SMGroup

SM Journal of Nutrition and Metabolism

Research Article

Effectiveness of Cat Fish Drying using Pneumatic Charcoal Kiln

Idi-ogede AM[1]*, Ogori AF[2] and Omoniyi SA[2]

[1]*Department of Fisheries and Aquaculture, Federal University, Nigeria*
[2]*Department of Home Science and Management, Federal University, Nigeria*

Article Information

Received date: Jun 19, 2018
Accepted date: Jul 13, 2018
Published date: Jul 17, 2018

***Corresponding author**

Idi-ogede AM, Department of Fisheries and Aquaculture, Federal University, Nigeria, Tel: +234 0803-6458-262; Email: ogorifaraday@gmail.com

Keywords Pneumatic kiln; Charcoal; Drying; Effectiveness; Cat fish

Abstract

An efficient pneumatic charcoal kiln powered with solar panel by fan that blows out heat via a chamber into fish chamber was developed. The kiln was constructed of local wrought iron materials for cost effectiveness and ease of reproducibility by local farmers. It was evaluated using catfish. The kiln was able to attain drying conditions of 89 0C for 2 hours. The heat distributions within the drying chamber trays were fairly uniform which led to uniform drying of the fish. The kiln was able to reduce a total weight of fresh catfish of 5.0 kg to 4.05 kg after 2 hours with an operating charcoal cost of N 1000. The provision of the pneumatic pump also powered via same solar power and the recirculation of heated air within the fish chamber of the pneumatic kiln helps to eliminate smoke, charcoal dust, Soot fish and burns usually experienced during kiln operations. The temperature distribution within the fish chamber trays, drying kinetics on smoke-dried catfish was conducted and the results proved the effectiveness of the pneumatic charcoal kiln for use among fish handlers and processors in rural settings due to low cost of operating materials and good nutritional quality envisaged.

Introduction

Fish is a major source of protein and its harvesting, handling, processing and distribution provide livelihood for millions of people around the world [1]. Different kinds of ovens and kilns have been developed in Africa [2]. The oven most used for smoking fish is traditional with considerable disadvantages [3]. The disadvantages are low capacity, inefficient fuel usage (firewood) contributing more to forest depletion, health hazard. Smoking is a popular traditional method of fish preservation in Nigeria and in most developing countries [4]. Local fishermen spend between 7-10 hours daily on the average, smoking fish depending on the percentage of oil composition, size in relation to the rate of water loss per body weight of the fish. Traditionally, fish food produce are dried by spreading in open sun in thin layer and smoking using wood [3]. Open sun drying and smoking processing requires longer drying time and product quality are difficult to control. In addition, fingers are burnt due to undue exposure to direct heat, the procedure is very laborious and poor quality smoked fish are usually produced [5]. These associated problems have not only limited fish smoking to the rural artisanal fisher folks but has also hindered the trade of smoke fish especially importations from African countries to Europe) due to insistent mold attacks resulting from poorly smoked products [6]. The disadvantages inherent in the traditional smoking method led to the development of smoking kiln for effective fish smoking process [5]. The pneumatic charcoal kiln is a mechanical drier for fish smoking under controlled conditions. Ensuring faster drying and thus increases freshness of smoke fish; prevent dirt, sand and dust [3].

The objective of this study was therefore to develop an effective fish smoking kiln that will reduce if not eliminate all challenges in the use of smoking kiln in the developing rural settings in Nigeria.

Materials and Methods

The pneumatic charcoal kiln

The pneumatic charcoal kiln was constructed with Chaka plates and wrought iron metal sheets as descripted by Idi-ogede et al., [3].

The charcoal and the smoking chamber were insulated with a thermosetting polymer of 100mm thickness. The fan chamber (0.457m x 0.305m x 0.457m) has the same size with charcoal chamber while the smoking chamber was 0.609m x 0.914m x 0.609m; wider and longer than the other two chambers (Plate 2). The fan was fixed to the fan chamber connected to a solar panel which supplied the electricity that blow the fan with a regulator attached to control the blade speed. Pneumatic pump was fitted at the base so as to allow recycling of heated air back into the kiln chamber.

The effectiveness of pneumatic kiln drying procedure

The effectiveness of the kiln at load and no load conditions were performed using charcoal at constant weight of 2.0 Kg and 1.0 kg respectively for all chamber positions C_1.C_2 and C_3 respectively.

OPEN ACCESS
ISSN: 2573-5462

The temperatures attained by the pneumatic kiln at an interval of 30 minutes were recorded using temperature probe a laser reader. The test was terminated when the charcoal were completely burnt. This was done to determine the ideal operating cost of charcoal for smoke-drying in terms of the quantity of fuel that can supply the needed energy over a known period. 1.0kg and 2.0kg Charcoal was weighed by a weighing balance (Atom Model 110C, electronic compact kilns scale) and put into the charcoal chamber of the pneumatic kiln for temperature determination with load and no load conditions respectively. The charcoal was ignited with fire; the burnt charcoal was later put inside the charcoal chamber. Power was generated through the solar panel connected to the fan chamber; air was blown from the fan chamber at 2 m/s to the smoking chamber which channel heat through the wire mesh and thus to the pneumatic kiln chamber. The kiln drying effectiveness was first determined from the amount of temperature distribution at load and no load conditions during the smoking processes in the pneumatic kilns. Temperature distribution when load was added and when load was not added.

Drying rate process

Fifty (50kg) *Clarias gariepinus* was obtained from fish farm in Gashua. The fishes were transported from the fish farm in an iced containerto the Federal University, Gashua where the research was carried. A total number of 25kg of *Clarias gariepinus* fish species were placed on wire meshed tray one and two respectively. The fishes were prepared as described by Idi-Ogede et al., [3]. When the kiln was loaded with fish (loading condition), the charcoal chamber was loaded with 2 kg charcoal, properly fired and projected inside the fish smoking chamber (pneumatic chamber) by a fan blower to attain a temperature of 180 °C. The drying was stopped when the fish were properly dried to safe moisture content (0.001 %) after which the heating chambers (charcoal chamber) was removed while the fans were still in operation to cool the dried fish to the ambient temperature before they were packed.

Drying rate

By the method of Johnson et al., [7], the weight and thickness of each sample were monitored hourly until it was dry to calculate the drying curves of the sample's mass (g) against time (h) and the drying rate curves determined.

Drying rate = Change in moisture content/ Change in time.

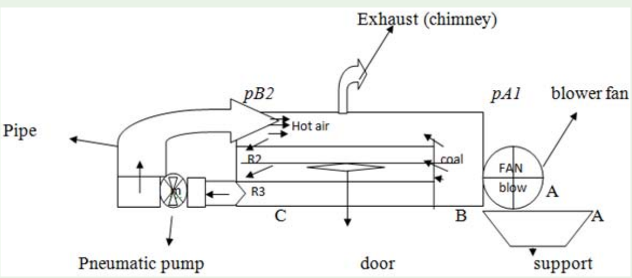

Figure 1: Design of Pneumatic Charcoal Kiln Drying [3].

Keys: R: Racks; pA1: Positional one of kiln chambers; pB2: Positional two of kiln chambers; A: Fan chamber; B: Charcoal chamber; C: Smoking chamber.

Figure 2: Plate 1- Pneumatic kiln [3].

Results and Discussion

The results of the performance of the smoking kiln conducted at NO Loading drying conditions are presented below on Figure 1.

Temperature distribution of pneumatic kiln at no load condition

The temperatures obtained in the smoking kiln at seven different conditions of operation at 'No-Load' with fan. The initial temperatures of the kiln at 'No-load' in chamber positions C_1 was 28.9°C and the temperatures inclined to 115 °C after 30 minutes. The weight of charcoal was kept constant at 1.0 kg, the temperature also increased to 140 °C, 148 at 60 and 90 minutes respectively with the fan blowing heated air into the fish/smoke chamber. A declined from 139 °C -119 °C at 120 and 180 minutes of operation was observed respectively. The undulation in temperature was similarly observed at chamber position C_2 and C_3 respectively, thus temperature deviations were observed. At C_1 it was 111 and 21, C_2 was 66 and 3 while C_3 was 61 and 3 respectively, indicating that heating and air circulating efficiency were decreasing by length of chamber on a steady state maybe because of no load to absorbed the heat except those by the walls of the chamber (Figure 2). An internal temperature far above 70 °C for hours is achievable and so could handle harmful pathogens [8]. It was observed that temperatures decreased at increased positional chamber however maintaining an equilibrate high temperature for fish safety. The costs for running the kilns at these conditions were N 500 (Table 1).

Table 1: Temperature distribution of kiln at no load condition with 1 kg charcoal= cost N 500.

Time	Temperature at chamber positions °c		
	C_1	C_2	C_3
0	28.9	33	31
30	115	88.1	77.6
60	140	98.6	91.9
90	148	112.6	108.1
120	139	113	103
150	135	105.3	92.3
180	119.9	101.2	89.0

Values are means from duplicate readings.

Figure 3: Plate 2- Pneumatic charcoal kiln showing the charcoal, smoking and fan chambers.

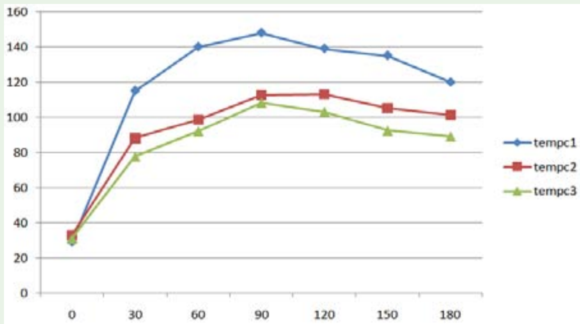

Figure 4: Temperature distribution of kiln at no load condition with 1 kg charcoal.

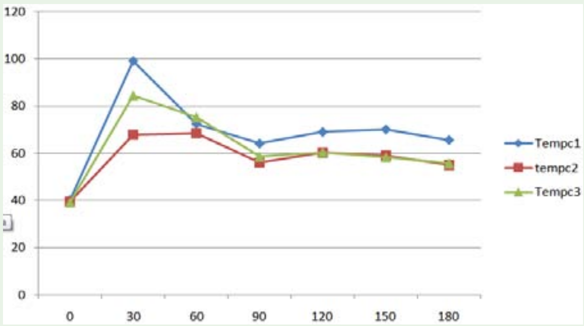

Figure 5: Temperature distribution of kiln at load condition with 2.kg charcoal.

Temperature distribution of pneumatic Kiln at load condition

The temperatures obtained in the smoking kiln at seven different conditions of operation at Load condition of 50kg fishes with fan. The initial temperatures of the kiln at fish load with 2.okg charcoal in chamber positions C_1 was 40 ˚C and the temperatures increased to 72 °C after 30 minutes. The weight of charcoal was kept constant at 2.0 kg, temperature however decreased to 64 °C, 69 at 60 and 90 minutes respectively with the fan blowing heated air into the fish/ smoke chamber. A further declined from 70 °C-66 °C at 120 and 180 minutes of operation was observed respectively. The steady decrease in temperature was similarly observed at chamber position C_2 and C_3 respectively, with temperature deviations at C_1 to be 32 and -6, C_2 was 39 and 1 while C_3 was 39 and 20 respectively, indicating that heating and air circulating were not efficient, unsteady maybe as a result of the soft tissue which readily absorbed heat . Olayimi et al., [8] implying that there was heat transfer between the fresh catfish and the kiln wall chamber. In figure 3, three phase levels were observed 0 to 30 minutes corresponds to the rise in temperature hence heat energy gain on cat-fishes. The 30-60 minutes of the second drying phase corresponds to the evaporation of the free moisture on the catfish surface. Stage two is the real drying phase of the catfish. The unsteady state of this Phase maybe due to the amount of air from the fan and efficiency the pneumatic pump as well as the heat energy from the charcoal. The Phase three 90-180 minutes corresponds to free water motion stage. Here evaporation of water from the fish surface is observable and directly affecting the bound water in the fish.

Table 2: Temperature distribution of kiln at load condition with 2 kg charcoal.

Time	Temperature at chamber positions °c		
	C_1	C_2	C_3
0	40	39.3	39
30	99	67.7	84.5
60	72.4	68.3	75.3
90	64	56	58.5
120	68.9	60	60.3
150	70	58.8	58.2
180	65.5	54.8	55.6

C0ST N1000 Values are means from duplicate readings.

Drying rate of cat fish

All the curves in figures 4 and 5 sloped down from left to right indicating that weight reduced as time increased in the drying temperatures of the two trays .There was change in weight after 60 and 90 minutes on catfish samples in tray 1 and 2 pneumatically dried corresponding to 72°C and 60°C respectively (Table 2). Moisture removal is temperature dependent. Here, drying time is shorter (2 hours), and dehydration is faster as temperature is increased. Moisture loss was faster and much in tray 2 cat fish samples than in tray 1 cat fish samples. This observation might be due to position of the chimney and pneumatic pipe design.

The drying rate decreased as moisture decreased under all drying conditions (Figures 4 and 5). As drying starts unbound water easily

Table 3: Drying rate of cat fish using pneumatic charcoal kiln.

Time (min)	Temperature (°c)	Drying rate	Mc (%)	
			Tray 1 (kgm^2)	Tray 2 (kgm^2)
0	39.43	0	0.002	0.02
30	84	0.00013	0.004	0.11
60	72	0.00005	0.003	0.010
90	60	0.00001	0.001	0.010
120	63	0.00002	0.0025	0.010
150	62	0.00003	0.005	0.00
180	59	0.0000005	0.0001	0.010

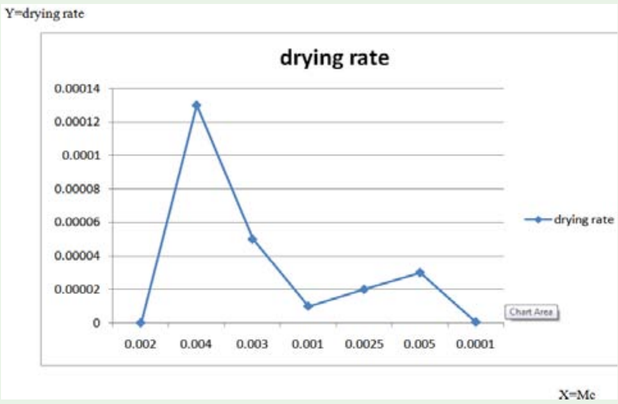

Figure 6: Drying rate curve of cat fish using pneumatic charcoal kiln in tray 1.

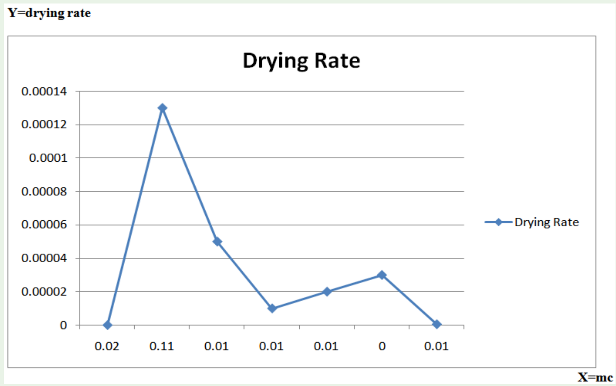

Figure 7: Drying rate curve of cat fish using pneumatic charcoal kiln in tray 2.

evaporated from the cat fish surfaces, resulting in higher drying rate at the onset of the drying process at attempt to equilibrate. The sharp fall of drying rate observed in this study was caused by wettability of the product tending toward the equilibrium moisture content [9] (Figures 6 and 7) (Table 3).

Conclusion

The developed pneumatic fish smoking kiln was able to attain the recommended temperature and time needed for cat fish smoking using conventional modern and traditional kilns. The design of the pneumatic charcoal kiln gave fair uniform distribution of heat and drying rate within the drying chamber at load and no load conditions hence good drying and safety of the cat fish. The use of solar panel and or battery to power the fans makes the kiln adoptable in any remote area of the world. The operating conditions at 1.0kg and 2.0kg charcoal and cost of N500-1000 respectively are cheap. The design and operations of the pneumatic kiln reduced smoke inhaling, burns and prevent deposition of soot or charring of the fish. The quality of the dried catfish was good and the challenges experienced by the kiln operators were virtually eliminated.

References

1. Al-Jufiali MS, Opara LU. Status of fisheries. Post-harvest indus1 try in the Sultanate of Oman. Part I. Handling and marketing system of fresh fish. Journal of Fisheries International. 2006; 2: 144-149.

2. Enofe OI. Sustainability of Indigenous technology in post-harvest fish operation in Edo State and Delta States. An Unpublished B.Sc Project submitted to the Department of Fisheries, University of Benin, Benin, Nigeria. 1996.

3. Idi-Ogede AM, Ogori AF, Omoniyi SA. Design and Fabrication of Pneumatic Charcoal Kiln Drying Characteristics and Residence Temperature for Cat Fish Smoking. J Nutr Health Food Eng. 2018; 8: 00250.

4. Odiko AE, Abolagba OA. Comparative Analysis of the effects of smoking with Indigenous Full Drum smoking kiln. Proceedings of 30th FISON Annual Conference, November. 2015; 22-27: 600-602.

5. Indian Council of Agricultural Research. Handbook of Fisheries and Agriculture. (1st Edition), Kuldeep Sherma, New Dellhi. 2006.

6. Adewole EO, Okomoda JK, Eyo AA. Construction, extension and evaluation of improved smoking kiln (Banda) in Kainji Lake Area. In: 16th Annual Conference of the Fisheries Society of Nigeria (FISON). 2001; 250-255.

7. Johnson PNT, Brennan JG, Addo-Yobo FY. Air drying characteristics of plantain (Musa AAB). Journal of Food Engineering. 1998; 37: 233-242.

8. Olayemi FF, Raji AO, Oyelese OA, Oyewole SN, Omodara MA. Effective Fish Smoking Kiln for Developing Country. International Journal of Scientific & Engineering Research. 2013; 4: 2229-5518.

9. Kabiru AA, Joshua AA, Raji AO. Effect of slice thickness and temperature on the drying kinetics of mango (mangiferaindica). International Journal of Research and Science. 2013; 15: 41-50.