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Blueprint and Production of Tomato Solar Dryer

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Abstract

The sun drier has been carefully designed and tested for its efficacy in drying tomato slices. The dryer's loading capacity was around 10 kg slices each batch. The dryer's drying qualities were investigated and compared to the open sun drying technique. The maximum temperature reached in the dryer's drying chamber was 52.63°C. The drying time for tomato slices in stated solar dryer was 12.5 h from beginning moisture content of 94 percent (wb) to final moisture content of 8.97 percent (wb), whereas 15 h was observed in open sun drying. The powder made from tomato slices dried in the solar panel drier exhibited a dark red colour when compared to the powder made from open sun-dried tomato slices. The gravel with iron scrap heat storage system was seen to provide heat to the drying chamber for an additional three hours after dark. As a result, the prolonged 3 hours after the sun set made it possible to finish drying in a single day.

Keywords: *Solar cabinet dryer, heat storage system, flat plate solar air heater*

INTRODUCTION

The most prevalent method for preserving and processing agricultural products is open air and uncontrolled solar drying. However, uncontrolled drying encounters the difficult issue of wind conceived dust, insect invasion, and item may be genuinely degraded to the point where it occasionally loses market value, and the resulting loss of and have to the nourishment quality may have unfavourable monetary impacts on the local and global market. Dryers are designed and used to extend the shelf life of agricultural goods. [1-5] (Esper and

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Muhlbauer, 1996), The great majority of them either use a pricey source of energy, for example, electricity (El Shiatry et al., 1991), or a combination of solar energy and some other sort of energy (Sesay and Stenning, 1996).

Most activities of this nature have not been well received by small farmers, either because the previous structure and data collection methods are frequently incorrect, or because the expense has remained blocked, and the resulting transfer of innovation from analyst to end client has been unquestionably unsuccessful (Berinyuy, 2004).

The goal of this research is to show some of the fundamental types of solar dryers in order to provide a better understanding of their usefulness in the drying of agricultural goods.

[8-12] MATERIALS AND METHODS

A solar cabinet dryer with a heat storage system of 10 kg per batch size was identified. The dryer's performance was assessed by drying tomato slices.

[13] Flat Plate Solar Collector

As a solar air heater, a flat plate sun collector is used. The drying chamber is directly attached to the flat plate solar collector. By using a basic thermo-syphon effect, natural air was pumped through the gap between the clear glass cover and the absorber plate. The flat plate solar collector had a size of 1.81.00.20 m. It was constructed from 22-gauge GI sheet. The flat plate solar collector was positioned on a stand at a 25°C angle to the horizontal. To optimise the sun energy impacting on the solar collector, the system was positioned to face south. To raise the temperature of the air via the greenhouse effect, a toughened textured glass cover with a thickness of 5 mm and a dimension of 1.81.0 m was employed and put on top of the flat plate collector. In the solar air heater, a 3 mm thick aluminium absorber sheet was employed. To absorb the most incoming solar energy, the aluminium absorber sheet was painted black on both sides. The absorber plate (3 mm thick) was 1.81.0 m long, and the absorber manuscript was 1.81.0 m long.

System for Heat Storage

To store heat throughout the day and retrieve hot air after sunset, a heat storage chamber is filled with heat storage materials such as gravel and iron scrap. The heat storage chamber was installed just beneath the 1.81.00.10 m aluminium absorber plate. It functions as a heat exchanger and is built of 22-gauge GI

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sheet. The system was appropriately insulated with 5 mm thick thermocol sheet to decrease heat losses. Insulation was installed beneath the heat storage chamber to prevent significant heat losses from heat storage.

Chamber for Drying

A drying chamber was built to accommodate the loading of the products to be dried. The length of 1.01.00.6 m was manufactured of 24-gauge MS sheet. The drying chamber's capacity was 10 kilogramme per batch. The drying chamber is made up of five perforated mesh trays with a diameter of 1.01.0 m. It was built of stainless steel wire mesh with a mesh density of 40 meshes per square inch and a gauge of 30. Each drying tray has a holding capacity of 2 kg. On the roof of the drying chamber, two chimneys with 0.15m diameter and 0.75m length were supplied.

Instrumentation Used to Evaluate the Performance of a Solar Cabinet Dryer

The temperatures of the ambient air, the collector heat storage bed, and the drying chamber of the solar cabinet dryer were measured using a digital type RTD (resistance temperature detector) and 12 channel indicators. A digital pyranometer with a data recorder was used to detect sun radiation at the dryer's tilt. The relative humidity was measured using a digital hygrometer. The wind speed at the dryer's chimney was measured using a wind vane anemometer. The weight loss of tomato slices in the dryer and open sun drying methods was monitored using a digital electronic weight scale on a regular basis. The moisture content of the slices was determined using the oven drying technique. The dryer observations were taken at 30 minute intervals.

[6] Mathematical Modeling

The moisture ratio, 't,' of tomato slices dried in a solar dryer integrated with and without a heat storage system and by open sun drying at a given period was estimated using the following equation:

Moisture Ratio (M. R.) = (Mt-Me)/(Mi-Me)= e-kt

Where,

Mt - Moisture content (db), %

Me - Equilibrium moisture content (db), % Mi - Initial moisture content (db), %

k - Drying rate constant per minute

t - Drying time, min

Solar Cabinet Dryer Performance Evaluation

Fresh air enters the air heater, which heats up as it comes into touch with the absorber copper plate, and then proceeds to the

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drying chamber. A heat storage system incorporating gravels and iron scrap material is located just beneath the copper plate sheet and absorbs heat when sunlight strikes the copper sheet via glass. This stored heat is then transferred to the drying chamber after sunset. Freshly picked tomatoes are thoroughly rinsed in cold running water before being hand sliced into 4 to 6 mm thick slices.

The installation of a solar cabinet drier was permitted with and without a heat storage system, as well as with and without a full load condition. The drying trays were loaded with 10 kg tomato slices, which were evenly distributed over the trays. Drying took place between 8:30 and 17:30 h. The samples' original weight was recorded. Each sample of 100 grammes was weighted every 30 minutes, while the temperature, relative humidity, sun radiation, wind velocity, and ambient temperature were all measured within the solar cabinet drier. Similarly, at full load, the enactment of the solar cabinet dryer with heat storage system was computed.

Tomato Slices' Drying Characteristics The drying process is dependent on simultaneous heat and mass transfer processes, and the parameters that dominate each process dictate the product's drying behaviour. The drying rates were computed using the experimental data and the drying feature curves, which included moisture content vs drying time, drying rate, and moisture ratio versus drying time.

Calculation of the Drying Rate

The drying rate, (mw), was calculated from the mass of moisture evaporated and the drying time using the following equation.

Mw=Mw/t

d Where,

Mw - Drying rate, kg h-1

Mw - Quantity of water evaporated from product, kg

Td - Assumed drying time,

Calculation of the Latent Heat of Vaporization

Latent heat is the amount of heat energy absorbed or released during a phase shift.

L = Q / M is the formula for latent heat.

Where Q is the quantity of heat

M denotes the substance's mass.

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Table 1: Solar Dryer Performance Characteristics.

Time	10.00 AM	11.00 AM	12.00 PM	1.00 PM	2.00 PM	3.00 PM	4.00 PM	5.00 PM
Quantity (gm)	1000	757	597	415	257	161	113	87
Inlet Temperature (°C)	40	40.98	41.4	39	36	35.2	34.4	32.7
Outlet Temperature (°C)	43.98	44.18	46	50	50	48	42	39.2
Latent Heat (KJ/Kg)		2.897	9.243	3.868	9.503	7.380	14.47	

Solar Dryer is initially performed for 1 kg of tomato during the day between 10.00AM and 5.00PM to record temperature and quantity of tomatoes variations. These parameters are shown in the following table: -

SOLAR DRYING SYSTEM ECONOMIC ANALYSIS

The benefit cast ratio and payback duration of the solar cabinet drying system with and without heat storage were calculated. The economic analysis was carried out with the following assumptions in mind:

1. The solar cabinet drying system has a batch capacity of 10 kg.
2. At a moisture level of 9%, the whole final product was generated per batch (wb).
3. The average cost of freshly grown tomatoes.
4. The cost of a solar cabinet dryer (the first investment) in rupees.
5. Depreciation cost of 10% of the initial cost
6. 10% interest on the first investment
7. The solar cabinet dryer system's useful life is ten years.
8. The daily labour expense.
9. The system's yearly repair and maintenance costs, multiplied by 2%
10. Grinding cost in rupees per kilogramme

RESULT

Tomato slices were dried using a solar cabinet drier with a heat storage device. The highest temperature achieved in a solar cabinet dryer was 52.63 degrees

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Celsius, despite the most severe surroundings.

Separately, the temperature and sun intensity were reported at 42.03°C and 991.70 W/m2, respectively. It was discovered that drying tomato slices in a solar cabinet drier took 12.5 hours.

The heat storage system provided warmth after nightfall hour as well, and an outstanding difference in temperature between the drying chamber and the surrounding environment was seen up to 20:30 h, and the drying of tomato slices was completed in one day only (08:30 to 20:30 h). Tomato slices were dried in a solar cabinet drier.

Characteristics were investigated. Figure 1 shows that in a solar cabinet dyer equipped with a heat storage system, the average moisture content of tomato slices samples put in T1, T2, T3, T4, and T5 trays decreased from 1566.67 to 9.78 percent (db) in 12.5 hours. In contrast, the average moisture content of the tomato slices sample decreased from 1566.67 to 12.91 percent (db) in 15 hours for open sun drying in May 2014. Babagana et al. (2012) reported a drying time of 14 hours in a solar vegetable drier with a heat storage system for tomato slices. The average drying rate of tomato slices dried in T1, T2, T3, T4, and T5 was displayed in Fig.

T5 trays of solar cabinet dryer combined with heat storage system were determined to be 0.9233, 0.8821, 0.8390, 0.7889, and 0.8132 gm/100gm bdm min. The drying rate of an open sun-dried tomato sample (OSD) was found to be between 2.3889 and 0.0111 gm/100gm bdm min.

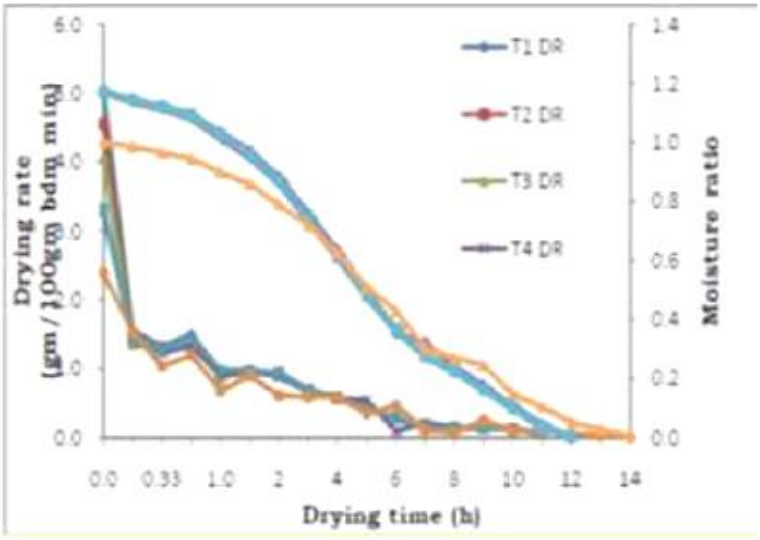


Figure 1: Temperature developed in the Heat Storage System at Full Load in May 2014.

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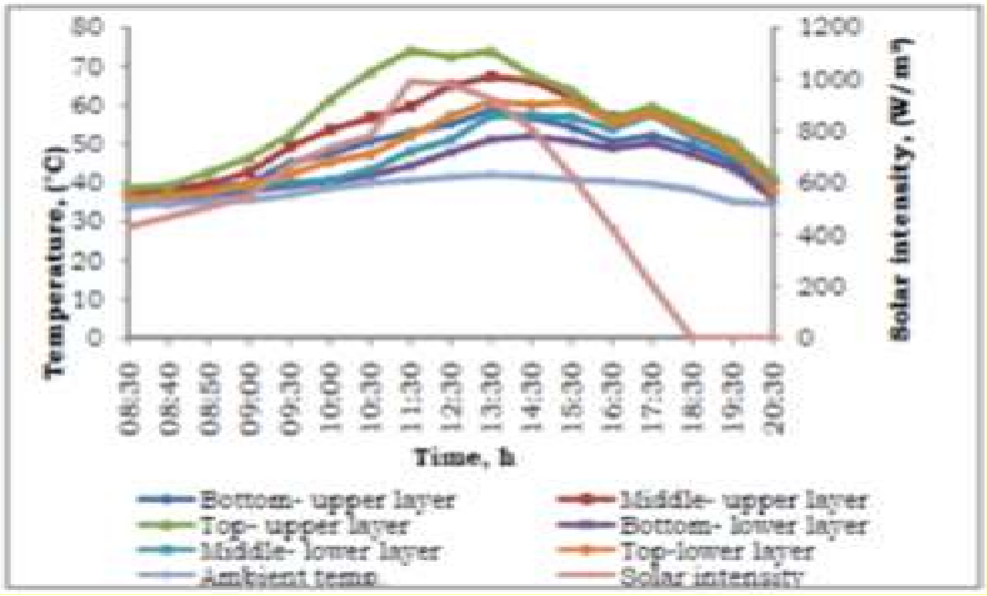


Fig. 2: Variation of Tomato Slice Drying Rate and Moisture Ratio in Solar Cabinet Dryer with Heat Storage System and OSD.

Temperature Developed in the Solar Dryer's Heat Storage System

The temperature generated in the heat storage system of the dryer during the day and after nighttime was estimated at full load at the higher and lower layers of the heat storage system, namely the base, middle, and top. According to Figure 2, the highest temperature in the heat storage system at its top layer was 73.97°C, while the temperature in the heat storage system at its bottom layer was 60.83°C. The highest ambient temperature was 42.03°C, and the sun intensity was 991.70 W/m2. The largest temperature differential between the ambient and drying chamber was 10.83°C from 0830 to 1730 h, and it ranged from 8.18 to 5.87°C from 1730 to 1830 h.

2030 h for drying tomato slices in a solar cabinet drier with a heat storage system. Senthilkumar et al. (2013) observed that even during off-peak hours, the collector maintained a steady air temperature (1700 to1900h) 3.3 Moisture Content Variation in Solar Dryer and OSD

Method

Figure 12 depicts the change of moisture content (db) with drying time. The drying time for tomato slices with a primary moisture content of 94 to 8.91 percent (wb), i.e. 1567 to 9.78 percent (db), was set to 12.5, 12 and 15 hours, respectively, in sun cabinet dryers with heat storage systems, solar cabinet dryers without heat storage systems, and OSD techniques.

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Tomato Slices Drying Model Using Thin Layers

Samples	Moisture (%)	Ascobic acid (mg/100g)	Beta-Carotene (mg/100g)	Lycopene (mg/100g)
Fresh	88.09±1.65^{a}	17.78±0.15^{a}	1.16±0.22^{d}	1.74±0.06^{e}
T_1	18.15±0.13^{b}	14.97±0.11^{b}	1.91±0.11^{a}	7.88±0.06^{c}
T_2	17.75±0.78^{b}	13.33±0.63^{c}	1.96±0.22^{a}	9.81±0.08^{a}
T_3	16.85±0.21^{b}	13.23±0.07^{c}	1.78±0.11^{b}	9.13±0.00^{b}
T_4	20.32±0.37^{c}	10.23±0.62^{d}	1.45±0.19^{c}	5.52±0.06^{d}

The results in the same column with the same superscript did not differ substantially (p0.05).

T1= Tomato slices dried at 40°C, T2= Tomato slices dried at 50°C, T3= Tomato slices dried at 60°C, T4= Sun dried Tomato slices.

Wang and Singh drying model was identified as the best ranking thin layer model and the model suitable to the change of moisture ratio with drying time of tomato slices dried in solar cabinet dryer with heat storage system by statistical analysis, and the equation is presented below.

The Cost-Effectiveness of a Solar Cabinet Dryer for Tomato Slice Drying

The economic feasibility of a solar cabinet dryer with and without a heat storage system for drying tomato slices was calculated by taking into account the initial investment, depreciation cost, annual interest, average repair and upkeep cost, raw material and tomato powder costs, and the cost of raw material and tomato powder. The economics of a solar cabinet dryer without a heat storage system for drying tomato slices were studied utilising various economic parameters of a solar cabinet dryer with and without a heat storage system. In a year, around 270 drying days are available for drying. Because one batch dried in one and a half drying days in a solar cabinet dryer without a heat storage system, a total of 180 batches could be dried.

Finished in 270 drying days The drying of tomato slices, on the other hand, was accomplished in a single day in a solar cabinet drier with a heat storage system, implying that 270 batches of drying might be performed in a year. The BC ratio of the solar cabinet dryer without a heat storage system was calculated to be 1.40,

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whereas the BC ratio of the solar cabinet dryer with a heat storage system was calculated to be 1.45. The payback period for a solar cabinet drier without a heat storage system was expected to be 16 months, however it was discovered to be 11 months in the case of a solar cabinet dryer with a heat storage system.

FUTURE PERSPECTIVE

Our understanding has advanced in four ways as a result of our project:

1. As a sunflower, a solar panel may be adjusted to the movement of the sun.
2. The electrical energy generated by the solar panel may be stored in a battery and used when sunshine is unavailable.
3. A temperature sensor can be used to prevent food grains from overheating.
4. [7]
5. Automatic container refilling
6. We can also add a solar-powered grinder to crush the dried tomato into tomato powder.

CONCLUSION

A review of the study article is stated in this paper that the solar dryer is Sun drying procedures are more useful. Solar dryers do have drawbacks. They aren't very useful when it's cloudy outside. They can function too well in good weather. Despite the fact that solar dryers are an initial investment, they produce better-looking, better-tasting, and more nutritious meals, boosting both their food value and marketability. They are also more efficient, safer, and effective than traditional sun drying processes.

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