IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET)
ISSN (P): 2347-4599; ISSN (E): 2321-8843
Vol. 5, Issue 7, Jul 2017, 11-18

DESIGN AND PERFORMANCE EVALUATION OF DIRECT MODE SOLAR DRYER

CHENDAKE A. D[1], PATIL S. B[2], MANE S. S[3], ANUSE P. A[4], GHADGES. B[5], NALAWADE R. T[6] & SHETE A. A[7]

[1]Department. of Renewable Energy Sources, Dr. D. Y. Patil College of Agricultural Engineering and Technology, Kolhapur, Maharashtra, India

[2]Department. of Farm Machinery and Power, Dr. D. Y. Patil College of Agricultural Engineering and Technology, Kolhapur, Maharashtra, India

[3, 4, 5, 6, 7]Dr. D. Y. Patil College of Agricultural Engineering and Technology, Kolhapur, Maharashtra, India

ABSTRACT

Now a day, drying becomes one of the important post harvest operation for fruits, to increase shelf life. Sun drying is one of the oldest, but the cheapest and widely used methods. So the Direct Mode Solar Dryer is constructed and investigated experimentally, for the drying efficiency at a geographic location of Talsande, in the city of Kolhapur. The highest daily solar radiation, obtained at 12:00 p.m. was 857 W/m^2. The highest ambient temperature was obtained at 12:00 p.m. i.e., 39.8ºC as well as the highest inside temperature was obtained at 13:30 p.m. & 14:30 pm i.e., 74.5ºC. The maximum temperature difference ΔT was observed, i.e., 40.5°C at 14:00 p.m. The time required to dry sapota from moisture content i.e., 52.38% to 2.22% is 9 hrs. The maximum efficiency of the dryer was obtained at 61.61%, for drying of sapota.

KEYWORDS: Direct Mode Solar Dryer, Drying, Ambient Temperature, Dryer Efficiency, Sapota etc

INTRODUCTION

Sun is abundantly and naturally available on earth. We are not using the energy which we get from the sun. Drying is one of the important net not only farmer, but also for other small industries. Because drying, increasing the shelf life and adding value to the product (Biplab Paul, 2013). Solar dryers are devices that use solar energy, to dry substances, especially food. In these systems, the solar drying is assisted by the movement of the air (wind) that removes the saturated air, away from the items being dried. More recently, complex drying racks and solar tents were constructed as solar dryers. The solar dryer absorbs heat energy, to dry substances. New technologies changes techniques, but at present the increasing demand for healthy, low cost natural foods and the need for sustainable income are, bringing solar drying to the fore, as a useful alternative for surplus products. The dried product improves family's nutrition because; fruits and vegetables contain high quality vitamins, minerals and fibers. It improves the bargaining position of farmers. Sometimes farmers sell at very low prices, during the harvest season because; they cannot store or preserve their surplus products.

MATERIALS AND METHODS

Experimental Location

Talsande has a diverse climate. It is exceptionally hot and dry during summer, with temperature reaching as high as 40^{0}C. Talsande receives about 1140 mm rainfall during monsoon.

The experiment was conducted in the year of 2015-16.

Details about Raw Material

Sapota fruits were selected for drying. Initial moisture content of Sapota ranged from 57 to 60 (%Wb).

Design of Dryer

The design of this dryer was based on thermal performance of the dryer. The box of dryer consisted of a rectangular box, made of wood with an open top. The wood was acting as an insulator. A 5mm window glass covered top of the box and edges, was coated with rubber got. This facilitates the opening and closing of the glass, for access into the box. Figure.1 and Figure. 2 shows the dimensions and construction details of the dryer. The physical parameters of the dryer are illustrated in Table 1.

Table 1: Physical Parameters of the Dryer

Type of Dryer	Direct Solar
Overall size – length × width (mm)	900 × 600
Height (mm)	300
Loading (tray) area (mm^2)	108000
Air inlet/outlet areas	For inlet - 4.90 cm^2 each For outlet – 0.19 cm^2 each
Box material	Ply Wood 10 mm
Tray materials	Wood and aluminium wire mesh
Glazing	5 mm window glass
Gap: Tray surface-Cover glass (cm)	5
Gap: Tray surface - Dryer bottom surface (cm)	6

The dryer has three trays inside the box, for loading the product to be dried. The trays were made of aluminium wire mesh and wood. The critical parameters set inside in the dryer box, are shown in the last two rows of Table 1. The distance between the tray surface, cover glass and dryer bottom surface has kept such that, air flows both above and below the tray, for maximum drying effect.

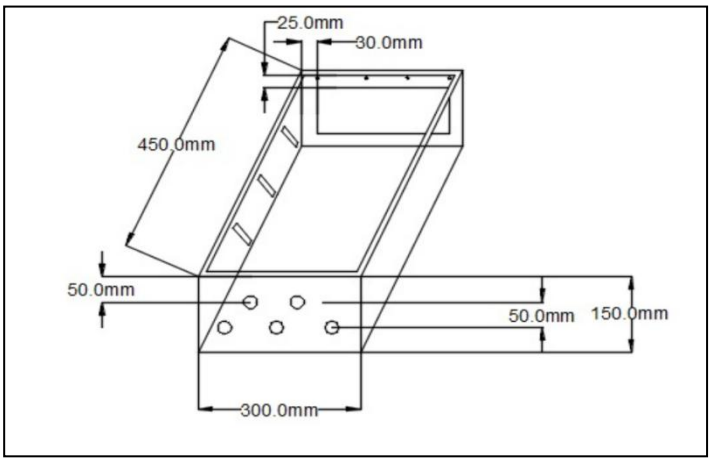

Figure 1: View of Direct Mode Solar Dryer

COMPONENTS OF DRYER

Wooden box

Generally it provides rigidness to dryer, but technically it provides thermal resistance to the heat transfer, that takes place in the system, to the surrounding. So it was made from the material which has low thermal conductivity. The thickness of the side wall is 10 mm.

Top glass opening

It is opening doors, for placing food inside the dryer, and it is the passageway for the solar radiation to enter the box. We were using 5 mm window glass.

Tray

Tray act as the place in the dryer, on which product was placed. The clearance between the bottom and tray were provided, for the circulation of air. The tray's size is 580 × 250 mm.

Insulation

Rubber insulation was provided to minimize the loss of heat from the box to the surroundings.

Stand

Stand was used to give support and for giving proper inclination to the box. It was made from angle iron.

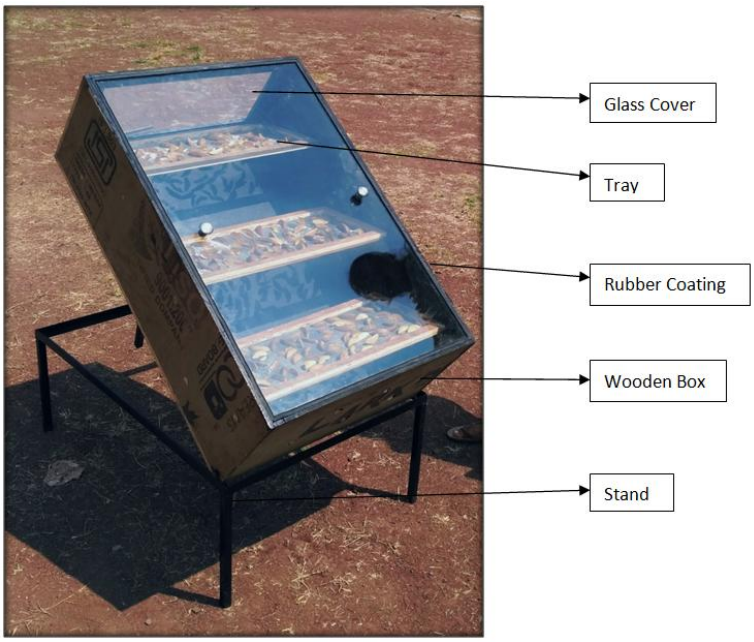

Figure 2: Components of Direct Mode Solar Dryer

FORMULAE USED

Moisture Content (%db)

The moisture contains of the slice of sapota, will be calculated on dry basis using formula (Seema Kumari, 2013).

$M = W_M / weed \times 100$

Where,

M = Moisture Content (% db),

W_M = Weight of moisture, g

W_d = Weight of bone dry matter, g

Moisture Content (%Wb)

The moisture contain of the slice of sapota will be calculated on dry basis using formula (Seema Kumari, 2013)

$M = W_M / W_s \times 100$

Where,

M = Moisture Content (% Wb)

W_M = Weight of moisture, g

W_s = Weight of sample, g

3.9.5 Dryer, Efficiency

$$\eta_c = \frac{Qu}{Acls}$$

Where,

$Q_u = mc_p\Delta t$,

A_c = is the collector surface area. m^2

$$\eta_s = \frac{MeLs}{AclavT}$$

Where,

M_e = Moisture evaporated, Kg

L_s = Sensible heat of evaporation of water at drying temperature

T = Drying time, s

$$\eta_d = \frac{\eta c}{\eta s}$$

RESULTS AND DISCUSSIONS

The dryer was tested with Sapota as a product. 900 grams of Sparta were loaded in the dryer.

Table 2: Observation Table of Parameters

Time (hr)	Outside Temperature (^{0}C)	Inside Temperature (^{0}C)	Solar Radiation (W/m^2)	Wind Velocity (m/s)	Relative Humidity (%)
08:00	23	23	55	0.26	40
08:30	25	26	60	0.23	30
09:00	25.7	42.5	170	0.36	20
09:30	26.5	50	375	1.32	20
10:00	28	60	534	1.15	20
Table 2: Contd.,					
10:30	30.1	63	700	1.47	20
11:00	30.6	66	762	3.40	20
11:30	37.5	70.5	825	3.00	20
12:00	39.8	71.5	857	2.30	20
12:30	36.4	73	780	1.80	20
13:00	35.3	73.5	740	1.74	20
13:30	35.8	74.5	703	1.83	20
14:00	34	74.5	610	0.60	20
14:30	34.3	72.5	591	5.00	20
15:00	33.7	70.5	531	3.86	20
15:30	33.4	64.5	388	2.30	20
16:00	32.7	59.5	141	1.45	20
16:30	31.5	52	102	2.30	20
17:00	29	49	65	0.82	20

TEMPERATURE PROFILE

Variation of Outside Temperature with Time

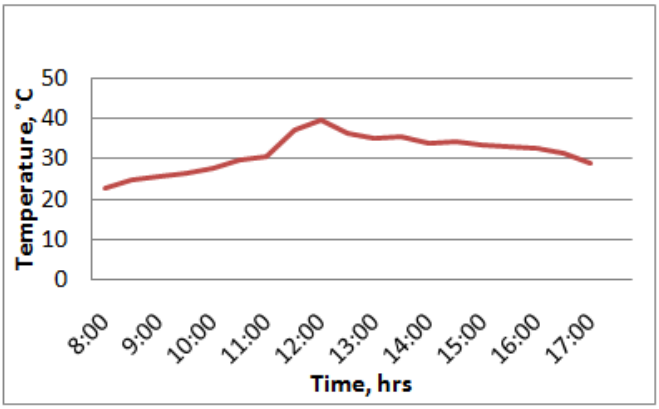

Figure3: Outside Temperature Vs Time

As per Figure.2 the maximum temperature attained is 39.8 ^{OC} at 12:00 pm and minimum temperature is 23 ^{OC} at 08:00 am.

Variance of Inside Temperature with Time

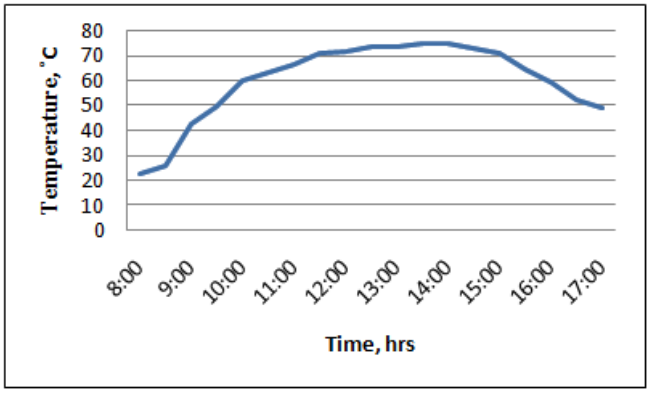

Figure 4: Inside Temperature Vs Time

As per the figure 3, the maximum temperature attained is 74.5 ^{OC} at 13:00 pm and 14:30 pm and minimum temperature is 23 ^{OC} at 08:00 am.

Variation of Solar Radiation with Time

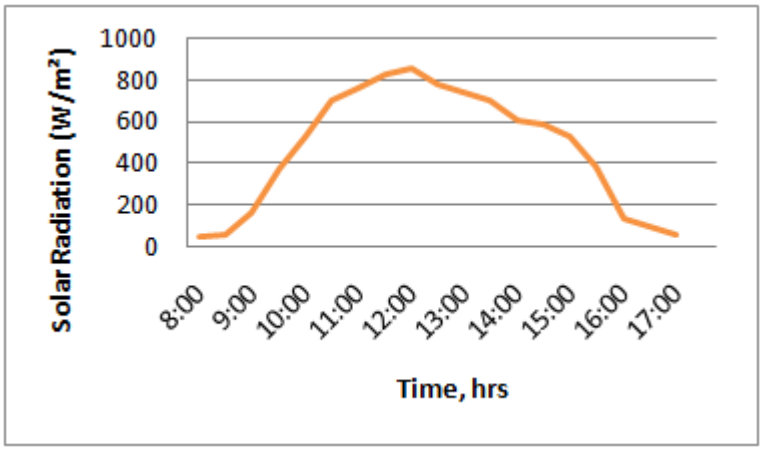

Figure 5: Solar Radiation Vs Time

As per figure 4, 4 the maximum solar radiation attained is 857 W/m^2 at 12:00 pm and minimum solar radiation is 55 W/m^2 at 08:00 am.

MOISTURE CONTENT

The initial moisture content of sapota was 52 per cent and final moisture content after drying was obtained as 2.22 per cent.

DRYING EFFICIENCY

The drying efficiency that was obtained from the observation is 61.61%. The drying time required to dry sapota is 9 hrs.

$$(\eta_d) = \frac{\eta c}{\eta s} \times 100$$

$$= \frac{0.3755}{0.6094} \times 100$$

η_d = 61.61 %

CONCLUSIONS

The maximum temperature attained inside the dryer is 74.5 ^{OC} , at 13:30 pm and 14:30 pm and minimum is 23 ^{OC} at 08:00 am. The time required to dry sapota from 52% moisture content to 2.22% moisture content in direct mode solar dryer is 9 hrs. The maximum solar radiation attained is 857 W/m^2 at 12:00 pm. The efficiency of the dryer has been obtained as 61.61%.

REFERENCES

1. Ahmed Abed Gatea. (2011). Performance Evaluation of a Mixed-Mode Solar Dryer for Evaporating Moisture in Beans. *Journal of Agricultural Biotechnology and Sustainable Development* Vol. 3 (4) 65-71.
2. Biplab Paul. & S. P. Singh. (2013). Development and Design of solar dryer for chili, *International Journal of Research into Advent Technology*. Volume 1 (4), 62-72.
3. Ganjyal, G. M., M. A. Hanna and D. S. K. Devadattam. (2006). Processing of sapota (Sapodilla): Drying studies. *J. of Food Sci.,(In press).*
4. Megha S. Sontakke. & Prof. Sanjay P. Salve. (2015). Solar Drying Technologies: A review, *International Refereed Journal of Engineering and Science (IRJES)* Volume 4, Issue 4, 29-35.
5. N. Rajeshwari. & A. Ramalingam. (2012). Low Cost Material Used To Construct Effective Box Type Solar Dryer, *Arch. Appl. Sci. Res.*, 2012. 4(3) 1476-1482.
6. Reddy. E. Siva Reddy. (2013). Design and Fabrication of Efficient Solar Dryer, *Int. Journal of Engineering Research and Applications.* 3 (6) 1445-1458.
7. Seema Kumari., N. Kranthi Kumari., J.Jyothi., J.Lakshmi Lavanya., & I.Swarnalatha.(2013). Study on Drying Behavior of Sapota (*Manilkara Achras*) in Solar Tray Dryer and Hot Air Cabinet Dryer, *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 10 (4), 40-64.
8. Suchita V. Gupta. & Bhagyashree N. Patil. (2014). Convective Drying of Osmo-Dehydrated Sapota Slices. *International Journal of Agriculture and Food Science Technology.* Vol. 5, 219-226.
9. Umesh Toshniwal. and S.R Karale. (2013). A Review Paper on Solar Dryer, *International Journal of Engineering Research and Applications (IJERA),* 3 (2), 896-902.