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Research Paper :

Design and development of solar paraboloid concentrator for ginger drying

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ABSTRACT

A solar paraboloid concentrator of 5 kg/day drying capacity of fresh ginger slices has been designed and developed at College of Technology and Engineering, Udaipur. In this paper attempt has been made to design and developed a solar paraboloid concentrator to dry the ginger slices. The arrangement has been made to circulate air within drying chamber using the 6.96 Wp DC exhaust fan having capacity of 120-180 m^3/hr operated on 18 Wp SPV panel. The study showed that peeled ginger slices took nine hours to dry at 10% (wb) moisture content. The temperature gradient inside the drying chamber was about 65-70^{0}C.

Key words : Solar paraboloid concentrator, Drying of ginger slices

Ginger is an herbaceous perennial plant, which belongs to the order, Scitamineae and the family, Zingiberaceae. The origin of ginger is India and China. It takes its name from the Sanskrit word stringa-vera, which means "with a body like a horn", as in antlers. It is a tropical herb extensively grown for its pungently aromatic underground stem or rhizome which is an important export crop valued for its powder, paste, oil and oleoresin (NEPC, 1999).

Dried ginger is used both as a spice and medicine. It contains an essential oil, which imparts an aroma, an oleoresin (gingerin) responsible for the pungent smell, starch, gums, proteins, carbohydrate, mineral matter and fiber. Dry ginger is utilized for manufacturing of ginger powder, ginger oil, ginger essence, ginger oleoresins, soft drinks, etc. It is also used as flavoring material in food products (Singh *et al.*, 2008).

Drying is a process to remove water from a substance is one of the most frequently and widely used operating processes in daily life and is undeniably an energy-intensive operation (Buig and Deng, 2008). The conventional practice of ginger drying is open sun drying which is a time consuming method (about 96 h) produces inferior quality product with high loss of volatile oil (Prasad *et al.*, 2006). Although many types of solar dryers have been developed during the last two decades (Bala *et al.*, 2003), their applications are still limited, mainly due to their unreliable performance and high investment cost related to a production capacity. A reduction of losses, an improvement of quality of product and an investment cost are also important criteria dictating the adoption of the solar dryer. A number of solar dryers do not meet these criteria. Therefore, development of a well-performed solar dryer is of significant economic importance. It is recommended that indirect type dryers are better for spices because of retention of color, texture and volatiles would be maximum in indirect drying. The objectives of this work are to design and develop a solar paraboloid concentrator for drying ginger slices and to investigate its performance.

METHODOLOGY

System design:

The view of solar paraboloid concentrator for drying of ginger slices is shown in Plate 1. It is essentially consisted of a paraboloid concentrator with mirror glass of 3 mm thickness as a reflecting material. The drying

Table 1 : Design parameter of drying system

1.	Capacity	5 kg fresh ginger slices
2.	Initial moisture content	83 % (wb)
3.	Final moisture content	10 % (wb)
4.	Loading rate (Lr)	1 kg/m^2
5.	Solar insolation	600-650 W/m^2
6.	Ambient temperature (Ta)	30^{0}C
7.	Drying temperature (Td)	65^{0}C
8.	Ambient relative humidity (RH)	50 %
9.	Drying time (td)	7 hours
10.	Specular reflectance of reflector	0.95
11.	Absorptance of absorber	0.78
12.	Intercept factor	0.75

Plate 1 : Solar paraboloid concentrator for ginger drying

chamber was also designed and developed.

The hot air from receiver was fed to drying chamber from bottom and exhausted by exhaust fan situated above the drying chamber. The arrangement was made to circulate air within drying chamber using 6.96 Wp DC exhaust fan having capacity of 120-180 m^3/hr operated on 18 Wp SPV panel. To avoid the heat losses insulation (asbestos wire) was provided from below the focusing area of copper tube to the inlet at drying chamber. Also to avoid the heat losses from drying chamber glass wool as insulating was sandwiched between two 16 swg M.S. sheets. The manual tracking mechanism was used to track the system. This manual tracking system controls the movement of a solar concentrator so that it was constantly aligned towards the direction of the sun. As the plane of the concentrator was always maintained normal to the sun's rays, maximum power was generated by the concentrator.

Instrumentation:

For drying ginger slices, experiments were conducted in the summer months of 2010 under climatic conditions of Udaipur (27^0 42' N, 75^0 33' E). The global solar radiation incident on a horizontal surface was measured using digital solarimeter. Wind speed and exit air velocity at drying chamber outlet were measured by using Lutron Anemometer Model no. AM-4822 and hot wire anemometer Model no.LM- 4204, respectively. Calibrated NiCr-Ni thermocouples connected to a multi channel Emcon – Digital Solar Data Monitor (Environmental Measurement and Control, Cochin) were used to measure the temperatures at different location of developed system. The temperatures of the different parts of system measured after every one hour as shown in Fig. 1. The ambient temperature were also recorded, the moisture content of product during drying were measured on the wet basis. The relative humidity was measured by using hygrometer.

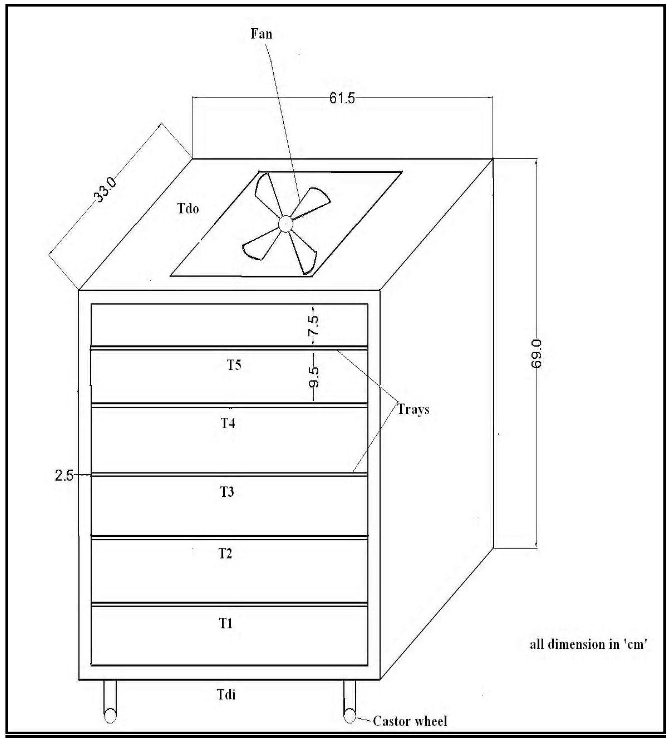

Fig.1 : Schematic of drying chamber and position of thermocouple in i

Experiment:

The ginger was procured from market. The ginger was washed thoroughly under running water to remove the dirt and extraneous matter. The undesirable portions were removed manually and again washed properly. The cleaned ginger was peeled by peeling machine and sliced to about 3 to 5 mm thick slices using a slicer. No chemical treatment was given before drying. Only water washed ginger slices were spread over trays.

RESULTS AND DISCUSSION

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

Thermal performance of drying system:

The drying system test was conducted from 26th to 31st of March, 2010. To analyze the temperature behavior of receiver and inside drying chamber, temperature was

Table 2 : Technical specifications of solar hot air drying system

1.	Loading capacity	-	5 kg fresh ginger slices
2.	Solar concentrator		
	Surface area	-	1.1 m^2
	Aperture diameter	-	1.08 m
	Focal length	-	0.28 m
	Rim angle	-	87.83^O
	Arc length	-	2.12 m
	Length of circumference	-	3.39 m
	Concentration ratio	-	16
3.	Air heating unit		
	Copper tube	-	Circular shape (with 5 rounds)
	Inner diameter	-	0.014 m
	Outer diameter	-	0.016 m
	Total length	-	4.3 m
	Area	-	0.07 m^2
4.	Drying chamber		
	Dimension	-	0.62 × 0.33 × 0.69 m
	Surface area	-	0.2 m^2
	Volume	-	0.14 m^3
	Product holder (tray)	-	S.S wire mesh fitted in aluminum angle of 25 x 25 x 2 mm
	Tray dimension	-	0.55 x 0.3 x 0.03 m
5.	Air flow rate	-	120-180 m^3 / hr
6.	Air flow arrangement	-	24 V, 0.29 A DC exhaust fan operating on 18 Wp SPV panel
7.	Insulation		
	Top, Bottom and Sides	-	0.025 m glass wool

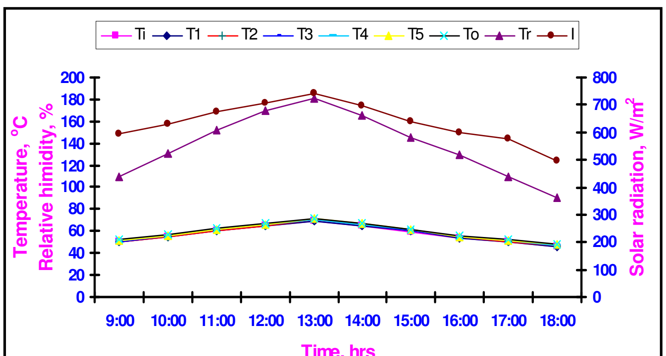

Fig. 2 : Performance curve for no load test

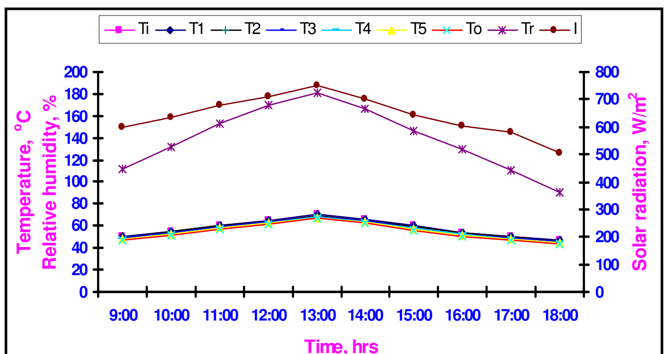

Fig.3 : Performance curve for full load test

monitored at selected point. Fig. 2 shows the temperature variation at receiver and inside the drying chamber at no load condition. The maximum temperature at receiver was 180.5^{0}C and inside the drying chamber at inlet point was 69.8^{0}C at 13:00 hr, when solar insolation was 744 W/m^2

The temperature variation for full load test is illustrated in Fig. 3. The maximum temperature at receiver was 181.4^{0}C and inside the drying chamber at inlet point was 70^{0}C corresponding to solar insolation of about 749 W/m^2. The temperature gradient in the period of 9:00 to 13:00 hrs was in the range of 50.4- 70^{0}C. Ginger may be dried at 85^{0}C up to moisture content of 50% (wb) during first stage and may be dried at 65^{0}C up to moisture content of 12% (wb) for reducing drying time and maintaining quality of ginger suggested by Mantri and Agrawal (1991).

Drying characteristics:

It is clear from Fig. 4, that moisture content was

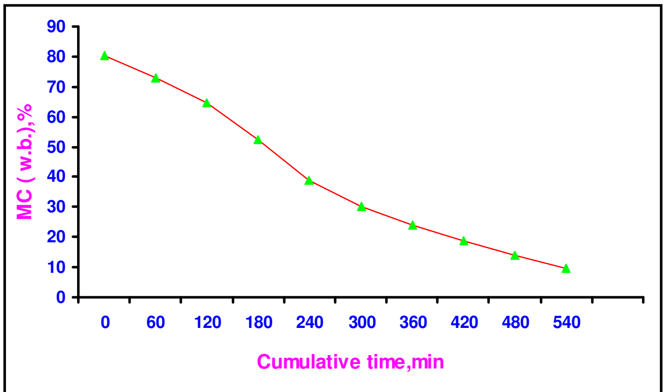

Fig.4 : Drying characteristics of ginger

reduced from 80.5 % (wb) to 10 % within 9 hrs. The pretreatment of sodium metabisulphite reduced browning and destroyed micro-organisms in dried ginger reported by YoomHee *et al.* (1995).

The dried slices of ginger have been shown in Plate 2.

Plate 2 : Dried ginger slices

Conclusion:

As most of the agricultural products are dried at temperature range of 45-75^{0}C, solar energy is being considered as most appropriate source energy for drying. Solar paraboloid concentrator was found satisfactory for ginger drying.

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