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Turmeric Slices Solar Drying in Drying System with Indirect Type Based ETSC

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Abstract **-** To solar dry turmeric slice, the key purpose of recent investigation is to illustrate the solar drying characteristic in indirect type based evacuated tube solar collector (ETSC) in Pune, India. It is revealed that outside fluid temperature of ETSC being noticeably above (66.8-15.4^{0}C) in relation to ambient fluid temperature. Inside the drying cabinet (DC), it speeds up the specific moisture extraction ratio of turmeric slices. Contrast to drying under open sun that needs 2.7days, turmeric slices just want 1.6days for obtaining equilibrium moisture ratio for drying with indirect type based ETSC. The solar dried turmeric slices is imaged being of better quality. This drying system is established being null contaminated since it uses non renewable source.

Keywords **-** *Turmeric Slices, Outside Temperature, ETSC, Indirect Type Drying System.*

I. INTRODUCTION

Preservation of agricultural product is the key problem to be faced by all rising countries [1]. During post harvesting, a lot of agricultural product contains huge quantity of water because of which product is spoiled [2]. Storage is a much necessary technique in agricultural preserving for lengthy tenure. Dehydration is mostly used as customary means in safeguarding agricultural product [3]. It is commonly define to employ in mass and heat transfer mutually for transporting water from the product. Dehydration is a primitive way for reducing micro-bacterial development that is usually used for sustaining the diet nutrition [4]. It moreover elongates the survival stages of moist product to utilize until it's lengthen time.

During modern time, several industrial drying systems moreover employ hot fluid in commercial drying technique. Furthermore the primary trouble of the industrial drying system being costly one and too uses high fossil fuel [5]. Owing to stated concern in various countries, drying system depending over the sun energy being the best choice compares to industrial drying system. This solution had lead to adopt the flexible approach for solar drying in some earlier era.

Turmeric are the most often grown and renowned herb around the globe. They are the important food product consisting adequate portion of fiber and vitamin. Turmeric is considered to be favorable product in daily food and an individual greatest all around loaded with nutritional value. Dried turmeric is a well familiar food supplement and is employed for curing constipation [6].

Parveen et al. explained the kinetics and modeling study for drying turmeric employing direct sun drying and solar greenhouse drying [7]. Prasad et al. have done the performance study and evaluation for direct solar dryer and traditional drying of turmeric. From the trial, the drying period of turmeric rhizomes was 1.5days and 11days in direct solar drying and traditional drying respectively from their initial content of 79% wb to final content of 6% wb [8].

Korese et al. investigated the influence of treatments on drying kinetics and drying quality of turmeric rhizomes. Blanching and ascorbic acid treatments were utilized before solar drying. The result demonstrates that treated specimen has a considerable influence on drying kinetics compared to untreated one. The drying quality of ascorbic acid immersed specimen is highest relative to the steam blanched specimen [9]. Salengke et al. performed drying kinetics in fully fluidized situation to dry turmeric. It is noted that fluidized situation requires lowest drying period for turmeric relative to traditional drying technique [10].

Tule et al. assessed the influence of chemical treatments on turmeric sliced rhizomes to the solar drying with physical treatments [11]. Kumar et al. studied the impact of inserted baffles on exit temperature of an evacuated tube solar collector. The experiment was performed at different flow rate of air. The result displays that the peak temperature is obtained with lowest thermal efficiency at lesser air flow rate [12].

Jose et al. assessed the drying characteristics of turmeric employing solar tunnel drying system differentiated from open sun drying system. The trial illustrates that the drying time reduces to half relative to open sun drying system [13].

Evacuated tube solar drying system was fabricated and analysed for herbs such as fenugreek leaves and spice such as ginger slice by Singh et al. [14] and Devi et al. [15].

As per literature survey, it is renowned that ETSC drying system performs better compared to remaining drying system. Also, it is being observed out in the survey that ETSC drying system has not till now being employed to solar dry turmeric slices. The present work hence directs to analyze the effective operation of indirect type drying system to dry turmeric slices whereas compare them with open sun drying system.

II. METHODOLOGY

A. Experimental Process

Figure 1 shows the diagrammatic photograph of the indirect type ETSC drying system. Air blower, evacuated tube collector, drying cabinet and chimney vent respectively are the vital elements for the indirect type ETSC drying system.

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Newly sliced specimen is consistently distributed over the double trays situated within the drying cabinet to be solar dried. By switching the centrifugal fan, the fluid being passed within the heater to speedily heat up so as to push for moving forward within drying cabinet that consist of turmeric slices. The turmeric slices begins drop in its weight by hot flowing fluid since water starts for vaporizing from the specimen. From hour to hour, the recording of turmeric slices weight is performed from beginning to till ending of the day time until the instant the specimen reaches its equilibrium moisture ratio. Likewise entire trial is done with the open sun drying system.

B. Measuring Apparatus

Hourly sun radiation is measured by solari-meter on daily base. Anemometer is utilized for recording wind velocity and environment temperature whereas humidity meter is utilized for recording relative humidity. Thermometer is employed for recording temperature over a number of locations placed across the ETSC drying system. Weight of solar dried turmeric slices is measured by electronic balance scale over every hour. Turmeric slices pre, while and post solar drying with indirect type ETSC and open sun drying system is displayed in Figure 2 and 3 respectively.

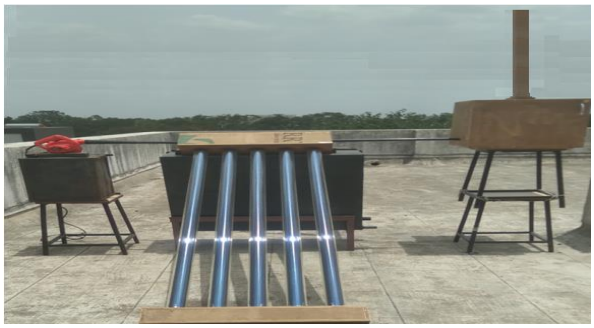


Figure 1. Photograph of drying system with indirect type based ETSC



Figure 2. Turmeric slices pre, while and post drying in drying system with indirect type based ETSC



Figure 3. Turmeric slices pre, while and post drying in drying system under open sun

III. DATA DETERMINATION

A. Moisture Loss

The moisture loss is evaluated as [18],

$$M_L = \left(M_i - M_f\right) \tag{1}$$

Where M_f and M_i are hourly reported turmeric slice final and initial weight.

B. Moisture Ratio

The moisture ratio is estimated as [16],

$$M_R = MC \,/\, MC_i \tag{2}$$

Where MC_i and MC are initial and at any instant moisture content of turmeric slices.

C. Drying Efficiency

The drying efficiency of the indirect ETSC drying system is find out as [19],

$$\eta_D = M_w\, L \,/\, I_s\, A_c\, t \tag{3}$$

Where I_s is solar insolation, A_c is solar collector area, t is drying time, M_w is vaporized weight of water from the produce; L is latent heat of evaporation of water.

D. Specific Moisture Extraction Ratio

The specific moisture extraction ratio of the indirect ETSC drying system is calculated as [17],

$$smer = M / P \tag{4}$$

Where P and M are power of blower and at any instant weight loss of turmeric slices.

IV. RESULTS AND DISCUSSION

Hourly variation of drying parameters i.e., wind velocity (V), solar insolation (I_s), relative humidity (RH_a) and surrounding temperature (T_a) throughout the entire trial is illustrated in Table 1, 2 and 3. All through the March month at Pune, India, the vent temperature (T_c) of chimney, top temperature (T_t) and bottom temperature (T_b) of tray in DC meanwhile outside temperature (T_o) and inside temperature (T_i) of ETSC for indirect type drying is found out.

Throughout the test, the solar insolation is observed to vary from 135.3 to 663.1W/m^2. Altogether DC's entry temperature and ambient temperature observed to range within 33.5 to 63^{0}C and 30.9 to 34.7^{0}C. It is revealed that the ETSC's outside temperature range within 46.25 to 101.5^{0}C. It's been considerably hot relative to the environment neighbor. This exhibits that the drying rate of drying system with indirect type based ETSC is much more relative to drying system under open sun that reduces the drying period of indirect type drying system.

Moisture parameters which were observed for drying turmeric slices in drying system with indirect type based ETSC and under open sun are displayed in Table 4, 5 and 6. Figure 4 and 5 describe the change in moisture loss against drying period of turmeric slices using drying with indirect type based ETSC and under open sun. The moisture loss from turmeric slices using drying with indirect type based ETSC is great in 1.6days relative than 2.7days drying under open sun.

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A chart of moisture ratio against drying period for investigating the change in moisture ratio of turmeric slices is represented in Figure 6 and 7. It has been inspected that the moisture drops at the start from its periphery whereas in the end within inner part. The peak efficiency to solar dry turmeric slices is estimated being 50.58% meanwhile the peak specific moisture extraction ratio of drying system with indirect type based ETSC is established being 0.3157kg/KWh. Along with this, dried turmeric slices with indirect type based ETSC is better in gloom, odor, form and flavor relative to dried turmeric slices under open sun.

Table 1. Hourly variation of several parameters to dry turmeric slices (Day I)

Day Time (hrs min)	Solar Insolation I_s (W/m²)	Wind Velocity V (m/s)	Relative Humidity RH_a (%)	Temperature at several positions					
				T_a (°C)	T_i (°C)	T_o (°C)	T_b (°C)	T_t (°C)	T_c (°C)
8:15	186.2	1.42	39.8	34.6	36.5	55.5	39.5	38.5	37.5
9:15	354.6	1.85	45.6	34.1	39.5	68.5	46.5	45.5	44.5
10.15	503.5	1.49	46.7	33.8	43.5	83	53.5	51	52
11.15	573.1	1.54	46.0	34.2	46.5	92	57.5	55.5	56
12.15	663.1	1.66	45.1	33.9	47	98	60.5	59	58
13.15	617.6	1.50	43.2	34.4	46.5	101.5	63	61.5	60.5
14.15	454.6	1.64	42.7	34.7	45.5	91	60	58	57.5
15.15	389.8	2.10	42.6	34.5	44	81	55	53.5	52.5
16.15	279.9	1.42	43.5	34.2	43	73	51.5	51	49
17.15	135.3	0.27	43.2	33.7	42	59	48	47	45

Table 2. Hourly variation of several parameters to dry turmeric slices (Day II)

Day Time (hrs min)	Solar Insolation I_s (W/m²)	Wind Velocity V (m/s)	Relative Humidity RH_a (%)	Temperature at several positions					
				T_a (°C)	T_i (°C)	T_o (°C)	T_b (°C)	T_t (°C)	T_c (°C)
8:15	335.3	2.31	38	32.8	36	37	33.5	33.3	33.1
9:15	341.1	1.94	44	32.5	38	56	41.5	41	40
10.15	284.1	1.42	47.6	31.6	40	69	47.5	46.5	45.5
11.15	325.3	1.67	48.7	31.9	41	69.5	47	46	45
12.15	505.2	1.98	48.6	33.2	42	87.5	54	53	52
13.15	535.2	2.23	45.1	32.9	43.5	98.5	59.5	58	57
14.15	437.9	2.19	47.1	31.4	44.5	97.5	59	58.5	57.5
15.15	341.1	1.07	49.5	30.9	45.5	97	58.5	58	57
16.15	320.1	1.85	50.3	30.4	43.5	95	56.8	56	54
17.15	121.3	0.79	51.3	30.4	43.5	81	51.8	52	50

Table 3. Hourly variation of several parameters to dry turmeric slices (Day III)

Day Time (hrs min)	Solar Insolation I_s (W/m²)	Wind Velocity V (m/s)	Relative Humidity RH_a (%)	Temperature at several positions					
				T_a (°C)	T_i (°C)	T_o (°C)	T_b (°C)	T_t (°C)	T_c (°C)
8:15	260.75	1.865	38.9	33.7	36.25	46.25	36.5	35.9	35.3
9:15	347.85	1.895	44.8	33.3	38.75	62.25	44	43.25	42.25
10.15	393.8	1.455	47.15	32.7	41.75	76	50.5	48.75	48.75
11.15	449.2	1.605	47.35	33.05	43.75	80.75	52.25	50.75	50.5
12.15	584.15	1.82	46.85	33.55	44.5	92.75	57.25	56	55
13.15	576.4	1.865	44.15	33.65	45	100	61.25	59.75	58.75
14.15	446.25	1.915	44.9	33.05	45	94.25	59.5	58.25	57.5

Table 4. Hourly variation of moisture loss and moisture ratio of turmeric slices in drying system with indirect type based ETSC and under open sun (Day I)

Drying Time (hrs)	Indirect Solar Drying (With ETSC)			Open Sun Drying (Without ETSC)		
	M_i (kg)	M_L (kg)	M_R	M_i (kg)	M_L (kg)	M_R
0	1.576		1.0000	1.576		1.0000
1	1.537	0.039	0.9692	1.550	0.026	0.9795
2	1.489	0.087	0.9315	1.492	0.058	0.9339
3	1.333	0.156	0.8089	1.388	0.104	0.8521
4	1.061	0.272	0.5950	1.209	0.179	0.7114
5	0.782	0.279	0.3757	1.023	0.186	0.5651
6	0.618	0.164	0.2467	0.875	0.147	0.4491
7	0.465	0.153	0.1265	0.766	0.109	0.3635
8	0.431	0.034	0.0997	0.661	0.105	0.2805
9	0.398	0.033	0.0737	0.559	0.102	0.2003

Table 5. Hourly variation of moisture loss and moisture ratio of turmeric slices in drying system with indirect type based ETSC and under open sun (Day II)

Drying Time (hrs)	Indirect Solar Drying (With ETSC)			Open Sun Drying (Without ETSC)		
	M_i (kg)	M_L (kg)	M_R	M_i (kg)	M_L (kg)	M_R
1	0.372	0.026	0.0534	0.497	0.062	0.1515
2	0.352	0.02	0.0375	0.475	0.022	0.1343
3	0.335	0.017	0.0242	0.453	0.021	0.1173
4	0.321	0.014	0.0132	0.432	0.020	0.1008
5	0.313	0.008	0.0069	0.413	0.019	0.0859
6	-	-	-	0.396	0.017	0.0726
7	-	-	-	0.381	0.015	0.0603
8	-	-	-	0.367	0.014	0.0494
9	-	-	-	0.354	0.012	0.0395

Table 6. Hourly variation of moisture loss and moisture ratio of turmeric slices in drying system with indirect type based ETSC and under open sun (Day III)

Drying Time (hrs)	Indirect Solar Drying (With ETSC)			Open Sun Drying (Without ETSC)		
	M_i (kg)	M_L (kg)	M_R	M_i (kg)	M_L (kg)	M_R
1	-	-	-	0.343	0.011	0.0309
2	-	-	-	0.333	0.010	0.0230
3	-	-	-	0.324	0.009	0.0159
4	-	-	-	0.317	0.007	0.0105
5	-	-	-	0.312	0.005	0.0065
6	-	-	-	0.309	0.003	0.0042

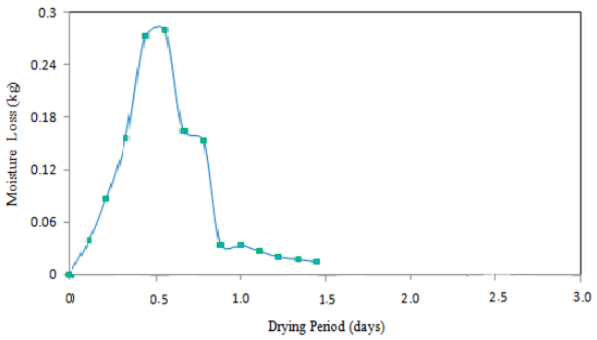


Figure 4. Variation of moisture loss vs. drying period to solar dry turmeric slices in drying system with indirect type based ETSC (Day I and II)

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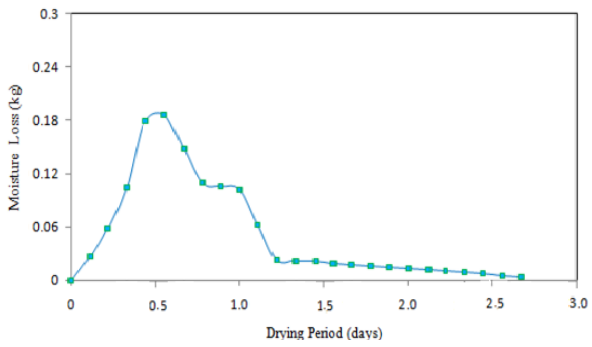


Figure 5. Variation of moisture loss vs. drying period to solar dry turmeric slices in drying system under open sun (Day I, II and III)

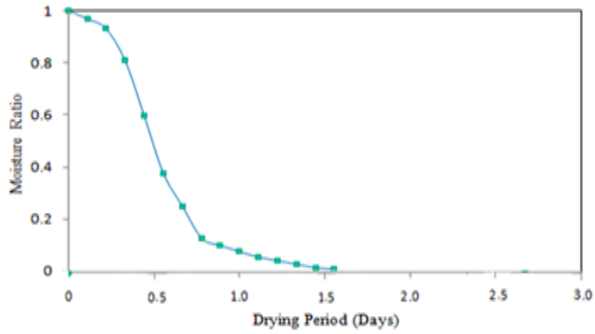


Figure 6. Variation of moisture ratio vs. drying period to solar dry turmeric slices in drying system with indirect type based ETSC (Day I and II)

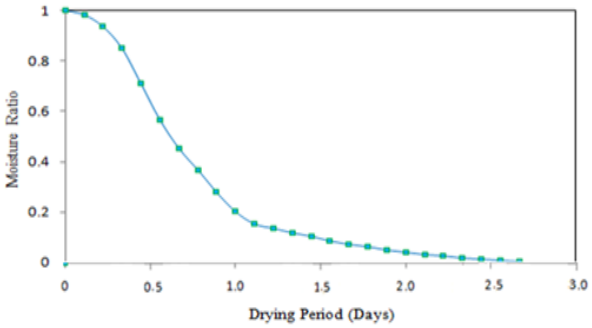


Figure 7. Variation of moisture ratio vs. drying period to solar dry turmeric slices in drying system under open sun (Day I, II and III)

V. CONCLUSION

The trial on drying system with indirect type based ETSC is performed to solar dry turmeric slices as well as compared upon to drying system under open sun. The drying period for turmeric slices is dropped down using indirect type drying system. The integration of DC causes entry fluid temperature to rise significantly above in comparison to its surrounding fluid temperature. This indirect drying system is noticed 50.58% competent for solar drying turmeric slices. Every variety of food products perhaps is solar dried by this indirect drying system. Along with this, there exist numerous options for saving non-renewable sources. By employing this indirect drying system, the solar dried product can be exported outside the country so that large turnover can be achieved from them.

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