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Development of a Low Cost Solar Dryer for Fish in Adamawa State Nigeria

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ABSTRACT: *A low cost solar dryer for fish was designed and constructed using locally available materials like woods, glass, rods and wire mesh, which makes it affordable to fish farmers and processors. It was found to be suitable for household drying of fish and other perishable agricultural produce in less time than the traditional method and under a hygienic condition. The constructed solar dryer reduced the drying time of fish by 33% to reach the required moisture content for storage.*
Key Words*: Solar Dryer, Fish, Affordable, Fish Farmers, Hygienic*

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I. INTRODUCTION

Globally fish is considered a very important component of human diet that supplies essential nutrients like protein, lipids, vitamins and minerals,which are vital in improving human health (Ladu, 2001 and Tsadoet al., 2012). It contributes significantly to the survival and wellbeing of a large number of people around the world. Fish is an efficient converter of food for human consumption it hashelped in saving children from kwashiorkor and there is little or no religious restriction on its consumption (FAO, 1989).

Akinbode and Dipeolu, (2012) stated that fish is relatively cheaper and readily available to poor people in most developing countries of the world including Nigeria, therefore making quality protein available to them. Almost half of the total animal protein consumed in Nigeria is from fish which makes itoccupies a unique position as the cheapest source of animal protein (FDF, 2009).

Fish production has contributed immensely to the economy as it employs 70% of the active labour force in the agricultural sector. Fish is considered a staple food in the tropical Forest regions of the West African coastal areas;it is a critical source of protein and the dried form is a common condiment for households in the coastal areas. Over 5oo,ooo,ooo people in developing countries depend directly or indirectly on fisheries and aquaculture for their livelihood (keith,2010).

In Nigeria, the annual demand for fish prior to year 2000 is 1.5 million tonnes, while local production stood at about 0.4 million tonnes with an import of over 1 million tonnes. However, deliberate government effort towards improving local aquaculture production and an increased awareness in fish farming especially in catfish and tilapia production using flow through and water re-circulatory culture systems, local fish production increased geometrically from the year 2000, in 2004 Nigeria's total fish supply was 1.16 million tonnes (Ibeun, 2005).

Fish is a highly perishable food product which inmost cases according to Clucas (1982) becomesinedible within twelve hours at tropicaltemperature. Spoilage therefore begins as soonas the fish dies and processing shouldtherefore be done quickly to prevent the growthof spoilage bacteria. It can be stored only by proper refrigeration, smoking or drying. Sengaret. al. (2009) reported that most fishermen are living in the coastal belt, live below the poverty line therefore refrigeration is distinct dream to them. The alternative storage methods available to them is drying or smoking.

Komolafeet. al. (2011) quoted Peter and Ann (1992) that fish is a low acidfood and is therefore very susceptible to thegrowth of food poisoning bacteria which makes itanother reason why it should be processedquickly. Clucas(1982) affirmed that the moisturecontent of fish is 80%; if this is reduce toaround 25%, bacteria cannot survive andautolytic activity will be greatly reduced. He further stated that at moisture content of 15 per cent or lessmould will cease to grow; well dried fish if stored under right conditions can be kept for several monthswithout spoilage.

Anonymous(2019) stated that dry fish production mainly consists of micro level cottageenterprises, carried out predominantly by fisherwomen as asupplementary source of income. As such, the quantitiesproduced tend to be low. Furthermore due to the long drawndrying process, the moisture retained creates an idealenvironment for growth of fungi. The practice of drying thefish in the open under the sun affects the hygienic conditionsof the dried fish, due to the high risk of contamination withdust particles and harmful contaminants.

In view of the above stated importance of fish, it's processing and storage condition has to be improved. This work is aimed at developing a fish solar dryer which enhances the drying process by reducing the drying time in a very hygienic condition using locally available materials which will make it cheap and affordable for the local fish farmers.

II. MATERIALS AND METHOD

The fish solar dryer was been designed to improve the drying rate of fish for fish farmers in Adamawa state Nigeria. The dryer was constructed from cheap and available materials likewood, glass, chicken wire mesh etc., which were obtained from the timber market in Yola, Adamawa State Nigeria to ensure that the fish dryer will be affordable to the local fish farmers and fish merchants.

The fish solar dryer as shown in Figure 1 has a size of 914 mm x 457 mm x 750 mm consisting of the following parts: a drying chamberconstructed from wooden plank, three drying trays made of chicken wire mesh, a loading door, three sun receptors made from glass andthree air circulation openings.

Construction of the dual mode fish dryer

The fish solar dryer was constructed by first cutting 2 x 3 inches wood into the required length which were used to form the frame of the dryer by holding them together using 3 inches nails, then a plank of wood was cut out and attached to the frame at the proper locations using 3 inches nails to form the drying chamber, then the drying trays were formed from a 5 mm rod and placed within the drying chamber and finally the glass and wire mesh were cut out and attached to the frame at their proper locations forming the sun receptors and air openings respectively

Operational description of the dual mode fish dryer

The dual mode fish dryer is designed to be a batch dryer which can dry 20 kg of fish per batch. It operates by the solar receptors receiving solar radiation from the sun which increases the intensity and temperature of the sun on the fish which increases the rate of water removal from the fish,at the same time air flows in and out of the dryer through the vents removing the vaporised water out of the drying chamber.

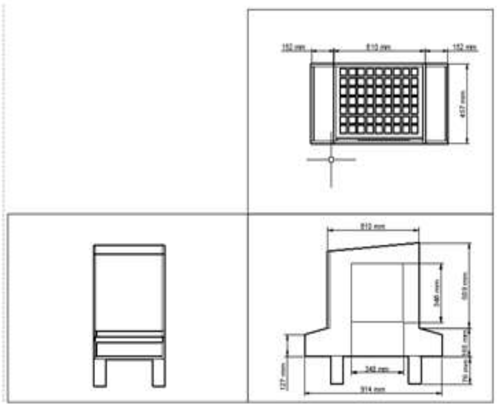

Figure 1: Orthographic View of the Solar Dryer for Fish

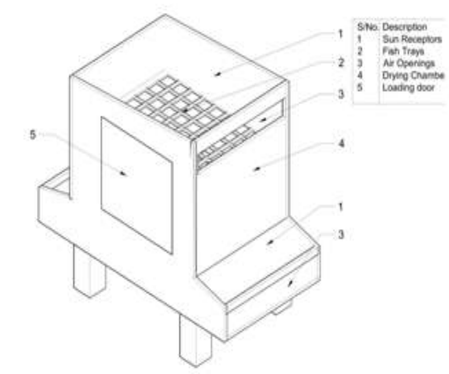

Figure 2: Isometric View of the Solar Dryer for Fish

Performance Evaluation of the dryer

After construction of the solar dryer,weighed quantity of clarias Catfish were placed on the drying trays inside the dryer which was placed in the open where the sun radiation can reach it. The temperature of inside and outside the dying chamber were measured at the start of the drying process and afterevery three (3) hoursincluding the weight of the fish, ambient and inside temperatures until when there is no further change in weight or constant weight were obtained repeatedly for the same fish samples.

Measurements

The temperature inside the drying chamber and the environment wererecorded at the start of drying and repeated after every 3 hours interval (that is 8.00am to 17:00pm local time) for each batch of fish using a digital thermometer, the weight of the fish at the beginning of drying and after every 3 hours interval was also measured using a digital weighing balance. Moisture content of the fish: The percentage moisture content of the fish was calculated using equation 1 and 2.(Sengar et. al., 2009)

$$MC_{db}(\%) = \frac{w_1 - w_2}{w_1} \times 100 \quad 1$$

$$MC_{wb(\%)} = \frac{w_{1-} \ w_2}{w_2} \times 100 \quad 2$$

Where: MC_{wb} = moisture content wet basis, %
MC_{db} = moisture content dry basis, %
W_1 = weight of sample before drying, (g)
W_2 = weight of sample after drying, (g)

Drying Rate of the fishwas calculated using equation 3 (Sengar et. al., 2009)

$$\text{Drying Rate (D.R.)} = \frac{\Delta W}{\Delta T} \quad 3$$

Where ΔW = Loss in weight per hour, (g)
ΔT = Time Difference, (hr)

III. RESULTS AND DISCUSSIONS

The constructed fish solar dryer is shown on Plate 1. It was constructed at the Centre for Equipment Maintenance and Industrial training (CEMIT) of the Modibbo Adama University of Technology, Yola Adamawa State Nigeria using locally available materials.

Plate 1: Constructed Fish Solar Dryer

Table 1 and 2 present the result of temperate inside the drying chamber, the environment and the weights of the fish samples respectively

Table 1: Average Temperature Inside the drying chamber and the surrounding at 3 hours interval

Time of the Day (h)	Surrounding (Degree)	Inside the drying Chamber (Degree)
8:00	30.72	34.34
11:00	37.76	43
14:00	39.74	44.1
17:00	37.06	38.96

Table 2: Weight of fish samples at 3 hours interval

Time (h)	Weight A (kg)	Weight B (kg)	Weight C (kg)	Weight D (kg)
0	350	326	290	310
3	310	310	270	280
6	280	280	240	260
9	260	270	230	250
12	250	250	210	250
15	240	240	200	240
18	240	240	190	240
21	230	230	190	230
24	200	200	160	200
27	200	200	150	190
30	190	190	140	180
33	160	160	130	160
36	160	160	130	160
39	140	140	100	140
42	130	130	90	130
45	130	130	90	130
48	130	130	90	130
51	130	130	90	130
54	130	130	90	130
57	130	130	90	130

The Temperature profile inside and outside the drying chamber shown in Figure 3 indicated that the solar dryer assisted in raising the temperature of the surrounding by 11% from 39.74^0 of the surrounding to 44.10^0 which is the maximum temperature reached inside the drying chamber at 14:00 pm this in turn increases the drying rate of the fish.

The moisture content of the fish was measured during the drying process at intervals of 3 hours and used to show the drying pattern of the fish, the fish drying pattern is presented in Figure 4. It shows that all the 4 samples of fish placed inside the dying chamber reached a minimum reduction of weight after drying for 42 hours.

Figure 5 shows the moisture reduction profile of the fish, it indicated that all the 4 samples stop losing moisture after drying for 42 hours at this point the moisture content of the fish is about 16% which is safe for storing the fish.

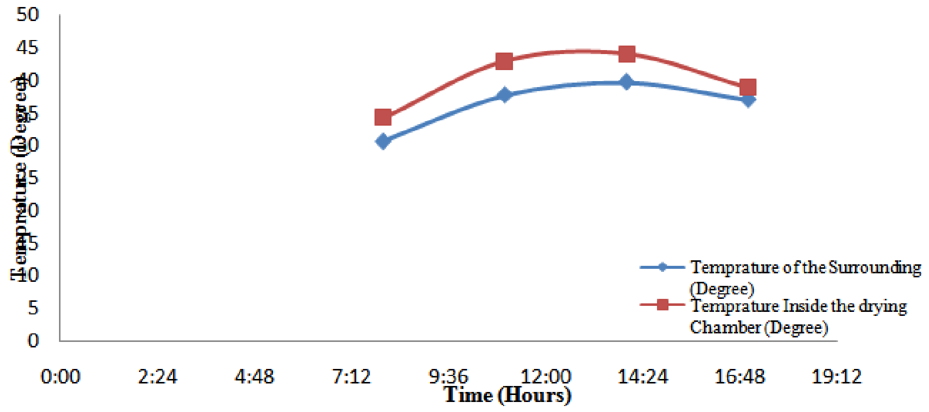

Figure 3: Temperature Profile inside the drying chamber and the surrounding

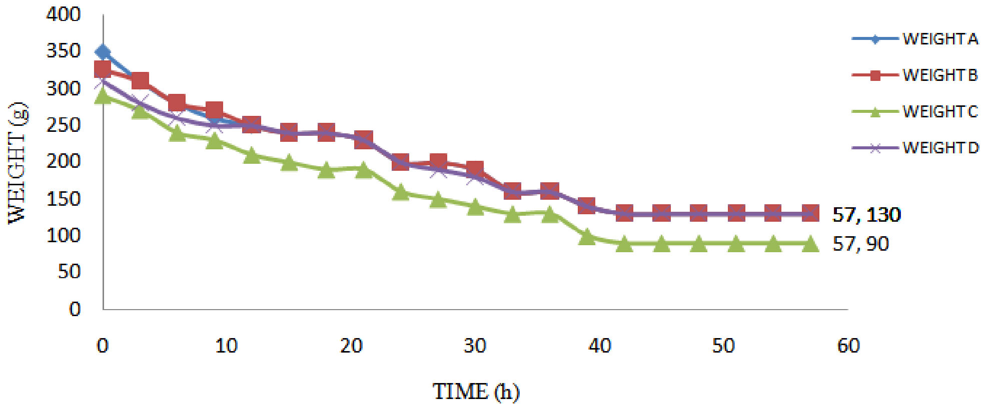

Figure 4: Fish Drying Pattern

IV. CONCLUSIONS

A fish solar dyer was designed and constructed using locally available materials which include woods, rods, glass and chicken wire mesh which makes it affordable to the local fish farmers and suitable for drying fish in a hygienic condition and faster than the traditional method of drying by 33%. The quality of the finished product is very good since taste, smell, colour and other hedonic properties of the fish were not affected in any way by this method of drying.

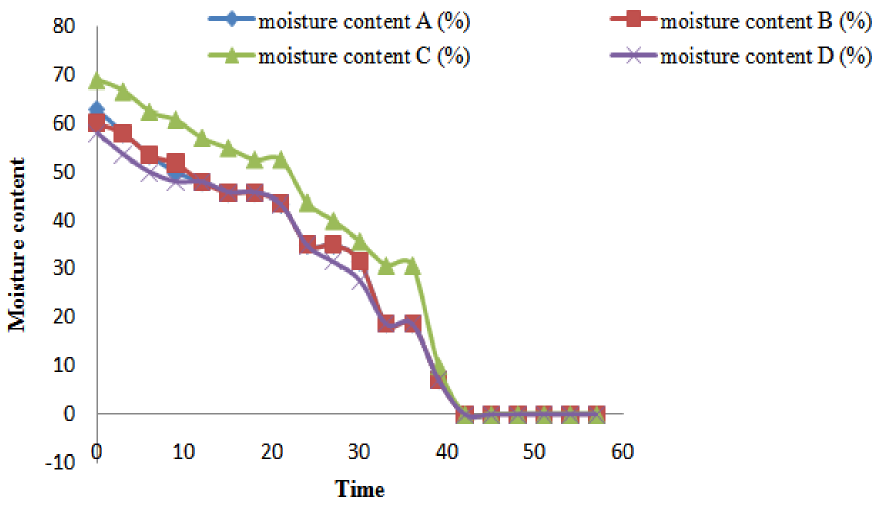

Figure 5: Moisture Reduction Profile

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