

## Evaluation of Traditional and Solar Fish Drying Systems Towards Enhancing Fish Storage and Preservation in Nigeria (Abeokuta Local Governments as Case Study)

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**Abstract:** This paper evaluates the traditional and solar fish drying systems in Nigeria. The results reveal that traditional methods still remain the predominant fish processing and drying methods employed in the country. The paper also discusses the advantages of using direct application of solar thermal energy employing some means of collecting solar radiation with the result that elevated temperatures and, in turn, lower relative humidity is achieved for drying fish in developing countries, like Nigeria. The use of solar dryer is an important step toward improving the traditional fish drying technology. Solar dryers can produce well-dried and dust free products. The contact between fish and flies which is virtually impossible to eliminate under traditional technique of fish smoking could be considerably eliminated if solar dryer are used. Three different types of solar dryers for drying fish were reviewed. Emphasis is based on the product quality and the economics of a suitable choice of design of the dryer, for improved drying of the important local fish species; over the local traditional sun-drying and smoking methods in Nigeria.

**Key words:** Evaluation, traditional, drying system, preservation

### INTRODUCTION

Solar thermal technology is a technology that is rapidly gaining acceptance as an energy saving measure in both domestic and commercial applications. It is fast becoming an alternative source of energy because of the high rate of depletion of the conventional energy sources. It is preferred to other alternative sources of energy such as wind and shale, because it is abundant, inexhaustible, and non-polluting<sup>[1]</sup>.

Solar energy has been used for centuries by man for drying animal skins and clothes, preserving meat and fish, drying agriculture crops and evaporating sea water in order to extract salt<sup>[2]</sup>. Due to unexpected high prices of agricultural products, their preservation is becoming more and more important nowadays. Also food preservation should be given priority in developing countries where agriculture plays crucial role in providing employment for the majority of the population<sup>[3]</sup>.

One of the applications of solar energy is in the drying of agricultural and food products. Drying is a process by which water is removed from a substance. According to Ikejiofor<sup>[4]</sup>, two types of water are present in food items; the chemically bond water and the physically held water. In drying, it is only the physically held water that is removed. The main reason for drying food items is

to reduce its water content to a level where it can be safely stored for future use.

The traditional practice of simply spreading the items in the open had proved very unsatisfactory. Large losses are generally incurred when this method is used. The losses are attributed to birds, rodents and domestic animals. Further disadvantage of this technique is due to lack of control over the drying rate, which usually results in under-drying or over-drying. Under-drying leads to deterioration of product due to fungi or bacteria whereas the over-drying may leads to case-hardening, which results in the spoilage of the product.

Artificial dryers have long been in existence, some of them powered electrically or by natural fuels such as fire wood, charcoal, dried refuse, sawdust, wood shavings and dried cassava peels. The ever-rising cost of electricity and natural fuels have kept the operating cost of these dryers rising and indication is that the trend will continue<sup>[5]</sup>.

Solar thermal technology can be used to assist with the drying of fish and fish products. Fish is an extremely perishable foodstuff. Spoilage occurs as the result of the action of enzymes (autolysis) and bacteria present in the fish and also chemical oxidation of the fat which causes rancidity. At the high temperatures prevalent in tropical countries like Nigeria, bacterial and enzymic actions are

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enhanced. Fish invariably become putrid within a few hours of capture unless they are preserved or processed in some way to reduce this microbial and autolytic activity and, hence, retard spoilage.

If the moisture content of fresh fish is reduced during drying to around 25%, bacteria cannot survive and autolytic activity will be greatly reduced, but to prevent mould growth, the moisture content must be reduced to 15%. Also the presence of salt retards bacterial action and, in addition, it aids the removal of water by osmosis<sup>[6]</sup>.

Due to increasing demand for fish, practical ways of cheaply and sanitarily preserving it are needed. Therefore, this paper estimates the supply of fishes and possible quantity of fish to be dried in the two Local Governments in Abeokuta. It also evaluates the current fish preservation techniques being practiced and finally considers the use of solar dryers as an important step toward reducing losses and improving quality of fish during fish drying.

## **MATERIAL METHODS**

In carrying out this research, questionnaires consist of a set of questions, designed to gather information and data for analysis were administered to the people engaging in fish smoking and other related businesses in Abeokuta North and South Local Governments. In this study, 100 questionnaires were administered and retrieved. Fifty questionnaires were administered in each of the Local Governments. In constructing the questionnaires, the following area were borne in mind: demography of the respondents, fish supply information, fish species smoked, quantity of fish stock processed daily, objectives for fish smoking, processing and preservation techniques, processing equipment utilized in fish smoking and sources of fuelling in fish smoking.

## **RESULT AND DISCUSSION**

The survey on the evaluation of traditional fish drying systems was carried out using well structured questionnaires. The results which were compared with the alternative of using solar fish dryers as preservation technique were presented in Tables 1 to 8.

Table 1 shows the demography of the respondents. The table reveals the average age of the people engaging in fish smoking activities in the Local Governments being considered as 32½ years. The highest education level of most of this people is primary education as shown also in Table 1. Therefore, the preservation technique employed is influenced by socioeconomic status of the people.

Table 2 shows sources of fish supply in the two Local Governments. The major source of fish supply is through cold store, followed by landing centers and then fishermen. The fish preservation in the cold store is through refrigeration and freezing, which is powered by electricity and as far as Nigeria is concerned today, the grid-connected electricity is unreliable and the cost of running diesel generator is high and not economical. This is one of the factors affecting the supply of fish in Nigeria. Therefore, the use of solar dryers can play a meaningful role in alleviating the problem.

Table 3 shows the fish species smoked in the Local Governments under consideration. Mud fish (Abori), Tilapia (Epiya) and Osan are the common fish species smoked in Abeokuta North Local Government while Herring, Mackerel, Hake and Sardin are the most common in Abeokuta South Local Government. The quantity of fish stock processed daily is shown in Table 4. The average quantity of fish processed daily by individual worker is 8.5 kg which could be handled by a simple cabinet solar dryer (Fig. 3). The objectives for fish smoking are shown in Table 5. As shown on this table, the main objective is to increase product pricing and other objectives are to facilitate supply to market, to prevent spoilage and loss, and for easier fish packaging.

Table 6 shows the processing and preservation techniques, and as shown on this table, smoking and smoking-drying are the most preservation techniques employed. The processing equipment mostly utilized for fish smoking is the cut-steel drum (Table 7). Also, sawdust, fire wood, dried cassava peels and wood shavings are the sources of fuelling in smoking with the following percentages of utilization: 26.3, 24.8, 23.7 and 22.6 % respectively.

Despite the rudimentary nature of the process involved in the traditional techniques, they still remain the predominant methods in Nigeria. The techniques expose the fish to unexpected winds, dust, dirt, infestation, and contamination by flies. The quality of the dried fish is often degraded seriously, sometime becoming inedible. To reduce post harvest losses and to improve the quality of fish and fishery products, traditional processing technology must be improved upon in Nigeria. This includes improvements in fish smoking and drying, and the use of solar dryers could play a vital role in fish processing technology in the country. In designing and building of the solar dryers, locally available, low-cost materials could be utilized to make the cost of the dryer affordable by the local users.

Table 1: Demography of the respondents

Characteristics	Frequency	Percentage %	Mean	Mode
<b>Age (Years)</b>				
< 20	15	15		
20 – 29	25	25		
30 – 39	45	45	32.5 years	35 years
40 – 49	8	8		
> 50	7	7		
Total	100	100		
<b>Educational Level</b>				
No Formal	22	22		
Primary	66	66	Primary Education	Primary
Post Primary	12	12		
Others	-	-		
Total	100	100		
<b>Business Experience</b>				
<4 Years	20	20		
5 – 9 Years	33	33		
10 – 14 Years	20	20	9.7 Years	7 Years
15 Years	27	27		
Total	100	100		
<b>Major Occupation</b>				
Fish Smoking	66	66		
Others	34	34		
Total	100	100		

Table 2: Fish supply information

Sources	Abeokuta North LGA		Abeokuta South LGA		Both Local Govts	
	Frequency of occurrence in 50 respondents	Percentage of occurrence in 50 respondents (%)	Frequency of occurrence in 50 respondents	Percentage of occurrence in 50 respondents (%)	Frequency of occurrence in 100 respondents	Percentage of occurrence in 100 respondents (%)
Cold Store	20	40	30	60	50	50
Fishermen	8	16	7	14	15	15
Direct Fishing	5	10	-	-	3	5
Landing Centres	17	34	13	26	30	30
Total	50	100	50	100	100	100

Table 3: Fish species smoked

Local Names	Scientific Names	Abeokuta North LGA		Abeokuta South LGA		Both Local Govts	
		Frequency of occurrence in 50 respondents	Percentage of occurrence in 50 respondents (%)	Frequency of occurrence in 50 respondents	Percentage of occurrence in 50 respondents (%)	Frequency of occurrence in 100 respondents	Percentage of occurrence in 100 respondents (%)
Mudfish (Abori)	<i>Clarias sp</i> <i>Heterobranchus sp</i>	45	90	7	14	52	52
Tilapia (Epiya)	<i>Tilapia sp</i>	46	92	9	18	55	55
Osan	<i>Gymnarchus niloticus</i>	12	24	2	4	14	14
Herring	<i>Sardinella maderensis</i>	9	18	38	76	47	47
Mackerel	<i>Scomberomerus sp</i>	4	8	42	84	44	44
Hake	<i>Merluccius sp</i>	3	6	47	94	50	50
Sardine	<i>Sardinella sp</i>	3	6	32	64	35	35
Total		122		177		297	

Table 4: Quantity of fish stock processed daily

Quantity (kg)	Frequency of occurrence in 100 respondents	Percentage of occurrence in 100 respondents	Cumulative	Mean	Class
< 5	42	42	42		Small
5 – 10	20	20	62	8.5	Medium
10 – 15	20	20	82		
15 – 20	12	12	94		
> 20	6	6	100		Large
Total	100	100	380		

Table 5: Objectives for fish smoking

Objectives	Frequency of occurrence in 100 respondents	Percentage of occurrence in 100 respondents (%)	Cumulative
Increased product pricing	98	98	98
Easier fish packaging	56	56	154
Prevent spoilage and loss	64	64	218
Facilitate supply to market	80	80	298
Total	298	298	

Table 6: Processing/preservation techniques

Techniques	Frequency of occurrence in 100 respondents (%)	Percentage of occurrence in 100 respondents (%)
Smoking	100	100
Salting	0	0
Drying	0	0
Salting and smoking	12	12
Smoking-Drying	78	78
Frying-Boiling	6	6
Total	196	196

Table 7: Processing equipment utilized in fish smoking

Equipment	Frequency of occurrence in 100 respondents	Percentage of occurrence in 100 respondents (%)
Coal Pot	2	2
Traditional Mud oven	5	5
Cut-steel Drum (half)	98	98
Charcoal oven	-	-
Open dug pit	-	-
Total	115	115

Table 8: Sources of fuelling in fish smoking

Fuel source	Frequency of occurrence in 100 respondents	Percentage of occurrence in 100 respondents (%)
Fire wood	68	24.8
Charcoal	2	0.8
Dried Refuse	5	1.8
Saw Dust	72	26.3
Wood shavings	62	22.6
Dried cassava peels	65	23.7
Total	274	100

## SOLAR DRYERS

Solar dryers employ some means of collecting solar radiation with the result that elevated temperatures and, in turn, lower relative humidity is achieved for drying. When using solar dryers, the drying rate can be increased, lower moisture contents can be attained and product quality is higher. The dryers are less susceptible to variations in weather, although drying is obviously slower during inclement weather, but they provide shelter from the rain. The high internal temperatures also discourage the entry of pests into the dryer.

Many forms of solar dryer for use with agricultural and fishery products have been developed in many parts of the world; only three different types are considered in this paper. Solar dryers can be categorized into two classes on the basis of the mode of air flow through the

dryers, i.e. natural convection or forced convection. Dryers that employ forced convection require a source of motive power, usually electricity, to drive the fan that provides the air flow. In Nigeria, like other tropical developing countries, motive power from any source is unreliable and expensive, and forced-convection dryers would not be a practical proposition for the majority of the people engaging in fish smoking activities in this country. Therefore, only natural-convection dryers are considered in this study.

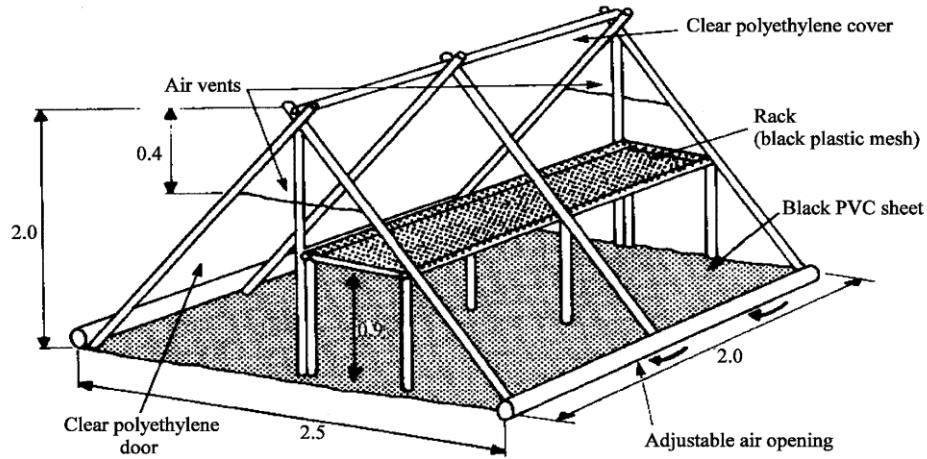
## SOLAR TENT DRYER

The solar tent dryer is shown in Fig. 1. The side facing the sun is of clear plastic sheet, while the other being a black plastic sheet, such that the combination of a dark surface with the plastic cover results in an “energy trap” of sorts. The principle of operation of the tent dryer is that insolation passes through the clean plastic side and ends of the tent and is absorbed on the black metal base, (collector) tilted from the ground at an angle depending on the geographical of area being used.

Air at the base is thereby heated and rises, thus including a draught within the tent. Openings at the base along both sides allow air to be drawn in, and vents in the apex at both ends allow air to exhaust. Some control of the internal temperature, and flow of air through the system, can be achieved by adjusting the height of the side openings. Design of the dryer is simple, using wood framework and plastic sheet. Metal sheet painted with black tar is used for the base of the tent. The drying rack is made using a black wire mesh. Access to the rack is through a movable plastic flap farming of half of one end of the tent. The flap could be closed and fastened when not in use.

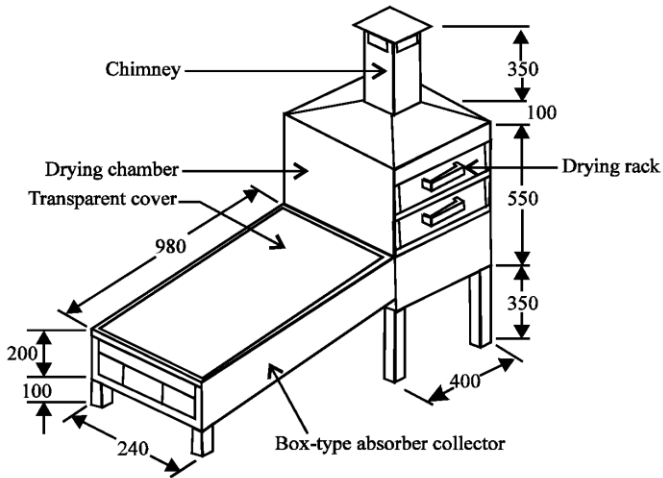
**Solar chamber dryer:** The solar chamber dryer is shown in Fig. 2. It differs distinctly from the tent dryer in that solar collector and the drying chamber are principally separate as shown in Fig. 2. The solar collector is inclined and it consists of a black metal sheet with a transparent plastic cover, one end of the collector has an air inlet vent and other end opens to the drying chamber. Air is heated during its flow through the collector and passes into the drying chamber before exhausting through the chimney. The function of the extended chimney is that the black sides absorb insolation and so heat the air within, thereby enhancing the natural convective flow of air through the dryer. The drying chamber houses drying racks which contained food item to be dried.

**Solar cabinet dryer:** This design of dryer is shown in Fig. 3 and is probably the most widely used dryer developed to date, being utilized for a large number of



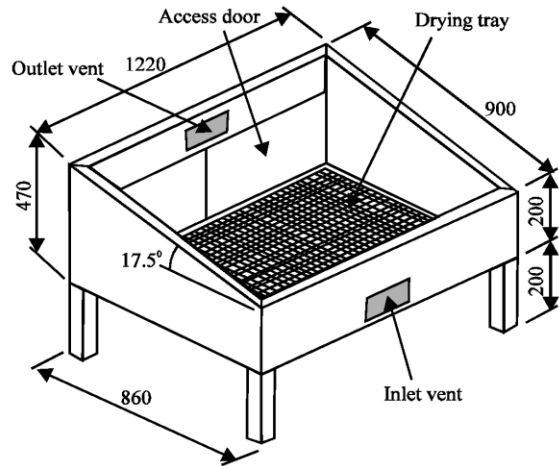
Notes: All framework constructed from bamboo  
Dimensions in meters  
Not to scale

Fig. 1: Solar tent dryer Tim and Curran<sup>[7]</sup>



All dimensions in mm

Fig. 2: Solar chamber dryer Bolaji, 2005b



All dimensions in mm

Fig. 3: Solar cabinet dryer Bolaji, 2005a

commodities. It is essentially a rectangular cabinet with an inclined plastic cover. The optimum angle of inclination of the cover is dependent upon the geographical latitude of the area being used.

Air inlet vent in the lower end of the front of the cabinet provide an entry for air which is then heated within the collector metal base and rises to exhaust through outlet vent in the upper parts of the back of the cabinet made of plywood with insulation between them, to avoid hot air escape. The potential of the cabinet to absorb insolation is enhanced by blackening all interior surfaces. The dryer is mounted on legs to facilitate air entry through the inlet vent and to reduce the risk of entry of pests into the cabinet. Simple temperature control may be achieved by leaving the doors partially open.

## CONCLUSION

The main reason for drying fish is to reduce water content (moisture content) so that the fish can be stored for future use without the need for refrigeration because, as is well known; dry fish can be stored safely for long periods. For this reason, this study evaluates traditional and solar fish drying systems in order to encourage fish storage and preservation in Nigeria. Abeokuta North and South Local Governments were used as case study area. The results reveal that traditional methods still remain the common fish processing and drying techniques employed in these Local Governments area. The methods incur losses that are often enormous and result in products whose hygienic quality leaves much to be desired. Due to

technical problems and inadequacies associated with traditional methods of drying fish, the advantages of low-cost, locally made solar dryers can be employed. Solar dryers produce well-dried products with reasonably long storage life. When used, the degree of losses due to insect infestation and contamination becomes insignificant. In this study, three different types of solar dryers (solar tent, solar chamber and solar cabinet) for drying fish were reviewed. Emphasis is based on the product quality and the economics of a suitable choice of design of the dryer for improved drying of important local fish species, over the local traditional drying and smoking methods in Nigeria.

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