

COMPARATIVE STUDY OF SUN AND SOLAR CABINET FISH DRYER OF THREE FRESHWATER FISH

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ABSTRACT

A simple solar drier was designed and constructed with metal drum. The solar drier was evaluated with three fresh water fish species; *Gymnarchus niloticus*, *Hetrotis niloticus* and *Clarias lazera*. The highest mean temperature that could be attained in the dryer was 70^oC at time 14.00 hour while the ambient temperature and insolation were respectively 33.5^oC and 857.6 w/m². Humidity recorded in the dryer was lower than that of sun dryer. The results of proximate analysis showed difference between the two techniques. The results of proximate analysis carried out showed that there was reduction in moisture of the solar dried *Hetrotis niloticus* and *Clarias lazera* and these were shown as follows solar dried *Hetrotis niloticus* 21% while the sun dried *Hetrotis niloticus* 26%, solar dried *Clarias lazera* 17% sun dried *Clarias lazera* 28%. Moisture reduction is very important in fish drying as low moisture will inhibit mould growth and increase the shelf life of the fish product. Microbial load was greater in sun dried than in the solar dried products and sun drying were infested by insects. The quality of the fish product dried in the solar drier was found to be superior to the open sun-dried ones. It took only three days for the fish to be completely dried in the solar drier compared with open-sun dried fish products which took complete seven days to be dried.

KEYWORDS: Fish, perishable, solar, processing, sun drying, solar energy

INTRODUCTION

Fish is highly perishable, nutritious and proteinous food as a result it is a suitable medium for growth and multiplication of micro-organisms after death. In the tropics as a result of high ambient temperature, spoilage is rapid combine with attack of micro-organisms, moulds, vermin and insects and chemical deterioration due to rancidity fish tend to spoil very fast (Conne, 1995). The aim of processing or preservation is usually to prevent these causes or usually reduce the rate at which they proceed. Sun drying is one of the traditional methods employed to preserve fish. It is the most common and cheapest form of preservation but very unhygienic due fact that products are expose due to the to the dust rain sand insects rats etc. The need to use solar energy for fish drying has become even more than necessary because of the huge cost of fuel and so many limitations of traditional methods of fish preservations. Solar drying is an improved method of sun drying. It minimizes or stops some of the limitations of open sun drying.

There has been a great deal of interest in the area of solar drying. The development of variety of solar driers as an improved method of drying fish in developing countries is indeed a welcome development. An indication of preparedness to tackle the problem of fish spoilage associated with the use of traditional techniques. This will greatly increase drying rates and produce lower moisture content in the final products with improvement in fish quality.

A wide variety of designs for solar driers have been developed. Some are built with inexpensive and readily available materials for example plastic film, bamboo, discarded oil drums, mud and thin metal sheeting.

In solar drying, solar energy is used as either the sole source of the required heat or as a supplemental source. The airflow can be generated by either natural or forced convection. The heating procedure could involve the passage of preheated air through the product or by directly exposing the product to solar radiation or a combination of both. The major requirement is the transfer of heat to the moist product by convection and conduction from surrounding air mass or by radiation from the sun at temperature above that of the product.

Absorption of heat by the product supplies the energy necessary for the vaporization of water from the product, (ECN, 1988).

A number of designs are available for achieving these objectives and they are usually classified according to the modes of heat transfer to the air and the manner in which the energy is utilized.

In this paper solar drier was constructed with metal drum which uses direct solar energy supplied directly to the product. The drum solar drier has been evaluated with fish species and found to be working effectively and efficiently. If it is introduced to fish farmers it will help to reduce the problems of traditional techniques of preserving fish to some extent.

Aims and Objectives

1. To develop a solar drier which can reduce fish losses and increase profitability.
2. To find out the solar drier that will help produce a better quality products.
3. To compare the traditional open-sun drying of fish with the experimental solar drying.
4. To evaluate the performance of a simple solar dryer using fresh water fish species that are of economic importance e.g *Clarias lazera*, *Hetrotis niloticus*, *Gymnarchus niloticus*

MATERIALS AND METHODS

An empty drum was used in the solar drier construction; this was cut into two by dividing it transversely. The two halves were reinforce with metal sheet of 16" gauge. The depth was increased by addition of 16.5cm metal sheet. Metal sheet was used to built the inside of drier which has the same shape with the cut out drier, by so doing double layer was created, having a narrow space between the outside and inside layer. The dimensions of the outside drier are Length. 93.8CM, width 63.8cm with diameter 58 cm. The dimensions of the inside are Length = 88.5cm, width = 53cm and the depth of 37cm.

The space between inside and outside drier was filled with saw dust as an insulator. The edge of the drier was framed with iron bar 93.8cm by 63.8 cm. The Perspex cover of the same dimension which acts both as a glazing material and as a cover that rests on the iron – framed edge when the drier is closed.

The solar drier has a creative design. The drum is mounted on a stand, with adjustable inclination to the sun. Angle – iron bar was used in the construction of the two lengths of the stand which measured 70 cm. Width of the drum was constructed with angle iron bar that was curved with diameter 53.3cm. At the bottom of the curved iron bar there is a triangle shaped stand on both sides. The dimensions are length. = 18 cm, width 7.5cm. The shape of the stand was designed in such a way as to hold the cylindrical shaped drum base.

Inside of the drum contain the tray and rack. The tray has the dimensions of Length= 85cm, width = 40.5cm Back has the dimensions Length=86.9cm and width = 48.7cm, fig 1.

Sun's radiation passed through the perspex into the drier and is absorbed by the walls of drier. Cool air enters the base of the drier through the opening created at the top of the drier of the drier. This heated air passes over the fish product and the fish is dried in the process and it goes out through the opening at the top. The depth of the drier is only 37cm, is a shallow drier as a result additional opening was not added.

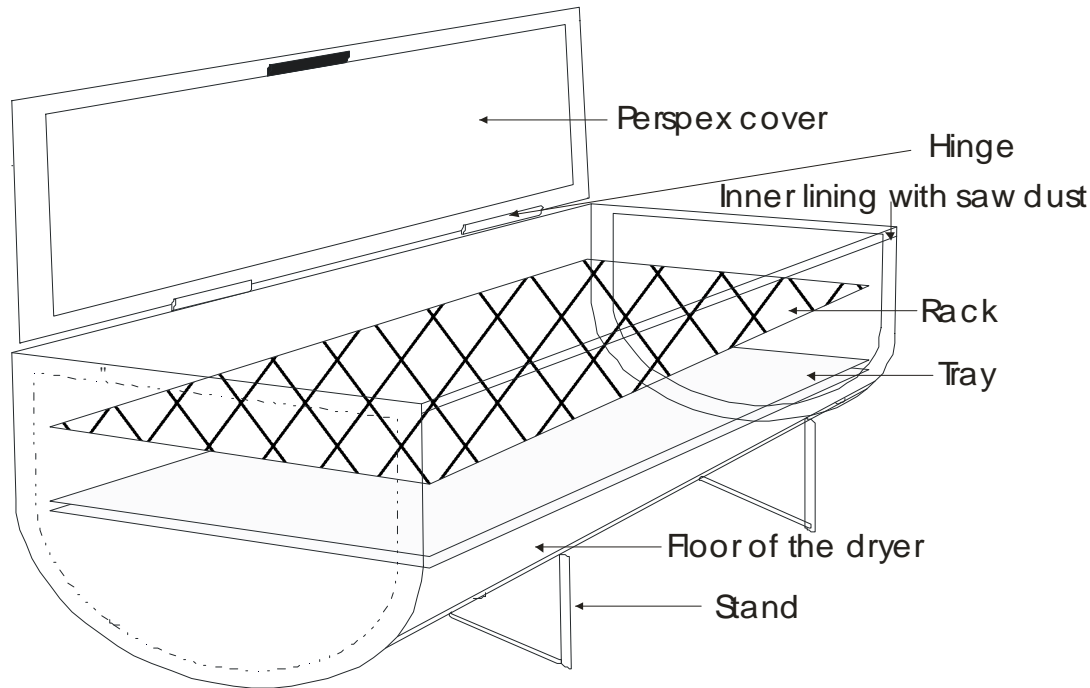


Fig.1: A Solar Dryer.

Fish Procurement and Preparation

Heterotis niloticus, *Gymnarchus niloticus* and *Clarias lazera* were used for the experimental trials. Fish were bought at Otuocha river side market. Otuocha is twenty minutes journey from the commercial city of Onitsha in Anambra State. The fish weighing about 2kg was used for the performance evaluation trial. The fish pieces cut into uniform sizes were used for the trial. The split, washed and weighed fish were treated in brine- salt of the following strength $10^0, 40^0, 50^0, 60^0, 80, 100^0$ and 0^0 . These are represented by Batches 1-7 respectively.

Fish were placed inside the solar in seven batches and were kept in the solar dryer till the end of the drying period. Sun drying was carried out using the same treatments and methods fish prepared for sun drying were placed on a rack suspended on top of the metallic pole and allowed outside for 9 hours daily and taken indoors at night, from 9.00am to 6.00pm.

Temperature and humidity was measured with temperature and humidity indicator. Measurements were taken every one hour and weight measurements were taken every two hours. At the end of the drying period, fish was stored away in clear polythene bags for subsequent analysis and for monitoring, both chemical and microbiological analysis were performed.

Determination of Total Viable Count (TVC)

1g of fish samples was macerated in sterile diluent (9ml of Ringer's solution). A measured amount of the suspension or of a known dilution of the suspension was mixed with malt extract agar medium in a petri dish. 1ml of each dilution was aseptically transferred into duplicate sets of disposable sterile petri dishes containing malt extract agar. After setting the plates were incubated at 37^0C for 24 hours. After which the number of colonies were counted.

Proximate Analysis of Product

The AOAC (1984) (Official methods of analysis of the Association of analytical chemist) method was used for ash content, crude fibre, fat, carbohydrate content, moisture and protein content was determined using the method described by Pearson (1976).

Determination of Acid Value or Free Fatty Acids (FFA)

25 ml of diethyl ether was mixed with 25 ml alcohol and 1ml of phenolphthalein solution (1%) and neutralised with 0.1M Sodium hydroxide. 1-10g of the oil or melted fat was dissolved in the mixed neutral solvent and titrated with aqueous 0.1M sodium hydroxide shaking constantly until a pink colour which persisted for 15 sec. was obtained.

$$\text{Acid value} = \frac{\text{Titration (ml)} \times 5.61}{\text{weight of sample used}}$$

The FFA figure is usually calculated as Oleic acid 1ml of 0.1 M sodium hydroxide = 0.0282g oleic acid) in which case the acid value = 2 x FFA

Determination of Peroxide Value

A 100ml of round bottomed flask with a ground glass joint is attached to a plain reflux tube, 75cm long 9mm internal diameter the upper 15cm of which are cooled by a water jacket. 10ml of chloroform and 10ml of glacial acetic acid was added to the flask and, using a micro gas flame close to the flask, the mixture was boiled to top of the tube where it was condensed by the water jacket. 1g of potassium iodide dissolved in 1.3ml was poured slowly down the condenser when the mixture was boiling steadily so that the refluxing was not interrupted. 0.3ml water was added to redissolve any precipitated iodide. 1g of the sample was added down the condenser without interrupting the refluxing and condenser water was turned off so that all the sample was washed into the flask. The mixture was boiled for more 4 min; the flask was removed, and cooled rapidly. 50 ml of water was added and the liberated iodine titrated with 0.01M sodium thiosulphate using starch.

Determination of Thiobarbituric Acid Number or Value (TBA)

Method

10g of fish was macerated with 50ml of water for 2min and washed into a distillation flask with 47.5ml water. 2.5 ml of 4M hydrochloric acid to bring the pH to 1.5, followed by an antifoaming preparation and a few glass beads. The flask was heated by means of an electric mantle so that 50 ml distillate was collected in 10 min from the time boiling commenced. 5 ml of distillate was pipetted into a glass stoppered tube; 5 ml of TBA reagent (0.2883g/100ml of 90% glacial acetic acid) was added stoppered, shook and heated in boiling water for 35min. A blank was prepared similarly using 5ml of water with 5ml reagent. The tubes were cooled in water for 10min and the absorbance (D) measured against the blank at 538nm using 1 cm cells TBA no (as mg malonaldehyde per kg sample) = 7.8D.

Water Activity (^aW) Determination

The water activity (^aw) of the fish sample was determined using the Germany made water – activity – wert – messer.

About 10g of the thoroughly minced sample sufficient to cover up to 1/5th of the ^aw- wert – messer was put into the instrument, covered and left undisturbed for 1 hour. Then the result was taken which is read out from ^aw- wert-messer -scale.

RESULTS AND DISCUSSION

Table 1: Total viable count on *Hetrotis niloticus* in the open sun and solar drier after 5days period of incubation on malt extract agar.

S/No	Sample Description	Dilution Used	Plate 1	Plate 2	Average	No. of org/g
1	Solar drum drier <i>Hetrotis niloticus</i> 100 ⁰	10 ⁻¹	6	9	8	8 x 10 = 80/g
2	Solar drum drier <i>Hetrotis niloticus</i> (10 ⁰ brine salting)	10 ⁻¹	5	2	4	4x10 = 40
3	Sundrying <i>Hetrotis niloticus</i> (100 ⁰ brine salting)	10 ⁻¹	188	176	182	182 x 10 = 1,820g

Table 2: Humidity changes with time during the solar drying fish.

Time	Humidity (%)	Humidity (%)
9.00	90	83
10.00	83	71
11.00	82	68.0%
12.00	76	63.5
13.00	56	34
14.00	63.3	42.9
15.00	84	44
16.00	57	53
17.00	52.7	33.8
18.00	91	83

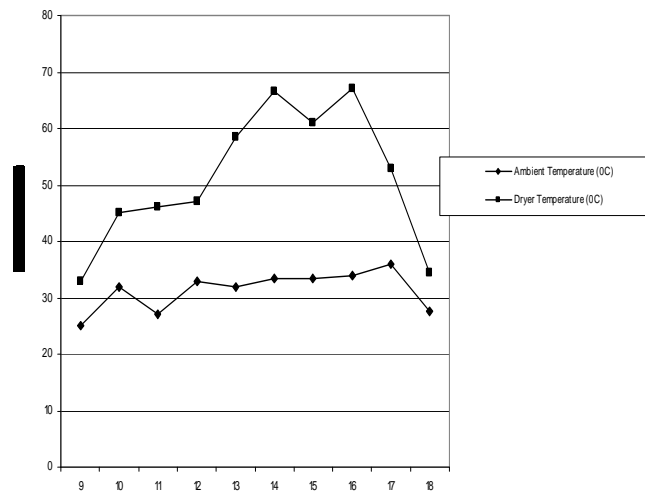


Fig 2 .Changes in dryer and ambient temperature .

Table 3: Proximate analysis of solar and sun dried fish

	Moisture	%protein	%fat	%fibre	%Ash	TBA	Peroxide value	Acid Value	FFA
1. Solar dried <i>Hetrotis niloticus</i> 100 ⁰	21.0	10.3	14.5	1.6	3.1	0.67	6.6.	17.9	0.51
2. Sun dried <i>Hetrotis niloticus</i>	26.0	13.6	13.3	1.3.	3.6	0.78	4.4	18.5	0.53
3. Solar dried <i>Clarias lazera</i>	17.0	14.6	11.1	1.4	3.8	0.75	2.4	17.4	0.49
4.Sundried <i>Clarias lazera</i>	28.0	17.0	9.0	1.2	3.9	0.78	2.0	18.9	0.50
5.solar dried <i>Gymnarchus niloticus</i>	11.6	15.0	16.1	1.0	2.1	106	5.8	20.2	0.57

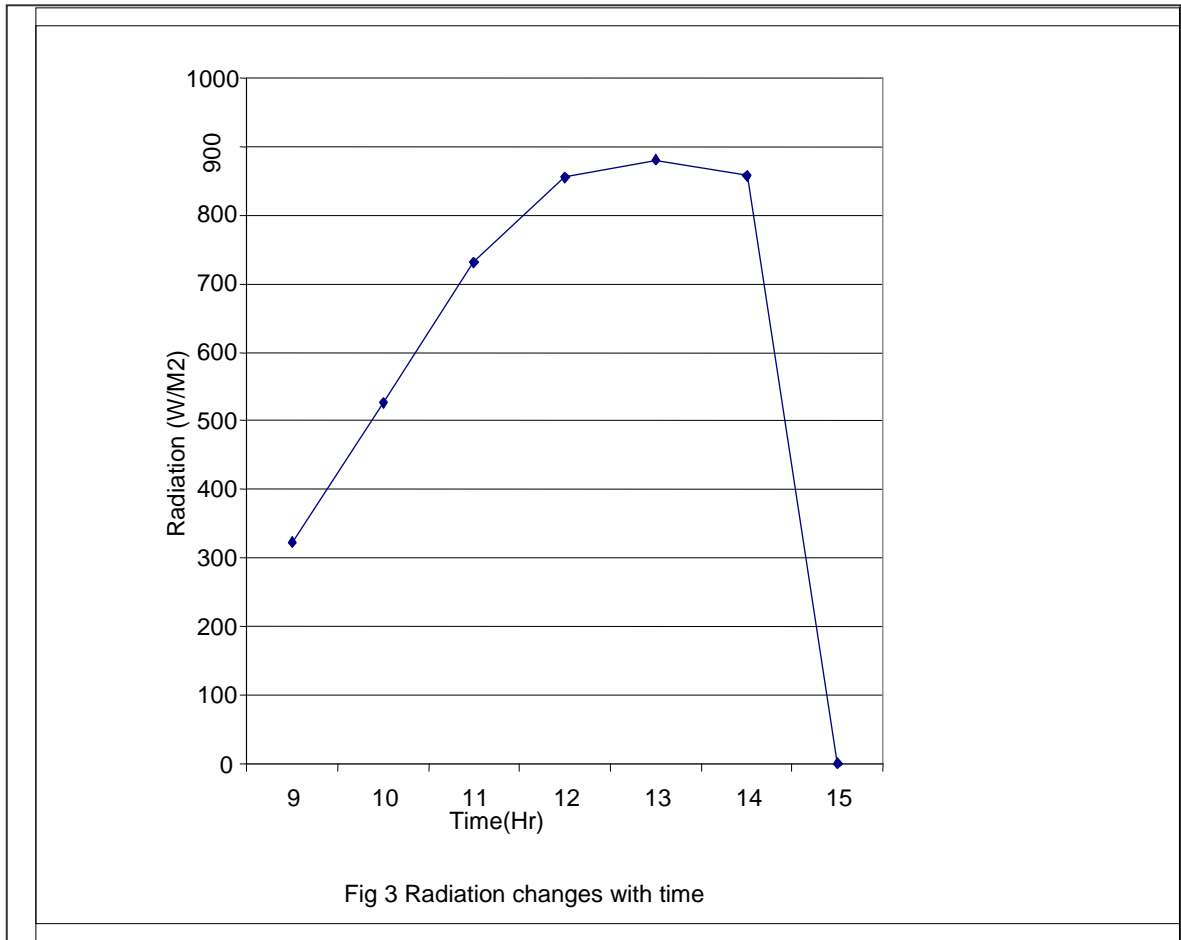


Table 4: Water – activity of solar and sun dried

Type of fish	Fish Batch1	Batch 2	Batch 3	Batch 4	Batch 5	Batch 6	Batch 7
Fresh <i>Clarias lazera</i>	0.93	0.93	0.93	0.90	0.89	0.89	0.89
Solar dried <i>Clarias lazera</i>	0.78	0.77	0.77	0.78	0.77	78	0.72
Sun dried <i>Clarias lazera</i>	0.79	0.76	0.70	0.76	0.76	0.74	0.75
Fresh <i>Hetrotis niloticus</i>	0.85	0.85	0.85	0.88	0.88	0.88	0.93
Solar dried <i>Hetrotis niloticus</i>	0.73	0.74	0.76	0.76	0.76	0.76	0.71

There were continually higher temperatures inside the solar dryer. The highest temperature recorded in the dryer was 70 °C at time 14 .00 hour when the insolation was 857.6 W/M² the ambient temperature recorded was 33.5°C. Fig. 2. Shows the temperature changes in the dryer. Temperature in the dryer increases with time. The high temperature in the dryer was measured between the hours of 13 and 14 and while low temperatures were recorded around the hours of 9-11 and 15-17. Higher radiation was recorded at noon time while lower radiation values were recorded in the morning and evening hours (see fig.3). Rate of drying are affected by temperature, radiation changes and humidity, salting and exposed surface area.

Rate of drying would be faster if the fish was placed in the dryer before noon, preferably between the hour 10.00 – 12.00 in the afternoon. The first 9 hours was the most critically period in the drying process. The first two days water removal from the fish was faster in the solar dryer while the last two days of the drying was very slow. The water removal was faster intially and later became slower.

As a result of higher temperature achieved in the solar dryer it took 3 days for the fish product to be completely dried for *Hetrotis niloticus* and *Clarias lazera* and 31 hours for *Gymnarchus niloticus*. Open sun drying took maximum of seven days to be completely dried. Case hardening was observed in the *Clarias lazera*, dried in the open- sun. After about four days of drying process, the fish was taken out for examination and when it was pressed slightly, so many maggots were seen falling out of the fish, the time when the fish was thought to have dried by merely looking at it. The fish surface was hard while the inside was soft, almost at the verge of spoiling that is case – hardening. The same thing was observed in all the seven batches. The case hardening could be as a result of rapid drying of the fish caused by high ambient temperature which only concentrated on the outside and could not penetrate the inside of the fish making the fish have outer hard casing. This outer casing made it difficult to allow further moisture loss in the fish. If it was not discovered in time could result in substantial losses of the fish product

Insects activity during the trials presented an interesting comparison. In the morning when insolation was low, insect activity was high especially during the first two days of sun drying. For the solar drier the few flies that attempted and entered the dryer in the morning when weighing was taking place, were found dead at the floor of the drier when the temperature of drier rises at time 10.00 hour.

During the solar drying of *Clarias lazera*, *Hetrotis niloticus* and *Gymnarchus niloticus*, the drying hour was only four hours the first day, yet the fish showed good quality throughout the period of solar drying.

Table 2 shows the humidity changes in the dryer. Humidity in the dryer was always lower than the ambient relative humidity. Highest humidity percentage obtained was during the morning and evening hours. For the ambient, the highest humidity was 91% when the dryer humidity was 83% at time 18.00 hour, followed by 90% ambient when the dryer humidity was 83% at time 9.00 hour. The lowest humidity 33.8% was obtained at time 17.00 hour when the ambient is 52.7%. These observations are in line with observations of Osei-Opare and Kukah (1988).

Compared with sun drying temperature found in the dryer was high enough to dry the fish product within three days while the products in the sun rely only on the ambient which was than the ambient temperature of the sun which is necessary for the drying to be faster.

Proximate analysis of open-sun dried and solar dried fish are shown in table 3. Low levels of moisture content were achieved for products from solar dryer than were achieved in the sun dried products. Protein % is higher in the sun dried than solar dried, though very little increase. It appears that *Gymnarchus niloticus*, *Hetrotis niloticus* and *Clarias lazera* are fatty fish. This was shown by the percentage crude fat found in all of them. *Gymnarchus niloticus* has the highest percentage followed by *Hetrotis niloticus* and *Clarias lazera*. Fish body oils are very susceptible to oxidation by atmospheric oxygen leading to rancid flavours. These flavours may decrease the acceptability of the product. In this work the product of solar dried was found in good condition throughout this work no off- colour nor off- odour was dictated except in the sun dried product that had a little change in both odour and colour.

Thiobarbituric acid test (TBA) (table 3) appears to measure deterioration in both extractible and non-extractible lipids and therefore has been more frequently applied in the fatty foods especially flesh foods. Initial high values

were reduced by drying processes. There is no much difference in the value of thiobarbituric acid value in the open-sun drying and solar drying. The resulting low value indicated a low level of lipid oxidation.

Peroxide value is commonly used to assess rancidity development. A rancid taste often becomes noticeable at peroxide value of 10-20. Peroxide value is low in both the solar and open-sun dried products(See table 3).

Free fatty acid (FFA) content measures the extent of lipid hydrolysis by lipase action. As rancidity could be accompanied by FFA formation. The FFA value recorded in this work is low and hence there is no fear of rancidity, which resulted in high free fatty acid values which seemed to be related to mould development and high water activities and most likely reflect the degree of enzymic activity. This agrees with the work of Frazier and Westhoff (1998).

The quality of fish product dried in the solar drier was found to be superior than the sun dried products. This is shown in the colour, taste and odour of the solar dried products. All the products were brined salted except batch 7 which contains no salt. Salting affects the appearance, flavour and shelf life of cured fish. The batch that contains no salt developed a putrid odour and batch one is found also to be putrid probably because of the low salt content ,it was brined in 10° brine - salt solution. This is in line with the findings of Bhandary (1988), ILO, (1986). Table 2 shows the total viable count on *Hetrotis niloticus* in open sun and solar drier after 5days period of incubation on malt extract agar.

Micro-organisms proliferate in the presence of water, so as the moisture content decreases during drying period, most micro-organisms that cannot survive dry environment die off and so the microbial load is decreased and so fish remain unspoilt even when kept for a long period, Frazier and Westhoff (1998).

Treatments of fish with salt helps to reduced bacterial load, but the fish sample treated with 100° brine- salting that were exposed outside during the open-sun drying was found to have the highest bacterial load. Exposing the fish to the air must have helped in increasing the bacteria load fish with dirt and dust these can help to increase bacterial load. Drying in an enclosure is better since it helps in reducing microbial load, it can be said to be more attractive than open-sun drying. This is in line with the findings of Bhandary (1988); Anderson and Mendesohn (1972).Table 4 Shows the result of water activity of solar and sun dried fish. Water activity is the index of the availability of water for chemical reactions and microbial growth. Decrease in moisture means decrease in water activity; the decrease is related to the type of treatment and duration of drying. Water activity recorded for dry meat and was 0.85- 0.93, Frazier and Westhoff (1998). In this work there was decrease in the water activity of fish in both system but lowest in the solar dried.

Solar drier constructed with drum has been found to be very effective and efficient, and it simple and easy fish operation. The drying system can be adopted by small scale fish farmers and fishermen; this will help them reduce losses resulting in poor processing techniques of the traditional methods of preservation of fish.

In conclusion, using locally available material, a low cost, high temperature, simple – to – operate solar dryers has been designed and constructed.. The results of proximate analysis carried out showed that there was reduction in moisture of the solar dried *Hetrotis niloticus* and *Clarias lazera* and these were shown as follows solar dried *Hetrotis niloticus* 21% while the sun dried *Hetrotis niloticus* 26%, solar dried *Clarias lazera* 17% sun dried *Clarias lazera* 28%. Moisture and water activity reduction is very important as low levels will inhibit mould growth and extend shelf life of the fish product. Microbial load was greater in sun dried due to exposure to dust and dirt. And were infested by insects. The dryer is most suitable for drying fish and other agricultural products.

Government should collaborate with private organizations, individuals, Co-operative societies, non-governmental organizations to ensure that small-scale fisher men or artisanal fishermen are provided with solar driers. This will ensure food safety and food security.

Awareness should be created so that the use of solar driers is popularized especially among the urban dwellers.

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