Experiment Analysis of Open, Simple and Modified Greenhouse Dryers for Drying Tomato Flakes

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Abstract: **- The use of solar energy in open sun drying in traditional way of drying crops, fruits, vegetables etc. The greenhouse drying is one of the techniques which overcome the problems associated with open sun drying. In the present work, an effort is made to improve the drying rate of traditional greenhouse dryer. An experimental investigation using tomato flakes has been done to compare the drying rates of both traditional as well as modified greenhouse dryers. Better drying conditions- high temperature & low relative humidity are found out to be for modified greenhouse dryer. Experiments were performed in October 2016.**

Keywords: **Solar drying, solar dryer, greenhouse dryer, inclined roof, tomato flakes.**

I. INTRODUCTION

Tomato (Lycopersicon esculentum) is the second most important vegetable crop next to potato in the world. According to FAOSTAT, present world production is about 100 million tons fresh fruit production on 3.7 million hectares. Tomato production has been reported for 144 countries (FAOSTAT Database, 2004), China, the United States, Turkey, Italy, and India, are the top five tomato produces in the world.[1]. It is used for India, in many forms, such as salad, fresh juice, etc. Tomato is a rich source of minerals, which is responsible for its red color and helps in lowering DNA damage. [2].

II. LITERATURE REVIEW

Tiwari et al. proposed a greenhouse dryer under natural convection mode. They dried cabbage and peas in greenhouse dryer under natural convection and the same time the same amount of these crops was also dried in open sun. [3]. Tiwari et al. Designed and used a mixed-mode natural convection solar crop dryer for drying cassava and other crop under full load the drying time was found out to be 35.5 hours which was very loss to the throatily calculated value. [4]. Gaware et al.Tomato pieces were dehydrated in a hybrid solar dryer. Temperature and sample size significaticatly affected critical moisture content. The color of dehydrated tomato indicates a notorious redness. Rehydration was achieved in less than 50 minutes. [5]. Reyes et al. Drying of tomato slices was carried out using five different methods, hat air (HAD), solar cabinet (SCD), heat pump (HPD), microwave vacuum (MVD), and freeze drying. (FD). During microwave vacuumed drying of tomato the highest values, whereas freeze drying resulted in lowest values. [6]. Prakash et al. Performance analysis, a mathematical modeling and an environmental analysis of tomato flakes drying in a modified greenhouse dryer was underactive mode. The nutrient content of the dried tomato in the dryer as well as in open sun drying tomato was found to have more nutrient content than with open sun drying.[7].Sahu et al. Performance of simple and modified greenhouse dryer with inclined roof under natural convection was evaluated and found that better condition for drying. [8]. Sahu et al. Presented work the performed experimentation simple and modified greenhouse dryer higher drying rate has been achieved in modified greenhouse dryer with inclined roof.[9].

III. MATERIAL AND METHODS

Experimental setup

The proposed greenhouse dryer is of inclined roof even type which is made of rectangular iron pipes and covered with transparent plastic film. The bottom surface of the dryer is packed by black colored plastic sheet. The roof of dryer is inclined to latitude of Bhopal i.e.23 ^{o} such that one side central and wall height of the dryers are 48 cm and 32 cm. side central and wall height of the dryer are 72.7 cm and 88.7 cm respectively with floor area of 96 x 62.4 $cm^{2.}$ The drying tray is made of wire mesh with an effective area of 94 x 58 $cm^{2.}$ The tray is also inclined with respect to base and made black for absorbing maximum solar radiation. For entrance of air inside the dryer two circular holes of 10 cm are provided on the south wall below the tray position. One AC exhaust fan of 12 cm diameter with specification of 20W, 0.14A having 2600 RPM is used to remove the inside air. The velocity of air at exit is 3.5 m/s at the upper portion of north wall of dryer in forced convection mode. All parameters at same as for inclined roof greenhouse dryer. The drying procedure was performed in three different modes open sun drying, simple greenhouse dryer and modified greenhouse dryer under forced convection.

Instruments used

For the measurement of solar intensity solar power meter TM-207 manufactured by Tenmmar. Taiwan was used. For

temperature measurement six channel digital indiator DTI-101 with J-Type thermocouple was used with temperature range of 0 to 199 ^{o} C. For measurement of relative humidity calibrated humidity meter HT-305 manufactured by Lutron was used. For measurement of wind velocity digital anemometer AM-4201 manufactured by Lutron was used. A calibrated digital weighing machine of top loading type with having weight capacity of 10 Kg was used. At the Fig.1 and Fig.2 shows the instruments used and the experimental setup.

Fig. 1: Instruments used

Fig.2: Experimental setup

Materials

Fresh tomatoes of in quantity of 3 Kg were procured from local market of Bhopal. India. All the tomatoes were washed by water to remove the dirt from the skin of the tomatoes. After cleaning, they were cut into flakes of 2 to 3 mm thickness. Equal quantity of tomato flakes were kept on the wire mesh of both the dryers and on open plastic sheet.

Experimentation

The experiment was performed between 11AM to 4 PM on 20 October 2016 at Radharaman Institute of Technology & science (Bhopal, India) located at 23.15^{o} N latitude. 77.25 ^{o} E longitude. The drying of tomato flakes was performed in open sun drying, simple greenhouse dryer and modified greenhouse dryer under natural convection modes. The dryer was kept on the ground and far from shade of the trees and buildings.

Figure 3 shows the variation of solar radiation with respect to time on 20 October 2016. The solar radiation varied from 1008 to 1180 W/ m^{2}.

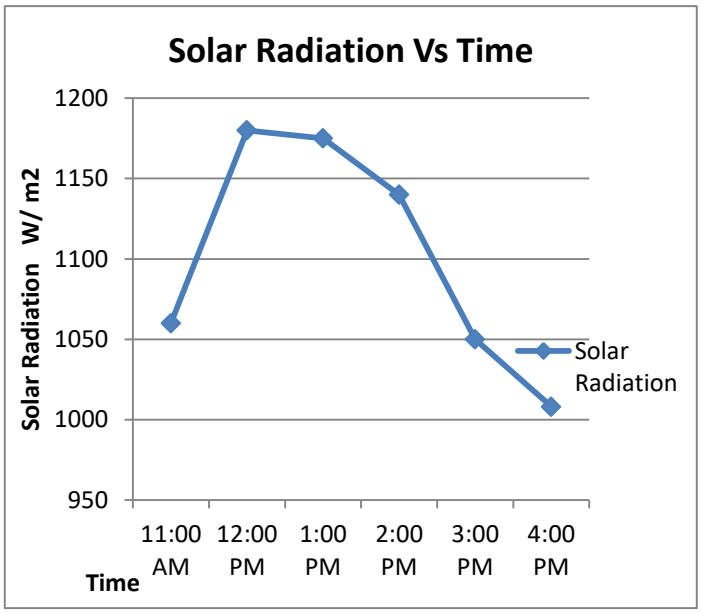

Fig. 3: variation in solar radiation with time

Fig 4 Shows variation of ground temperature, modified greenhouse room temperature, simple greenhouse room temperature, atmospheric temperature, and tomato flakes temperature with respect to time. The solar radiation varied from 1008 to1180 W/m^{2} . The ground temperature varied from 38 to 50 ^{o}C . The modified greenhouse room temperature varied from36 to 48^{o}C. The greenhouse room temperature varies from 35 to 47 ^{o}C. The atmospheric temperature varied from 32.2 to 38.1 ^{o}C. Initially tomato flakes placed inside the dryers were at the temperature of 30 ^{o}C which reached to maximum temperature of 45 ^{o}C modified greenhouse dryer and 44 ^{o}C in traditional greenhouse dryer. It has found that the temperature directly vary with solar radiation. When solar radiation increases, temperature increases. When temperature decreases, the solar radiation also decreases. It is always observed that the ground temperature is higher than temperature at other experimental location. The modified greenhouse room temperature was always higher than greenhouse room temperature, and atmospheric temperature which is beneficial for quick drying the tomato flakes.

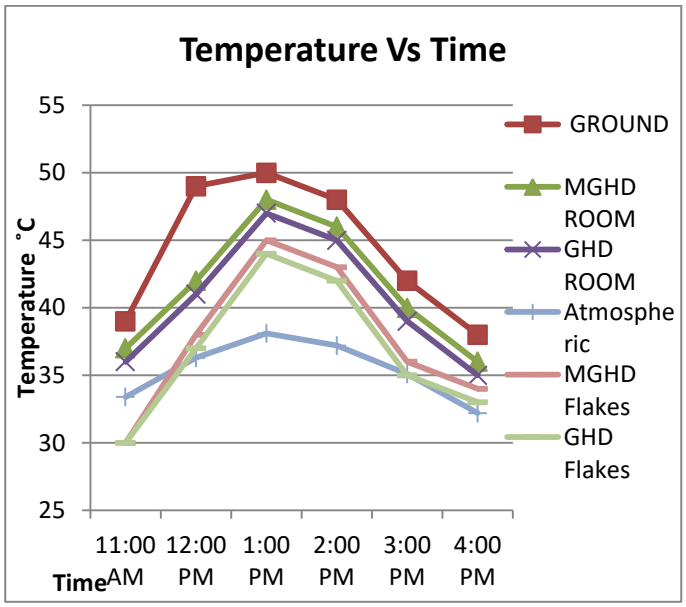

Fig. 4: Variation in temperature with time

Figure 5 shows the variation of relative humidity with time. The relative humidity varied from 21.3 to 25.3 %. The relative humidity in modified greenhouse dryer from 16.5 to 23.1%. The greenhouse dryer relative humidity variation from 18.8 to 23.7%. It was observed that relative humidity in modified greenhouse dryer is always less than the values in greenhouse dryer.

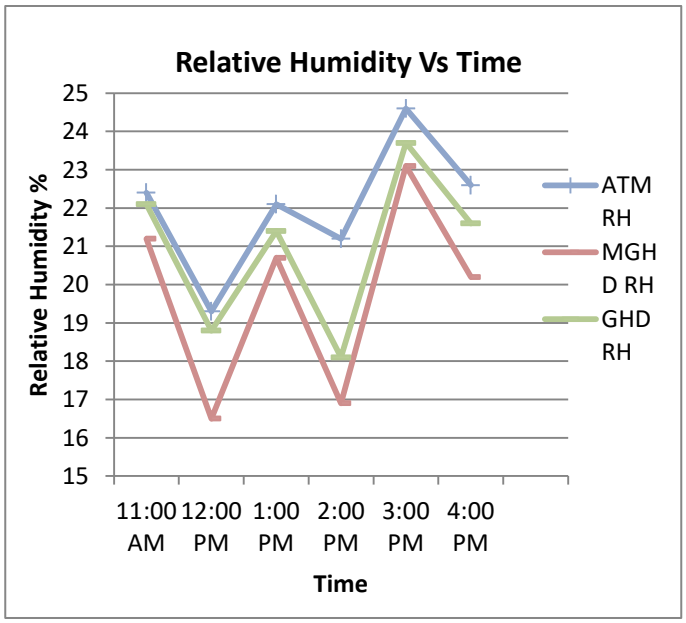

Fig.5: Variation in relative humidity with time

Figure 6 shows the variation of atmospheric wind velocity with time. The atmospheric wind velocity varied from0.1 to 0.7 m/s . The moisture removed from the crop also depends upon the atmospheric wind velocity. Wind velocity also affects the atmospheric temperature. It is also observed that high atmospheric wind velocity leads to reduction in atmospheric temperature due to which greenhouse dryer room temperature and modified room temperature also reduces.

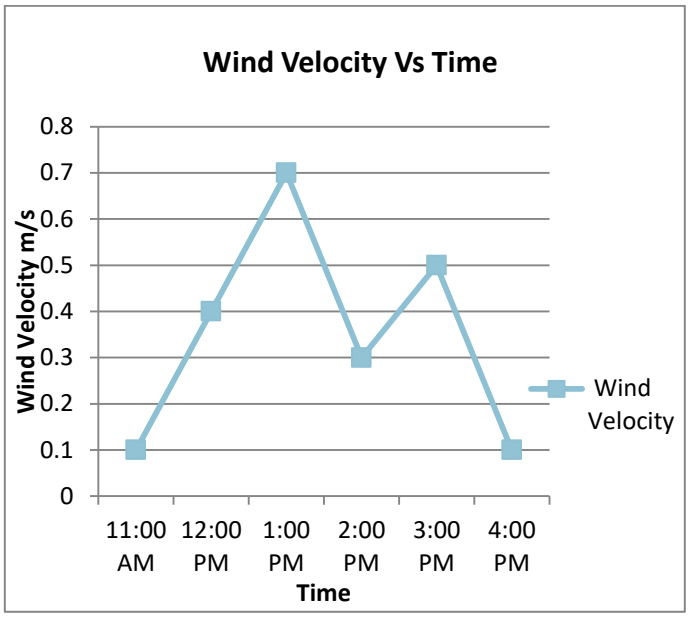

Fig. 6: Variation in wind velocity with time

Figure 7 shows the weight reduction of tomato flakes with time. It can be observed that in the modified greenhouse dryer moisture removal is faster than conventional greenhouse dryer. It has been found that the weight of the dried tomato flakes in modified greenhouse dryer is 82 gms, for conventional greenhouse dryer the weight is 96 gms and in open sun drying it is 185 gms. The drying in modified greenhouse dryer is found to be faster as compare to greenhouse dryer and open sun drying.

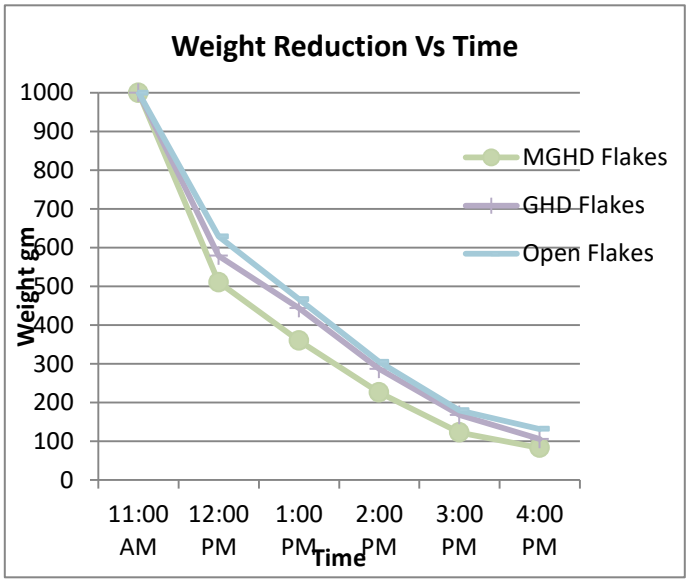

Fig. 7: Drying curve for different mode of drying

Fig. 8(a) MGHD dried Tomato flakes

Fig. 8(b) GHD dried Tomato flakes

Fig. 8(c) Openly dried Tomato flakes

Payback period of modified greenhouse dryer

The payback period of modified greenhouse dryer is calculated as follows [10]

$$N=\frac{ln(1-\frac{Dc}{S}(d-f))}{\ln(\frac{1+f}{1+d})}$$

Where

Dc = Total cost of dryer

S = Salvage value

d = Rate of interest

f = Inflation rate

Total quantity of dried potato flakes per year can be calculated as [7]

DTa = Ta × Dh

Where

DTa = Total quantity of dried potato flake per year

Ta = Total quantity of dried potato flakes per year

Dh = Total no. of sunny day in a year

In Bhopal, India, average sunny days in a year is 300 days.

In our observations average weight obtained of dried potato is approximately 198 gm (0.198kg)

Table 1.1 Economic evaluation for modified greenhouse dryer

S. No.	Parameters	Value
1	Cost of modified greenhouse dryer (Rupees)	3000 INR
2	Salvage Value	100INR
3	Life of modified greenhouse dryer (Year)	10
4	Payback period (year)	1.9
5	Rate of Interest per year	7.25
6	Rate of inflation per year	5.77
7	Total dried potato flakes per year (in kg)	59.4

The economic evaluation of modified greenhouse dryer for drying potato flakes is given in table 5.16. The dryer is made up of local available material and by local skilled labours. Fabrication material includes polythene sheets, rectangular pipe, wire mash tray etc. Due to this the fabrication cost is less and payback period is only 1.9 years.

IV. CONCLUSION

In the present study, an attempt has been made to design and develop a modified greenhouse dryer and further reduce drying time for crops. The conventional greenhouse dryer and modified greenhouse dryers with inclined roof and north wall covered with black sheet has been compared for the time taken for drying tomato flakes. It has been observed that the maximum room temperature in modified greenhouse dryer is 48 ^{o}C whereas in conventional greenhouse dryer it is 47 ^{o}C. The maximum temperature of tomato flakes is 45 ^{o}C which is achieved in modified greenhouse dryer whereas in greenhouse dryer it is 44 ^{o}C. The lower value of relative humidity was observed in modified greenhouse dryer (17.5%) whereas in greenhouse it was 18.8%.The modified greenhouse dryer is found to have faster drying rate as compared to conventional greenhouse dryer and open sun drying.

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