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RESEARCH ARTICLE

ANALYSIS AND STUDY OF SOLAR DRYER FOR CAULIFLOWER AND LADIES FINGER DRYING WITH PEBBLE BED STORAGE SYSTEM

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ABSTRACT

The solar drying unit with a solar air heater and a storage unit were used for thermal testing. Cauliflowerand Ladies finger were dried using the dryer and the effect of thermal storage was studied. Different quantities of storage material (585kg,166kg and 48kg) were employed to study their performance on drying. Pebble bed storage was employed. The collector efficiency was found to be 23-37 % for Cauliflowerand 21-36% for Ladiesfinger. The efficiency of the dryer was 32-41 % for Cauliflower and 30-39% for Ladiesfinger. The moisture content of Cauliflower was reduced from 74% to 7.1% and 82% to 6.8% for Ladiesfinger. It was seen that the product dried under solar dryer has faster drying rate (8hrs for Cauliflower and 9hrs for Ladies finger) when compared to open sun drying (9.5 hrs for Cauliflower and 10hrs for Ladies finger).

INTRODUCTION

Drying using the sun under the open sky for preserving food and agricultural crops has been practiced since ancient times.However, this process has many disadvantages: spoilt products due to rain, wind, moisture and dust; loss of produce due to birds and animals; deterioration in the harvested crops due to decomposition, insect attacks and fungi, etc. Further, the process is labor intensive, time consuming and requires a large area for spreading the produce out to dry. Artificial mechanical drying, are relatively recent development, is energy intensive and expensive, and ultimately increases the product cost.(Sodha MS,1985).Solar-drying technology offers an alternative which can process the vegetables and fruits in clean, hygienic and sanitary conditions. Solar drying can be used for the complete drying process or as a supplement to artificial drying systems, in the latter case reducing the fuel energy required. Solar dryer technology can be used in small-scale food processing industries to produce hygienic, good quality food products. At the same time, this can be used to promote renewable energy sources as an income-generating option. The employment of solar dryer taps on the freely available sun energy while ensuring good product quality via judicious control of the radiative heat. Solar energy has been used throughout the world to dry food products.(Atul Sharma ,2008).

Methodology

Fig 1 shows the experimental unit. The solar unit consists of three Flat Plate solar air heaters each of $1.87m^2$ and with total area $5.625m^2$. The drying chamber was made up of aluminum, with length, breadth and height (1.06x1.09x1.05) m respectively. The drier is capable of holding 5 trays. The tray dimensions are, length 85cmx breadth 96.5cm and is made of steel mesh with iron frames of 19mm thickness. Storage chamber consists of a bin and a box. Pebbles are loaded in the bin and placed inside the storage box. The bin is made up of steel mesh of dimension (0.8x 0.9)m frames. The length, breadth and height of storage chamber inner dimensions are (0.825x0.905x0.485)m respectively.

Fig 1 The entire unit with solar air heater, a dryer and a storage chamber

The experiment was performed at Sun best Factory, Theni (Latitude: 10° 01', North. Longitude: 77° 28', East). The experiment was performed with no load and load with and without thermal storage. 2kgs of cauliflower and 2kgs ladiesfinger were selected for study. Products are cleaned and ladies finger were cut into slices of 4-5mm thickness. Products with same weight are placed inside solar dryer and in open –sun drying. The readings are recorded and weights of the product were noted for every half an hour interval. The time taken for drying of the product is noted. To test the performance of the thermal storage, same quantity of cauliflower and ladiesfinger were placed inside the dryer during off sunshine hours(night time). The test were

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performed with three different quantities of pebble bed storage (i.e 585kg, 166kg and 48kg). The mass flow rate was set to 132kg/hr, 108kg/hr and 75 kg/hr for study with 585kg, 166kg and 48 kg respectively. The time taken for drying is noted. Depending upon the storage capacity, the mass flow rate was varied. Temperatures of Glass cover, Absorber, Collector inlet and outlet, dryer inlet and outlet, Storage inlet and outlet and ambient were measured along with solar intensity, wind speed, air velocity meter and Relative Humidity.

Thermal Analysis

Collector efficiency: This is computed from,

$$\eta = \frac{\rho V c_p \Delta T}{A I_t}$$

Dryer efficiency: This is given by ,

$\rho V C_p \Delta T$

$$\eta = \frac{ML}{IA_t}$$

Heat energy Q needed for crop drying at moderate temperature**:**

This is given by:

$$Q = \rho V C p \Delta T$$

where (ρ) is the density of air (kg/m^3), (I_t) is the insolation on the collector, (Δ T) is the temperature elevation, (c_p) is the specific heat capacity of air at constant pressure (J/kg K), (V) is the volumetric flow rate (m^3/s), and (A) is the effective area of the collector facing the sun (m^2).

Moisture Content (M.C.): The moisture content is given as:

$$MC = \frac{M_i - M_f}{M_i} \times 100\ \%$$

Where M_i= mass of sample before drying and M_f= mass of sample after drying.

Moisture loss ML**:** The Moisture Loss is given as

$$ML = (M_i - M_f)$$

where M_i is the mass of the sample before drying and M_f is the mass of the sample after drying.

Useful heat gain:

$$Q_u = mC_p (T_o - T_i)$$

RESULTS AND DISCUSSIONS

Experiments were carried out during April 2010. Solar intensity, temperatures of glass cover, ambient, absorber plate, dryer and storage are tabulated for every half an hour. Table 1 gives the collector, dryer and storage efficiencies of the system. It is seen that the storage efficiency in case of 45kg of pebbles was found to be higher because of higher temperature rise within the storage. Table 2 shows the drying time and temperature inside the dryer at different stages. The initial and final moisture content of cauliflower was 73% and 6.5%. The moisture content was reduced from 72% to 5.6% for Ladiesfinger. Average useful heat gain was found to be 1053 kJ, 1045kJ, and 518kJ for cauliflower and for Ladiesfinger it was 3156kJ, 1195kJ, and 648kJ for 585kg,166kg and 48kg respectively. Variation of ambient and storage temperature with time for Ladiesfinger(166Kgs) on 12.5.2011 is shown in Fig 2. Fig.3 shows variation of storage and ambient temperature with time on 14.05.2011 for cauliflower (48Kgs). Temperature inside the storage was consistently above the ambient. Variation of different temperature for the time period of 24 hours on 13.4.2011 for cauliflower (48kg) is given in fig 4.

Variation of collector outlet and ambient temperature with time for Ladiesfinger on 29.05.2011(585kg) is shown in Fig.5.

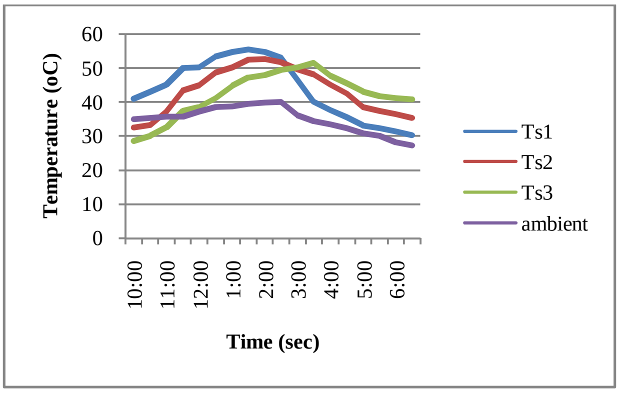

Fig 2 variation of ambient and storage temperatures with time (166 kg of pebbles) on12.5.2011 for Ladiesfinger

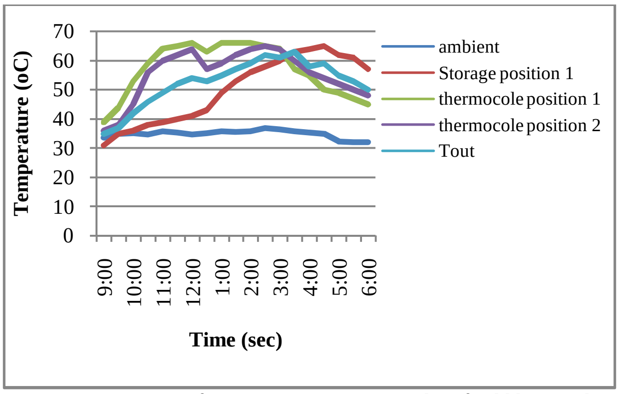

Fig 3 Comparison of storage temperatures (48 kg of pebbles) with ambient temperature on 14.5.2011 for cauliflower

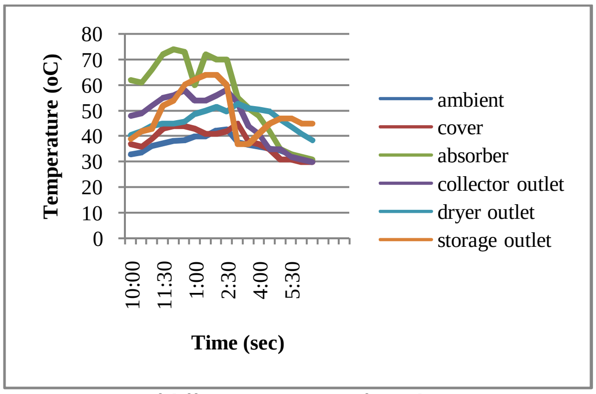

Fig 4 variation of different temperatures for 24 hours on 13.4.2011 forcauliflower(48kg)

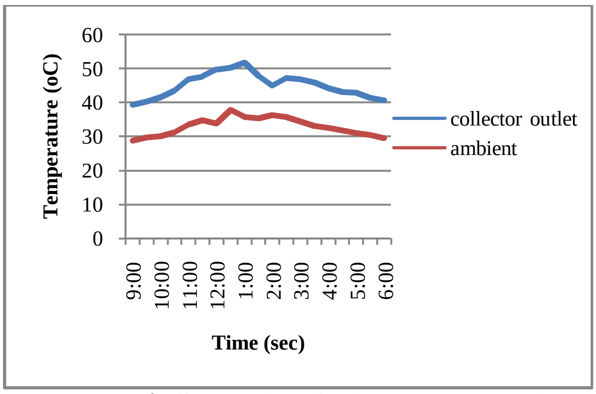

Fig 5 variation of collector outlet and ambient temperature with time for Ladiesfingeron 29.5.2011(585kg).

Table 1 Efficiency of the System

		CauliflowerEfficiency (%)			Ladiesfinger Efficiency (%)		
		Collector	**Dryer**	**Storage**	**Collector**	**Dryer**	**Storage**
Without storage		24-32	32-37	-	25-34	32-37	-
	585 kg	22-30	27-33	13-19	23-36	31-35	14-20
With	166 kg	22-27	32-39	14-20	23-34	34-37	14-18
storage	48 kg	23-30	31-33	16-21	24-36	32-39	17-23

Table 2 Drying time and Temperature inside the dryer at various stages

		Cauliflower		Ladiesfinger	
		Drying time (hrs)	**Temp. inside the dryer (°C)**	**Drying time (hrs)**	**Temp. inside the dryer(°C)**
Without storage		6	56-63	5	55-62
	585 kg	9	23-29	11	26-32
With storage	166 kg	8	25-31	10	30-34
	48 kg	6.5	31-35	8	33-37
Open sun		7		7	

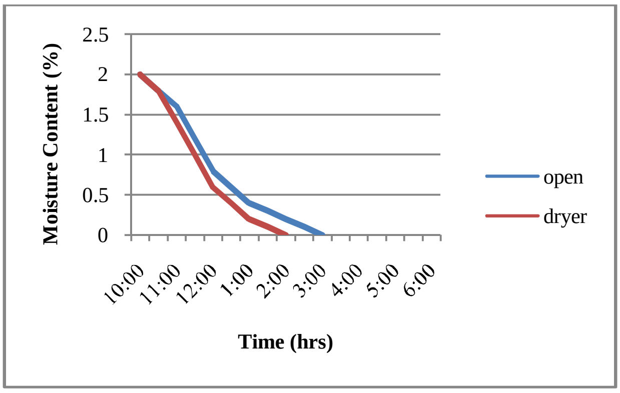

Fig 6 Comparison of moisture loss with time in open and solar drying for cauliflower on 6.5.2011(48kg)

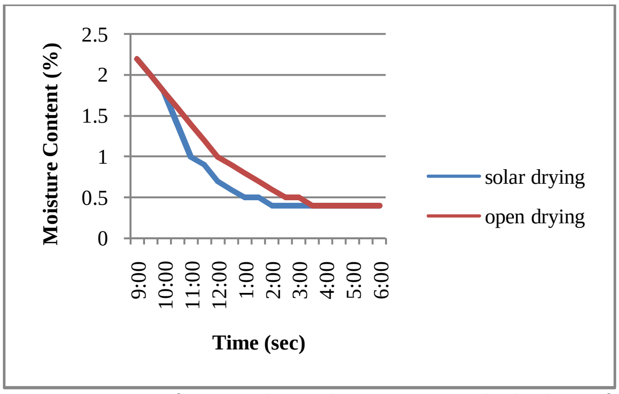

Fig 7 Comparison of moisture loss with time in open and solar drying for Ladiesfinger on 8.6.2011.(166kg)

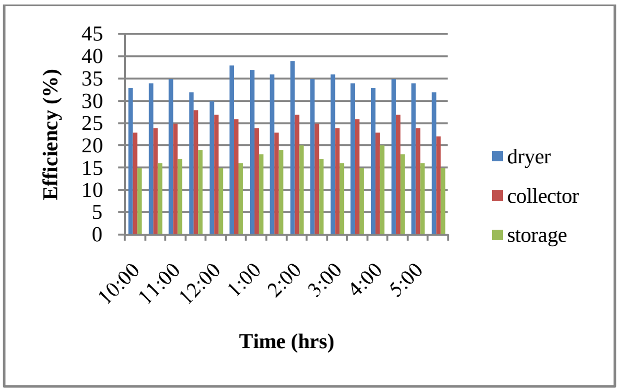

Fig8 Efficiency of the system for cauliflower drying on 25.5.2011(166kg)

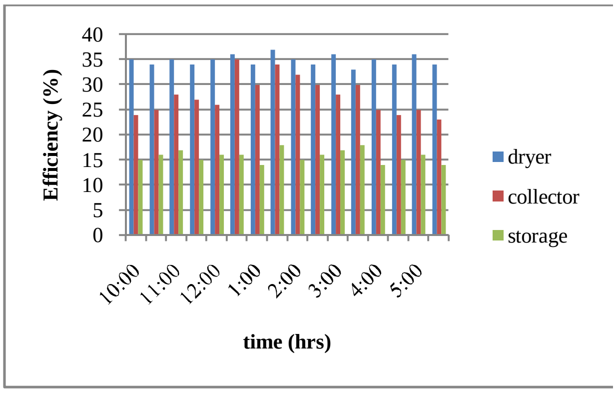

Fig 9 Efficiency of the system forLadiesfinger drying on 10.6.2011(166kg)

Variation of moisture content with drying time for cauliflower on 6.5.2011(48kg) is given in Fig. 6.Fig 7: shows the Variation of moisture content with drying time for Ladiesfinger on 8.6.2011(166kg). The higher moisture reduction during the initial stages of drying was observed due to evaporation of the moisture migration from the inner layers to the surface, which results in the process of uniform dehydration.. From the results, the overall loss in weight of the samples inside the dryer was higher than those outside the dryer. It also shows that the crop drying inside the dryer will dry faster when compared with one, dried outside. The higher loss in weight inside the dryer was because of higher drying temperature inside the dryer. Efficiency graph for cauliflower on 25.5.2011 (166kg) and Efficiency graph for Ladiesfinger on 10.6.2011 (166kg) was given in Fig 8 and Fig 9 respectively.

CONCLUSION

From the results of the test carried out, the following conclusions are arrived at:

1. The efficiency of the entire unit with different quantities of pebbles was found out.
2. The solar dryer can rise the ambient air temperature to a considerable high value for increasing the drying rate of agricultural crops.
3. The product inside the dryer requires lesser frequent attention compared with those in the open sun in order to prevent the attack of the product by rain or pest.
4. The dryer can dry any type of crops under a protected environment
5. Thermal storage can be employed for continuous and better drying of products.

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