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Low cost material used to construct Effective box type solar dryer

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ABSTRACT

A solar dryer system with multi tray rectangular section which consists of flat plate collector. In this study, temperature inside the solar box dryer and grapes moisture content with drying efficiency of grapes clusters dried in the solar box dryer have been investigated. A prototype of the dryer was constructed to specification and used in experimental drying tests. A number of experiments were conducted using potato slices, chilly and grapes. For all the test conditions, the material gets dried with system's efficiency of 15 % to 18%.The drying time compared to open air drying was reducing by about 20% and produces the drying material on the trays are better quality. The minimum of 0.045m^2 of solar collection area according to the design is required for an expected drying efficiency of 69.6% under average ambient conditions of 30°C and 76.1% relative humidity with average solar radiance of 650W/m^2, the average drying efficiency was evaluated as 69.6% .

Key words: solar dryer, temperature performance, collection efficiency, moisture content

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INTRODUCTION

In many countries of the world, the use of solar thermal system in the agricultural area to conserve vegetables, fruits, coffee and other crops has shown to be practical, economical and the responsible approach environment Waewsak et al., [1]. Solar heating system to dry food and other crops can improve the quality of the product, Food processing Engineers and Scientists have found that by reducing the moisture content of food from 15 % to 20%.

Drying and preservation of agricultural products have been one of the oldest uses of solar energy. The traditional method, still widely used throughout the world, is open sun drying where diverse crops such as fruits, vegetables, tobacco, etc. are spread on the ground and turned regularly until sufficiently dried [2].

Traditional drying, which is frequently done on the ground in the open air, is the most widespread method used in developing countries because it is the simplest and cheapest method of conserving foodstuffs. Some disadvantages of open air drying are: It requires both large amount of space and long drying time. Exposure of the foodstuff to rain and dust. The crop is damaged because of uncontrolled drying and hostile weather conditions, infestation by insects and attack by animals. This could lead to slow drying rate, contamination and poor quality of dried products, because of the above mentioned factors of open sun drying process and a better understanding of the method of utilizing solar energy to advantage, have given rise to a scientific method called solar drying. [3].

However the availability of good information is lacking in many of the countries where solar food processing system is most needed [4]. The solar drying process is depended on different parameters, such as weather parameters like ambient air temperature, relative humidity, solar radiation and wind speed, amount on initial moisture content, type of dryer, etc., the determination of the drying efficiency of such process is too complex. Drying of banana in a solar cabinet took three days and better quality product was obtained as compared with that in the case of natural open sun drying.

There are a large variety of solar dryers. They can be classified basically into two types: natural convection type dryers and forced circulation type dryers [5]

Natural convection dryers do not require a fan to pump the air through the dryer. The low air flow rate and the long drying time, however, result in low drying capacity. Where large quantities of fresh produce are to be processed for the commercial market, forced convection dryers should be used [6].

The objective of this study is to develop a rectangular box solar dryer in which the grains are dried by direct radiation through the transparent walls and roof of the cabinet and by the heated air from the solar collector. The temperature development of the dryer was also evaluated.

Objectives

The specific objectives of this study were

- Design and construction of a box type solar drying system with different wire mesh layer
- Thermal Performance study of Box type solar dryer with flat plate
- Studying the efficiency of box type solar dryer for drying different Fruits and Vegetables.

CONSTRUCTION

The figure (1) shows the sectional view of Box type solar dryer device consisting of the solar collector heat absorber plate, wire mesh, wooden box, thermocouple wire and glass cover. The construction of materials is used in the solar dryer available in the local market. The system has been installed in the physics department of Government Arts College, Dharmapuri.

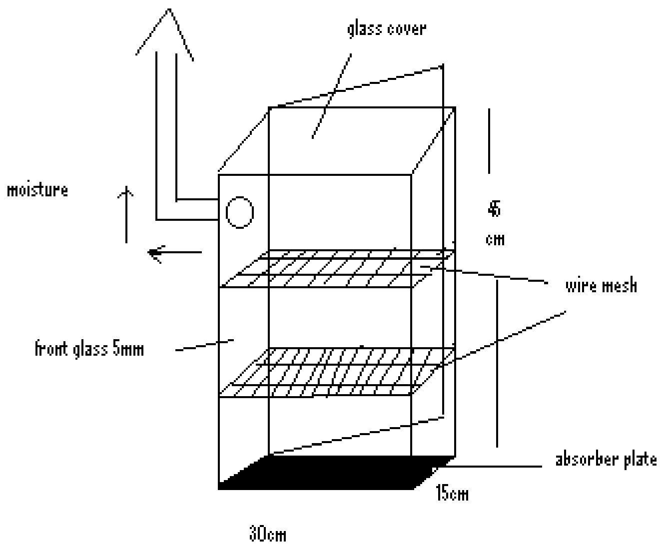


Fig.1 Sectional view of low cost material used solar dryer

Fig.2 Experimental set up of box type solar dryer with potato slices

MATERIALS AND METHODS

The box type solar collector system, with length of 30cm and width of 15c m, and height of 45cm. The system consists of absorber plate, single glass cover, back door and thermocole used as insulation. The system is framed with the single logs. A single typical glass covered with thickness of 5mm is placed in the top surface of the collector. Both side and bottom of the collector are insulated with 3cm of thermocole. These minimize the heat losses from inside of the box to surrounding the box through both side wall and bottom wall.

The materials used for the solar dryer box, plywood, transparent glass, high range thermocouple wire, thermocole, aluminum sheet, PVC pipe, wire mesh, digital multimeter and thermometer. The solar dryer made by plywood material in the shape of rectangular length 30cm, height of 45cm and width of 15cm. Inside the solar dryer, two layer of wire mesh has been placed between top glass cover and bottom heat absorber plate. The distance between the bottom to first wire mesh layer is 10cm and the distance between the second mesh to top layer is 10cm each layer having a thickness of 0.5mm with length of 30cm and width of 15cm total area of a single wire mesh is 0.045 m^2. A small hole of 3cm diameter is provided on top of the dryer to remove the moisture content through the PVC Pipe.

The performance of the box type solar dryer was evaluated by different climatic conditions during observation period to dry different vegetables and fruits like potato, chilly and grapes. 1) Inside plate temperature and air temperature of the solar dryer 2) incident solar radiation of the solar collector 3) variation of moisture content of the vegetables and fruits during the observation period. J –type thermocouples were installed at various points of solar dryer. The experiments started at 9 am and stopped at 4 pm during the observation period.

Estimation of Dryer Efficiency

The solar dryer efficiency can be calculated under : Collection efficiency(η_c)
And the system efficiency (η_s)[7].
The collection efficiency measures (η_c), the ratio of the useful energy output to the total radiation energy, available during the same period.
Collection efficiency

$$\eta_c = \frac{Qu}{AcIs} \qquad 2.0$$

Where, $Q_u = mc_p\Delta t$, A_c is the collector surface area Eq.(2.0)can be interpreted only as a transient value owing to the time dependence of the irradiance. For definite period, the long term efficiency of the collector can be expressed with the time integral of utilized and input energy flow rates [8].

$$\eta_c = \frac{\int_0^t Qu\, dt}{Ac \int_0^t Is\, dt} \qquad 2.1$$

System drying Efficiency

The system drying efficiency is the ratio of the energy required to evaporate the moisture of the food material to the heat supplied to the drier.

$$\eta_s = \frac{WL}{IsAc} \qquad 2.2$$

Where, W is the mass of moisture evaporated
L, is the latent heat of evaporation of water at the dryer temperature
A_c is the solar collector area and the dryer efficiency is given by

$$\eta_d = \frac{\eta s}{\eta c} \qquad 2.3$$

RESULTS AND DISCUSSION

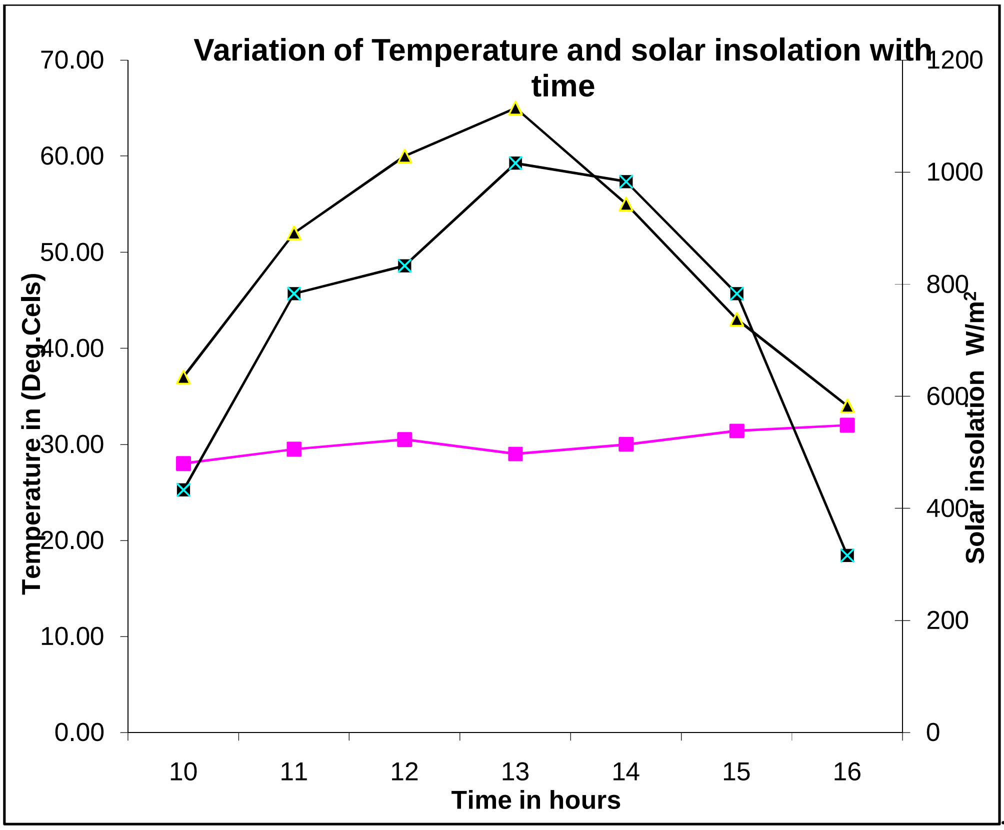


Fig. 3. Variation of solar radiation, absorber plate temperature and ambient temperature with time in hours on first day observation

Constructed solar dryer and its experimental set up are shown in fig.2. Performance of solar dryer have been studied and reported under various climatic data's included in the calculation and estimated the efficiency of the dryer, the first day variation of solar insolation and ambient temperature were measured with the help of pyranometer and thermometer for every one hour interval and its values are reported in fig.3.

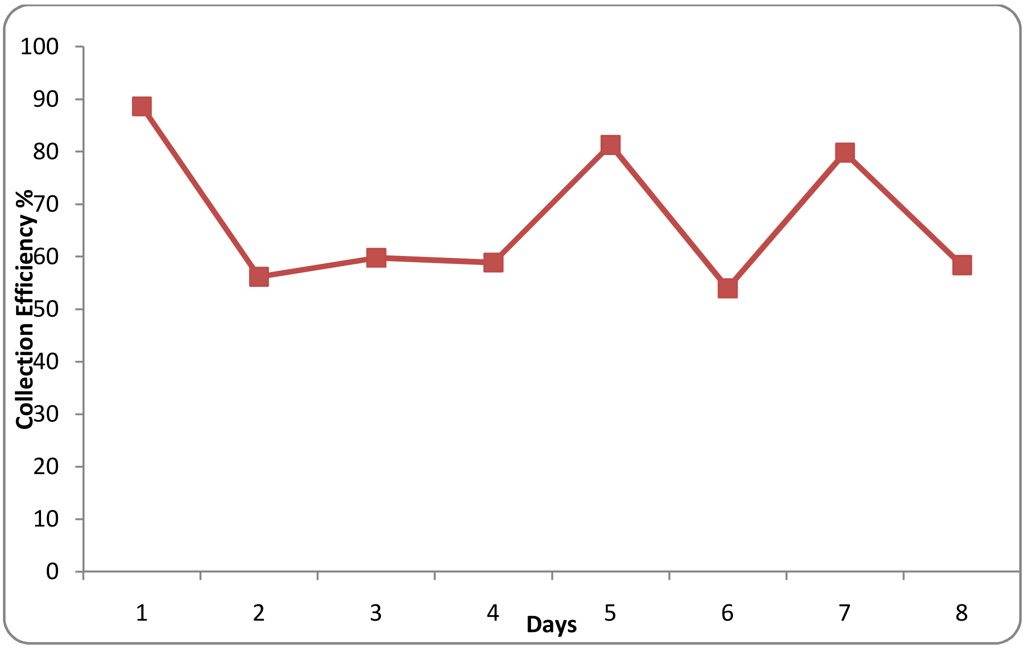


Fig.4 Variation of system collection efficiency with number of days

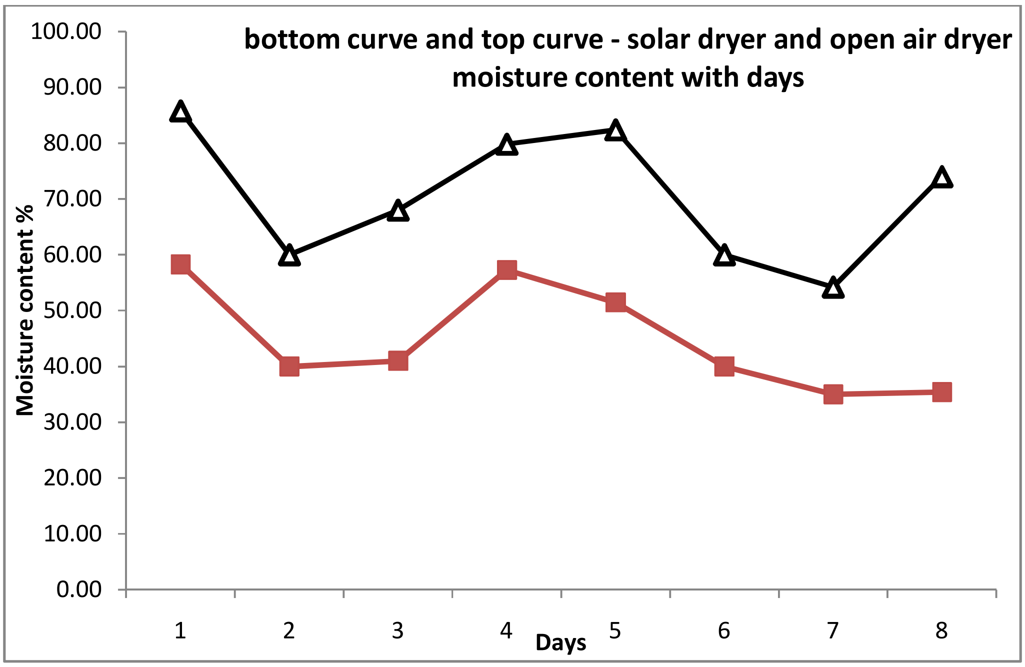
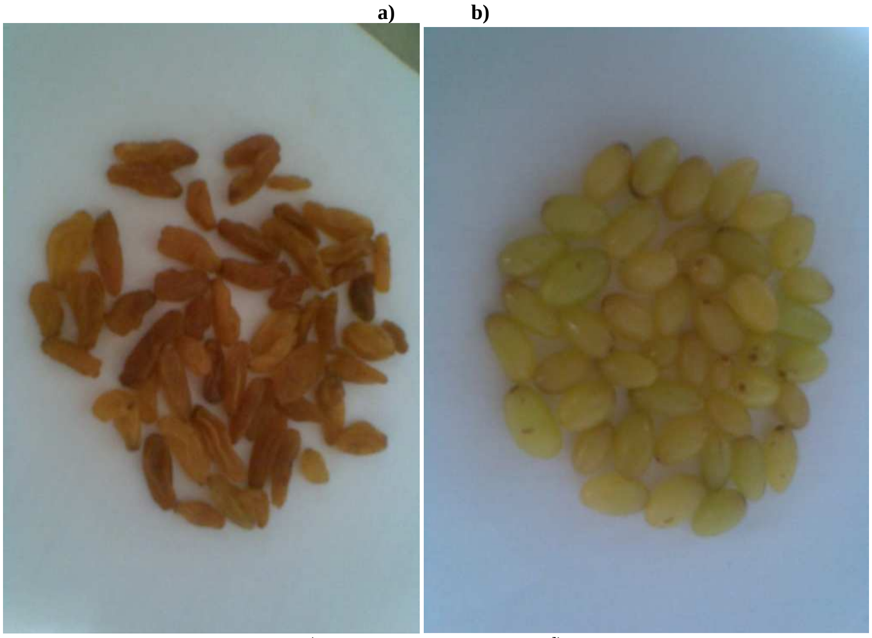


Fig. 5. Comparison of solar drying material moisture content and open air drying material moisture content efficiency with number of days.

The first day the maximum value of solar insolation at 1 pm was 1016 W/m^2 and minimum of 310 W/m^2, ambient temperature and plate temperature is measured 30°C and 62 °C. and observed values are plotted in fig.3.

The system collection efficiency was found to increase with increasing intensity of solar insolation falling on the collector area. The average system drying efficiency was estimated as 69.6% during the observation period and measured values are plotted in fig.4. Compared the variation of moisture content efficiency of box type solar dryer and open sun moisture content, testing material (potato slices, chilly and grapes) values is plotted in fig.5.and dried product is shown in fig.6.

a) b)



c) d)

Fig.6 a) and c) solar drying of chilly and grapes
b) and d) open drying of chilly and grapes

CONCLUSION

A portable and inexpensive rectangular box type solar dryer was designed and constructed using locally available materials. The collection efficiency of solar drying system is calculated using the climatic condition which includes ambient temperature, solar radiation, relative humidity, air velocity and atmospheric pressure. The drying rate and average collection efficiency and percentage of moisture removed for drying potato slice, chilly and grapes during the test period was found to be 1kg/h and 69.6% respectively. The hourly variation of the plate temperature and air temperature inside the solar dryer higher than surrounding temperature during the observation period. The drying rate increased due to increase in plate temperature between 11am to 2pm. The observed plate temperature was up to 62 °C at noon time and decreased due to low intensity of radiation received thereafter. Depends on intensity of radiation received on earth surface maximum the dryer was able to remove 80% of moisture on dry basis in one day observation.

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