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Proximate Composition and sensory Evaluation of *Auchenoglanis occidentalis* smoked in a New Developed Fish Smoking Kiln in Nigeria.

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Abstract

Fish drying is a popular method of processing fish in Nigeria. Nature has endowed Benue state with one of the two major rivers in Nigeria – River Benue. With this river and other minor rivers inclusive, fish business is very prominent and fish smoking operations are mostly carried out manually and under unhygienic conditions. The concept of the new developed fish smoking kiln is to ease the drudgery associated with traditional methods (mud oven and open drum smoking) in the riverside communities. In this study, a simple and relatively cheap new fish smoking kiln was designed, fabricated with locally available materials. This new developed kiln uses charcoal as heat source. The performance test was conducted to ascertain its performance. Auchenoglanis occidentalis was used for the performance evaluation. The result showed that moisture content was reduced from 100% to 53.1% within an average smoking time of 15.3hrs. The proximate analysis showed an increase in protein, while fat, moisture and ash reduced after smoking. Sensory evaluation showed that the product from this new developed kiln was liked and cherished by the populace.

Key words: Smoking kiln, sensory evaluation, proximate analysis, moisture, protein.

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INTRODUCTION

Fish is a source of animal protein in the diet of man. Fish constitutes about 69.6% of the total supply of protein available to Nigeria (Fishnet, 2009). Smoked or dried fish is a traditional part of the diet of a large section of the world's population. However, the gap between the demand and supply of fish is widening due to increase in population, poor postharvest handling and lack of processing facilities.

Nigeria is endowed with an extensive network of rivers, natural and man –made lakes, coastal waters and offshore waters, which are abundant in fin fish and shellfish resources (Arawomo, 2004). Yet, Nigeria is lagging behind in the aspect of fish supply because of post-harvest losses. According to Akande, Oladosu, & Tobor (1998), about 40% of fish caught in Nigeria is lost to post- harvest losses because this fish do not get to customers in a wholesome state.

Preservation of fishes is a very important part of commercial fisheries (Pandey and Shukla, 2005). Currently, smoking is the main method of fish preservation in the artisanal sector. According to FAO (1997), smoke curing includes all the processes starting from the raw material stages to the final smoking which result in changes in colour, flavour and texture of the fish. This is so because this method of preservation is effected by combination of drying and decomposition of naturally produced chemicals resulting from thermal breakdown of wood (Tobor, 2004).

Smoking activities are carried out using locally constructed oven such as the traditional mud ovens and cut-up drum barrels (Essuman, 1992). Traditional fish smoking kilns are poorly constructed and lack mechanisms for the control of smoke and heat production, all of which affect the efficacy of smoking and the quality of the final products.

It is based on these lapses of the traditional smoking kilns that this new fish smoking kiln is constructed to abate the troubles of the old ones. This new kiln takes into consideration factors such as;

Cost effective factor: cheap and locally available materials such as wood, mild steel, galvanized materials, fibre glass materials, etc are used for the construction

Functionality requirement factor: the operation of this new kiln does not require electricity or complicated technicalities in its operation. Rather it requires just charcoal to keep it functional.

Reliability factor: products produced are of high hygiene quality since dirt and char materials does not come in contact with the processed fish.

Resistance to environmental factors: the new kiln is operated under shed to avoid rain only, outside rain; the kiln can be operated in open and unsheded environment.

The preservation of food (such as meat and fish products) by curing it with wood

smoke has been used since antiquity. Fish smoking is receiving great attention because of its simplicity and acceptability by consumers. Nowadays, fishermen form the habit of smoking their fish rather than disposing it fresh because it attracts more income. Fish species are preserved and processed via distinct means such as drying, frying, freezing, salting and smoking in order to ensure sustainable supply of fish all year round and to meet up with post-harvest loss challenges in Nigeria which had reached about 25 to 50 per cent (Ikenweiwe, Bolaji & Bolaji (2010), Magawata & Oyelese, (2000), Goulas & Kontominas (2005)).

Originally the purpose of smoking fish was to preserve the food, partly by drying and partly by adding anti-microbiological constituents such as phenols from the smoke to the food. At the present time smoking is mainly used to achieve the characteristic taste and appearance of smoked food with preservation playing a minor role. However, smoking has an influence on the shelf life of food because smoke may inhibit growth of some microorganisms depending on the contents of some components like phenols in the smoked food. Fish smoking accelerates drying by hastening the water activity and preventing microbial activities as reported by Olayemi, Adedayo, Bamishaiye & Awagu(2011), Ahmed, Dodo, Bouba, Clement & Dzudie, (2011), Ames, Clucas & Paul (1999).

Fish processing through hot smoking or Kiln is an age long practice in most parts of the world. Nigeria's fish smoking practices are yet to gain prominence on a large commercial scale due to lack of appropriate technological approach to assist the fish farming business. Locally available methods such as mud bricks stone and firewood are predominantly used and these affected the quantity and quality of fish processed. Quality control and improved hygienic condition are difficult to sustain while market value diminishes due to damage and non attractive appearance of the processed fish (Ames *et al*, 1999). Mechanisms

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used by traditional fish smokers have a lot of limitations.

Brief about Auchenoglanis

Materials and Methods

Location of the Study

The construction and utilization of the smoking kiln was carried out at the welding and fabrication Department of the Technical College of Benue State University, while laboratory analysis was done at the Biological Sciences and Chemistry Department laboratories of the Benue State University Makurdi. Benue state is located in the North Central Zone (Middle Belt area of Nigeria). It is situated between latitudes 6^0 25' and 8^0 8', and Longitudes 7^0 47' E and 10^0E.

The construction of this new fish smoking kiln (Figure 1) wouldn't have been possible without the works of Magawata & Musa (2015) and Ikeweiwe *et. al.,* (2010). However, due consideration such as economic status, literacy level of the fishers and the need to reduce post-harvest losses within the study area and Nigeria in general were born in mind before coming up with this kiln.

The fish smoking kiln is comprised of two major components, each with a specific function and they include the charcoal stove (Abacha stove) and the drying chamber (kiln).

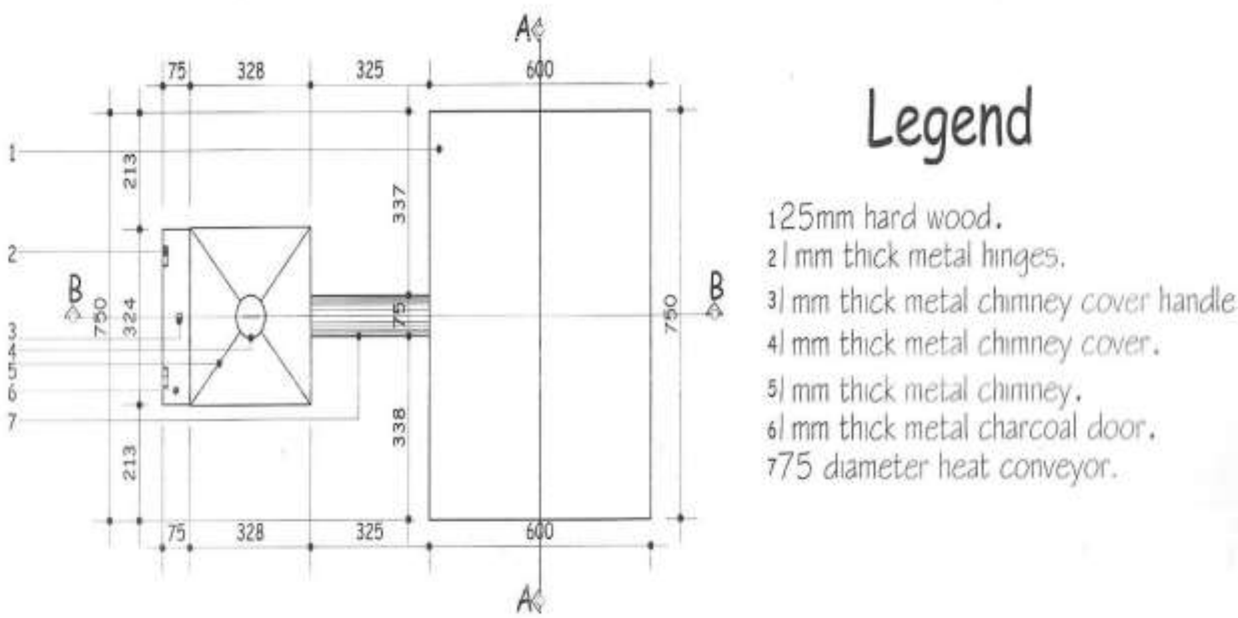

Figure 1: Floor Plan of the new Fish Smoking Kiln

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Charcoal Stove (Abacha Stove)

The stove components which included ash tray, charcoal unit and chimney were measured, machined, welded and assembled according to the design specification.

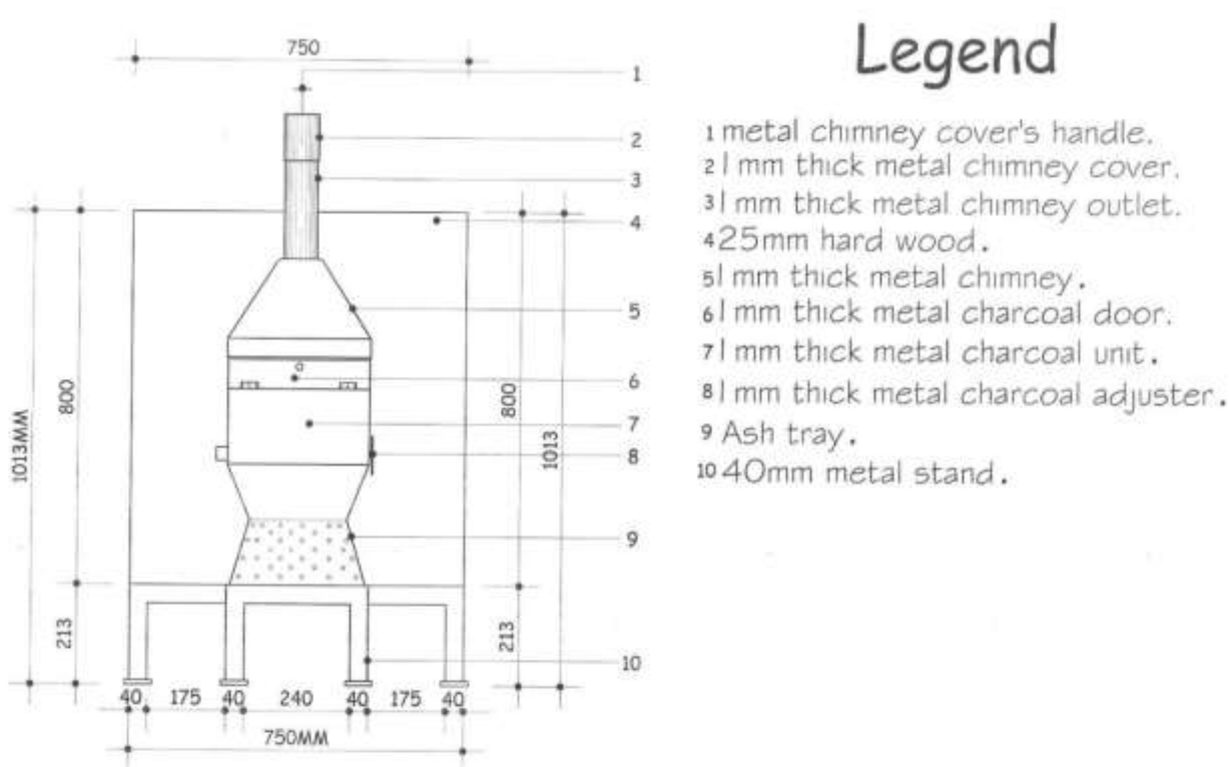

Figure 2: Back Plan View of the New smoking Kiln showing Stove

Ash Tray: The ash tray which is rectangular in shape is located at the base of the stove. It was constructed using 1mm mild steel material. An opening is made on one side of the tray unit to serve as door for ash evacuation. 4mm perforations are made all over this unit to enhance ventilation.

A rectangular stand made from angle iron bar with the dimension of 320mm x 320mm x 213mm was constructed to place the stove on.

Charcoal Tray: this is located at the middle region of the stove. This is the container for burning the charcoal to provide energy for smoking/drying the fish. It is constructed with mild steel of 1mm thick. It has the dimension of 320mm x 324mm x 230mm. above this unit is the chimney which is constructed using mild steel of 1mm.

Drying Chamber

This is a wooden box made from hardwood of 25mm thick. The box has a dimension of 750x600x80omm. The inner part of the box is covered with galvanized sheet of 1.8 guage and in between the inner walls of the box and the galvanized sheet are wood shavings (insulator). A door is fitted at one side of the box with the help of 100mm metal hinges while a thermometer is hung at the inner wall of the door. Other components of the chamber include;

Detachable fish trays

This is a container in which the fish is placed and loaded unto the drying chamber for drying or smoking Four detachable fish trays of 700mm x 500mm x 5mm dimension each are constructed using galvanized 2mm mesh material and 5mm rods to form its frame. The fish trays are demarcated from each other by 138mm distance and fitted inside the box to rest fish on.

Fish Oil Collector

This is a piece of 1.8mm galvanized sheet slantingly fixed at the outer part of the drying chamber’s floor to collect fish oil that dribs from the fish to the floor of the chamber. This sheet is attached with the help of copper nails. As the oil drops on the floor, it rolls by gravity to the fish oil collector which is then collected from the tilted end of the collector.

Heat Conveyor Pipe

A heat conveyor pipe of 75mm galvanized material was constructed; this pipe has an inner pipe of 50mm galvanized material. In between the inner and outer pipe, fibre glass materials are tugged in and sealed at both ends by welding to serve as insulator. This pipe is then attached to the charcoal unit by welding while the other end of the pipe has a ring welded at 2mm distance to serve as a stop. The ring side of the heat conveyor pipe is then inserted into a 76mm hole made behind the drying chamber.

Heat Regulator

The heat regulator in the charcoal unit is a 1mm flat sheet of mild steel material fitted over the inner part of the heat conveyor pipe to regulate heat passing through this pipe. The sheet is calibrated to indicate closed, opened and half opened or half closed by sliding.

Wire mesh Screen Protector

Wire mesh of 2mm is placed at stove end of the heat conveyor pipe to prevent charred particles with flames into the drying chamber. This also prevents rodents from gaining access to the drying chamber when not in use.

Drying Chamber Stand

A stand was constructed using iron angle bar. The dimension of the stand is 780x550x200mm . The drying chamber is rested on this stand to suspend it from the ground.

Performance evaluation of the new smoking kiln

Sample Collection and preparation

In determining the performance of the smoking kiln, a fish species - *Auchenoglanis occidentalis* was procured alive from Wadata market in Makurdi Benue state. These species is common, abundant and widely cherished by the populace. The sample was killed, eviscerated and washed in clean water, salted and allowed to stay for a period of 30 minutes before placing in the kiln.

Smoking Process

The detachable fish tray was greased with groundnut oil to prevent the fish from sticking unto the mesh in the kiln. Charcoal was put into the charcoal tray and ignited with the help of kerosene, the ignited charcoal was allowed to burn for 10 to 15 min to allow the kerosene odour to be exhausted. More charcoal was added to the burning ones.

The prepared fish sample (5 pieces) was weighed (Initial weight) and put on the heated tray. During the smoking or drying process, the fish was turned regularly to enable uniform smoking and to avoid charring. Similarly the weight of the fish was determined intermittently whenever the position of the fish was changed and the corresponding moisture content determined according to the method of AOAC (2002). This continued until the final weight and hence the final moisture content was determined. The final moisture content that is safe moisture content (10 to 15%) (Ikenweiwe, Bolaji, & Bolaji 2010) was calculated using Equation (1) when there was no further reduction in the moisture content. The time taken for the smoking was the total time taken including the time for the intermittent determination of moisture content and that of changing the position of the fish. After smoking and determination of final moisture content, the fish was allowed to cool and sent for proximate analysis and sensory evaluation.

3.7.2 Final Moisture content

$$Mc_{db}\ (\%) = \frac{Initial weight - Final weight}{Final weight} X100 \qquad (1)$$

Where:

Mc_{db} = moisture content dry basis in %

Initial weight = Weight of sun dried fish (kg)

Final weight = weight of smoked fish (kg).

The weight loss was determined using Eq. (2):

(See Table 1& 2)

Weight loss=initial weight-final weight

The percentage weight loss was determined using Eq. (3):

$$\% \text{ wt loss} = \frac{\text{initial wt} - \text{final wt}}{\text{Initial wt}} \times 100$$

3.7.4 Sensory (Organoleptic) Evaluation

The sensory analysis was carried out using the 9-point hedonic scale (SSP, 2016). The template which is a rating method allows the panellists to choose from a range of options; from 'like extremely' to 'dislike extremely'. The options include; like extremely (LE – 9 points), like very much (LVM- 8 points), like moderately (LM- 7 points), like slightly (LS- 6 points), neither like nor dislike (NLND- 5 points), dislike slightly (DS- 4 points), dislike moderately (DM- 3 points), dislike very much (DVM- 2 points) and dislike extremely (DE- 1 point). The panellists consisting of twelve people were given a template for the sample. Each person in the panel analysed the smoked dried fish. After the test, the result was extracted by collating the allocated points for each option chosen by the panelists *(See Table 2).*

3.7.5 Proximate Analysis

After the preparation of the edible parts of the fish sample, the proximate components; Moisture, crude protein, fat, Ash and fibre were assayed as described by AOAC, (2000). The analysis was carried out in triplicates (see table 3&4).

Statistical Analysis

The data obtained from the proximate analysis in triplicate were expressed in means (±) standard deviation using Gen Stat Discovery Edition (Version 2012), while the sensory evaluation was expressed in mean.

RESULTS

The results obtained from the Weight Loss of the fish from the new fish smoking kiln, Sensory evaluation of the smoked fish and Proximate composition of both the fresh and smoked fish samples are presented in tables 1 to 4 respectively.

Table : 1 Determination of fish weight loss from the new fish smoking kiln.

Fish species	No of fish	Initial average weight (g)	Final average weight (g)	Weight loss (%)	Smoking time (h)
Auchenoglanis occidentalis	5	315.0	167.3	53.1	15.32hrs

Table: 2 Sensory evaluations of smoked fish

Parameters	*Auchenoglanis occidentalis*
Flavour	8.1
Texture	7.6
Odour	7.5
Appearance	8.2
General Taste	8.4

Table 3: PROXIMATE COMPOSITION OF THE FRESH FISH SAMPLE

Parameters	*Auchenoglanis occidentalis*
ASH	1.140±0.69
FAT	2.830±0.76
FIBRE	0.000±0.00
MOISTURE	31.70±1.14
PROTEIN	24.23±0.06

Values are presented as Mean ± Standard deviation.

Table 4: PROXIMATE COMPOSITION OF THE SMOKED FISH SAMPLE

Parameters	*Auchenoglanis occidentalis*
ASH	0.101±0.52
FAT	1.667±0.23
FIBRE	0.010±0.00
MOISTURE	13.80±4.66
PROTEIN	26.50±0.60

Values are presented as Mean ± Standard deviation.

The result of the weight loss of the smoked fish sample used in this research is shown in Table 1. The results revealed that there was a drastic weight reduction. The total weight of the fresh fish sample was 315.04g and was dried (dried sample) to 167.3g after 15.32hrs at about 80 ^{0}C. This amounted to 53.1% of the moisture lost in the fish sample.

Tables 3 and 4 showed the results of the proximate composition of fish sample before and after smoking used in this research. There was a significant increase in the protein content after smoking with moisture and fat being reduced drastically. The value for fat contents of the species ranged from 5.67 to 0.18 before and after smoking. Protein values recorded increase from fresh to smoked (24.97-34.73), while moisture reduction was from 32.60 — 9.40. For ash content before and after smoking, there was a decrease from 1.140 to 0.101. This species had no fibre for fresh and 0.010 for smoked.

Figure 3: New developed kiln interior

Figure 4: The new developed fish kiln

DISCUSSION

The new developed fish smoking kiln proved to be effective in drying the fish to safe moisture content which can make it suitable to deliver products in a wholesome state to the consumer. Weight losses (Table 1) observed in the experiment was due to the evaporation of water content of fish, which depends on the temperature of the heat source, the higher the temperature, the faster the drying (smoking) rate. Davies and Davies in Magawata and Musa (2015) and Osuji in Magawata and Musa (2015) made a similar observation that the weight loss of the smoked fish was a result of the drying or dehydration effect from the burning charcoal. The weight loss for this specie was 53.1 in consonance with the work done by Magawata and Musa

(2015). Ahmed *et al*. (2010) reported the relation of smoked fish protein, fat and ash content increased with decreased amount of moisture content during smoking process. The moisture content of the raw sample was higher than smoked sample. According to Sigurgisladottir *et al*. (2000), the weight loss is due to dehydration during smoking. This is known to vary, depending on several factors such as, origin of raw material, final product characteristics and parameters used in the process, time and temperature.

The moisture reduction found in smoked sample was due to species variation coupled with the heat the fish sample was subjected to during the hot smoking process. This has reduced fish deteriorating agents from acting on the tissue which will ultimately render the fish unsafe for human consumption. This observation is in agreement with the findings of KumoluJohnson and Ndimele (2001) and Salan *et al*., (2006) who reported that spoilage of fish resulting from the action of enzymes and bacteria can be slowed down by the addition of salt as well as reduction in moisture through sun drying or smoking.

Dehydrating temperature can be easily controlled by the heat regulator sheet which is fitted over the inner part of the heat conveyor pipe. The new developed fish smoking kiln can be used by both farmers and elites, because of the simple, hygiene and aseptic way of handling the smoke products.

Some sensory (organoleptic) parameters like flavour, texture, odour, appearance and general taste (Table 2) of the fish sample were examined and the result is presented in Table 2. The results of sensory evaluation rated the fish sample as liked in terms of flavour, texture, odour, appearance and general taste with a mean score of 8.1, 7.6, 7.5, 8.2 and 8.4 respectively. Food appearance helps to determine quality, degree of processing or spoilage level (Clifford *et al*., in Olopade, *et al* 2013). Flavour is a combination of odour and taste and is considered an important factor in consumer acceptance of smoked fish. Sensory analysis showed that, products from this new developed fish smoking kiln is liked and generally cherished.

Protein contents was generally high in the smoked fish sample, which is an expected outcome since fish is a good source of protein, (Tidwell, 2001). The percentage crude protein in smoked fishe was higher than the values in the fresh fish. This is because of the inverse relationship that exists between moisture and protein. As moisture decreases, the protein content tend to become more concentrated thereby making its percentage increases. Similar results for chemical composition of smoked fish have been reported in previous studies of Goulas and Kontominas (2005) and Bilgin *et al*., (2008). Doe and Olly (1983) reported that smoking resulted in concentration of nutrients like crude protein and fat. Processing method, quality of feed given to the fish and storage are some of the factors responsible for differences in proximate composition of smoked fish (Abdullahi *et al*., (2001); Akinola (2006). Crude fat contents was generally high in the smoked fish sample, and this is in support of Daramola *et al*., (2007) that, reduction in crude fat content could have been due to oxidation and crude fat break down into other components. That is, oxidation of poly-unsaturated fatty acids (PUFA) contained in the fish tissue to products such as peroxides, aldehydes, ketones and the free fatty acids. In contrast, Koral *et al.*, (2009) opined that, the percentage of total protein, lipid and ash contents of smoked garfish increased due to water loss during smoking (Table 3).

The increase in the crude fibre content of smoked *Auchenoglanis occidentalis* sample could be accounted for by the fact that in this sample, there had been an oxidation of their poly-unsaturated fatty acids (PUFA) components, contained in their tissues to products such as peroxides, aldehydes, ketones and free fatty acids, (Daramola *et al*., 2007). Also increase in their protein component could also have increased the crude fibre content of the fish.

The new developed fish kiln (figures 9 & 10) is simple to operate and does not require any complicated technicalities. The kiln looks appealing and portable.

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