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COMPARATIVE PERFORMANCE EVALUATION OF NCAM DEVELOPED FISH SMOKING KILNS

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ABSTRACT: *Fish smoking is an activity that is commonly employed by fish farmers and entrepreneurs to preserve fish products. However, the method employed by fish farmers mostly is unhygienic and laborious. NCAM had produced charcoal fired fish smoking kilns to address this bottleneck. However, the heat loss became a source of worry, coupled with the increasing cost and non-availability of charcoal to fuel the fish kiln. This paper looked at the heat preservation in the smoking chamber and went ahead to lag the upper part of the chamber with the primary aim of conserving the heat thus reducing the quantity of charcoal utilized. Comparative performance evaluation was carried out between the fully lagged and the partially lagged charcoal fired smoking kilns. Results indicated that the fully lagged had a better overall efficiency than the partially lagged. The fully lagged generated an average temperature of 63^oC over 31 hours while the partially lagged generated an average temperature of 59^oC over 43 hours for the two kilns to effectively smoke catfish from 65% to 4% fish moisture content.*

KEYWORD: Fish, Smoking kiln, moisture content

INTRODUCTION

Fish is a very important source of animal protein, whose importance has been recognized by man from the distant past. The flesh of fish is rich in minerals like Calcium, Phosphorus and Iron. (Chukwu and Shaba, 2009). It forms an important component in the diets of most Nigerians.

According to statistical information from FAO, the world's fish production (from captured fisheries and aquaculture) reached 121 million tons in 1996, which is 3.7 million tons more than what was obtained in 1995 (Adamu, 2013) A lot of pressure is has been mounted on the worldwide fish population, for it to reach the high demand from the teeming human population which has hit 6.0 billion marks as at the year, 2000 A.D. This demand is higher in the tropics where the human population is rising increasingly. (Southgate, 2009). A decline in fish availability will have a serious negative effects on the nutritional status of the country's citizenry, particularly in countries like Nigeria where fish contributes significantly (about 40%) of the protein intake of its people (Adeyeye and Olalekan, 2016).

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Therefore, since aquatic resources are finite although renewable, every effort should be geared towards increased fish population through improved resource management, resource conservation and intensive aquaculture practices (FAO, 2016). This should therefore be matched with post-harvest fish handling, preservation and processing to prevent spoilage and subsequent loss of fish.

Fish Smoking is predominant in most communities of Nigeria, despite modern fish preservative techniques such as drying, canning, use of additives, freezing, refrigeration, aseptic packaging and pasteurization, which are sometimes expensive. Fish is highly susceptible to deterioration when it is without any processing or preservative measures. (George et al., 2014)

During smoking, the smoke from the burning wood/charcoal containing a number of compounds inhibits bacterial growth, while the heat from the fire causes drying, however when the temperature is high enough, the flesh will be cooked, preventing bacteria, fungal growth and enzyme activity (Goulas and Kontominas, 2005).

Since food is generally dried to preserve it for a longer period as high moisture content results in microbial degradation in food items. The dried product can then be put into use in periods of scarcity. This phenomenon is also applicable to fish when dried for preservation due to its high perishability. The smoked fish owes its storage life primarily to the drying and cooking process, rather than the preservative value of the wood smoke chemicals (Cardinal et al., 2001).

There are over 330 chemical compounds in wood smoke with more than 45 phenols, 70 carbonyls, 20 acids, 11 furans, 13 alcohols and esters, 13 lactones and 27 polynuclear aromatic hydrocarbons in smoke. Many of these compounds are important in chemical reactions leading to the production of the flavor (a combination of odor and taste), color, anti-oxidative, bacteriostatic and preservative properties of smoked fish (Peter, 2002). The advantages of smoking fish are: -

i. To prolong shelf-life;
ii. To enhance taste/flavor and increase its use in soups and sauces;
iii. To reduce waste at bumper catches;
iv. To store for a longer period of time;
v. To increase the availability of protein to people throughout the year;
vi. Slows down the growth of bacteria; and
vii. Preserves fish by slowing down the spoilage of fats and oils.

Objective

The specific objective of this work is to improve on the existing NCAM smoking Kiln and carry out comparative performance evaluation of the improved kiln and the existing kiln.

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Justification

The spoilage and decay of foods especially fish, has no simple solution to prevent it. There are however basic principles of preservation which can be applied to fish to inhibit spoilage. NCAM smoking kiln designed to smoke fish and other perishables takes about two days to achieve good smoking that is storable. The time taken to achieve the desired safe moisture level for the smoked fish is too long hence the need to re-design a more efficient smoking kiln in order to lower the drying/smoking time. For the purpose of this research work, fresh catfish was smoked and analyzed. Also, the cost and availability of charcoal presently is a source of concern and reducing the quantity needed to effectively dry fish to a safe moisture level is imperative.

LITERAUTRE REVIEW

Most of the fish harvested are used for direct and indirect human consumption. In developed countries, it is also processed into fishmeal for livestock and pet feeds. A significant quantity is also lost through the absence of adequate technology and the know-how to prevent losses in most tropical countries. An estimated 20-50% of the fish produced in the remote coastal areas and hinterland of most tropic countries perish before reaching the consumers due to poor handling, preservation and processing practices adopted by processors (Abolagba and Akise, 2011). These losses are highly significant when considered on a national scale and thereby further exacerbating the problems such as malnutrition, unemployment and poor foreign exchange earning of these countries (Eyo, 2011). The flavor of smoked fish is what normally attract consumers to it, but its nutritive value is of great importance due to the fact every consumer wants good quality protein from fish-consumption. The relative humidity (RH) affects the rate of smoke absorption through its effect on temperature. If humidity is high, the rate of heating has to be longer and at higher temperature. The high temperature contributes to the loss of amino acids as result of Millard reaction, which involves amino group of amino acids with sugars and carbonyls. It is this reaction that necessitates the characteristic golden-brown color of fish. The loss of water also raises the concentration of nutrients, and the denaturation effect of smoking increases the digestibility of protein and hence the availability of some essential amino acids. (Opara et al., 2013).

METHODOLOGY

Materials and methods

The materials used for the performance evaluation of the NCAM fish smoking kiln are two (2) units of 50kg capacity fish smoking kiln (partially and fully lagged), fresh cat fish, digital weighing scale, thermo-hygrometer, water, digital stop watches, plastic containers and salt.

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Description of the smoking kiln

The smoking kiln was designed and constructed from mild steel. It is rectangular in shape with dimension of 610 x 620 x 1350 mm. It consists of one compartment with 7 netted trays of dimension 560 x 550 mm. It has double walls lagged with fiber glass to reduce heat loss by conduction. It has a chimney for escape of moist air. The lagged wall structure conserved heat and also keep the working environment conducive for the user. The trays were constructed of durable, light weight frame and wire mesh which prevents the dried fish products from falling through. The trays can easily be slid in and out to allow the fish to be moved without tipping. The drying capacity varies with species and size of the fish. The kilns has a single door which can easily be opened and closed, the doors fit smoothly when in a closed position. The source of heat used in the kiln is charcoal. The charcoal was placed in a charcoal pot with dimension of 280 x 280 x 400 mm. The partially lagged fish smoking kiln has all its sides lagged except the conical part of the kiln while the fully lagged fish smoking kiln has all the sides including the conical part lagged. The diagrammatic representation of the fish smoking kiln is shown below.

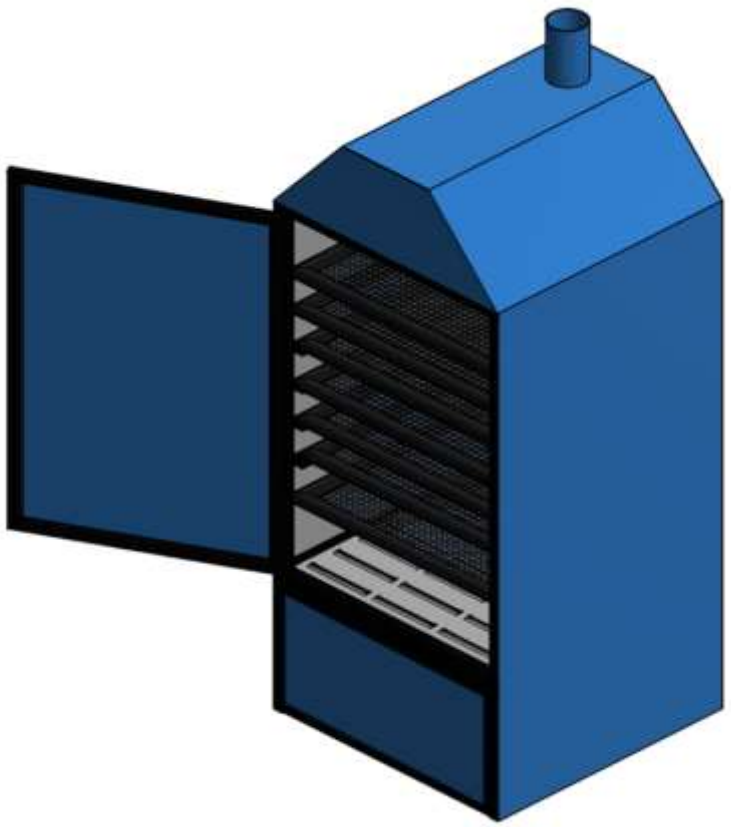

Figure 1: Isometric view of the fish kiln

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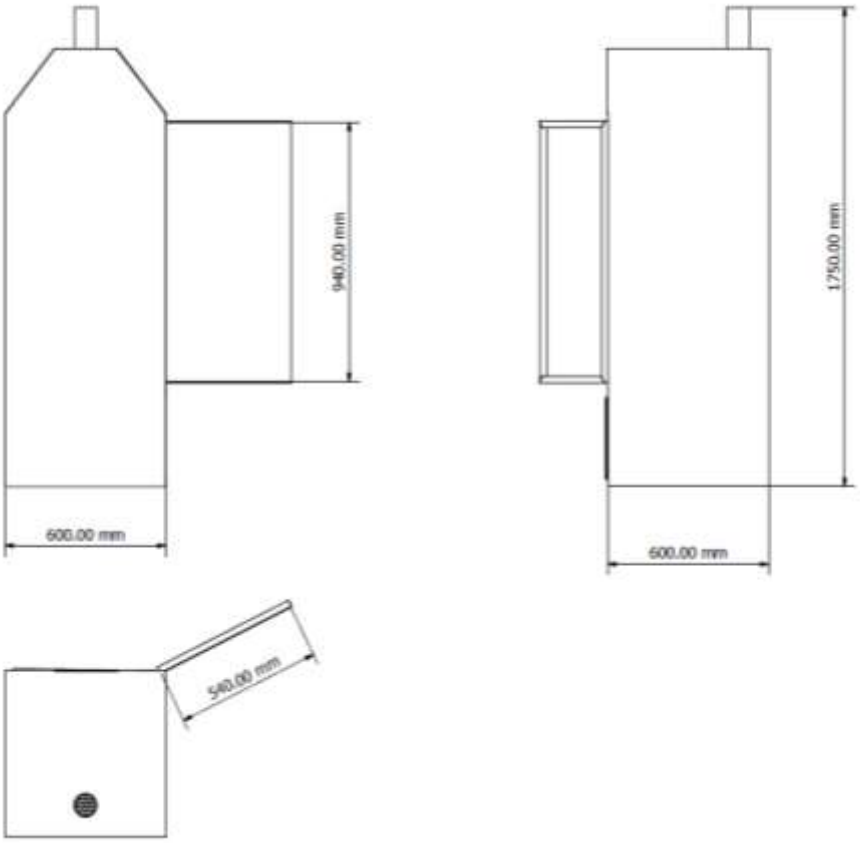

Figure 2: Orthographic view of the fish kiln showing overall Dimensions.

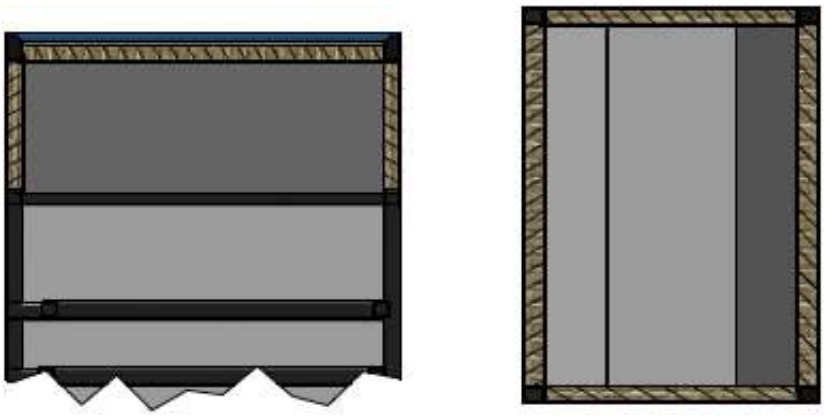

Figure 3: Section showing the lagged portion of the smoking kiln

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Preparation of fish for smoking

Fresh cat fish of good quality was used for evaluating the performances of the fish smoking kilns. The whole fish was washed with salt to remove slime, then gutted and beheaded (if required). The belly cavity were cleansed to remove traces of blood, and any black belly wall lining. The moderately sized catfish were folded while the big ones were cut into smaller sizes for ease of drying.

The smoke-drying procedure

The performance test of the kiln was carried out using 2 kg charcoal at an interval of two (2) hours. The fish was loaded on the smoking trays. Temperature readings were taken hourly using mercury glass thermometer until the fish was properly smoked. Ambient temperatures and humidity were also taken hourly using thermo-hygrometer. The upper and lower trays were interchanged at two (2) hours intervals to prevent the fish in the lower trays from getting burnt.

RESULTS AND DISCUSSION

Results

The results of the temperature gradient of the NCAM fish smoking kilns conducted using a partially and fully lagged fish smoking kilns is as shown in figure 4 below: -

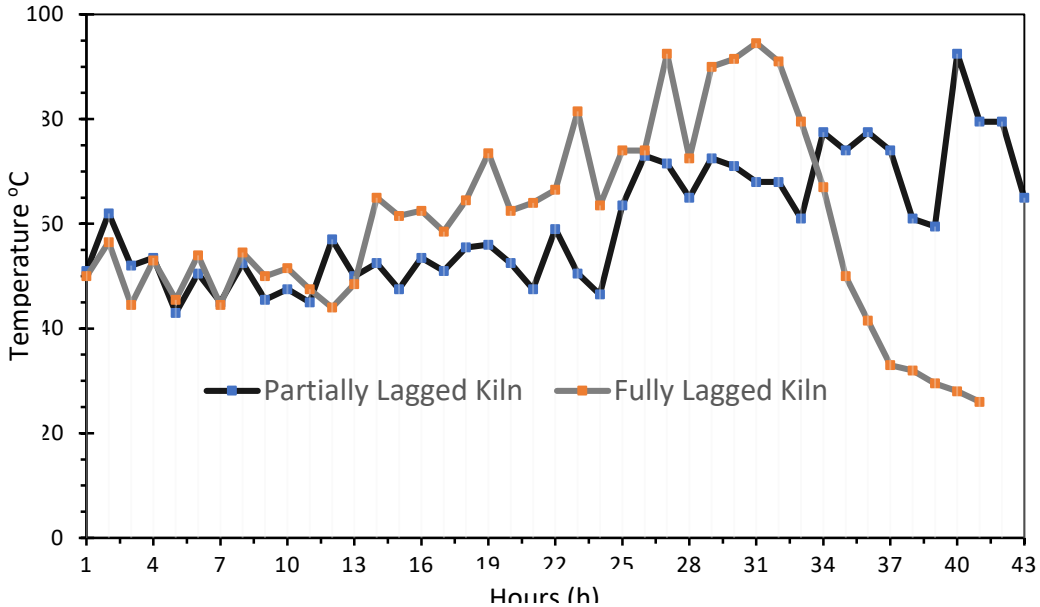

Figure 4: The graph of temperature and time for partially and fully lagged fish smoking kiln.

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It was observed that the fully lagged kiln was consistently higher in temperature compared to the partially lagged kiln. From the figure above, the partially lagged kiln consumed additional 10 kg of charcoal for the fish product to attain the same moisture content as the fish in the fully lagged kiln. The fully lagged kiln still maintained higher temperature than the partially lagged kiln for over an hour even after the partially lagged kiln had been re-loaded with charcoal as shown in figure 4.

The rapid increase in temperature of the fully lagged charcoal fired smoking kiln was as a result of the low heat loss. The temperature of the fully lagged charcoal fired smoking kiln was consistently higher and steadier compared to the partially lagged smoking kiln. The fluctuations observed was due to the humidity of the environment which affected the overall temperature. However, the partially lagged kiln had high fluctuation in temperature due to the quick and steady heat loss to the surroundings which resulted in more charcoal consumption in order to maintain the desired temperature. There was more loading of charcoal in the partially lagged kiln as the moisture content had not reached the desirable point even when the fully lagged kiln had completed the smoking/drying process, the fully lagged kiln still maintained a steady and high temperature even after the heat source had been removed whereas the partially lagged kiln had a sharp drop in temperature when the heat source was removed due to the heat loss to the surroundings through the unlagged part of the kiln. The fully lagged kiln has a better overall efficiency than the partially lagged kiln in the following areas: -

i. The quantity of coal used was lower;
ii. The time spent to reach drying point was shorter;
iii. The quantity of heat lost to the surroundings was minimal;
iv. Heat was stored at the upper section of the fully lagged kiln while the heat dissipated at the upper part of the partially lagged kiln; and
v. Maintains consistent higher temperature compared to the partially lagged kiln.

The humidity rose as the sun was going down and remained fairly stable throughout the night. There was a drop in humidity at sunrise and dropped further until mid-day. The lowest point for both experiments was around mid-day and the humidity started rising almost as fast as it dropped (figure 5).

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The increase in humidity affected the overall temperature at the latter end of the experiment as the highest temperature recorded for both tests carried out was at the periods of high humidity. The humidity level of both experiments was similar hence no change could be attributed to the humidity level.

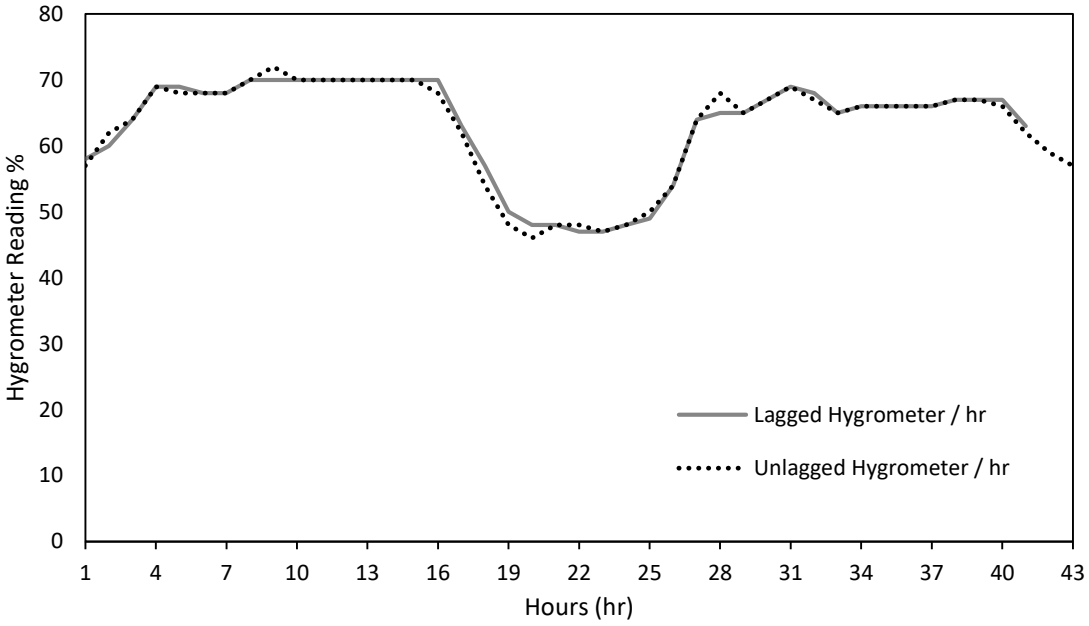

Figure 5: The graph of hygrometer readings (%) against time (hrs) for partially and fully lagged fish smoking kilns.

Result of the moisture content of the fresh and dried catfish (dried in the laboratory at 65°C for 48 hours)

The results obtained was to compare the effectiveness of the smoking kiln with the laboratory oven which was preset to 65^{o}C and utilized to dry the cat fish for 48 hours. The initial moisture contents for the smallest size, medium size and biggest size were 59.18%, 67.65% and 67.85% respectively, after drying, the moisture content for the dried fish samples were 9.76%, 1.29% and 1.02% for the smallest, medium and biggest sizes respectively. The average moisture obtained for fresh fish sample was 64.89% and average moisture for dried fish sample was 4.02% in the laboratory.

It was observed that in the partially lagged kiln, the heat loss was more than the heat gained as it takes longer time to smoke fish to the desired moisture level while the fully lagged kiln conserved more heat and the fish dries faster. Heat was conserved and retained at the upper part of the fully lagged charcoal fired smoking kiln while the heat dissipated at the upper part of the partially lagged charcoal fired smoking kiln.

From the study, it was clear that the improved version of the smoking kiln has conserved more heat in the smoking chamber and reduced the consumption of charcoal for smoking. This has

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proven that lagging the upper chamber of the smoking kiln would go a long way to assist the rural farmers in reducing the cost of production of dried fish. The timeliness of drying experienced using the improved smoking kiln would reduce the drudgery and health challenges involved in smoking fish to the desired moisture level.

CONCLUSION

A fully lagged charcoal fired fish smoking kiln was fabricated and comparative evaluation of the fully lagged and partially lagged charcoal fired smoking kiln was carried out using cat fish. The performance evaluation showed that the fully lagged fish smoking kiln conserved more heat compared to the partially lagged fish smoking kiln with an average temperature of 63^{o} C over a period of 31 hours while the partially lagged fish smoking kiln at highest temperature of 59^{0} C over a period of 43 hours. The fresh fish with average moisture content of 65% dried to an average moisture content of 4%.

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