International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 02 February 2024
Page No: 333 - 338
https://irjaeh.com

Experimental analysis on Solar Drying of Tomatoes and Cucumbers using PV/T Hybrid Solar Air Dryer

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Abstract

Drying is a method for removing moisture from food that is frequently used for storage and preservation. The most important goods in the agriculture industry are fruits and vegetables. Because of its extremely high nutritional value, it needs to be kept. The best way to maintain a food's nutritional worth is to keep it fresh. There are numerous ways to preserve this food, but nut drying is the most popular because it lengthens the item's shelf life. These items can contain up to and sometimes even more than 90% moisture. The key contributing factor to the proliferation of microorganisms that cause putrefaction is thought to be water content. This study compares the effectiveness of solar drying versus sun drying for drying fruits and vegetables. Rate of drying, weight. The experiments were carried out on tomatoes and cucumbers. The collector is inclined at 45° with horizontal and oriented in South – North direction with drying time of 5 hrs per day. During experimentation 5 temperatures, absolute humidity, air velocity and solar intensity were measured hourly in the month of March and April, 2023 for drying of tomatoes and cucumber slices. The hot air was transferred through the pipes to the chamber to dry the tomatoes and cucumber slices. The drying of tomatoes and cucumbers are reached around 90% with half of the time compared to conventional drying.

Keywords: *Solar Drying, PV/T Hybrid Solar Air Dryer, Drying efficiency.*

1. Introduction

Drying is the process which plays major role in the food preservation that is often carried out after harvest, especially with highly perishable crops. By using Thermal energy, the vegetables, fruits and meat can be stored for a longer time and it is easy for transportation by [1] decreasing the moisture content. Water Content of Product for Low Speed in Table 1. If the process is done in a proper way like by adjusting the temperature and time management [10] Most of the developing countries are facing the problem related Preservation of Agricultural produce. Table 7 Average of Decreased Moisture Content at 3 Experiments as the population increasing the Growing dietary needs are increasing. All the countries the quantities of Vegetables and fruits spoil due to infrastructure, insufficient processing Capacities and difficulties of marketing growing because of competition across the world agricultural markets. Flow Chart of Drying Process are shown in Figure 1. By Drying the products can help to solve these [2] problems and also helps to improve the population's income

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and supply, it helps to reduce the growth of harmful bacteria in the food and preserve the nutrition's in the food. Based on the drawbacks of [11] natural sun drying, such as exposure to direct sunlight, vulnerability to pests, lack of proper monitoring, and longer drying times compared to the solar dryer, a solar dryer was developed to address these drawbacks and help commercial establishments [3] like restaurants use dried produce in their cuisine. This enables the consumption of seasonal fruits year-round. [4]

2. Experimental Methods or Methodology

Solar drying is a method that transforms incident solar radiation into the thermal energy needed for drying operations. The majority of solar dryers employ solar air heaters, and the heated air is then fed through a drying chamber that [5] contains the material to be dried. The moisture in the substance evaporates as a result of the air's energy transfer to it. Indirect Types Solar Drying is shown in Figure 3. From the Table 3 Water Content of Product for High Speed

2.1 The Following Flowchart Shows The General Steps Involved In Drying Of Vegetables

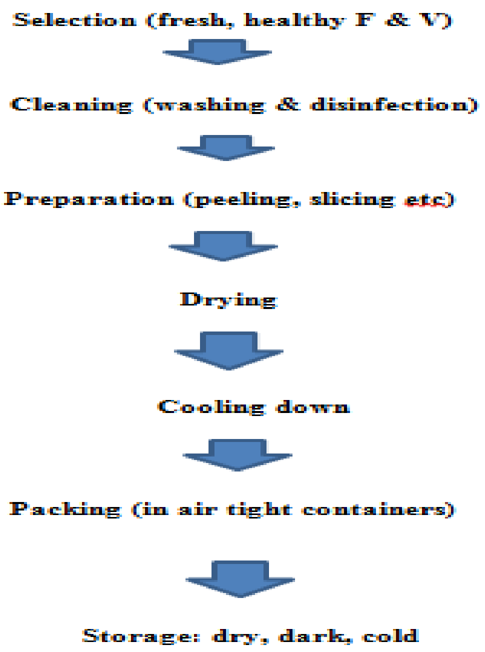

Figure 1 **Flow Chart of Drying Process**

Solar drying is a method that transforms incident solar radiation [9] into the thermal energy needed for drying operations. The majority of solar dryers employ solar air heaters, and the heated air is then fed through a drying chamber that contains the material to be dried. The moisture in the substance evaporates as a result of the air's energy transfer to it. [6] Direct Types Solar Drying are shown in Figure 2. Evolution of Absolute Humidity For Low Speed are in Table 2.

2.2 Drying Mechanism

The movement of moisture from a material's interior to its surface and the evaporation of moisture from the surface into the surrounding air are the two fundamental [8] mechanisms involved in the drying process. Drying is a simplex heat and mass transfer process that depends on both internal and external factors, including surface characteristics, chemical composition, physical structure, size, and shape of the product. External factors include temperature, humidity, and air stream velocity. Depending on whether the material is hygroscopic or not, the pace at which moisture moves from a product's interior to the air outside varies from one product to another. [7] Graph: on X- Axis Time, on Y Axis weight of Vegetable are shown in Figure 4. Table 5 Water Content of Product for Low Speed

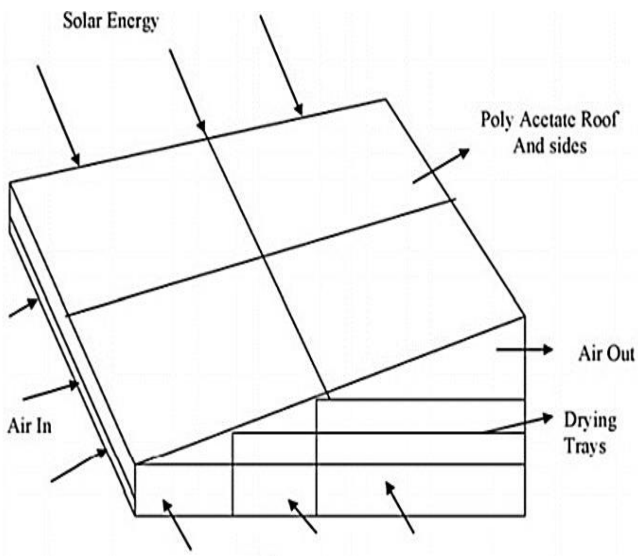

Figure 2 **Direct Types Solar Drying**

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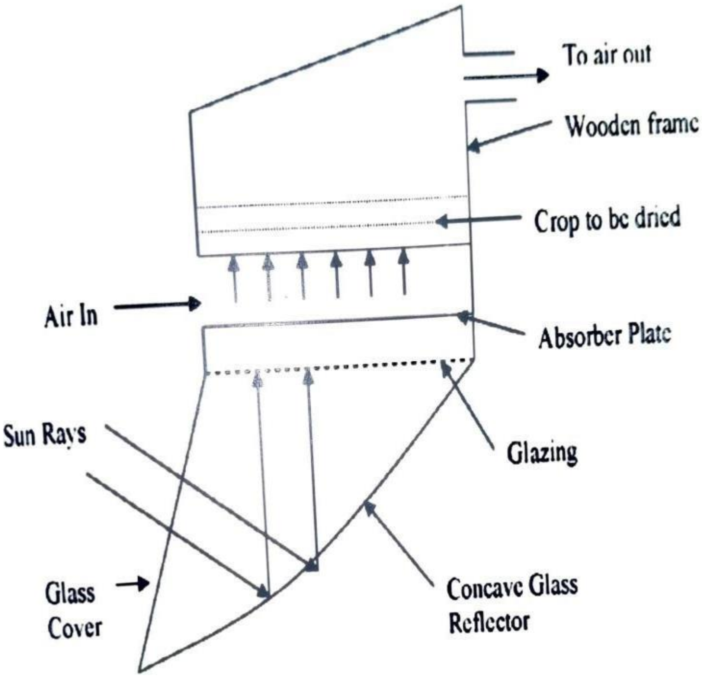

Figure 3 Indirect Types Solar Drying

3. Results and Discussion

3.1 Calculations

X (t) =M (t)-Ms/ MS
X (t=0) =Mi-Ms/ Ms
Where
X (t) = water content at any instant t (kg water | kg DM)
M (t) = wet product mass (kg)
Ms = dry matter mass (kg)

3.2 Before Double Coated Black Painting

3.2.1 Water Content of Product for Low Speed

Table 1 Water Content of Product for Low Speed

Timings	With dryer	Without dryer
10am	0.70	-0.72
11am	0.63	-0.66
12pm	1.16	-0.53
1pm1	1.56	-0.24
2pm	2.31	0.00
3pm	3.14	0.13

3.2.2 Evolution of Absolute Humidity for Low Speed

Table 2 Evolution of Absolute Humidity for Low Speed

Timings	With dryer	Without dryer
10am	4.20	2.16
11am	5.02	2.52
12pm	7.06	3.03
1pm	9.00	3.51
2pm	11.5	4.85
3pm	14.6	5.50

3.2.3 Water Content of Product for High Speed

Table 3 Water Content of Product for High Speed

Without drier	With drier	
-0.75	0.08	
-0.68	0.14	
12pm	0.45	-0.63
1pm	0.93	-0.36
2pm	1.37	-0.22
3pm	2.20	-0.09

3.2.4 Evolution of Absolute Humidity for High Speed (Table 4)

Table 4 Evolution of Absolute Humidity for High Speed

timings	With drier	Without drier
10am	3.38	2.08
11am	4.10	2.42
12pm	5.25	2.78
1pm	6.57	2.63
2pm	8.25	2.88
3pm	10.36	3.21

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Figure 4 **Weights of Vegetables Before and After Drying**

3.3 After Double Coated Black Painting

3.3.1 Water content of product for low speed

Table 5 **Water Content of Product for Low Speed**

timings	With drier	Without drier
10am	7.05	0.36
11am	7.70	1.07
12pm	8.06	1.34
1pm	7.75	1.84
2pm	6.15	2.04
3pm	5.55	1.77

3.3.2 Evolution of Absolute Humidity for Low Speed (Table 6)

Table 6 **Evolution of Absolute Humidity for Low Speed**

timings	With drier	Without drier
10am	12.15	4.68
11am	14.60	5.57
12pm	16.80	6.81
1pm	19.80	8.25
2pm	21.72	9.41
3pm	24.00	10.31

3.4 Average of Decreased Moisture Content at 3 Experiments

Table 7 **Average of Decreased Moisture Content at 3 Experiments**

Time	With drier (in grams)	Without drier (in grams)
10 AM	115.3	136.6
11 AM	99	123.1
12 PM	85.3	112.6
1 PM	57.6	102.6
2 PM	54.3	94.3
3 PM	47	85

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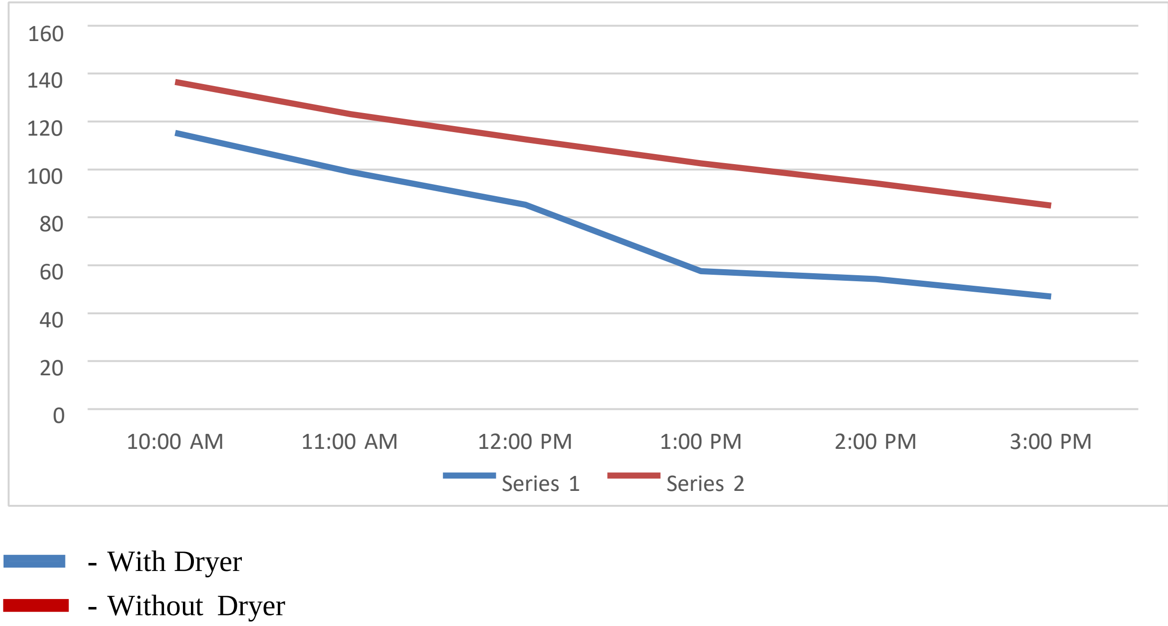

Figure 5 Graph: on X- Axis Time, on Y Axis weight of Vegetable

Conclusion

The tests were conducted, and the results led to the following findings. The ambient air temperature can be significantly increased by the solar drier, speeding up the rate at which food products dry. When compared to products drying outside in the sun, products inside dryers require less maintenance due to factors like rain or pest (both human and animal). The dryer can also be used to dry other types of produce, such as grapes, apples, green apples, etc. Compared to the natural sun drying method, monitoring is simpler. The system uses solar energy and has a cheap initial investment cost. Additionally, based on the results of the test, a straightforward, low-cost solar dryer was created using supplies that could be found nearby. In this study, tomatoes were used. Some tomatoes were dried, while others were left to dry naturally in the air. The moisture content of the tomatoes was then compared in relation to time and temperature. We find that temperature inside the dryer is almost two times outside the temperature. As per our experiment the maximum peak temperature inside the drying chamber is during mid-day(2pm) and in an average approximately 54 °C to 57 °C in a full sunny day (10:00 AM to 03:00 PM). In Hours, Continuous drying in one full sunny day under the same climatic condition and in same time the solar drying removed a maximum of 40-50% moisture content from drying chamber for drying of low moisture content food products. Based on experimental findings, people can create their own solar dryers at home, especially in developing nations where the demand for energy is rising sharply. This is especially true given that the efficiency of the solar dryer is adequate and it can be used as a substitute for freezing food. During recessions, it can be useful. This dryer can be used to store food items so they can be utilized for days on end without going bad. It has been noted that the dryer's air has a temperature range of 52 to 64 degrees Celsius. It takes the dryer about five hours to achieve this temperature. According to observations, it might take anywhere between 4 and 7 days to sun dry food products. The time can be excessively cut down by employing a solar air dryer. Produce drying can be completed in as little as 3-4 hours.

- Illustrates tomatoes at the start of their drying process in the sun.
- From 10 AM to 3 PM, the tomatoes are exposed to the sun for approximately 5 hours.
- The tomatoes weigh about 250grams before sun drying, but after losing all of their

moisture, they weigh about 72gram. The tomatoes are dried in the sun for 5 hours on the third day as well.

- The moisture content loss is 89%.

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