DESIGN AND PERFORMANCE OF AN ECO-FRIENDLY DOMESTIC SOLAR DRYER FOR AGRICULTURAL PRODUCTS IN AGBOR, DELTA STATE, NIGERIA

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ABSTRACT

A passive solar dryer in the form of a wooden box covered with Perspex, capable of drying about 1.5kg of agricultural products was designed for use in Agbor, a predominantly agricultural setting of latitude 6^{0}.4'N. The design is simple and the technology is not complicated, as it considers the average poor farmers dwelling in the rural areas. To corroborate this research, Yam chips were dried in the dryer and in the open. Comparatively, drying with the dryer yielded a better result than open air-drying. In the brief period of monitoring, a maximum average dryer temperature of 49.5^{o}C was recorded, as against a maximum average ambient temperature of 37^{o}C. This gives the utilization of the dryer a lot of advantage over open air-drying.

INTRODUCTION

The energy forms present in the earth can be classified into renewable energy (energy derived directly or indirectly from the sun) and non- renewable energy (energy derived from fossil fuels, such as coal, oil and natural gas). The energy from the sun (solar energy) has inherent advantages over all other forms of energy because of its renewable nature, wide range of application, near non- hazardous nature, abundant availability even in regions remote from the source of fossil fuels and direct usage (not being processed before use) (Edward, 1978 and Richards, 1972). These advantages, thus encourages research in the technology and application of solar energy

The direct use of solar energy cannot be said to be new, as it was used by pre-historic man for the traditional drying of his crops, by simply spreading the crops on the bare ground (Daniel, 1964). However, this method of exposing the products to be dried in the open, makes the farmer suffer some inconveniences, such as: rainfall, insect and rodents (animals) attack, which will demand his constant presence to gather the crops when it is threatening to rain and to chase away animals coming to feed on the crops (Eggers, 1976). Also, Agbor is a predominantly agricultural community cultivating such crops as: maize, yam, melon, pepper e.t.c.

Most crops planted here are harvested annually, often in the rainy season with reduced insolation. Since harvested crops must be dried to 12%-14% moisture content to prevent loss in quality and quantity due to attack by micro- organisms e.g mould before they can then be stored till when needed, at other times of the year either for planting or for food and to forestall the aforementioned inconveniences the use of the solar dryer (for drying these crops becomes imperative.

The dryer used here, was designed and constructed locally, but the emphasis here is on its performance/evaluation.

STUDY AREA

Agbor is a town in Ika south Local Government Area of Delta State, located approximately at latitude 6.43°N.

This research was carried out specifically in the geography station of the college of education, Agbor. The choice of this location for this work was informed by its reserved/isolated nature and the presence of instruments needed to measure other parameters such as, ambient temperature needed in this research, among other things.

METHODOLOGY

This paper compared drying rate in the dryer and in the open (outside), and temperature in the dryer and ambient. To this end two thermometers T_1 and T_2, were used to measure the temperature inside the dryer (with T_1 at the upper end and T_2 at the bottom of the rack and the mean temperature. T obtained in degrees centigrade. while a third thermometer, T_3 was used to measure ambient temperature in degrees centigrade.

To reduce the volume of this work, only yam chips/ slices was dried, both in the dryer and in the open. Two yam tubers of the same size (mass) were cut into slices/chips (of equal sizes). The chip from one of the tuber was then dried on a rack, in the dryer while the other was dried on a rack in the open.

The mass of the yam chips in the dryer was designated M_1 (g) while the mass of that in the open was designated M_2 (g). Temperature and mass in the dryer and in the open were then recorded at hourly interval from 8.00am-4.00pm each day, for five consecutive days. The result is presented in

Table 1 (A-E) below. The percentage loss in mass also recorded in the table was computed using $\frac{b-a}{b} \times 100$

Where b in grams, is the initial mass and a in grams is the mass at the end of each day. A graph of the dryers temperature and ambient was then plotted against time (in hours) as shown in Fig. 1(A-E) below. This affords the comparison of the dryer's temperature and ambient. Also using the data in Table 1 (A-E), it is possible to draw a graph of percentage loss in mass against time. A bar chart is obtained which will make it easy to compare the rate of drying inside the dryer and in the open, Fig. 4.

DESIGN AND CONSTRUCTION

In the design of a cabinet dryer, a lot of design factors must be taken into consideration, so that the dryer can serve the purpose for which it is intended. The collector area, height of vent and height of drying rack, should all be given thorough consideration.

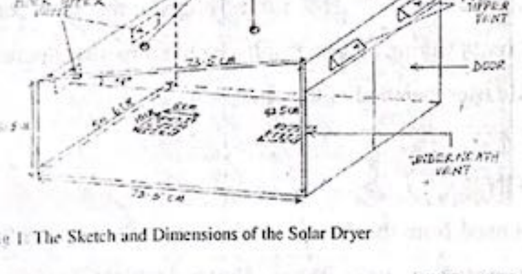


Fig 1: The Sketch and Dimensions of the Solar Dryer

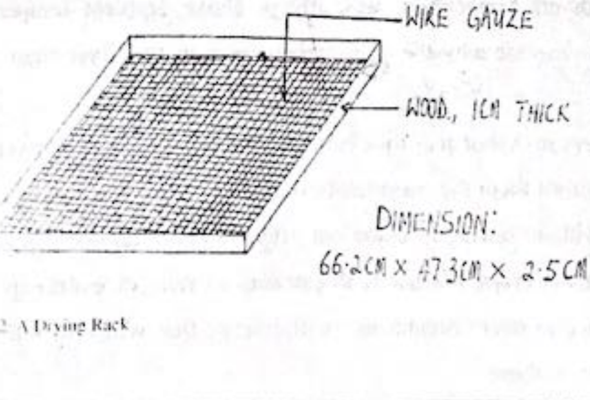


Fig 2: A Drying Rack

The dryer constructed has the following basic features: transpare top cover (glass), the drying chamber, drying rack, collector, the ve and the doors. The sketch and dimensions of the solar dryer and th of the drying rack are shown above in figures 1 and 2. In order th all the parts of the dryer should lose heat at the same rate, it w made sure that the thickness of the wood was uniform.

The front part of the box was made higher than the back part makin the top of the box to be oblique at an angle of 9^0. This helps maintain air current, as cooler enters through the back vent and h air leaves through the front vents.

RESULTS

Table 1: Temperature measurement of dryer and ambient ar percentage moisture loss by yam chips for five consecutive days of drying 9-13th July, 2005. Mass of yam chips =1135g

(A)

Date	Time, t (Hours)	T_1 °C	T_2 °C	T_3 °C	$T=\frac{(T_1+T_2)}{2}$ °C	M_1 (g)	M_2 (g)
09/07/05	10.00	42.0	40.0	32.0	41.0	1110	1125
	11.00	45.0	43.3	33.0	44.0	1055	1118
	12.00	50.0	49.0	36.0	49.5	1015	1109
	13.00	49.0	48.0	35.0	48.5	998	1094
	14.00	54.0	55.0	38.0	54.5	925	1071
	15.00	44.0	44.0	36.0	44.0	876	1058
	16.00	49.0	50.0	37.0	49.5	842	1039
	Percentage loss in mass				=	24.11	7.64

(B)

Date	Time, t (Hours)	T_1 °C	T_2 °C	T_3 °C	$T=\frac{(T_1+T_2)}{2}$ °C	M_1 (g)	M_2 (g)
10/07/05	9.00	37.0	35.0	39.0	36.0	828	1036
	10.00	44.0	43.0	32.0	43.0	804	1016
	11.00	48.0	46.0	34.0	47.5	785	1003
	12.00	49.0	48.0	35.0	48.5	763	991
	13.00	52.0	51.0	36.0	51.5	748	976
	14.00	49.0	47.0	35.0	48.0	724	959
	15.00	46.0	45.0	34.0	45.5	710	947
	16.00						
	Percentage loss in mass				=	36.04	15.82

(C)

Date	Time, t (Hours)	T_1 °C	T_2 °C	T_3 °C	$T=\frac{(T_1+T_2)}{2}$ °C	M_1 (g)	M_2 (g)
11/07/05		26.0	26.0	24.0	26.0	707	945
	9.00	30.0	30.0	26.0	30.0	699	942
	10.00	35.0	35.0	28.0	35.5	683	928
	11.00	45.0	44.0	30.0	44.5	674	921
	12.00	47.0	46.0	33.0	46.5	669	916
	13.00	53.0	52.0	35.0	52.5	661	909
	14.00	51.0	51.0	35.0	51.0	657	902
	15.00	50.0	50.0	35.0	50.0	654	891
	16.00	44.0	43.0	34.0	43.5	652	886
	Percentage loss in mass				=	41.26	21.24

(D)

Date	Time, t (Hours)	T_1 °C	T_2 °C	T_3 °C	$T=\frac{(T_1+T_2)}{2}$ °C	M_1 (g)	M_2 (g)
12/07/05	8.00	28.0	27.0	26.0	27.5	652	884
	9.00	25.0	34.0	28.0	34.5	650	880
	10.00	47.0	44.0	31.0	45.5	650	880
	11.00	52.0	50.0	33.0	51.0	648	871
	12.00	51.0	49.0	35.0	50.0	645	863
	13.00	54.0	52.0	36.0	53.0	641	859
	14.00	53.0	51.0	36.0	52.0	638	857
	15.00	49.0	46.0	36.0	47.5	638	854
	16.00	44.0	41.0	35.0	42.5	638	853
	Percentage loss in mass				=	42.52	24.18

(E)

Date	Time, t (Hours)	T_1 °C	T_2 °C	T_3 °C	$T=\frac{(T_1+T_2)}{2}$ °C	M_1 (g)	M_2 (g)
13/07/05	8.00	28.0	28.0	26.0	28.0	638	853
	9.00	34.0	33.0	27.0	33.5	638	852
	10.00	44.0	42.0	30.0	43.0	637	846
	11.00	49.0	46.0	31.0	47.5	636	844
	12.00	47.0	45.0	33.0	46.0	636	844
	13.00	45.0	44.0	33.0	44.5	636	843
	14.00	46.0	45.0	34.0	45.5	636	842
	15.00	47.0	46.0	34.0	46.5	635	842

	16.00	41.0	40.0	31.0	40.5	635	842
	Percentage loss in mass				=	42.79	25.16

Figure 3 (A-E): Dryer Temperature compared with Ambient Temperature.

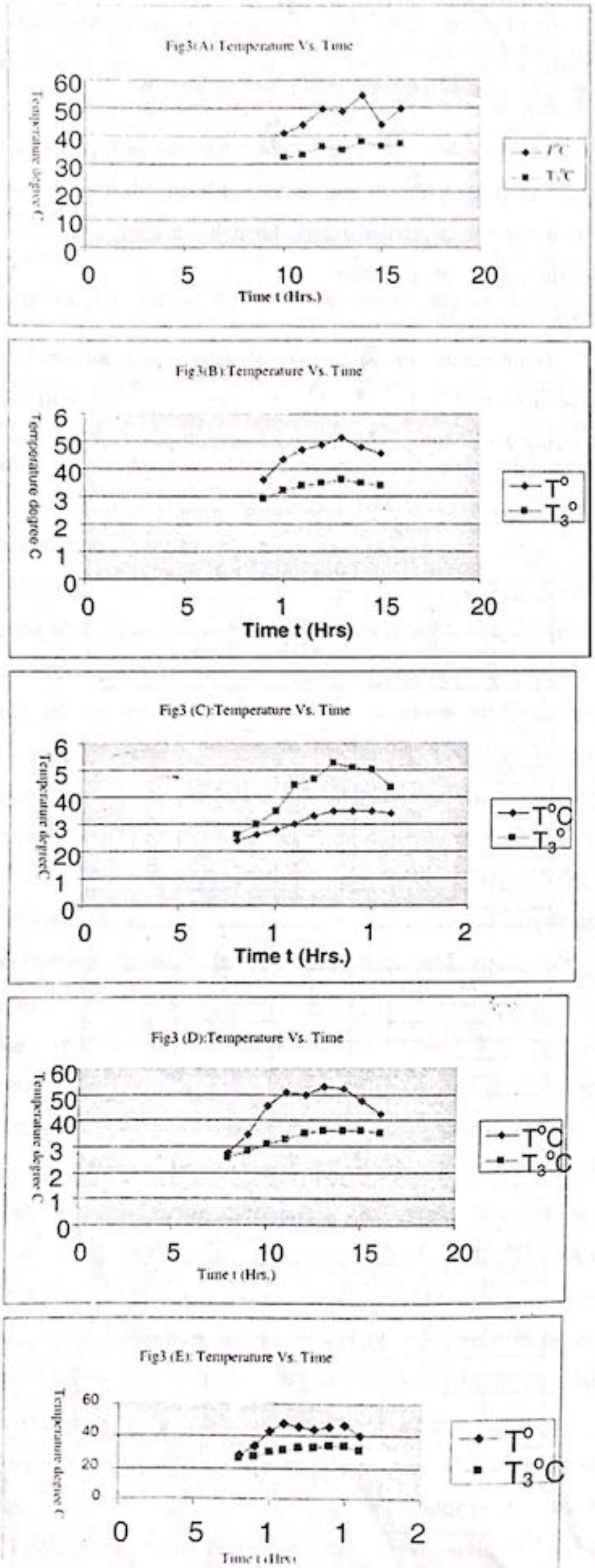
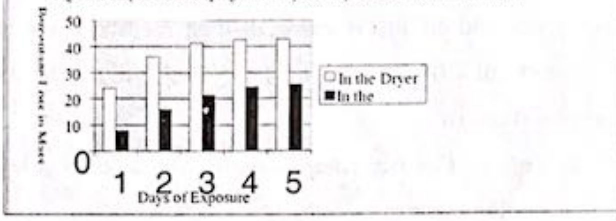


Table 2: Comparison of the drying rate of yam chips inside and outside dryer

	Percentage Loss in mass	
Days	In the Dryer	In the Open
	24.11	7.64
2	36.04	15.82
3	41.26	21.24
4	42.52	24.18
5	42.79	25.16

Fig. 4: Comparison of Drying rates of yam chips inside and outside dryer



DISCUSSION OF RESULTS

During the drying of the yam chips two simultaneous processes occurred; the transfer of heat and the transfer of mass (Garner, 1971). Heat was transferred to the wet yam chips and consequently, its temperature increased. The moisture content reduced, as it evaporated into the environment. Mass transfer occurred within the solid (yam chips), as the internally held water was brought to the surface resulting in the changes in the size, colour and geometry of the yam chips. Drying was enhanced by: high temperature, low humidity, high wind speed, large surface area and nature of the surface (dryer's surface). The heat transfer in the drying operation occurred in the form convection, conduction and radiation.

The results obtained in the tables and in the graphs shows that the temperature of the dryer was always above the ambient temperature. A dryer temperature, as high as 54.5 °C, was recorded in the cause of drying. The chips in the dryer recorded a loss in mass of about 42.79% as against a loss of 25.16% for the chips in the open, for five consecutive days of drying. These results go to show that the item in the dryer dried faster than that in the open.

CONCLUSION

The result obtained from the dryer's analysis reveals its potentiality. The dryers temperature was always above ambient temperature, accounting for why the chips dried faster in the dryer than in the open.

Farmers in Agbor will thus benefit from the use a solar dryer, as it will afford them the opportunity of drying their farm produce faster and without having to come out often to chase animals away or to gather the crops when it is threatening to rain, or even expose the produce to micro organisms.; with energy that will cost him or her little or nothing.

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