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A Review on Experimental Investigation of Solar Dryer For Tomato Drying

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Abstract: Solar drying is an oldest method of drying. In rural areas open sun drying technique is used for drying agriculture crops. There are enamors solar dryers available and lot of research is going on to find out efficient, economical solar dryer for drying of different food commodities. From energy conservation point of view solar dryer is valuable device. Drying with solar dryer has advantage over conventional open sun drying that it requires less area, saves drying time without affecting the quality of drying product. This paper review different types of dryers used for drying of tomatoes and compares with open sun drying.

Keywords: Tomato drying, Solar drying, Open sun drying.

I. INTRODUCTION

Solar energy is inexhaustible, ample and free of cost available all over the world. In rural areas open sun drying was used to dry agricultural products merely laying on floors, mats. In recent days solar dryers are used which protect farming produce from insect, dust and rain. Solar drying is economical as compared to artificial drying methods [1]. Fruits and vegetables are easily contaminated because they contain water more than 80%. In developing countries loss of 30-40% fruits and vegetables produce, and more than US$1.5 billion/year of Loss of worth in India [2]. Apart from the root vegetables, tomatoes having the highest production figures among all the vegetables in the world, they are a natural source of carotenoid, lycopene [3]. The purpose of this paper is to review research and development work on tomato drying using different solar dryers.

II. REVIEW OF EXPERIMENTAL INVESTIGATION

A natural convection solar tunnel dryer was manufactured and experimental study was conducted by Demir et al. [4]. The dryer was 5.4 m wide and 20m long and covered with 120 μm thickness semi-transparent polyethylene plastic film. The dryer had two conical frames 10 m long with outlet and inlet radius of 1.7 m and 2.7 m respectively. Two mesh trays, 10m long and 3m wide were used to put on the tomato slices. Samples of tomato were taken from different points, weighted initially after 60 min interval and later at 120 min interval. During experimental work, dryer inside and outside temperature difference was found to be 11.5ºC. Also, inside relative humidity was observed to be 6.9% less than that on outside. Initial mass of tomato sample was 11.71 kg [H_2O]/kg [DM] and final mass in between 0.09-0.11 kg [H_2O]/ kg [DM]. Total drying time in solar tunnel dryer was found to be 80-92 hours and in open sun drying it was 96-106 hours. Authors reported that drying time went on increasing as moisture content decreased i.e. drying rate decreased with decrease in moisture level.

Arun et al. [5] designed, developed and experimentally tested a natural circulation solar tunnel greenhouse dryer 4 m wide, 10 m long and 3 m high in India at Pollachi (latitude, 10.39°N;

longitude, 77.03°E). Dryer was covered with UV (200µ) stabilized polyethylene film, similar to that used in study of Demir et al. [4]. One Exhaust fan having 30 cm diameter was fixed at both the front and back end. Racks were provided for placing products in layers. Pyranometer, thermocouples, hygrometer were used to compute solar radiation, temperature at four different points and relative humidity, respectively. During 3 days of experimental observation, variations in ambient temperature, solar intensity, and dryer temperature were recorded. Also, authors reported variation in moisture content for different shaped of tomato slices and methods of drying. This data has been collectively represented in following Table 1 and Table 2. Relative humidity inside the dryer was ranging from 27% to 53% and that of surrounding air was ranging from 47% to 75%.

Table 1: Ambient Temperature, Sun intensity, Dryer temperature

Sr No	Parameters	Day 1	Day 2	Day 3
1	Ambient Temperature	31°C to 39°C	30°C to 39°C	32°C to 39°C
2	Sun Intensity	313 W/m^2 to 717 W/m^2	305 W/m^2 to 737 W/m^2	320 W/ m^2 to 720 W/m^2
3	Dryer Temperature	39°C to 61°C	34°C to 63°C	41°C to 67°C

Table 2: Moisture Removal Of Slice Cut And Cube Cut Tomatoes In Open Sun Drying And Solar Tunnel Drying

No of days	Open Sun Drying		Solar Tunnel Drying	
	Slice cut tomatoes	Cube cut tomatoes	Slice cut tomatoes	Cube cut tomatoes
1	90% to 56%	90% to 65.5%	90% to 40%	90% to 53.5%
2	56% to 30.5%	65.5% to 46%	40% to 9%	53.5% to 27.5%
3	30.5% to 12.5%	46% to 31.5%	----	27.5%to 9.5%
4	12.5% to 9.5%	31.5% to 20%	----	----
5	----	20% to 11.5%	----	----
6	----	11.5% to 9.5%	----	----

From Table 2, it is seen that time required for slice cut and cube cut tomatoes to be dried in open sun drying from initial moisture content 90% (w.b.) to final moisture content of 9% (w.b.) was 74 hours and 123 hours respectively. Similarly, in greenhouse solar tunnel dryer, slice cut and cube cut tomatoes were dried in 26 hours and 56 hours respectively from initial moisture contain 90% (w.b.) to final moisture contain to 9%. So, Arun et.al. [5] concluded that drying rates are faster in tunnel dryer than open sun drying. Also drying rate improves by taking slice cut of tomatoes instead of cube cut.

Low cost small scale solar tunnel dryer with base area 0.75 m^2 and height 0.6 m height was designed manufactured by Perasiriyan et.al [6]. Black painted, galvanized corrugated absorber plate of iron sheet was used. Before drying the tomato samples were dip in the solution of sodium metabisulfite for 3 minutes. In solar tunnel dryer moisture removal was found to be 58%, 22% and 13% at the end of first, second and during third-fourth hour respectively, where as in open sun drying it was found to be 32%, 15% and 27% at the end of first, second and during third-fourth hour respectively.

Table 3: Temperature and Relative Humidity at Different Time Period [6]

Sr No	Temperature (^{0}C)		Relative humidity (RH %)	
	Out side	Inside	Out side	Inside
1	33.3	33.9	51	39
2	34.3	43.4	42	34
3	32.2	38.1	54	40
4	31.1	35.5	42	32
5	30	35	34	25
6	29	33	31	32

Table 4: Weight In Grams Of Tomato Under Drying Process [5]

Sr No	Product	Solar drying				Sun drying			
		Initial	1 hour	2 hour	4 hour	Initial	1 hour	2 hour	4 hour
1	Tomato	50	21	10	4.5	50	34	26.5	13

Table 5: Percentage Of Moisture Removed Under Solar And Sun Drying [6]

Sr No	Product	Solar drying			Sun drying		
		1 hour	2 hour	3rd & 4th hour	1 hour	2 hour	3rd & 4th hour
1	Tomato	58	22	13	32	15	27

Aliyu et al. [7] conducted experimental study with an objective to compare the performance of drying of tomato sample using a fabricated solar dryer with open sun drying. For this study, authors constructed a small scale solar dryer to operate in Yola climate of Northeastern Nigeria. The tray collector glass of the dryer had thickness of 3 mm with an area 600 mm × 410 mm. The absorber plate was made up of alluminum of area of 600 mm × 400 mm with 30 mm thickness. The air vent of area 400 mm × 100 mm was provided. The chimney was 310 mm high and 73 mm in diameter along with wooden frame of 50 mm thickness. Both the types of drying were conducted simultaneously to under same metrological conditions. At the beginning of the test, mass and moisture content of both the samples were 1.6 kg and 95% respectively. Authors reported that at the end of open sun drying process carried out for 5 days, moisture content of the sample was observed to be 15 % while, for the drying carried out in the dryer, moisture content was observed to be only 4% at the end of 3 days of drying. Hence the authors concluded that use of solar dryer is an efficient method to dry the products as well as to harness the freely available solar energy, especially during crop harvest and poor weather.

Direct and indirect natural circulation solar dryer was designed, constructed and studies by S.S.Nandwani [8] and experiments were taken for 3 days in Costa Rica. At the beginning of experiment, moisture content and mass of tomato sample was 97.5 % and 1847.5g respectively. Authors reported that after three days of drying, mass of dried tomato sample was 102.2g .Also loss of moisture was observed to be 94 %.

III. CONCLUSION

The methodology of drying the tomato by solar dryers is feasible, economical and can be implemented at the grassroots level in diverse climatic conditions across the globe. The method is faster compared to traditional open sun drying along with added benefits of maintained quality of food products at the end of completed drying. Along with this, method offers the advantage of somewhat precise control over the drying rate as compared to open sun drying. Additionally, the technology is inherently simple to construct and operate. This will surely help to enhance the opportunities for utilization of freely and abundantly available solar energy in domestic areas.

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