

## **DESIGN OF A PROTOTYPE SOLAR TENT DRYER.**

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### **ABSTRACT**

The design and test of a solar tent dryer leads to the understanding, of how best we can obtain a dried commodity under solar drying technology. Local materials are used in the construction. The rates of moisture lost by commodity during drying are determined such that drying rated curves are constructed. The solar Tent dryer has been used to achieve a high quality product without any contamination by dust and infestation by insects and with the retainments of the commodity nutrients.

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### **INTRODUCTION**

The preservation of crops and foodstuffs is one of the first and most important techniques of food processing. Man has to store proportional amount of agricultural produce grown or produced during the harvest period to feed him until next harvest. In the early stages, the sun had been the choice of method of preservation of foodstuffs in the warmer or sunnier areas of the world.

Among the method of preservation are drying of grain, foodstuffs, salting of fish, meat, vegetable and sugaring of fruits. The preservation of commodities depends on the climatic condition, nature of foodstuffs, availability of materials and degree of technology available to the processor. Sun drying is widely used in the world for agricultural processing. Solar dryers make an improvement of traditional methods of sun drying of crops and foodstuffs. it makes use of solar energy that arrives at the earth in form of electromagnetic radiation covering a wide range of wavelengths and energies. The dryers are developed due principally to increasing labour costs, improving quality standards and uncertain weather during sun drying. The dryers are capable of providing high quality product independently of the weather and with a low labour requirements. There are three main types of solar dryers widely acceptable thus:- Direct dryers employing natural convection with a combined solar collector and drying chamber e.g. cabinet dryer and tent dryer, the indirect dryers employing forced convection with separate collector and drying chamber and the direct dryers employing natural convection with separate collector and drying chamber e.g. a chimney dryers. The objective of this present paper is to study the performance of solar tent dryer relative to the direct sun dried product, understanding its mechanism and share the experience with other researchers working in the same field and developing a better solar tent which can be use in the country.

### **Solar Dryer**

Here we will describe the solar dryer designed by us. The solar tent dryer is originally designed for use with fish. It consists of ridge like tent framework covered with clear glass on the ends and the part facing the sun, and black glass sheet on the side in the shade and on the ground within the tent. The clear glass sheet serves as the transparent cover called solar collectors, which is used to gain useful heat energy from the sun's radiation. It may be either concentrating or non-concentrating i.e. flat plate type. For the purpose of the dryer a flat plate air heating collectors are used to provide the desired temperature elevation. Painting the clear glass makes the black glass sheet black and it serves as the absorber plates. The drying rack is placed centrally along the full length of the tent with area of  $1575\text{cm}^2$  and is used naturally to dry fish. The drying rack is made of wire gauze or wire netting with stands. The glass sheet is arranged in such a way that the sun has access to the rack. The solar tent dryer was built having surface areas of  $3772\text{cm}^2$  as shown in fig. 1. Wood poles are used as a support for this dryer. It was placed at the edges and on top of the dryer. Holes were made in the lower wood to effect the

passage of air into the drying chamber while the two wood placed at the top will be raised up and down for the exhaust air to flow out of the drying chamber. screws were used to attach the glass to the bamboos.

#### Experimental measurements.

A pre-drying process of cleaning and salting was carried out before starting the drying. The cleaning is to remove dirt while salting is used to achieve some moisture removal by osmosis and inhibit microbial attack. After this, the Gallenham weighing scale was used to measure the fish that was to be dried and another one (to act as a control which is to be dried under the sun) is also measured. They were loaded on the tray and pushed inside the drying chamber or rack. The subsequent measurements of the fishes at every one-hour to determine the loss in weight due to drying are taken. The ambient temperature was measured by using the Digital thermometer every thirty minutes. Ambient temperature above the fish in the dryer (absorber temperature) was noted every 15 minutes. The relative humidity of ambient air was taken at every hour. The amount of solar radiation reaching the earth surface was measured with the Eppley pyranometer and the beginning time of drying was noted with stopwatch.

The standardized drying rates is given as

$$SDR = (dm/dt)_{\text{measured}} (60/T_p - T_a)^{2/3} (B/RH)^{5/3}$$

Where SDR = Standardized drying rates

$dm/dt$  = drying rate

$T_p$  = plate temperature

$T_a$  = ambient temperature

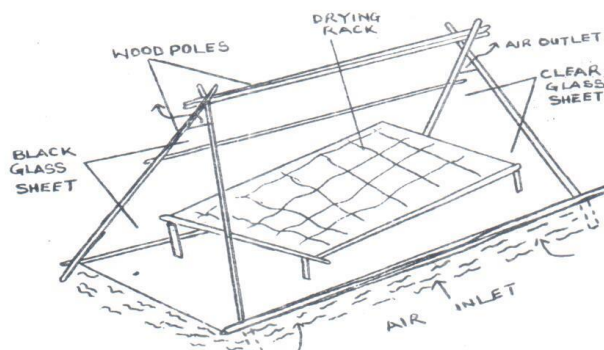
$B$  = height of packed bed

$RH$  = relative humidity

The out door testing of the solar tent dryer starts in the morning and was done between the month of August and September 1998.

#### Result and Discussion

There is comparison of the fishes dried in the dryer and under the sun, it is noted that the fish in the dryer was fully dried while that placed under the sun shows some variable with the part facing the sun fully dried while the other side is not dried. The control fish was contaminated by dust due to the weather conditions and there is infestation by flies. The flies infesting on the fish in dryer was later found to disappear after some time-this is due to increase in temperature. The maximum temperature attained is 35 °C, this is because the testing of the solar tent dryer was done in the month of August which is in the rainy season.



Diagram

Fig 1: Schematic Diagram - of Solar tent dryer

◆ absorbertemp(oc) ■ Ambtemp(oc)



Fig. 2

◆ Rate of drying(ghr) ■ control fishrate of drying(ghr)

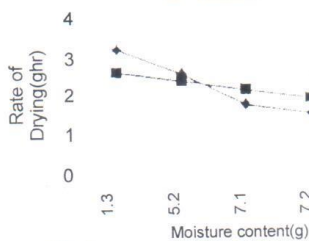


Fig. 4

◆ fish dryerweight (g) ■ control fishweight (g)

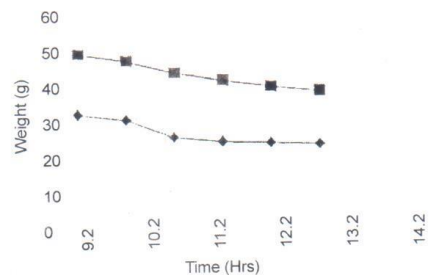


Fig. 3

◆ absorbertemp(oc) ▲ ambtemp(oc)

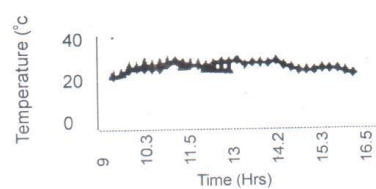


Fig. 5

◆ Fish dryerweight (g) ■ control fishweight (g)

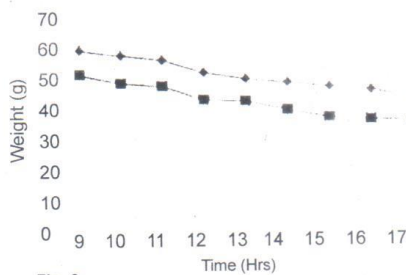


Fig. 6

◆ Rate of drying(ghr) ■ control fishrate of drying(ghr)

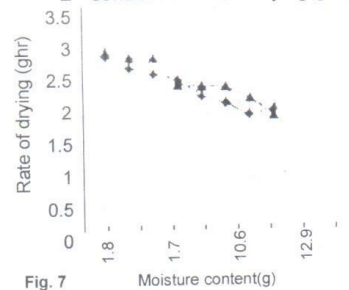


Fig. 7

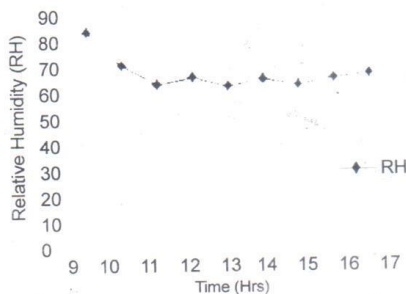


Fig. 8



Fig.1 Ambient and Absorber temperature( $^{\circ}\text{C}$ ) versus Time (Hrs)measured on the 30th August

Fig.2 Weight(g) versus Time (Hrs)of the fish in the Dryer and control fish on 30th August.

Fig.3 Rate of drying (ghr) versus moisture content(g) on 30th August

Fig.4 Ambient and Absorber temperature( $^{\circ}\text{C}$ ) versus Time (Hrs)measured on the 3rd September

Fig.5 Weight(g) versus Time (Hrs)of the fish in the Dryer and control fish on 3rd September.

Fig.6 Rate of drying (ghr) versus moisture content(g) on 3rd September.

Fig.7 Relative Humidity versus Time(hrs)

Fig.1 and 4 show the measurement made on 30<sup>th</sup> August and 3<sup>rd</sup> of September for absorber and ambient temperature ( $^{\circ}\text{C}$ ) with time (hrs). The absorber maximum temperature is  $35^{\circ}\text{C}$  and the maximum ambient temperature is  $32^{\circ}\text{C}$ , although there was variation in the ambient and absorber temperature due to the wind and solar radiation received in the atmosphere. The productivity of solar dryer increases as the ambient temperature increases. In sun drying the ambient temperature is used and this has an average of  $32^{\circ}\text{C}$  during the period, which this analysis is made. Fig.2 and 5 shows the variation of the fish weight in the dryer and control fish weight with time. One notices that as solar radiation increases, the weight of the fish in the dryer and control fish decreases with time. The rate of drying (ghr) versus moisture content (g) is shown in fig 3 and 6. This decreases with moisture content. This is due to the fact that the rate of drying is controlled by the rate of evaporation from the wet spots, partly by moisture migration within the particle and the condition of the air adjacent to the surface. As drying continuous, the dry surface proportion of the particle increases and the rate of drying becomes less dependent on air velocity. Eventually the surface of the particle becomes dry and internal moisture migration becomes the rate controlling process. If the temperature of the air increases, then rate of drying would increase as intra-particulate moisture movement becomes more rapid as the temperature increases.

The variation of relative humidity with time is shown in Fig.7. The productivity of the solar dryer increases as the relative humidity of the air decreases with time. The prototype solar tent dryer was first designed by Doe *et al* (1977), they noted that the maximum temperature for the drying of fish is  $50^{\circ}\text{C}$ , above this temperature the fish cooks. They were able to achieve internal temperature of  $45^{\circ}\text{C}$ .

## CONCLUSION

A prototype solar tent dryer has been produced using local materials that are cheap and readily available. The technology is simple, local artisans can produce such driers easily. The solar tent dryer can be used to dry produce that has high moisture content like fish, grains and onions.

The dryer has a high-energy gain of about  $3762\text{WM}^{-1}$  for a typical August day and overall efficiency of 30%. Its moisture removal capacity is high; in addition, it has a drying advantage over the open air-drying method. One can estimate that the drying airtime is about half the open air-drying time. Thus the dryer has a high capability of reducing spoilage, contamination by dust, inappropriate drying rates and eliminating infestation associated with open air-drying, which is practice in Nigeria.

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