RESEARCH PAPER | International Journal of Agricultural Engineering | Volume 6 | Issue 1 | April, 2013 | 157–161

Drying of onion slices in solar tent dryer

P.S. BANDGAR, S.A. MEHETRE AND J.S. GHATGE

Received : 10.01.2013; **Revised :** 03.03.2013; **Accepted :** 23.03.2013

See end of the Paper for authors' affiliation

Correspondence to:

P. S. BANDGAR
Department of Renewable Energy Sources, Padmashree Dr. D.Y. Patil College of Agricultural Engineering and Technology, KOLHAPUR (M.S.) INDIA
Email : psbandgar@gmail.com

ABSTRACT : The experiment was conducted to study this drying of onion slices in solar tent dryer designed by D.Y. Patil College of Agricultural Engineering and Technology, Kolhapur. The minimum temperature was 35.5°C at 8:00 am while maximum temperature attained in solar tent dryer was 54.3°C at 02.30 pm. Solar radiation received was increased from 300 W/m^2 to more than 900W/m^2. The initial moisture content of fresh onion slices were taken for drying was 84.7 per cent which was reduced to 11.13 per cent (wb) in three days drying period, whereas open drying required five days. Cost analysis revealed that the cost of dried onion slices was Rs.90/- per kg and break-even point was 85.45 per cent. Payback period was 2.24 years. The profit of solar tent dryer was found to be Rs.2005.24/-

KEY WORDS : Solar tent dryer, Onion slices, Solar radiations

HOW TO CITE THIS PAPER : Bandgar, P.S., Mehetre, S.A. and Ghatge, J.S. (2013). Drying of onion slices in solar tent dryer. *Internat. J. Agric. Engg.*, **6**(1) : 157-161.

Solar drying is the best alternative as a solution to all the drawbacks of natural drying and artificial mechanical drying. Solar dryers are used in agriculture for food and crop drying. For industrial drying process, dryers can be proved to be most useful devices from energy conservation point of view. Open sun drying has several disadvantages like spoilage of product due to adverse climatic condition like rain, wind, moisture, dust, loss of material due to birds and animals, deterioration of the material by decomposition, insects and fungus growth. Also the process is highly labour intensive, time consuming and requires large area. With cultural and industrial development artificial mechanical drying came in to practice. It not only saves energy but also saves lot of time, occupying less area, improves quality of the product, makes the process more efficient and protects environment. Solar dryers consist of a transparent panel above a chamber or collector that is painted black to absorb the suns heat. Polythene, which is very cheap, is commonly used to glaze the panel but it turns yellow and opaque after a few months and needs to be replaced. Plastic films that are not damaged by sunlight are now increasingly available and should be used if possible. While more expensive they have a life of 5 years or more. Tent solar dryers are cheap and simple to build and consist of a frame of wood poles covered with plastic sheet. Solar tunnel dryer becomes popular due to considerable reduction of drying time and significant improvement of product (Chaw *et.al.*, 1997). It has been used to dry fruits, vegetables, root crops, medical plant and fish (Gahur, 1998). Tent dryers provide protection against rain, insects and dust. Assembling and dismantling of this solar tent dryer is very easy with help of clips and require very less time. The performance and techno-economic feasibility was tested for drying of onion slices in the present study.

METHODOLOGY

The experiment of drying of onion in solar tent dryer was conducted in college campus at , Pad. Dr. D. Y. Patil College of Agricultural Engineering and Technology, Talsande, Dist. Kolhapur.

DYP solar tent dryer :

The solar tent dryer was designed and fabricated in the Department of Renewable Energy Sources, Pad. Dr. D. Y. Patil College of Agricultural Engineering and Technology, Talsande, Dist. Kolhapur having 10 kg capacity. The design parameters were decided on the basis of quantity of moisture removed per day (Seveda *et al.,* 2004).

The salient features of solar tent dryer are given below

- It is tent shaped type and has base area of 1.82 m x 0.91m and maximum ceiling height of 0.762 m. Low cost materials possessing high rigidity, long life and superior thermal characteristics have been used for construction.
- The metallic frame structure of the tent dryer has been

covered with an UV rays stabilized semi-transparent polythene sheet of 200 micron thickness.
- The plywood floor has been painted black for better absorption of solar radiation.
- Capacity of dryer for one batch drying is 10 kg
- Arrangement for loading the product inside the tent dryer varies depending upon the product characteristics
- The orientation of solar tent dryer is in east-west direction. The structural components of solar tent dryer included wooden floor bed, UV stabilized polythene film.
- Assembling and dismantling of this solar tent dryer is very easy with help of clips and require very less time.

Fig. A: Solar tent dryer

Table A : Dimensions of solar tent dryer	
Parameters	Specifications
Length of solar tent dryer	1.82m
Width of solar tent dryer	0.91m
Ceiling height	0.762m
Floor area of solar tent dryer	1.65m^2
Aperture area	2.28m^2

Procedure for drying onion :
- Onions having medium size were selected for drying.
- Onion was cleaned and sliced with the help of cutter.
- Slices were spread on floor in the dryer for drying.
- Onion slices after drying were removed from the dryer and packed in polythene bags.

During study performance of following parameters were calculated,

Moisture content :

The 200 grams of representative sample of onion slices was taken and placed in vacuum oven at 73°C temperature. The sample was kept in it for 24 Hours. Afterwards, the sample was taken out from the oven and placed in the desiccators to cool down to room temperature. Moisture content of sample was measured based on drop in weight from initial weight of sample :

$$M(db) = \frac{Mw}{M} x100 \quad .....(1)$$

where,

M (db) = Moisture content, per cent

Mw = Weight of water *i.e.*, loss in weight, g

M = Initial weight of the sample, g

Dryer efficiency :

The efficiency of dryer was calculated using the formula (Ezekoye and Enebe, 2006)

$$\text{Dryer efficiency } (\eta\eta = \frac{M_e x L}{I_{av} x A x t} x 100 \quad ..... (2)$$

where,

M_e = *Moisture evaporated, kg*

L = Latent heat of vaporization, kJ/kg

I_{av} = Average solar radiations, kW/m^2

A = Aperture area, m^2

t = Drying time, s

■ RESULTS AND DISCUSSION

The results of the present study as well as relevant discussion have been summarized under following heads:

Evaluation of solar tent dryer :

Evaluation and testing of the solar tent dryer was carried out under no load and load conditions during the month of March, 2012 for drying of onion slices. Open drying was carried out as control test. Three trials were conducted for each treatment.

No load test :

No load testing was conducted with a view to find out temperature profile inside dryer and outside of solar tent dryer. The testing on no load was done for the single day at 20 March 2012. It was observed that the minimum inside temperature was 36.8°C at 8:00 am while maximum temperature reached inside the tent dryer was 59.2°C at 03.30 pm. Corresponding, minimum ambient temperature was 32.7°C at 08:00 am while maximum ambient temperature was 44.9°C at 03:00 pm. It was also observed that the minimum and maximum solar intensity was 630 W/m^2 at 08:00 am and 1100 W/m^2 at 01:00 pm, respectively (Fig. 1 and 2).

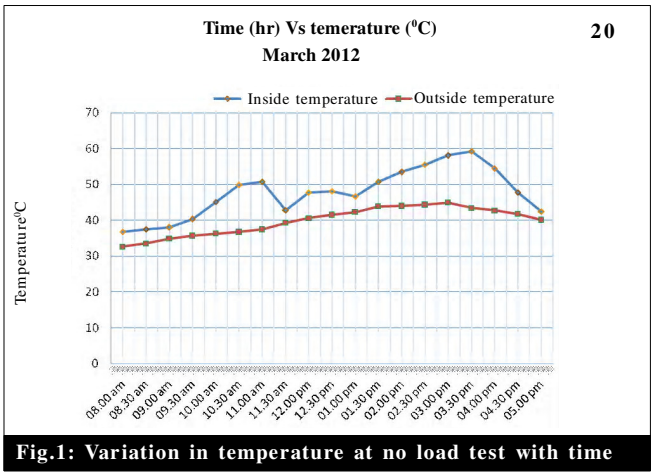

Fig.1: Variation in temperature at no load test with time

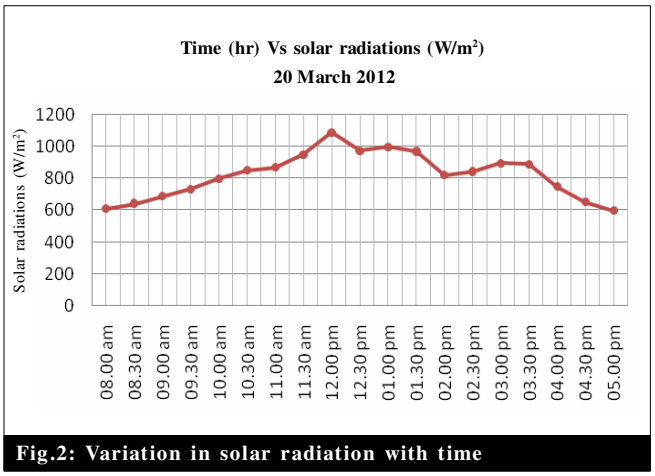

Fig.2: Variation in solar radiation with time

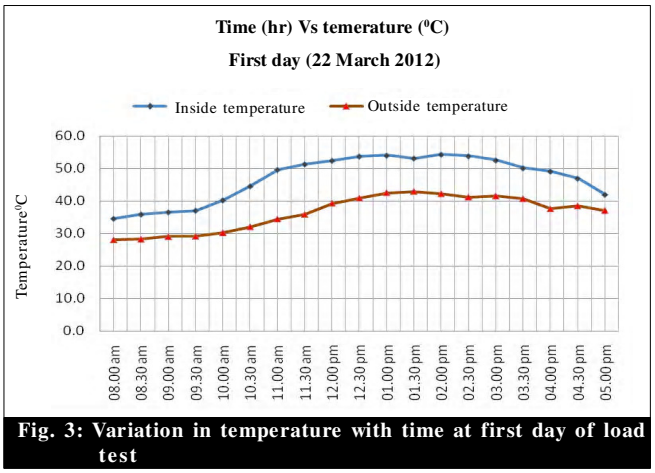

Fig. 3: Variation in temperature with time at first day of load test

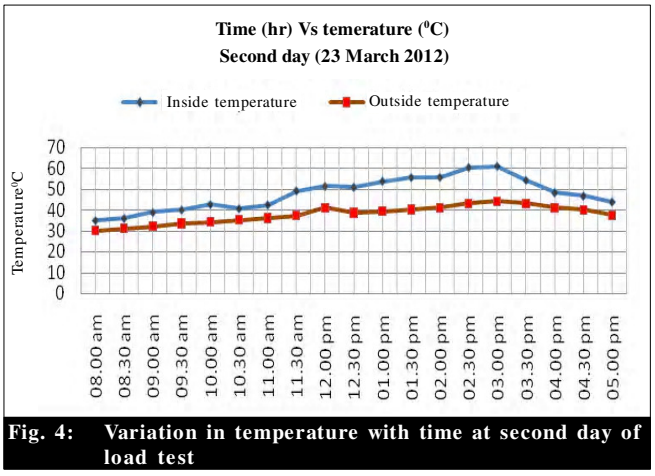

Fig. 4: Variation in temperature with time at second day of load test

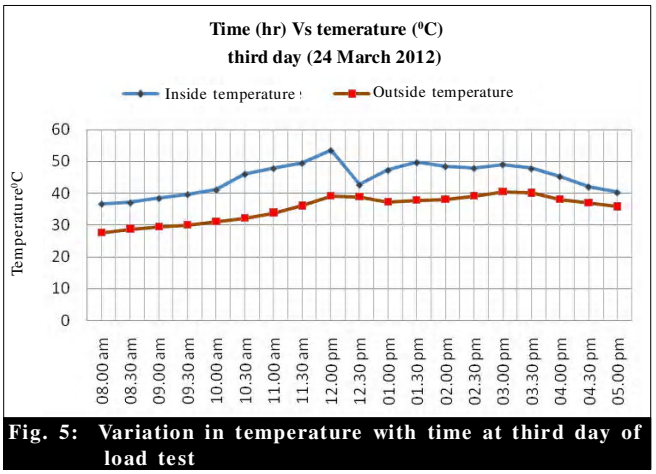

Fig. 5: Variation in temperature with time at third day of load test

Load test :

Load Testing of solar tent dryer was done for evaluating the performance of solar tent dryer in actual loaded condition. Onion slices with initial moisture content of 84.7 per cent were taken for study. Commodity selected, that is, onion slices were loaded in morning in drying chamber of solar tent dryer.

For the purpose of evaluation of solar tent dryer load test was done in the month of March for 3 consecutive days. The testing on load was done for the first day at 22 March 2012 (Fig. 3 -6). In the first day of drying it was observed that the minimum inside temperature was 35.5°C at 8:00 am in the month of March while maximum temperature attained inside the tent dryer was 54.3°C at 02.30 pm. Corresponding, minimum ambient temperature was 28.1°C at 08:00 am while maximum ambient temperature was 42.9°C at 01:30 pm. It was also observed that the minimum and maximum solar intensity was 430 W/m^2 at 08:00 am and 1050 W/m^2 at 01:00 pm, respectively.

From the Fig 6. it is revealed that due to change in solar radiation falling on the surface of solar tent dryer, relatively quick change occurred inside temperature but relatively slight change occurred in ambient temperature.

Moisture content :

The variation in moisture content of onion slices was

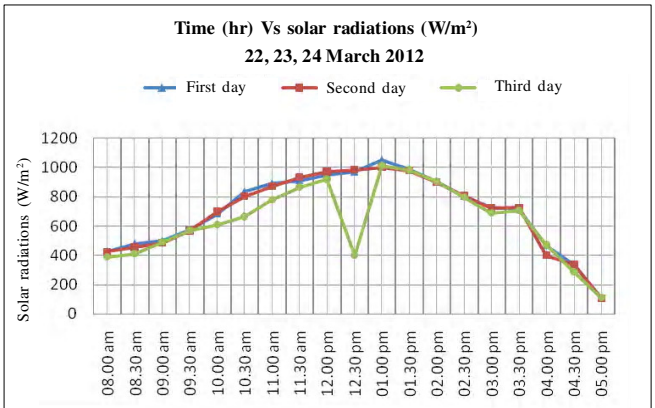

Fig. 6: Variation in solar radiations with time during of onion slice

recorded with 84.07 per cent initial moisture content taken for study. The moisture content of onion slices reduced from 84.07 per cent on wet basis to 11.13 per cent and 12.16 per cent on wet basis in three days and five days during solar tent drying and open sun drying, respectively (Table 1). From the analysis it is observed that as number of days increased the rate of drying decreased (Fig; 7).

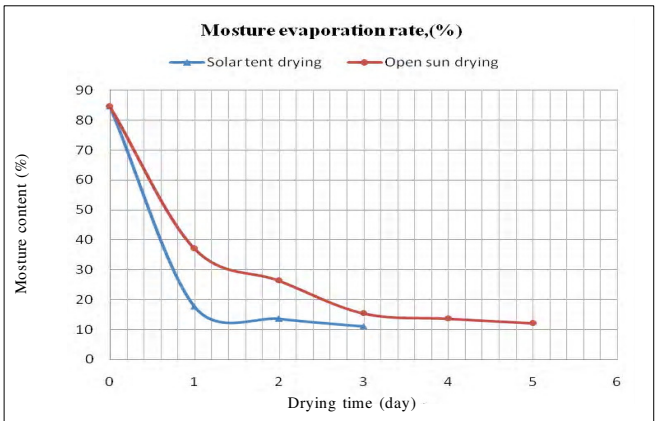

Fig. 7: Moisture evaporation rate

Efficiency of solar tent dryer :

Efficiency of solar tent dryer was calculated for a

Table 1 : The dimensions of solar tent dryer

Drying time (day)	Moisture content in onion slice (wb) ,%			
	Drying in solar tent dryer		Sun drying	
	Initial moisture content	Final moisture content	Initial moisture content	Final moisture content
1	84.07	17.73	84.07	37.14
2	17.73	13.68	37.14	26.39
3	13.68	11.13	26.39	15.43
4	-----	-----	15.43	13.66
5	-----	-----	13.66	12.16

Table 2: Moisture evaporated, average solar radiations and Solar tent dryer efficiency for Onion drying (22 to 24 March, 2012)

Days	Moisture evaporated per day (kg)	Average solar radiation (W/m²)	Dryer efficiency, %
First day	6.634	701.94	30.79
Second Day	0.405	693.78	1.899
Third day	0.255	634.93	0.581

Table 3: Cost economics of drying onion slice with solar tent dryer

Sr. No.	Economic indicators	Onion
1.	Cost of solar tent dryer, Rs	5776/-
2.	Raw material, onion 1000kg @ Rs.6/-per kg.	6000/-
3.	Working capital per year, Rs	11776/-
4.	Interest on capital investment @ 8% + Raw material, Rs (Without considering labour cost)	7,981.76/-
5.	Sale revenue per annum (111.3kg x 90 Rs/kg)	10,017.00/-
6.	Net profit per annum	2,005.24/-
7.	Breakeven point, %	85.45
8.	Payback period, years	2.24
9.	Return on investment, %	34.17

capacity of 10 kg onion slice drying requiring 3 days.

From Table 2 and its corresponding hiotogram (Fig. 8) it is observed that dryer efficiency was directly proportional to moisture evaporated *i.e.* efficiency decreases with moisture evaporated.

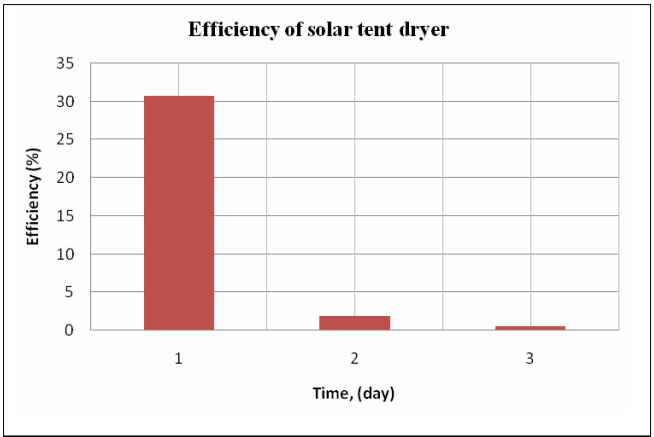

Fig. 8: Efficiency of solar tent dryer

Techno-economics analysis of onion slices dried by solar tent dryer :

The economic analysis for a solar tent dryer for onion slices was done by discount cash flow method. Cost of fabrication was found to be Rs 5776/-.

The following assumptions were considered in cost economics of onion slices drying in solar tent dryer.

Assumptions :

- The project is proposed to function 300 days per year with capacity of 10 kg per batch.
- The annual rate of interest was assumed @ 8%.
- The rate of raw material, workers, products etc. as prevailing in the market.
- The rate of purchase of onion is Rs 6/- per kg and selling Rs 90/-per kg.
- The onion slices drying in 100 batches per year.

Conclusion :

- In the first day of drying it was observed that the minimum inside temperature was 35.5°C at 8:00 am in the month of March while maximum temperature reached inside the tent dryer was 54.3°C at 02.30 pm. Corresponding, minimum ambient temperature was 28.1°C at 08:00 am while maximum ambient temperature was 42.9°C at 01:30 pm.
- The moisture content of onion slices was reduced from 84.7 per cent on wet basis to 11.13 per cent and 12.16 percent on wet basis in three days and five days during solar tent drying and open sun drying, respectively. From the analysis it is observed that as number of days increased the rate of drying decrease.
- Efficiency of solar tent dryer deceased with number of days increased.
- The complete analysis revealed that the cost of final product was Rs. 90/kg. The breakeven point found was 85.45 per cent. The payback period was 2.24 years. The profit of solar tent dryer per year was Rs.2005.24/-

Authors' affiliations:

S.A. MEHETRE, Department of Renewable Energy Sources, Padmashree Dr. D.Y. Patil College of Agricultural Engineering and Technology, KOLHAPUR (M.S.) INDIA

J.S. GHATGE, Department of Farm Machinery and Power, Padmashree Dr. D.Y. Patil College of Agricultural Engineering and Technology, KOLHAPUR (M.S.) INDIA (Email:jayant.ghatge@gmail.com)

REFERENCES

Chou, S.K., Hawlader, M.N.A., Chua, K.J. and Teo, C.C. (1997). A methodology for tent dryer chamber design *Internat. J. Energy Res.*, **21**: 395 - 410.

Ezekoye, B.A. and Enebe, O.M. (2006). Development and performance evaluation of modified integrated passive solar grain dryer. *Pacific J.Sci.& Technol.,* **7** (2): 185-190.

Gahur, A.M.(1998). Performance enhancement of the AIT solar tunnel dryer, Thesis, Asian Institute of Technology, BANGKOK, THAILAND.

Seveda, M.S., Rathore,N.S. and Singh, P. (2004). Techano-economics of solar tunnel dryer– A Case study. *J Agril. Engg.,* **41**(3):13-17