Design and Fabrication of a Charcoal Fish Smoking KILN

Issa, W.A., Fatile O.E., Abdulmumuni B., Ologunye, O.B., Okpara, I.N.

Abstract: ***The fabricated charcoal fish smoking kiln was done to improve on the performance of the existing technology and determine its performance for future applications. The charcoal fish smoking kiln is made from rectangular mild steel of 2mm thickness and has three chambers such as the blower chamber, charcoal chamber, and the smoke chambers respectively. The chambers were insulated with 20mm thick thermosetting polymer welded in between two mild steel plates. The end of the smoke chambers is connected to a blower to assists in the heat convective flow mechanism during operation. The weight loss of the fish sample being calculated can be used to determine the smoking efficiency, including the smoking time by using charcoal and the temperature can as well be determined. The smoking kiln was tested by using two different species of fish: cat and panla smoked to an average moisture content of 62.5% within an average period of 4 hours, the average final weight of the dried fish was 0.24 Kg, weight loss 22.45Wb, residence temperature of 60-80^{0}C, heat exchanger temperature is 243^{0}C, and heat different at chimney 242^{0}C. The fabricated machine is highly efficient. It produced dried smoked fish that lasted for seven weeks without spoilage. The fish produced had a golden brown colour. The fish processing itself took less than one hour and the temperature of the heat supplied was quite higher than the traditional drum oven type.***

Keywords: smoking kiln, weight loss, moisture content, and heat exchanger temperature

I. INTRODUCTION

Drying has been the main method of preserving agricultural food products in Nigeria due to its simplicity and low energy cost and for the fact that the production of foodstuff is seasonal while the consumption is all year round. Almost all the geopolitical zones in Nigeria are characterized by good climatic conditions with the long dry season; high ambient temperatures and very low relative humidity that are favorable for drying, were other preservation techniques, such as refrigeration and freezing are a lot difficult and less economical.

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Excess food is wasted in rural areas in Nigeria due to a lack of technical and socio-economic information on alternative food processing technics as a result of excessive production without adequate preservation plans for scarce period. Importance of drying various food products is to reduce moisture level, weight and makes handling easier; to prolong shelf life; to preserves nutritional quality of food; and reduce risk of contamination by toxic molds, etc [5].

The water content of properly dried food varies from 5 to 25 percent depending on the food type [5]. It is, therefore, necessary to improve on the yields of agricultural food product using appropriate food preservation and storage methods to increase the amount of food available for human consumption through processing techniques such as canning, sun drying, dehydration, smoking, curing, fermentation, freezing, refrigeration, and use of chemical additives.

Most techniques require high cost of sophisticated equipment, constant electricity and/or fossil fuel such as gas or oil to provide the energy required to power them. But these energies are rarely available or limited in many parts of Nigeria couple with a continuous increase in their price. The sophisticated methods such as solar drying, smoking, curing and fermentation gain higher demand as methods of food processing and preservation.

According to [5], pyrolysis is the process of smoking fish through chemical decomposition by heat t with the use of firewood made of three components broken down in the burning process. Smoking is one of the best and oldest methods of preservation comprising the effects of salting, drying, heating, and smoking. Smoking of fish can either be cold (280C-320C) or hot (700C – 800C). Cold smoking is not meant to cook the flesh, coagulate the proteins, inactivate food spoilage enzymes, or eliminate the food pathogens thus, refrigerated storage is important to preserve before consumption.

Fishes like catfish (Tachysurus Spp.) and Mackerel (Caranx Spp.) have 78.13% and 56% to 74% moisture content respectively, 18.63% and 16% to 20% protein content respectively [7].; 8% to 14% fat depending on the species [4]. This shows that fish have high moisture and protein content together with other constituents. Freshly cut fish has a moisture content of 65% to 85% wet basis, drying temperature of 550C to 650C and safe dry moisture content of 25% wet basis depending on the fish species [4].

Fish are washed in a salt solution and dried/smoked slowly over the fire for 23% to 25% moisture content wet basis [6]. Further application of heat is important to keep and transport the fishes for a long period of times and to reduce its water content between 18% to 20% wet basis through the application of charcoal assisted dryer that ensure the

development of the reasonable quantity of heat to dry the fishes within the stipulated time.

Smoking fish is a fish that has been cured by smoking. Originally this is done as a means of preservative. Fish is preserved by refrigeration, freezing and smoking generally done for the unique taste.

However, fish is a very important source of animal protein of high nutritive value in the diet of Nigerians for the low and middle-level income groups [3]. It is regarded as one of the most diverse groups of animals known to man with more than 20,500 species in existence [7]. Solar fish dryer provides higher air temperature, lower relative humidity, enhancing drying rates, produce lower moisture content in the dried fish resulting in a higher quality of fish products and reduction in risk of spoilage. The rural households consume an average of 0.5 –1kg of dry fuelwood per person daily equivalent to 10 to 20MJ per day which is 80% of the overall energy consumption in Nigeria [9].

In contrast, the use of charcoal as a source of thermal energy does not require the felling of trees specifically for fuelwood. This underscores the need for alternative drying/smoking fuel to eliminate the conventional drying fuel system. Such an alternative is cheap, clean, and available, in abundance supply and environmentally friendly. This, therefore, makes solar energy a very attractive option for domestic drying fuel in Nigeria.

There are several methods of preserving meat, fish, walnut, and other household consumables. Out of which the preservation and consumption of fish through smoking is preferred. Fish is an important source of protein made up of 20,500 species and the world production of fisheries and aquaculture has reached about 121 tones. Efforts are made to increase fish production through improved resource management with effective post-harvest handling, preservation, and processing to prevent spoilage and wastage. Most of the fishes harvested in the tropics are used for direct consumption but a great deal is processed into fishmeal for use in feeds [7].

Significant quantity is lost due to lack of technology, poor handling, preservation, and processing practices adopted by the artisanal fishermen, fish farmers and fish entrepreneurs to prevent post-harvest losses. It is estimated that 20% to 50% of the fish produced in the remote and hinterlands in Nigeria perish before reaching the consumers [7].

Consequently, as a result of the availability of the energy and low operating requirements; high drying efficiency; low running cost and high dried product of a charcoal fish smoker to the palatable and nutritious effects of smoked food products. The need to produce better equipment compared to the conventional ones used traditional cannot be overemphasized. This led to the invention of an economic blower supported charcoal smoking kiln for local fish processing in a rural fish farming environment in Nigeria.

II. AIM AND OBJECTIVES

This project aims to design, construct and test the performance of a fish charcoal smoking kiln.

The objectives of the project are:

- To design, a blower supported fish charcoal smoking kiln
- To fabricate a charcoal smoking kiln for smoking cat and panla fish
- To carryout performance characteristics of the smoking Kiln

III. LITERATURE REVIEW

Fish is an important source of food and income for both the rich and poor people in Nigeria. A lot of people in the riverine area depend wholly or partly on the fisheries sector for their livelihood [2].

Due to the lack of adequate technology processes and locally available methods such as mud bricks stone and firewood the Nigerian fish smoking business is yet to gain enough recognition. Consequently, the quantity, quality control, and hygienic condition are affected while market value diminishes that result in damage and non-attractive appearance of the processed fish.

The mechanisms used by traditional fish smokers have a lot of limitations. Smoking contains substances that kill bacteria and destroy enzymes because of high temperature thus helping to preserve the product while the heat dries the fish.

The smoking efficiency of a Mechanical smoking kiln or drier can be improved to produce high-quality fishes with uniform heat distribution using forced-draft through an appropriate distribution of the heat generated by electricity, gas or oil from the drying chamber and air passing over it [11].

The problem of preservation is becoming a serious issue and several researchers have worked on the need in providing a new affordable and effective method to reduce post-harvest losses.

- [15], reported that most of the fish processing communities employed traditional techniques such as chilling, super chilling, freezing, drying, smoking, salting and fermentation that has existed for over 10 years to Protect the processed fish for storage and consumption.
- [12], develop a multi-crop dryer to dry crops and catfish. The dryer component includes the drying chamber, heat exchanger and combustion chamber. The heat is supply to the heating chamber through the kerosene stove placed on top of it. The heat exchanger comprises of four (4) pipes with two (2) intake pipes for fresh air while the other two (2) serves as the exhaust for a smoke. The drying chamber is thus barricaded from receiving the smoke coming from the stove and with this, the fryer fish becomes of better quality.
- [13], designed and developed an active solar dryer with adjustable airflow rates for agricultural products. The components of the system are solar collector, heat storage unit, drying chamber, air outlet unit, and suction fan. The suction fan used is at 27.29 m3/s alongside the suction fan at suction rate. From the result, 8 to11 hours of drying period was achieved. The dryer performed satisfactorily compared with the drying period of 42 to 50 hours associated with other driers.
- [8], developed a multipurpose dryer for drying agricultural and bio-resource products to the required moisture content for storage and preservation.

- [2], designed, fabricated and tested of a prototype column dryer for paddy rice. The system is portable, durable and it is techno-economically important for small-scale rice farmers and processors. The dryer can be used to dry paddy rice with a moisture content of 13.37% considered to be safe for storage.

IV. MATERIALS AND METHODS

(A) Materials and Specification

- *Fish Tray:* It is a container made of wire mesh and metal sheet with the following specifications: height 50 mm, breadth 290 mm and length 4980 mm. It contains the fish to be smoked.
- *Charcoal pot:* This is the container for burning the charcoal to provide energy for smoking the fish. It is constructed from metal sheets of 1 mm thick. It has a dimension of 490 mm x 290 mm x100 mm.
- *Rotating Handle:* The rotating handle was constructed from the steel rod. This handle controls the speed of the blower which provides air for the effective burning of the charcoal.
- Blower**:** The blower of 20 mm diameter with five blades and a thickness of 1 mm were chosen. A shaft is attached to the sprocket which is inline directly with the charcoal tray at 10 mm underneath the fish tray and the blower is screwed to this shaft.

Table 1: Material specification of a blower supported charcoal smoking kiln

S/N	PARTS	MATERIAL	SPECIFICATION	QTY	COST (N)
1.	Kiln Box	2mm Mild steel sheet and 1-inch square pipe	490x290 x100mm	1	**12000**
2.	Heat chamber cover	2mm Mild steel sheet and 1-inch square pipe	50x40x80mm	1	**8000**
3.	Charcoal pot	2mm Mild steel sheet and 1-inch square pipe	498x290x50mm	1	**7000**
4.	Fish tray	1-inch angle galvanized mesh	498x290x50mm	3	**6000**
5.	Door	2mm Mild steel sheet and 1-inch square pipe	498x290x50mm	1	**5500**
6.	Ashtray	2mm Mild steel sheet and 1-inch square pipe	-	1	**4200**
7.	Blower	AC or DC	20mm diameter	1	**3700**
8.	Bolt and Nut	Hexagonal	10mm and 14mm	6	**600**
9.	Lagging material	Thermosetting polymer	20mm thick	1	**2000**
10.	Heat exchanger	2mm Mild steel sheet	2 length	1	**5000**
11.	Chimney	Mild steel rod	½ length	1	**2500**
12.	Purchase of Fabrication Materials	cutting, welding, grinding, painting & assembly	-	-	**30000**
13.	Transportation	-	-	-	**15000**
14.	Miscellaneous	AutoCAD drawing, Typing work, and others	-	-	**20,000**
	TOTAL				**125,000**

(B) Methods

Design Considerations

- The quantity and variability of the products to be dried over a specified period; average ambient temperature and relative humidity for the area where the kiln will be used. The initial moisture content of fresh products; and final moisture content considered safe for dried products
- The ability to loading and unloading fresh products into the drying chamber; method of heat generation, conservation, and transfer as well as a mass transfer during the drying process
- The materials used in fabrication must be strong enough to withstand the amount of heat required to dry the fish, to support the dryer and the quantity of the smoked fish
- The system must have enough power to overcome the backpressure caused by the trays containing the products during the drying process
- The suction pipe must be used to control the flow of the dry air and reduce the speed of airflow through the trays to prevent products to be blown off the drying trays
- The airflow and heat distribution system including the spacing, the total products weight, the ease of loading and unloading, vapour condensation, hygiene, smoking (drying) temperature and durability of materials used are other factors considered before the design

Table 2: Characteristics of Charcoal (Source: http//:www.google.com/charcoal)

Source	Calorific Value (Kcal/kg)	Density	Volatile Matter (%)	Fixed Carbon (%)	Ash Content (%)	Burning Time (min)
Wood	7400-8000	0.23-0.73	17.1-19.1	77.6-79.5	2.7-3.6	30-45
Fossil Fuel	7300	0.6	18.8	76.5	4.65	-
Bio-gas	8691	0.8	32.46	-	-	60-75
Crop Residues	75-7800	1.4	7	-	-	60-90
Char Peat	4780	1	5.6	45.9	48.5	-
Raw Wood	400-5000	0.31-0.88	75-80	18-24	1.6-4.6	-
Others	4000-500-	0.35-0.88	60-75	16-20	-	-

❖ Design Calculation

➢ Mass of the moisture to be removed from the products

According to [8], the mass of moisture required to be removed from the fish product is given by;

$$m_w = m_i = \frac{M_o - M_f}{(100 - M_f) \times M_m} \quad (1)$$

where; m_w and m_i are the mass of moisture to be removed and initial mass of products respectively in kg; Mo and M_f are the initial and final moisture contents of fish product respectively in % (wet basis).

➢ Design the capacity of the fan to convey the drying air

According to [4], the fan size can be determined by calculating the volumetric flow rate of the drying air as shown in equation 2 below:

$$m_v = m_a \times v_s \quad (2)$$

Where; m_v is the volumetric flow rate of the drying air in m^2/s and v_s is the specific volume of the drying air in m^3kg-1.

➢ Design for the energy required for drying

To determine the quantity of energy needed for the dryer, the quantity of heat energy required is calculated from Equation 5 according to [4] as:

$$Q = maf\ (h_2 - h_1) \quad (3)$$

Where, Q - $kJ\ s^{-1}$ (Heat energy amount)

maf is air mass flow rate in $kJ\ s^{-1}$

h_1 is specific enthalpy of air at the inlet in $kJ\ s^{-1}$ air; and

h_2 is a specific enthalpy of air at the drying temperature in kJ/kg.

➢ Design for the quantity of charcoal needed for combustion

The quantity of charcoal required to be burnt in the combustion chamber was determined using equation 4 below:

$$Q_c = \frac{Q}{C_c} \quad (4)$$

Where; Q_c is the quantity of charcoal needed for combustion in kg;

Q is the amount of heat energy required for drying in kJ; and

C_c is the calorific value of charcoal in kJ/kg

❖ *Weight of Water to be removed*

The smoking Kiln was designed to dry a maximum number of 6kg fresh fishes per batch. Taken a batch weight of 6kg at 62.5 percent moisture content after brining, thus the total weight of the water present is:

$$M_1 = 6kg \times \left(\frac{62.5}{100}\right) = 3.8kg \quad (5)$$

i.e. 3.8kg of water, which means that the dry matter (with zero percent moisture) will be:

$$W_d = 6kg - 3.8kg = 2.2kg$$

After drying, the dry matter will still be 2.2kg which will be equivalent to 82 percent of its weight at 18% moisture (safe moisture content). That is, $100 - 18 = 82$.

Therefore the 18% of the moisture content and the final weight of the product will be:

$$M_{18\%} = \left(\frac{wd}{wt}\right) \times 100 = \frac{2.2 \times 100}{82} = 2.7kg$$

i.e. 2.2kg of dry matter and 0.5kg of water (i.e. 2.7 – 2.2)

This means that the weight of water that has to be removed is:

$$W\,H_2O = M_1 - M_2 = 3.8 - 0.5 = 3.3kg\ per\ batch\ of\ 6kg.$$

➢ Moisture Content

The percentage required drying moisture content was determined by using the expression given by Ohanwe. (2001):

$$Moisture\ content\ (M.C\ (wb)\ \%) = \{\frac{(W_1 - W_2)}{W_1}\} \times 100 \quad (6)$$

Where: W_1 = weight of fresh fish sample = 6kg = 6000g; W_2 = weight of dry fish sample = 2.2kg = 2200g.

$$Moisture\ content\ (M.C\ (wb)\%) = \left\{\frac{(6000 - 2200)}{6000}\right\} \times 100 = \frac{3800}{6000} \times 100 = 63.3\%$$

The heat generated

The heat generated in

$$(KJ/hr) = \frac{\text{Heat generated by charcoal}}{\text{processing time}} \quad (7)$$

Calorific value of charcoal= $7600KJ/Kg$, Total processing Time = $4\ hrs$

$= 4 \times 60 \times 60 = 14{,}400s$ and Mass of Charcoal used $= 4.85\ Kg$

Then, heat generated by burning $4.85\ Kg$ of charcoal $= 7600 \times 4.85 = 36860\ KJ$

The heat generated in

$$(KJ/hr) = \frac{\text{Heat generated by charcoal}}{\text{processing time}} = \frac{36860}{4} = 9215\ KJ/H$$

- **Heat dissipated by the charcoal box**

$$Q = \frac{KA\,(T_1 - T_2)}{X} \quad (8)$$

K = thermal conductivity of mild steel = 45.5 w/mk, A= Area of the charcoal box = 0.96m^2, T_1 = Temp of charcoal in the combustion chamber = 160^{0}C, T_2 = Temp of the charcoal outside wall of the combusting chamber = 270^{0}C, and X = Thickness of the mild steel sheet = 2.0mm = 0.002cm.

$$Q = \frac{KA\,(T_1 - T_2)}{X} = \frac{45.5 \times 0.96\,(270 - 160)}{0.002} = \frac{4804.8}{0.002} =$$

$$2402400 = 2402.4\ KJ$$

V. RESULT AND DISCUSSION

(A) Result

The different species of cat and panla fish were obtained from a fish pond and used for the test with the following procedure;

- The fresh fish was gutted and the gills, intestines, and dirt were removed, and then washed in clean water
- The fish were soaked in a solution of salt for about 5 minutes to remove any bacterial and aid dehydration processes
- The charcoal on the charcoal chamber was first ignited using kerosene and allowed to burn for 6-10minute, this allows odour of kerosene to go up and then charcoal added.
- The fish were loaded into the fish tray and placed inside the drying chamber for smoking and the fan was set in motion of speed one and timed.
- The heat was supplied into the kiln by convention from the blower through the heat exchanger and distributed by the suction pipes into the perforated heat distribution pipes.

Table 3: Temperature Deviation and Power Cost of Operating the Smoking Kiln

Operation Condition	Temperature Deviation (^{0}C)	Cost (N: K)
1.5 kg charcoal Without fan	1.65	720:00
1.5 kg of charcoal with a fan	4.15	680:00
1.0 kg of charcoal with a fan	1.40	550:00
1.0 kg charcoal without fan	3.21	460:00
0.5 kg of charcoal with a fan	1.12	280:00

Table 4: Operating Time (hrs) and temperature of the drying chamber

Operating Time (Hour)	Drying Chamber Temperature (^{o}C)
1	180
2	240
3	270
4	278
5	245
6	220

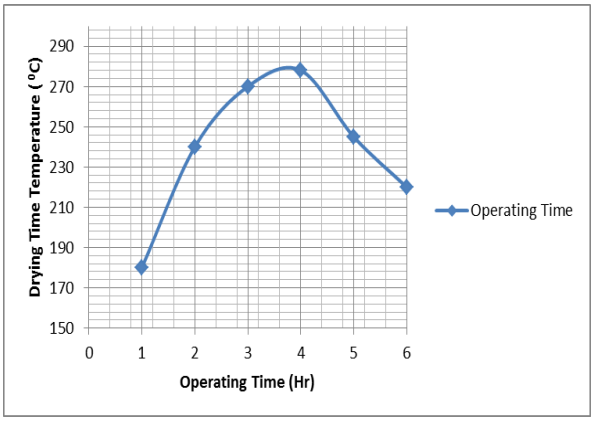


Fig. 1: Drying Time Temperature against Operating Time

Table 5: Drying rate of catfish, drying chamber temperature, drying time and ambient air conditions for the smoke dryer heat output for sample A

Time (hr)	Moisture Content (g)	% Weight Loss (Wb)	Drying Chamber Temp (^{o}C)
1	380	21.5	165
2	300	33.33	180
3	200	14.3	190
4	175	18.2	186
5	140	25.0	173

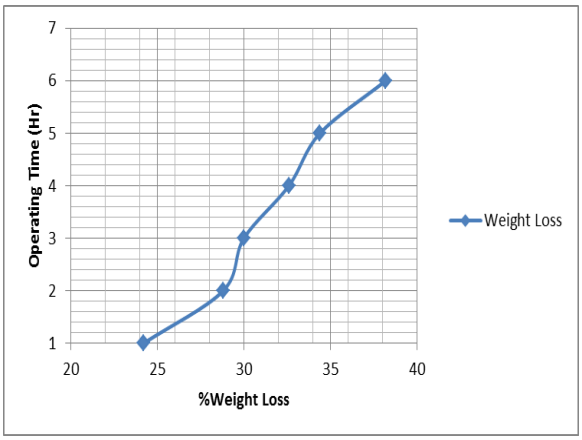


Fig. 2: Operating Time (hrs) against Weight Loss (Wb)

Table 6: Drying rate of catfish drying chamber temperature, drying time and ambient air conditions for the smoke dryer heat output for sample B.

Time (hr)	Moisture Content (g)	% Weight Loss (Wb)	Drying Chamber Temp (^{o}C)
1	400	20.0	160
2	320	48.9	185
3	215	14.0	190
4	185	16.2	186
5	140	32.0	173

Table 7: Drying rate of catfish, drying chamber temperature, drying time and ambient air conditions for the smoke dryer heat output for sample C

Time (hr)	Moisture Content (g)	% Weight Loss (Wb)	Drying Chamber Temp (^oC)
1	240	22.0	160
2	168	32.0	185
3	142	18.6	190
4	100	24.8	186
5	85	16.8	173

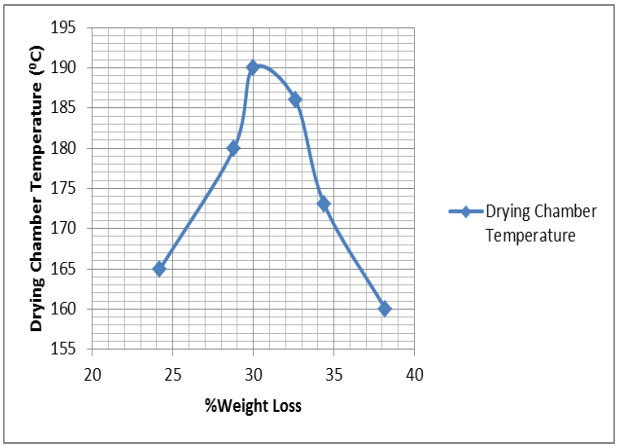


Fig. 3: Drying Chamber Temperature (hr) against Weight Loss (Wb)

Table 8: Operating Time (hrs) and the temperature of the drying chamber

Operating Time (Hour)	Drying Chamber Temperature (^oC)
1	80
2	110
3	130
4	120
5	100
6	80

Table 9: Drying rate of Panla, drying chamber temperature, drying time and ambient air conditions for the smoke dryer heat output for sample A.

Time (hr)	Moisture Content (g)	% Weight Loss (Wb)	Drying Chamber Temp (^oC)
1	190	24.2	165
2	167	28.8	180
3	135	30.0	190
4	94	32.6	186
5	140	34.4	173

Table 10: Drying rate of Panla, drying chamber temperature, drying time and ambient air conditions for the smoke dryer heat output for sample B

Time (hr)	Moisture Content (Wb)	% Weight Loss (g)	Drying Chamber Temp (^oC)
1	100	20	160
2	84	36.2	185
3	60	44.8	190
4	38	36.6	186
5	18	32	173

Table 11: Drying rate of Cat Fish and Panla, drying chamber temperature, drying time and ambient air conditions for the smoke dryer heat output for sample C

Time (hr)	Moisture Content (g)	% Weight Loss (Wb)	Drying Chamber Temp (^0C)
1	240	22.0	160
2	168	32.0	185
3	142	18.6	190
4	100	24.8	186
5	85	16.8	173

Table 12: Heat differences at the chimney

Time (hour)	Temperature (^oC)
1	15
2	21
3	26
4	27
5	32

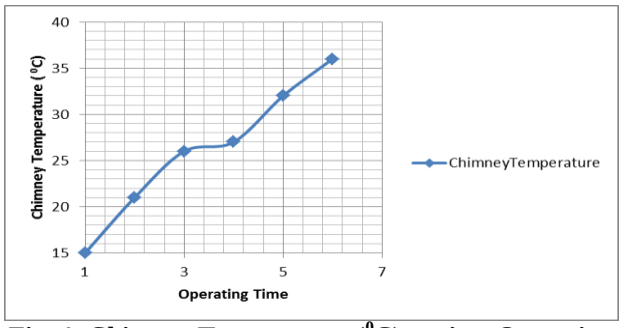


Fig. 4: Chimney Temperature (^0C) against Operating Time (hr)

Table 13: Temperature of the Heat Exchanger at different Time

Operating Time (hour)	Heat Exchanger Temperature (^0C)
1	**185**
2	**240**
3	**260**
4	**285**

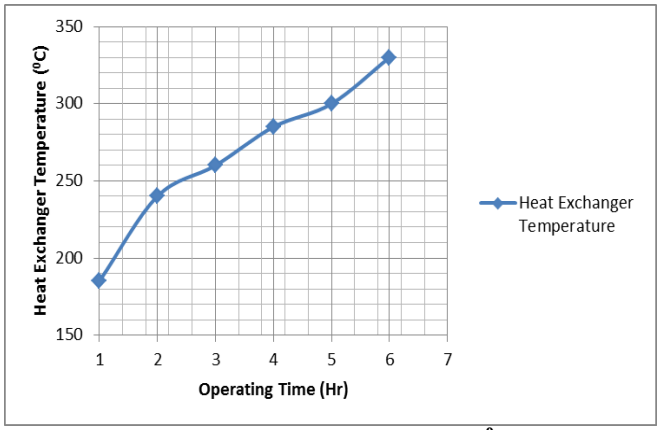


Fig. 5: Heat Exchanger Temperature (^0C) against Operating Time (hr)

(B) Discussion

Fish smoked using the charcoal heat was found to be better in terms of appearance and based on the black golden lustre, which the charcoal smoke may have conferred on the product as opposed to those with the traditional smoking kiln.

The charcoal fish smoking kiln machine was rigid and operate perfectly with less manual effort in operation. The blower supported charcoal smoking kiln was tested with fresh catfish of 1.5kg on each tray (See table 1). The moisture content though averagely low but are not to a safe level. The short time give is (1hr) as seen in Table 1 above. If the following parameters are properly considered i.e., the moisture content at onset, fish weight, fat content, heat intensity supplied, including the smoking chamber heat dynamics; a moisture content reduction to a safety level of 10% -15% can be achieved by a projected 4-5 hours of smoking [1], see table 2.

This system will replace the local method of smoking fish that normally spans over 24 hours in addition to intensive labour and heat skin laison effects. The residence temperature of the system is 83.6^0C and 60.4^0C in the chamber and may increase the drying rate by recycling the drying process.

VI. CONCLUSION AND RECOMMENDATION

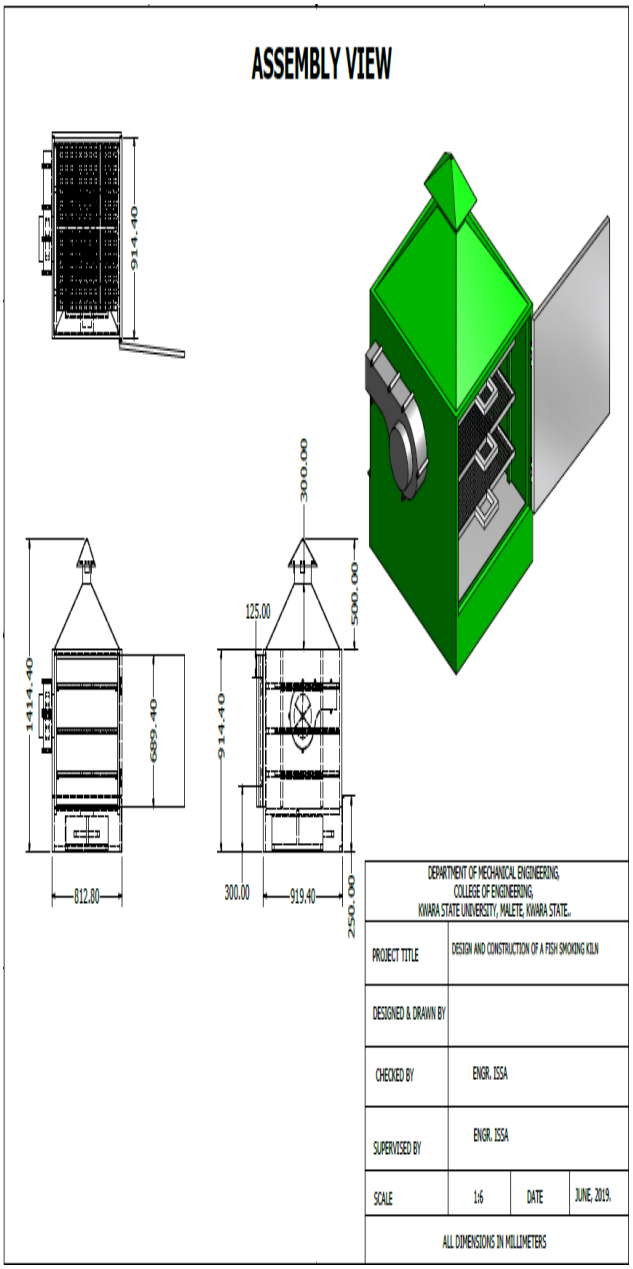
(A) Conclusion

The developed fish smoking kiln is easy to operate, maintain, cheap, portable and environmentally friendly. The kiln was tested using catfish/Panla, and found to perform efficiently while drying the fish with a safe moisture content of 10% to 15% within five (5) hours. It can also be used for drying and re-drying soft tissue of animal and plant food sources. The fish smoking kiln attains a recommended temperature within the shortest possible time and has fans Incorporated to it with uniform distribution of heat within the drying chamber by ensuring uniform smoking and drying of the fish. The oil from the charcoal or wood-fired fish drier does not drop on to the flame, reducing cancerous element from depositing on the smoked products and the weight loss of 62% after 9 hours of processing showed an improvement over the weight loss reported by some researchers which implies a longer shelf life of the finished products. The duration of the operation can be regulated according to the customer's demand and the temperature rose to above 80^0C within the first 2 hours and continued even after fueling has been stopped through the night due to the lagging of the equipment. The overall production cost is one hundred and twenty-five thousand Naira (N125, 000) and is affordable by the local fish farmers. The drying chamber is easy to operate, the temperature distribution is uniform inside the smoking kiln and the external body temperature is equal to the surrounding temperature due to lagging thus, operators are safe to be close to the system when operating it. The dried fish is not covered with black soot because the design prevents direct contact of flame to the content of the smoking chamber.

(B) Recommendation

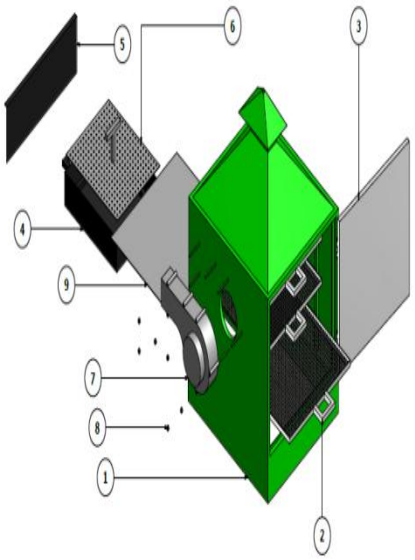
- Financial resources of most of the fish processing farmers should be kept in mind to reduce the cost of the smoking, cost of incorporating a blower and maintaining it, if otherwise can increase the selling price.
- It is important to improve the quality of the smoked/dried products and labour reduction
- There is a need to improve the quality of the smoked fish in the market to reduce the effect of direct contamination of fish by the smoke which is not unhygienic
- Hybrid power should be implored to supply the heat needed by the system thus removing the fear of the fish being contaminated by smoke

Appendix A: Orthographic view Diagram of a blower supported charcoal smoking kiln



Appendix B: Assembly view Diagram of a blower supported charcoal smoking kiln

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Kiln Box	2mm M/S Plate, 1" Sq Pipe
2	3	Tray	1" Angle, Galv. Mesh
3	1	Door	2mm M/S Plate, 1" Sq Pipe
4	1	Charcoal Pot	2mm M/S Plate, 1" Sq Pipe
5	1	Heat Chamber Cover	2mm M/S Plate, 1" Sq. Pipe
6	1	Ash Tray	2mm M/S Plate, 1" Sq. Pipe
7	1	Blower	
8	6	Nut	
9	1	Heat Exchanger	2mm M/S Plate



Appendix C: The fabricated blower supported charcoal smoking kiln



Appendix D: Fishes arranged on the Tray



Appendix E: The fish smoked with the kiln



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