Journal of Engineering Research and Reports

13(4): 15-21, 2020; Article no.JERR.57247
ISSN: 2582-2926

Design and Construction of Electric Fish Smoking Kiln Using Locally Available Composite Materials

Ogundana Odunayo Seyi[1*], Abdulkadri Abdulakeem[1], Jibril Danladi[1] and Owa Taiwo Wumi[2]

[1]Department of Agricultural Technology, Federal College of Freshwater Fisheries Technology, P.M.B. 1500, New Bussa Niger State, Nigeria.
[2]Ondo State Fadama Coordination Office, Alagbaka Akure, Ondo State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author OOS designed the study, wrote the protocol, wrote the first draft of the manuscript and supervise the construction work. Authors AA and JD managed the analyses of the study, performed the statistical analysis. Author JD managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JERR/2020/v13i417109
Editor(s):
(1) Dr. P. Elangovan, Sreenivasa Institute of Technology and Management Studies, India.
Reviewers:
(1) Şükrü Kitiş, Dumlupınar University, Turkey.
(2) Olapade Olufemi Julius, Njala University, Sierra Leone.
Complete Peer review History: http://www.sdiarticle4.com/review-history/57247

Original Research Article

Received 01 April 2020
Accepted 06 June 2020
Published 23 June 2020

ABSTRACT

The design and construction of low cost electric fish smoking kiln was undertaken with the aim of improving the existing fish-smoking kiln. The newly constructed kiln was made using locally available composite materials and technologies sourced locally. The kiln consists of smoking kiln chamber, heating elements, a variable thermostat, lagging materials of insulating clay wall which has a duration of not less than five years and metal frame made of angle iron on which the fish tray, oil collector pan were assembled. The production cost of the electric fish-smoking kiln is one hundred thousand naira compare with mechanical ones that cost within the range of three hundred thousand and four hundred thousand naira excluding transportation charges.

Keywords: Fish; thermostat; heating element; oil collection pan; circuit breaker.

**Corresponding author: Email: odunmansam@gmail.com;*

1. INTRODUCTION

Fish is an important source of food and income to many people in developing countries. In Nigeria, most people depend wholly or partly on the fisheries sector for their livelihood. In recent time, many individuals and cooperatives are going into small and big scale fish farming [1]. Fish is an extremely perishable food item [2]. Soon after death, fish begins to spoil. In the healthy live fish, all the complex biochemical reactions are balanced and the fish flesh is sterile. After death however, irreversible change that results in fish spoilage begins to occur. The resultant effect is the decomposition of the fish [3]. Various factors are responsible for fish spoilage. The quality of capture is important at determining the rate of spoilage. Notably are the fish health status, the presence of parasites, bruises and wounds on the skin and the mode by which the fish was captured. The caught fish quality depends on the handling and preservation of the fish received from the hands of the fishermen/fisher folk after capture.

The handling and the preservation practice after capture affects the degree of spoilage of the fish [4]. The quality of the freshly caught fish and its usefulness for further utilization in processing is affected by the fish capture method. Unsuitable fishing method does not only cause mechanical damage to the fish, but also creates stress and the conditions, which accelerate fish deterioration after death. Fish is highly susceptible to deterioration without any preservative or processing measures [5]. Akinola et al. [3] reported that immediately the fish dies, a number of physiological and microbial deterioration set in and thereby degrade the fish [6]. Fish is a major source of protein and its harvesting, handling, processing and distribution provide livelihood for millions of people as well as providing foreign exchange earning to many countries [7]. Improper processing especially with rudimentary smoking kilns can also negatively impact the amino acids profile and other mineral constituents of the fish.

In order to improve on these methods, several technological approaches has been reported, including harnessing the solar energy for fish drying, the use of electric heaters [3], and the use of smoking kiln [8]. This present study is aimed at designing and construction of a cost effective locally made electric fish smoking kiln. This study was carried out to design and construct a cost effective locally made electric fish-smoking kiln using materials sourced locally.

1.1 Study Area

Lake Kainji was formed by damming the river Niger at Kainji Island. The dam was closed on 2nd August, 1968 and the reservoir created after closure it has a surface area of 1,120km^2 at maximum-recorded level. The lake is 137km long, 24 km wide and a maximum depth of 60 meters [9]. Kainji Lake is in the Guinea savannah vegetation zone of the northwestern Nigeria. Kainji lake is located between longitude 9^0 20' and 10^0 55' East and latitude 4^0 22' and 4^0 45' North and a mean annual water temperature of 27.85^0C after construction [10], and catchment area of 1.6× 10km^2. The river Niger has two flood regimes, the black floods and white floods. Although the primary aim of the impoundment is to generate hydroelectric power. The lake also offers opportunities for developmental projects like irrigation farming, fisheries and navigation. Kainji Lake has its source from Futa Jalon in Niger Republic and from local rivers around the lake basin. It takes three to four months for the water from Futa Jalon to get to Kainji Lake especially the southern basin [11].

2. RESEACH METHODOLOGY

2.1 Research Materials

The materials used to construct the electric fish-smoking kiln includes 1.5mm flat mild steel sheet, angle bar of 2.54 cm thickness. The electrical components (2000 watts capacity heating elements, 1.5mm wire, switch, and thermostat) were sourced from Owode Onirin Market Lagos, Nigeria. Mortar to build the kiln wall was formed from anthill clay (sourced from New Bussa, Nigeria).

3. RESULTS

3.1 Kiln Capacity (Volume)

The volume of a flat top kiln, V_k was calculated using Eq. 1 [12].

$$V_k = w \times h \times d \quad (1)$$

Where,

W = width of the electric fish smoking kiln = 0.80m
h = height of the electric fish smoking kiln = 0.2m
d = depth of the electric fish smoking kiln = 0.76m

V_k = 0.80 × 2 × 0.76 = 1.22m³

3.2 Cross-Sectional Area of the Kiln's Heating Chamber

The interior cross sectional area of the kiln was computed using Eq. 2:

Cross-sectional Area = Length × Width (2)

Cross-sectional Surface Area = 80 × 76 = 608cm²

3.3 Element Surface Load

The surface load of an element estimates the wear or deterioration during a given period and it is measured in watts per square centimeter (W/sq. cm) [13].

Element Surface Load = power/ surface area (3)

Element surface Load = 2000/608 = 3.290 w/sq.cm

3.4 Electric Kiln Power (Kilowatts) Requirement

The required power for power (in kilowatts) of the electric kiln is a function the kiln's volume temperature and the time required to reach the temperature [13]. Kiln voltage depends on the local power voltage. The voltage supply from Kainji hydro-electric station is 240V in New Bussa, Nigeria. The rate of the resistance element used is 2KW.

Thus:
P = IV (4)

Where,

p = power, I = current and V = voltage
Voltage = 240v, power = 2000watts
Current = 2000/240 = 8.33amps

3.5 Resistance of the Electric Kiln Element (R)

Resistance is given according to ohms as:

$$R = \frac{v}{L} \quad (5)$$

Where,

V = voltage, I = current,

Therefore; R = 240/8.33 =28.8Ω

3.6 Smoke Chamber Volume Design

The volumetric capacity of smoke chamber in Fig. 2 was calculated in relation to the volume of sawdust it occupies. The chamber was separated from the heating chamber by perforated clay partition.

VP = L × b × h (6)

Where,

L = length of smoke chamber = 0.66m
b= width of smoke chamber = 0.26m
h= height of smoke chamber = 0.18m
VP = 0.66 X 0.26 X 0.18 = 0.0309 m³

3.7 Fish Tray Design

The volumetric capacity of each fish tray was calculated in relation to the volume of fish it occupies. Each tray was designed to contain 10 kg of fish per unit operation. In the designing of fish tray volumetric capacity, the shape of the compartment was designed to be rectangular. Lengths and breadth of the tray were assumed to be the same 0.75m, while the height was selected as 0.045m.

4. RESULTS AND DISCUSSION

The fish kiln built with anthill clay to enable sustainability of heat within the heating chamber having an iron frame structure inside the clay wall with structural dimension of 0.92 x 0.76 x 1.24m [14]. Opined that using locally available composite materials reduce the cost of production. The electric heater is sited at the center wall inside the kiln and oil collecting pan is below the heating chamber which collects the fish oil extracted during drying. Adamu et al. [15] reported that increase in fish smoking with kiln powered by firewood has greatly increased the rate of aforestation. The right side of the chamber has a structure for smoking drawers separated from the heating chamber by a perforated clay wall that supplied smoke into the heating chamber, which has a rectangular shape to give the fish fine texture. Eyo, [16] agreed that introduction of small combustibles will give fish brownish colour which is well accepted in Africa. There are provisions for eight rails of wire mesh trays in the chamber; each tray rests on the structure frame.

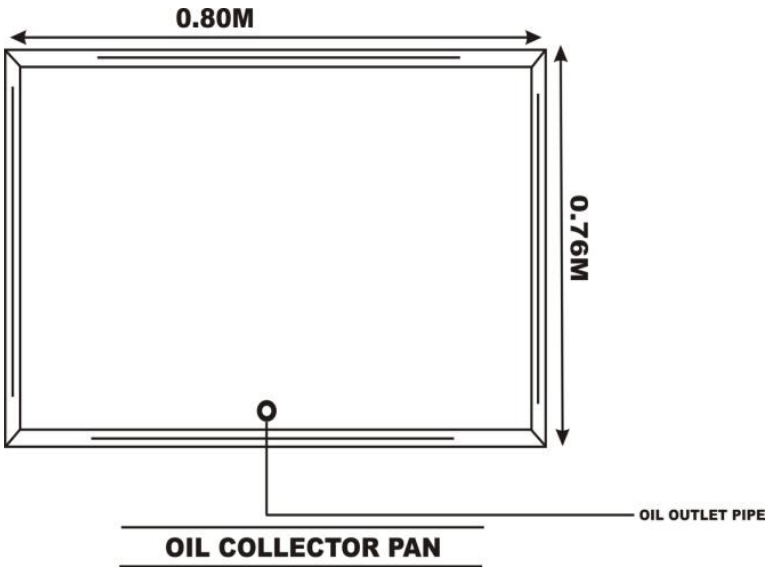

Fig. 1. Oil Collector pan

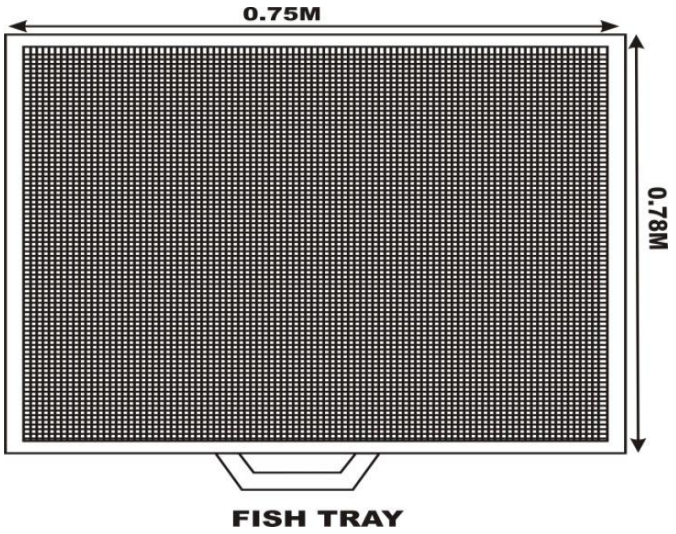

Fig. 2. Fish Tray

The kiln door was fabricated with galvanized iron having a thick cover lagged with fibers, which minimize heat loss from the kiln system. Temperature control meter was installed to control heat generated in the kiln system [14]. Reported of lack of temperature control device in the existed kiln which leads to over drying. At the upper most point of the kiln, an opening (chimney) was provided for exit of excess heat and pressure in the kiln system.

4.1 Resistance Heating Element

The heating element used for the construction of the kiln is manufactured by Kenton incorporated with capacity of 2000watts, two elements pieces were installed and connected to an electric power source.

4.2 Mortar Paste

Clay is calcined at 1000°C, crushed and grounded to its finest form. The calcined clay is allowed to cool, there after ground using a pan mill and sieved with mesh 100 (< 150 µm) to the required size. Saw dust is sieved with mesh 100 (<150 µm) in a pan mill. 70% of clay will be weighed out into a plastic container and the sieved saw dust of 30% is also weighted out and

mixed with the clay and water to make the mix. The recipe will be thoroughly mixed to obtain a uniform body mixture. It is allowed to age overnight and re-mixed again to produce an insulating block. It was used for constructing kiln's wall, base and cover.

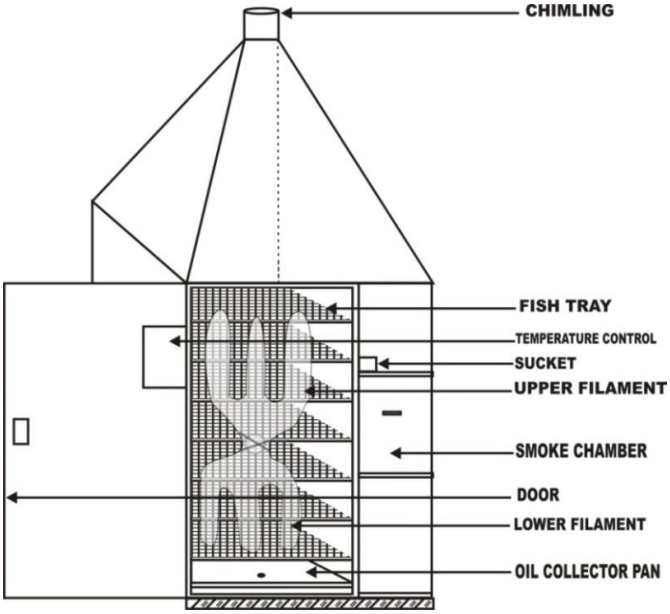

Fig. 3. Schematic Diagram of Electric Fish Smoking Kiln

Plate 1. Kiln wall under construction

Plate 2. Electrical fish smoking kiln structure

4.3 Material Selections

The materials selections for this research work were mild steel; the reason for choice of mild steel is its corrosion resistant property, strength durability and cost effectiveness. Basic drawing tools and computer software were used for the design work. The materials used for construction includes; Angle iron, Temperature control meter, Wire, Sawdust, Heating element, Insulating wool and fish species.

5. CONCLUSION

The materials used to construct the electric fish-smoking kiln to accommodate 70 – 80 Kg were sourced locally. The construction design is simple and provided avenue for easy maintenance and replacement of heating elements and further modification on the kiln. This kiln is simple to operate, cheap to maintain and the heat generated inside the smoking chamber is up to 350°C. The cost of the electric fish-smoking kiln is about #200,000.00k which would be profitable and reliable if all the necessary environmental factors are observed, to Kainji lake artisanal fish processor. Although there is wealth of theoretical and practical knowledge of fish kiln, this knowledge is applied irregularly or wrongly; designers and builders make avoidable mistakes owing to inadequate appreciation of local content (materials) to produce cheaper and highly efficient machineries.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Adewuyi SA, Philip BB, Ayinde IA, Akerele D. Analysis of profitability of fish farming in Ogun State, Nigeria, J Hum Ecol. 2010; 31(3):179-184 .
2. Agbon AO, Ezeri GNO, Ikenwiewe BN, Alegbeleye NO, Akomolede DT. A comparative study of different storage methods on the shelf life of smoked current fish. J. Aquat. Sci. 2002;17(2):134-136.
3. Akinola OA, Akinyemi AA, Bolaji BO. Evaluation of traditional and solar drying systems towards enhancing fish storage and preservation in Nigeria (Abeokuta Local Government as a case study). J. Fish. Int. 2006;1(2-4):44-49.
4. Akinneye JO, Amoo I, Amoo A, Arannilewa ST. Effect of drying methods on the nutritional composition of three species of

(*Bonga* sp., *Sardinella* sp. and Heterotisniloticus). J. Fish. Int. 2007;2(1): 99-103.

5. Okonta AA, Ekelemu JK. 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. 2005;557-560.
6. Delgade CL, Wada MWN, Rosegran SM, Ahmed M. Fish for 2020: Supply and demand in changing global markets. International Food Policy Research Institute, Washington, D.C. and World Fish Centre, Penanng, Malaysia; 2003.
7. Al-Jufaili MS, Opara LU. Status of fisheries postharvest industry in the Sultanate of Oman: Part1 handling and marketing system of fresh fish. J. Fish. Int., 1(2-4): 144-149b. Applied Science and Environmental Management. 2006;7(2):9-13.
8. Ikenweiwe BO. Fabrication and performance assessment of a locally developed fish smoking kiln, Ocean Journal of Applied Sciences. 2010;3(4). [ISSN 1943-2429]
9. Welcome RL. The Kainji experience in fisheries management in Large River, Compiled by R.L. Welcomme, Rome, 1972: FAO 1979. V 160p-171, FAO Fisheries Technical papers No; 1994.
10. Abiodun JA. Evaluation of fisheries catch trend on Lake Kainji in Nigeria. Journal of Accessibility: A Case Study of Kainji Lake Basin, Nigeria; 2002.
11. Ogundana OS. A study of fish farmers agricultural information needs and accessibility: A Case Study of Kainji Lake Basin, Nigeria. Unpublished article; 2014.
12. Ward M. Calculating kiln volume. Retrieved April 15, 2015, from Clay Times Incorporation; 2015. Available:http://www.claytimes. Com
13. Olsen FL. The Kiln Book: materials, specification and construction. London: Krause Publication; 2001.
14. Micheal OA. 'Development and performance evaluation of a motorized fish smoking kiln'. African Journal of Food Science and Technology. 2014;5:199-124.
15. Adamu IG, Kabri HU, Hassain ID, Mada AD. Design and construction of fish smoking kiln. Journal of Engineering and Technology Research. 2013;5(1):15-20.
16. Eyo AA. Provost alerts Federal Government over foreign fishermen in LakeKainji. In The Guardian Newspaper Thursday, October 7. 2004;21(9,451):50.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/57247