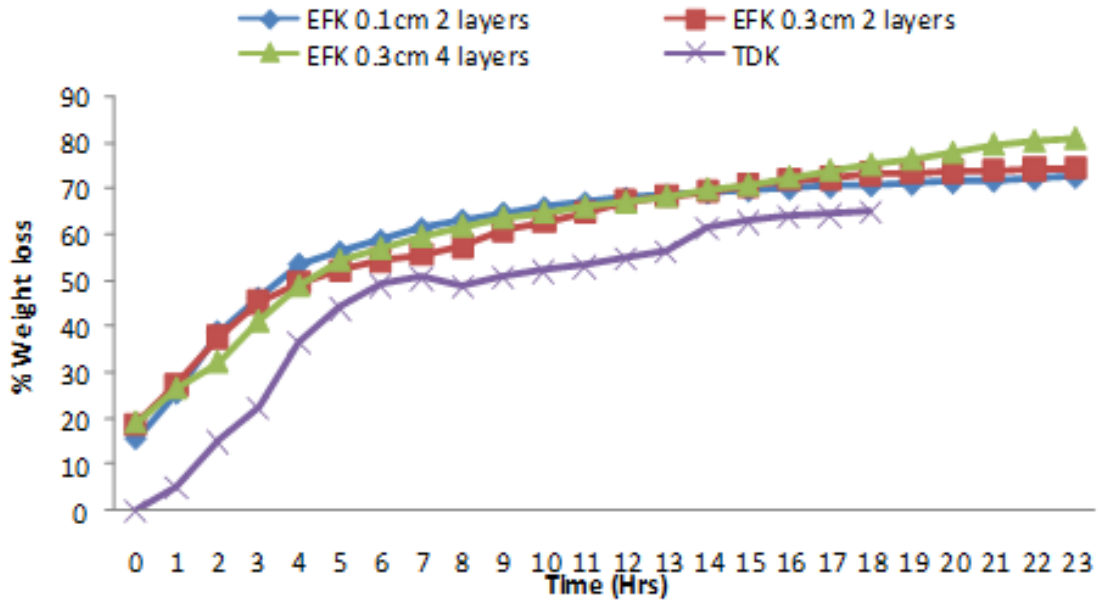

Fig. 2: Percentage Weight Loss of Smoke-dried Catfish using Eco-Friendly and Traditional Smoke-drying Kilns

Table 1: Seasonal Variations of the Mean Values of Sensory Evaluation of Smoke-Dried *Clarias gariepinus* using Traditional Drum Kiln and Ecologically Friendly Kiln

Sensory Parameters	Smoke-drying Kilns with Varying Temperatures	Wet Season	Dry Season
Appearance	TDK 1	5.98 ± 0.72^{a}	6.62 ± 0.72^{a}
	EFK 1	7.02 ± 0.67^{ab}	7.12 ± 0.62^{ab}
	TDK 2	6.76 ± 0.23^{ab}	7.00 ± 0.21^{ab}
	EFK 2	7.51 ± 0.24^{b}	7.79 ± 0.21^{b}
Odour	TDK 1	6.78 ± 0.58^{a}	6.46 ± 0.65^{a}
	EFK 1	8.02 ± 0.49^{b}	7.36 ± 0.65^{a}
	TDK 2	6.55 ± 0.29^{a}	6.39 ± 0.30^{a}
	EFK 2	7.50 ± 0.23^{ab}	7.20 ± 0.27^{a}
Taste	TDK 1	7.36 ± 0.53^{ab}	7.58 ± 0.49^{a}
	EFK 1	8.00 ± 0.34^{b}	7.68 ± 0.44^{a}
	TDK 2	6.58 ± 0.34^{a}	6.67 ± 0.34^{a}
	EFK 2	7.96 ± 0.24^{b}	7.79 ± 0.27^{a}
Flavour	TDK 1	7.91 ± 0.58^{a}	7.96 ± 0.53^{ab}
	EFK 1	8.04 ± 0.32^{a}	8.26 ± 0.41^{ab}
	TDK 2	7.42 ± 0.25^{a}	7.23 ± 0.22^{a}
	EFK 2	7.61 ± 0.21^{a}	7.47 ± 0.20^{b}
Mould Growth	TDK 1	3.31 ± 1.03^{a}	3.12 ± 0.65^{a}
	EFK 1	2.42 ± 0.75^{a}	2.80 ± 0.56^{a}
	TDK 2	2.60 ± 0.57^{a}	2.88 ± 0.77^{a}
	EFK 2	2.29 ± 0.49^{a}	2.30 ± 0.58^{a}

Mean ± S.E (standard errors) of each Sensory Parameter with the same alphabet(s) in the same column are not significantly different ($p > 0.05$)
TDK 1: Traditional Drum Kiln Ambient Temperature (28 ^{0}C)
EFK 1: Ecologically Friendly Kiln Ambient Temperature (28 ^{0}C)
TDK 2: Traditional Drum Kiln Adjusted Temperature (14 ^{0}C)
EFK 2: Ecologically Friendly Kiln Adjusted Temperature (14 ^{0}C)

DISCUSSION

Smoke-dried fish is an integral part of the diet of many Nigerians and processing by smoke-drying is the main source of income for many people, especially in rural areas. The challenge of standardization of the smoke-drying process was eliminated in this work by maintaining the smoke-drying temperature between 60 and 80 ^{0}C in both TDK and EFK (Clucas, 1990). This was achieved with the aid of electrical components that sent simple colour and sound signals to notify the processor of the temperature range at which the catfish samples were being smoke-dried.

The direct exposure of the smoke-drying fish and fish processor alike to the flame and smoke generated from smoldering plant materials is a major challenge with the use of TDK and has negative health implications such as eye inflammation for the fish processors. This challenge was ameliorated by constructing Ecologically Friendly Kiln (EFK) with two chambers namely the flame chamber where the fuel was arranged for the smoke-drying process and the drying chamber where the fish were arranged to be smoke-dried. The fortification on the outside of the drying chamber ensured that excess heat was not lost and agreed with the work of Ashaolu (2014) who built a kiln in the form of a cabinet from galvanized sheet metal with lagged insulator but disagreed with the work of Ikenweiwe *et al.*, (2010) who built an improved smoke-drying kiln which was not insulated against excessive heat loss. EFK, however, had the advantage over

the work of Ashaolu (2014) in that the structure of EFK is similar to what local fisher folks are accustomed to and as such adoption would be easier.

The drying profiles of TDK and EFK fitted with 0.1cm smoke filters in two layers, 0.3cm smoke filters in two layers and 0.3cm smoke filters in four layers all showed a general rapid loss of moisture in the first six hours before tapering off as the time progressed. This is in conformity with studies by Bolaji, (2005) and Davies and Davies, (2009) who stated that the higher the temperature from the heat source when smoke-drying fish, the faster the evaporating process thereby increasing the smoke-drying rate. The process of smoke-drying the catfish samples with TDK was stopped after twenty-one hours because the catfish were deeply coated with smoke particles, the moisture loss at this time averaging 76%. This finding is in line with the work of Obande *et al*., (2012) who in their study of the nutritive values of *Clarias gariepinus* using the traditional drum kiln found that when the catfish was smoke-dried at a temperature of 500^0C for twenty-four hours, there was an average moisture loss of 73.58%.

The smoke-drying process using Ecologically Friendly Kiln with different combinations of smoke filters was done for about twenty-four hours and achieved an average moisture loss of 79%. The use of 0.1cm smoke filters in two layers fitted in EFK showed the poorest drying profile followed by EFK fitted with 0.3cm smoke filters in four layers. This could be attributed to the smoke filters being highly clogged by smoke particles which prevented the easy passage of heat to the smoke-drying catfish samples. The drying profile in terms of percentage weight loss with time was best with the Ecologically Friendly Kiln fitted with two layers 0.3cm smoke filters and could be attributed to the fact that the diameter was just big enough to allow small-sized smoke particles and the layers being only two prevented heavy clogging as was evidenced with EFK fitted with four layers of 0.3cm.

The sensory evaluation of appearance, odour, taste and flavour as determined by the 10-man panel used for this study showed that all the catfish samples smoke-dried using both kilns were of good quality and could be attributed to the standardization of both TDK and EFK used for the smoke-drying process which increased the sensory and shelf life values by maintaining smoke-drying temperature between 60 - 80^0 C. These findings were in agreement with the work of Olayemi *et al.,* (2011) who carried out a sensory evaluation of smoke-dried catfish using Nigerian Stored Products Research Institute (NSPRI) developed kiln and also found high average ratings for smell, texture, colour, taste and general acceptance respectively. The values were however mostly significantly higher in smoke-dried catfish samples smoke-dried using Ecologically Friendly Kiln and can be attributed to the separation of the drying chamber from the flame chamber and also the smoke filters used in EFK. The panelist found the smoke-dried catfish samples still acceptable for human consumption at seven weeks using TDK and nine weeks for EFK, disagreeing with the work of Daramola *et al*., 2013 who found a disagreeable colour change by week six when catfish samples were smoke-dried using TDK.

The shelf life quality was determined by the panel based on the presence of visible mould growth. Catfish samples smoke-dried using EFK were assessed lower on shelf-life quality. This could be a result of the separation of the flame and drying chambers and also the use of smoke filters to prevent excessive soot deposits on the catfish samples though making the smoke-drying process a little longer but more thorough. The smoke-dried samples assessed for this work stayed fresh for at least seven weeks, disagreeing with the work of Abolagba *et al*., 2011 who considered the smoke-dried catfish in their study unfit for human consumption at three weeks.

A common challenge of stored smoke-dried fish is insect attack which often hastens the spoilage process (Abowei and Tawari, 2011). The catfish samples smoke-dried using both TDK and EFK and stored over the weeks at ambient and controlled temperatures in wet and dry seasons showed no evidence of insect attack as judged by the assessment panel. This could be because the smoke-dried catfish samples were individually stored in air-tight ziploc bags which prevented the uptake of moisture by the smoke-dried catfish samples.

This work showed that when smoke-drying temperature is regulated between 60 - 80 ^{0}C, smoke-dried fish products generally have high sensory and shelf life qualities but showed that with the use of Ecologically Friendly Kiln, the smoke-drying process becomes simplified, is no longer subjective to the processor's skill and the smoke-dried fish products have higher nutritional values.

REFERENCES

Abolagba, O. J. and Melle, O. O. (2008). Chemical Composition and Keeping Qualities of a Scaly Fish Tilapia, *Oreochromis niloticus* Smoked with Two Energy Sources. African Journal of General Agriculture. 4 (2): 11-15.

Abolagba, O. J., Adekunle, A. T., Dede, A. P. O. and Omoiguil, G. O. (2011). Microbial Assessment of Smoked Fish (*Clarias* spp.) in Benin Metropolis, Edo State, Nigeria. Nigerian Journal of Agriculture, Food and Environment. 7 (3): 55 - 58.

Abowei and Tawari, C. C. (2011). Some Basic Principles of Fish Processing in Nigeria. *Asian* Journal of Agricultural Sciences. 3(6): 437 - 452.

Adekoya, B. B and Miller, J. W. (2004). Fish Cage Culture Potential in Nigeria- An Overview National Cultures. Agric Focus. 15: 10pp.

Agbede, S. A., Adedeji, O. B., Adeyemo, O. K., Esuruoso, G. O. and Yusuf, H. (2003). Small Scale Fish Production in Veterinary Practice. Nigerian Veterinary Journal. 24 (3): 160-171.

Akinneye, J. O., Amoo, I. A. and Arannilewa, S. T. (2007). Effect of Drying Methods on the Nutritional Composition of Three Species of Fish (*Bonga* sp., *Sardinella* sp. and *Heterotis niloticus*). Journal of Fisheries International 2: 99-103.

Ashaolu, M. O. (2014). Development and Performance Evaluation of a Motorized Fish Smoking Kiln. African Journal of Food Science and Technology. 5(5):119-124.

Bolaji, B. O. (2005). Performance Evaluation of a Simple Solar Dryer for Food Preservation. Proceedings of the 6th Annual Engineering Conference of School of Engineering and Technology, May 12 – 15, 2005, Minna, Nigeria. 8 – 13pp.

Clucas, I. J. (1990). *Fish Handling Preservation and Processing in the Tropics*. Tropical Development and Research Institute, Clerkenwell Road, London. 184 pp.

Davies, R. M. and Davies, O. A. (2009). Traditional and Improved Fish Processing Technologies in Bayelsa State, Nigeria. European Journal of Science Research 26**:** 539 – 548.

Essuman, K. M. (1992) Fermented Fish in Africa: A Study on Processing, Marketing and Consumption. FAO Fisheries Technical Paper. 1329 pp.

Eyo, A. A. (1992). The Nutritive Value of Traditionally Prepared Fish Meals. FAO Fisheries Report. 467: 147-149.

Eyo, A. A. (2001). Fish Processing Technology in the Tropics. *Nigeria Institute for Freshwater Fisheries Research (NIFFR)*, New Bussa, Nigeria. 1–403.

Fawole, O.O., Ogundiran, M.A., Ayandiran, T.A. and Olagunju, O.F. (2007). Proximate and Mineral Composition in some Selected Fresh Water Fishes in Nigeria. Journal of Food Safety. 9: 52-55.

Ikenweiwe, N. B., Bolaji, B. O. and Bolaji, G. A. (2010). Fabrication and Performance Assessment of a Locally Developed Fish Smoking Kiln. Ocean Journal of Applied Sciences 3(4): 363 - 369.

Kabaherda, M. K., Omony, P. and Hiisken, S. M. C. (2009). Post Harvest Handling of Low Value Fish Products and Threats to Nutritional Quality of Life. A review of practices in the lake Victoria region. Fisheries and HIV/AIDS in Africa: Investing in Sustainable Solutions. World Fish Center. Project Report 1975. 15pp.

Kumolu-Johnson, C. A., Aladetohun, N. F and Ndimele, P. E. (2010). The Effects of Smoking on the Nutritional Qualities and Shelf-life of *Clarias gariepinus* (Burchell, 1822). African Journal of Biotechnology. 9 (1): 73 -76.

National Bureau of Statistics (2013). 2012 and Estimate for Q1, 2013. Gross Domestic Production for Nigeria. National Bureau of Statistics, Abuja-Nigeria. May, 2013. 15pp.

Obande, R. A., Omeji, R. A. S and Ityumbe, M. (2012). Organoleptic Assessment and Nutritive Values of *Clarias gariepinus* Smoked Using Coal and Firewood. Pakistan Journal of Nutrition. 11 (9): 762-764.

Obodai, E. A., Muhammad, B. A., Obodai, G. A. and Opoku, E. (2009). Effect of Fuel Wood on the Quality of Smoked Freshwater Fish Species sold in Tamale Central Market, Northern Region Ghana. Ethiopian Journal of Environmental Studies and Management. 2(2): 27 - 35.

Odekunle, T. O. (2004). Rainfall and the Length of The Growing Season in Nigeria. International Journal of Climatology. 24: 467 – 479 pp.

Okonta, A. A. and Ekelemu, J. K. (2005). A Preliminary Study of Micro-organisms Associated with Fish Spoilage in Asaba, Southern Nigeria. Proceedings of the 20th Annual Conference of The Fisheries Society of Nigeria (FISON), Port Harcourt, 14th-18th November. 557-560 pp.

Olayemi, F. F., Adedayo, M. R., Bamishaiye, E. I. and Awagu, E. F. (2011). Proximate Composition Of Catfish (*Clarias gariepinus)* Smoked in Nigerian Stored Products Research Institute (NSPRI): Developed kiln. International Journal of Fisheries and Aquaculture. 3(5): 96-98.

Olokor, J. O., Ihuahi, J. A., Omojowo, F. S., Falayi, B. A. and Adelowo, E. O (2007). Handbook of Practical Fisheries Technology. Fisheries Technology Division, National Institute for Freshwater Fisheries Research (NIFFR). New Bussa,, Niger State Nigeria. Pp 22 - 29.

Oriakpono, O., Frank–Peterside, N. and Ndome, C. (2013). Microbiological assessment of stored *Tilapia guineensis.* African Journal of Food Sciences. 5(4): 242 – 247.

Osibona, A. O. (2011). Comparative Study of Proximate Composition, Amino and Fatty Acids of some Economically Important Fish Species in Lagos, Nigeria. African Journal of Food Science. 5 (10): 581-588.

World Bank. (2012). Gender Analysis of Aquaculture Value Chain in Northeast Vietnam and Nigeria. Agriculture and Rural Development Discussion. Paper 44.