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Study of Experimental Performance of an Indirect Solar Dryer for Drying Yam Peels in Aliero, Nigeria

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Abstract:
The solar drying system utilizes solar energy to heat up air and to dry any food substance loaded, which is beneficial in reducing wastage of agricultural product and helps in preservation of agricultural product. The dryer is composed of solar collector (air heater) and a solar drying chamber. The air allowed in through air inlet is heated up in the solar collector and channeled through the drying chamber where it is utilized in drying. The dimensions of the dryer is 460cm x 60cm x 100cm (length x width x height). Locally available material were used for the construction, chiefly comprising of wood, glass, aluminum metal sheet and the black paint was applied to it to increase the intensity of heat. The optimum temperature of the dryer is 50.50°C with a corresponding ambient temperature of 34.50°C. The moisture content removal of 43.2% in yam peels using the solar dryer was achieved as against 28.2% using the sun drying method which gives the difference of 15.0%, the rapid rate of drying in the dryer reveals its ability to dry food items reasonable rapidly to a safe moisture.

Keywords: *Collector efficiency, drying efficiency, drying rate, moisture content*

1. Introduction

Drying is one of the oldest preservation processes available to the mankind, on that we can track since prehistoric times. The main feature of this process consists on lowering the water content in order to avoid or slow down food spoilage by microorganism (Naseer *et al*., 2013). There are various types of drying technologies, namely: sun drying, solar drying, freeze drying and oven dry (Naseer *et al*., 2013).

In another study, George *et al*. (2004) categorized drying technologies into two parts, namely: convective air drying technologies and other drying technologies. The convective air-drying technologies are tray drying, fluidized bed and spouted bed drying technologies; whereas, other drying technologies include freeze drying, convective air drying, vacuum oven and micro-convection drying technologies.

Sun drying is a traditional *drying* method for reducing the moisture content of paddy by spreading the grains under the *sun*. The *solar* radiation heats up the grains as well as the surrounding air and thus increases the rate of water evaporating from the grain. Solar drying is a controlled type of sun drying using solar dryers. S*olar dryers* are devices that use solar energy to dry substances, especially food.

In direct solar dryer, a structure with transparent covers and side panels is used to keep the agricultural produce to be dried. Solar radiation absorbed by the product and the internal surfaces of the drying chamber generate heat thus increasing the temperature of the crop and its enclosure (El-Sebaii and Shalaby, 2012). These types of dryers are suitable for places where direct sunlight can be received for longer periods during the day (Mustayen *et al.*, 2014).

A typical direct Sun dryer is shown in Figure 1. It can be made from wooden box insulated at its base and side. The material to be dried is kept on a perforated tray. Air coming from the lower part of the cabinet flows through the holes and leave through the upper ventilation holes maintaining a natural air circulation (Mujumdar, 2006).

1.1. Performance Evaluation of Indirect Solar Dryer

1.1.1. Solar Dryer Efficiency

The System Efficiency of a solar dryer can be defined as a measure of how effectively the input energy (solar radiation) to the drying system is used in drying the product. In other words, efficiency is the ratio of output to the input.

$$\eta = \frac{output}{input} \tag{1.1}$$

It is usually between a range of 0-1. Therefore, efficiency can be expressed as (Ezekoye, 2006, in Onigbogi)

$$\eta = \frac{workoutput}{workinput} \times 100\% \tag{1.2}$$

According to Leon, (2002), for natural convection solar dryer,

$$\eta = \frac{WL}{IA} \tag{1.3}$$

Where W is weight of water evaporated from the product in kg, L is the latent heat of vaporization of water at exit air temperature in (J/kg),I is the hourly average solar radiation on the aperture surface in (kWh) and A is the Aperture area of the dryer (m^2).

According to Bolaji *et al* 2011, efficiency was obtained by using the relation below:

$$\eta = \frac{mC_f(t_0 - t_i)}{I} \tag{1.4}$$

Where m= mass flow rate (Kgs^{-1}), I = incident insolation (Wm^{-2}), C_f = specific heat of flowing air at constant pressure (kJkg-1K-1), t_i = air inlet temperature (K) and t_o= air outlet temperature (K)

In 1999, Henry *et al.* in Ahmed 2011 gave dryer efficiency as:

$$\eta_d = \frac{ML}{IcAt} \tag{1.5}$$

Where (L) is the latent heat of vaporization of water, (M) is the mass of the crop, and (t) is the time of drying, (I_c) is the insolation on the collector.

1.2. Moisture Removal

The moisture Loss is given as follows: (Ezekoye, 2006)

$$M_L = M_1 - M_2 \tag{1.6}$$

Where M1 is the mass of the sample before drying and M2 is the mass of the sample after.

According to Stephen 2014, moisture loss can be obtained using either equation (6) or (7).

$$M_w = \frac{m_i(M_i - M_e)}{100 - M_e} \tag{1.7}$$

Where:

m_i= initial mass of the food item (kg), M_e = equilibrium moisture content (% dry basis), M_i = initial moisture content (% dry basis).

$$m_w = (m_i - m_f) \tag{1.8}$$

Where;

m_i is the mass of the sample before drying and m_f is the mass of the sample after.

2. Methodology

Construction, fabrication and performance evaluation of the developed Solar dryer required the use of construction materials, devices and measuring instruments. In addition, prescribed procedures are followed in achieving the aim and objectives of this study. These step-by-step procedures followed in achieving the aim and objectives of this study is referred to as the method. In this chapter, the kind of materials used and the procedure that is adopted will be described and discussed.

Measuring devices are instruments that show the extent or amount or quantity or degree of something. E.g. weighing balance, meter rule, pyranometer, etc. below is a table showing list of measuring devices used in performance evaluation of solar dryer.

S/No	Measuring Devices	Uses/Applications
1.	Weighing balance	For measurement of Mass (Kg)
2.	Wooden meter rule	For linear measurement
3.	Pyranometer	For solar radiation flux density measurement (W/m^2)
4.	Steel square	For distance measurement
5.	Data logger	Storage of data over time

Table 1

In addition, from the equations presented in chapter two (2) for performance evaluation, the parameters: solar radiation, temperature and time can be measured with pyranometer, temperature data logger (or thermometer) and stop watch.

2.2. Experimental Setup

The experiment was set up at the testing area of Kebbi State University of Science and technology, Aliero. Within 26th and 27th April, 2021 and between the hours of 9:00am to 4:00pm. The initial mass of yam peel was measured and recorded for solar Dryer and open Sun Drying. The time, solar radiation, ambient temperature, absorber temperature, and the cabinet temperature were all measured and recorded.

After one hour, the yam peels were removed from the cabinet; its mass was measured and recorded. At the same time, the mass of the yam peel for open sun drying was also measured and recorded. The experiment was repeated every one hour interval until 4:00pm.

3. Results

The result in Figure 1 shows that the mass of yam peels decreases as the day advances from 10:00am and 04:00pm. However, the mass of yam peels dried by open sun drying lower compared to that solar drying since the gradient or slope of the line graph for open sun drying is lower.

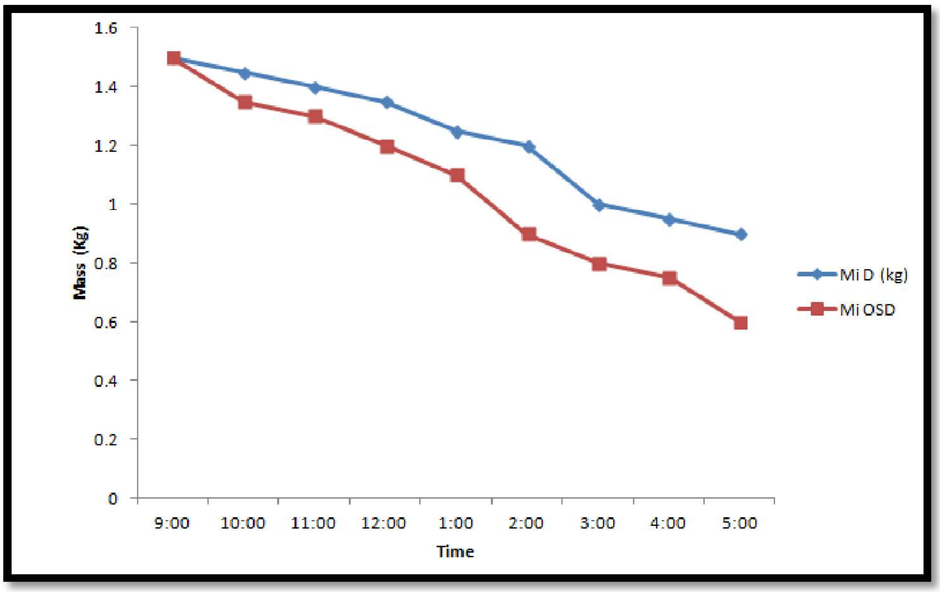

Figure 1: Comparison between Drying Process for Open Sun and Solar Drying

Figure 2 shows the results of the final weight for open sun drying and solar drying. Just as earlier explained for initial mass, the final mass for open sun drying is lower compared to solar drying.

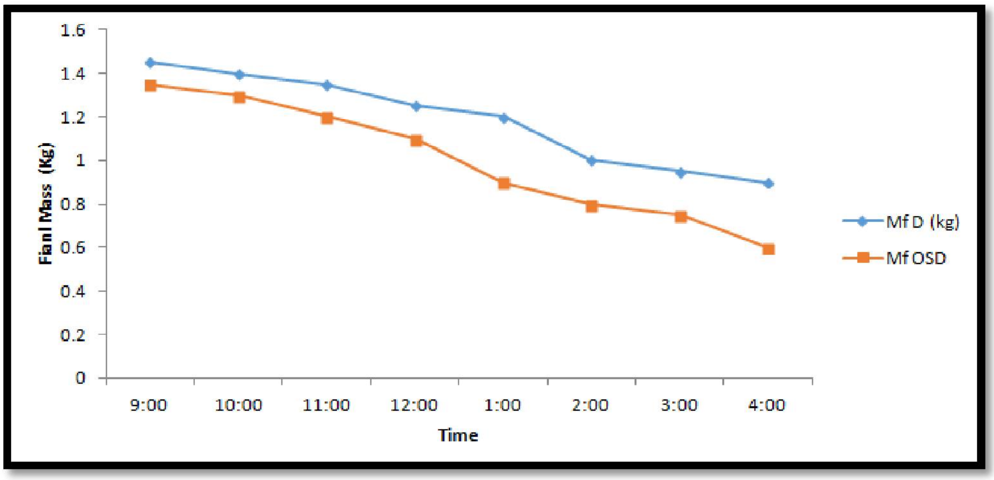

Figure 2: Final Mass of Drying for Open Sun and Solar Drying

4. Result Discussion

It is obvious from the results presented in Figure 4.1 that the initial mass is equal but as the day advance from 10:00am to 04:00pm, both masses decreases however, the mass of open sun drying is less in mass compared to mass of the sample that is dried using solar dryer. In addition, the mass of both samples dried by open sun drying and that of solar dryer seem to decrease. This is an indication that there was drying for both. 2 has shown that the mass of yam peels decreases as the day advances from 10:00am and 04:00pm. However, the mass of yam peels dried by open sun drying lower compared to that solar drying since the gradient or slope of the line graph for open sun drying is lower., the final mass for open sun drying is lower compared to solar drying. The final mass of yam peels dried by open sun drying is lower than that of solar drying. Hence, open sun drying was more effective than the solar drying. The initial mass is expected to be greater than final mass; in worse scenario, it can be equal, i.e., if the is not solar irradiance. Hence, the result is clearly inlet with the assumption. That is, the final mass (for both sun and solar drying) is lower compared to initial mass. Hence, there was drying at every stage of the drying process. The temperature of the absorber, through which air is heated, is greater compared to the temperature of the cabinet as area under the curve is greater. The least of the temperature is the ambient temperature.

5. Conclusion

The results presented have clearly shown that the drying was more effective under open sun drying, compared to solar drying. This might be as a result of the losses and the current season of harmattan. The inefficiency in the drying might also be as a result of the materials used and design errors. It could also be seen that the initial mass of the yam peels was higher than the final mass. It could also be observed that the absorber temperature was higher compared to others.

6. References

i. Alonge, A. F. and Adeboye, O. A. (2012). Drying Rates of Some Fruits and Vegetables with Passive Solar Dryers. *International Journal of Agricultural and Biological Engineering*, *5*(4): 83–90. DOI: 10.3965/j.ijabe.20120504.0010
ii. B. O. Bolaji., M. A. Tajudeen. And T. O. Falade. (2011). Performance Evaluation of a Solar Wind-Ventilated Cabinet Dryer. The Indian Journal of Engineering. Vol. 33(1/2) pp. 12-18
iii. Bahnasawy, A.J and Shenana, J. R. 2004. Evaluation of a solar crop dryer for rural applications in
iv. E. C. Okoroigwe., M. N. Eke and H. U. Ugwu. (2013). International Journal of Physical Sciences. ISSN 1992-1950. Vol. 8(25) pp. 1341-1349.
v. Mujumdar, A. S. (Ed.). (2006). Handbook of Industrial Drying (3rd edition), Taylor & Francis Group, LLC, Singapore.1282 p.