Eco. Env. & Cons. 28 (December Suppl. Issue) : 2022; pp. (S400-S405)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i08s.059

Effect of Solar Tracking on the Drying Behaviour of Potato Chips in Box Type of Solar Dryer

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(Received 9 July, 2022; Accepted 19 September, 2022)

ABSTRACT

A Solar cabinet dryer is used to dry Potato chips under controlled and protected conditions. An attempt was taken to perform uniform drying in each tray of the dryer from top to bottom. A solar dryer is used to dry 1.5 - 4 kg of Potato chips in 1-2 days. The maximum temperature is 56 °C. When ambient air temperature was 42 °C at no load condition. The air temperature at 1^{St} inlet and 2^{nd} inlet of the dryer were 5-8 °C and 12-18 °C more than ambient air temperature respectively. An effect of solar tracking on the performance on the solar dryer was estimated by two methods. Firstly, the drying of Potato chips was done in the dryer without tracking of sun. Secondly, drying of same amount of Potato chips was carried out with tracking of sun manually. Both the modes of drying were performed well in the dryer. It was found that by using tracking method, the drying time can be reduced by 2-4 hours for the given amount of Potato chips. The quality of dried Potato chips in both the methods was found to be the same which was examined by organoleptic evaluation.

***Key word :** Solar dryer, Potato chips drying time, Organoleptic evaluator.*

Introduction

Potato (*Solanum nigrum*) is a high moisture food and one of the most potential crops having high productivity and supplementing major food requirement in the world. It is rich with proteins, phosphorus, calcium, vitamins etc. The better method for drying the high moisture food is to use hot temperature drying. Potatoes are used as such or as ingredients in various foods, for starch extractions and other industrial purposes. The demand and use of such crops has increased since recent past due to changing food habits. More than half of the potatoes grown in developed countries are used as processed products (Bakal *et al.,* 2010).

One of the important factors of drying is diffusion coefficient. The diffusion coefficient of a food is material property and its value depends upon the conditions within the material. Effective moisture diffusivity describes all possible mechanisms of moisture movement within the foods, such as liquid diffusion, vapor diffusion, surface diffusion, capillary flow and hydrodynamic flow. A knowledge of effective moisture diffusivity is necessary for designing and modeling mass-transfer processes such as dehydration, adsorption and desorption of moisture during the storage. There are many research of potato drying modeling, but mostly represent experimental data processing with nonlinear regression depending on drying time (Olawale *et al.*, 2012 and Aboltins 2013)

Drying is the process of moisture removal due to simultaneous heat and mass transfer under controlled conditions (Radhika *et al*., 2011). It is one of the oldest methods of preservation and widely applied owing to its simplicity, ease of operation and cost-effectiveness. Besides these advantages, drying decreases the bulk of foods by reducing the volume which eases handling and processing operations, in turn reducing packaging, handling and storage and transportation costs (Patel and Kar, 2012).

Current agriculture technologies are heavily based on oil because so far electricity share around 22 percent and diesel oil share 78 percent of so called commercial energy input into Indian agriculture. The present social structure and activities are extremely limited. Therefore solar, wind and biomass energy are the most appropriate renewable source of supplement us the rural energy demands.

When food is available more than the present use it is preserved for future consumption. Foods such as fruits and vegetables have short growing reason and preservation makes them available to use throughout the year and avoid wastage of surplus food. Foods bought when they are most plentiful, heaper and of good quality, money can be saved by buying and preserving foods by this time.

Solar crop drying has been demonstrated to be cost efficient and could be an effective alternative to traditional and mechanical drying system. The increased consumption of energy, resulting in soaring prices of fossil fuels and ecological imbalance, has increased the interest in utilization of solar dryers.

Solar tracking is the method of turning drier along with the sun, which means following the Sun's track from it's rising in the east to its setting in the west. Because the solar tracker turns after the sun all day long, the solar panels are set to the sun directly all day long, and so their performance is substantially enhanced.

Advantages associated with the solar tracking are:

- It is enhances the photo voltaic modules performance by 30%.
- It enhances the water pump performance by 70%.
- Works even in the water.

Materials and Methods

Potatoes were washed under running water to remove the adhering impurities, dried and cut into slices with using a sharp stainless steel knife. The potato slices were placed on the tray.

All samples were dried at different day temperatures at morning, noon and evening. The box type of solar dyer was used for the drying experiments with accuracy of temperature control ± 4.5 ºC. The drying chamber is a flat type four tray solar dyer in which the air flows upwards through the sample trays that provide the access of hot air to the potato slices on both sides. Each tray was weighed before inserting it in dryer. A laboratory electronic balance (0.00-1 Kg) was used for weighing, which is equipped with a digital display and have the measurement accuracy ± 0.01 g.

The samples were regularly weighed during the experiment and values were recorded to determine the mass changes on drying time at certain temperature. For measuring the weight of the sample, the trays with samples was taken out of the drying chamber, weighed on the digital balance and placed back into the chamber.

Drying Procedure

Procurement and Preparation of the material

Fresh vegetable (potato) were purchased from local market of Nani Prayagraj (Allahabad). Potatoes washed thoroughly in water and cut into chips.

Pre-treating vegetable to enhance quality and safety

Pre-treating vegetable by the dried vegetable Blanching helps to slow or stop the enzyme activity that can cause undesirable changes in flavor and texture storage. Blanching also relaxes tissues so pieces dry faster, helps to protect the products carbohydrates color and reduces the time needed to refresh Potato, before cooking. Water balancing achieves a more even heat penetration than steam blanching and blanching in a microwave. The process of blanching was follows:

- Large kettle was half filled with plain water and brought to a boil
- The Potato chips pieces incheese cloth were kept.
- Potato chips Bag was dropped in boiling water, making sure water covers the Potato chips. Bag was shaken so hot water reached to all pieces.
- Time was started when Potato chips were in boiling water. Heat was adjusted to ensure continuous boiling.
- Heated for length of time.
- Bag was dropped in cold water to cool.
- Water was drained by paper, towel or cloth.

Determination of initial moisture

Moisture content of fresh blanched Potato chips samples was measured by standard air-oven drying method. The samples were dried in hot air oven at 102 °C ± 1 °C for 18 hrs. Moisture content was determined by the equation for determination of moisture content as discussed before.

Working

After washing and pre-treating as per requirements the products are loaded in the trays. All the trays should be filled to the top and at no place should the bottom of the tray be visible. Otherwise, the hot air will flow through that area and by pass the product, resulting in reductions of the thermal efficiency. The trays are loaded in the dryer and the dryer is placed. The drying process was carrying out for 1-2 days.

The drying of product was done by two methods. Firstly the drying of product was done without tracking of sun and all the parameters were from morning to evening. Secondly, again the drying of the same amount of product is done by tracking of sun. The data recorded in the second method were now compared with first one, to look at the effect of solar tracking on the performance of solar dryer.

Quality testing of dried Potato chips

Testing for dryness

Foods should be dry enough to prevent microbial growth and subsequent spoilage. Dried Potato chips should be hard and brittle. Dryness in the case of potato chips, it should be crisp and tough, brittle respectively.

Organoleptic Evaluation

The organoleptic attribute of dehydrated Potato chips was tested. Sensory evaluation was carried out with the help of a test panel of 4 judges of different age groups with different eating habits. The evaluation is done on the basis of a 9-point Hedonic scale recommended by bureau of Indian standard (IS: 6273, 1997). A score board was prepared for sensory evaluation.

Rehydration Ratio

Adequate rehydration is essential in order to have satisfactory rating quality. Dehydrated Potato chips are rehydrated to study the reconstitution of dried sample. Rehydration ratio shows the originality gained and acceptability attributed of a product. Higher the rehydration ratio better is the product

Three samples of 7.5-9g weight of dehydrated Potato chips were taken in three individual 500 ml beakers an amount of 50m1 to 100 ml of water added into each beaker and it has boiled for 5 min, the same procedure was repeated for 10 to 15 min then, it was removed from the gas stove and excess water was drained off. The sample was weighted to determine the rehydration ratio.

The rehydration ratio is calculated by following formula;

$$\text{Rehydration ratio} = \frac{\text{Wt. of the soaked product}}{\text{Wt. of dehydrated product}}$$

Results and Discussion

Variation in drying air relative humidity

Table 1 and 2 show the hourly variation in relative humidity of drying air for a day of solar drying of potato chips. From the Tables it is noted that relative humidity of drying air increases from morning to noon and then decreases with slower rate. The maximum drying air humidity attained to noon and then

Table 1. Variation in air Temperature, Relative Humidity inside and outside the dryer loaded with potato chips without sun tracking.

Drying day	Time	Air Temperature (°C)				Relative Humidity (%)	
10/06/2019		Ambient	1st inlet	2nd inlet	Outlet	Ambient	Dryer
	10:15	35	38	36	34	58	59
	11:15	30	37	40	37	59	61
	12:15	35	44	37	43	53	57
	13:15	35	42	45	51	52	62
	14:15	32	52	53	59	48	33
	15:15	40	38	48	43	59	44
	16:15	34	47	55	52	40	38
	17:15	43	48	59	50	61	53

decreases with slower rate. The maximum drying air humidity attained was 70% at 2:15 pm without tracking of sun and it was 72% at 12:15 pm when tracking of sun was done. Difference between the relative humidity of ambient air and drying air was 14% at 12:15 pm when tracking is done. It shows that the relative humidity is in increasing trend in 1st half of drying and in decreasing trend in second half of drying. It was found that when tracking of sun was done manually there was a steep rise in the drying air humidity mostly in the afternoon. The same results are also discussed by Garg and Krishnan (1974).

Solar drying of potato chips

The balanced samples of potato chips were dried in the solar cabinet drying and different parameters like, drying air temperature at two inlets and at one outlet, drying air relative humidity, moisture losses were recorded. The result and discussion are summarized in the following

Variation in drying air temperature

Table 3 shows the hourly variation in temperature of ambient air and drying air at two inlet and outlet for different days of potato chips in the month of June The drying air temperature are minimum in morning at 10:15 am and in evening at 5:15 pm minimum drying temperature at 1st inlet on first drying days and 2nd drying 35 °C and 37 °C respectively. At 2nd drying inlet minimum temperature were 37 °C and 38°C on first and second day respectively. The maximum drying temperature achieved during two drying of potato chips was 45°C at 1:15 pm and 47°C at 1; 15 pm on second drying day 2nd an 1st inlet respectively without tracking of sum. It was 48 °C at 1:15 pm and 38 °C at 1; 15 pm on second drying day in 2nd and 1St inlet respectively when tracking of sun was done. The ambient temperature for both the time was 44 °C. There was about 5 °C to 10 °C temperature difference between two inlets of drying air same result found by Ahmed *et al.*, (2002).

The outlet temperature was slightly more than ambient air temperature. The maximum outlet air temperature was 48 °C on second drying on second drying day at 3:15 pm without tracking of sun and 45°C at 1:15 pm when tracking was done. It shows that the solar drying was fast during 10:15 am to 2:15pm every day. The temperature falls every evening rapidly. The reading shows that when

Table 3. Variation in air Temperature, Relative Humidity inside and outside the dryer loaded with potato chips with sun tracking

Drying day	Time	Air Temperature (°C)				Relative Humidity (%)	
		Ambient	1st inlet	2nd inlet	Outlet	Ambient	Dryer
10/06/2019	10:15	32	36	38	39	54	42
	11:15	38	45	54	42	59	31
	12:15	40	32	41	42	52	53
	13:15	31	44	41	53	56	49
	14:15	38	48	54	46	53	46
	15:15	38	48	51	46	54	22
	16:15	38	46	44	43	58	20
	17:15	35	40	40	38	60	28

Table 3. Variation in air Temperature, Relative Humidity inside and outside the dryer loaded with potato chips without sun tracking (2nd day)

Drying day	Time	Air Temperature(°c)				Relative Humidity (%)	
		Ambient	1st inlet	2nd inlet	Outlet	Ambient	Dryer
11/06/2019	10:15	30	35	38	36	63	60
	11:15	30	37	40	36	66	64
	12:15	35	40	45	38	62	70
	13:15	38	44	55	45	59	72
	14:15	34	44	50	44	58	70
	15:15	35	41	51	42	58	69
	16:15	34	41	49	51	61	62
	17:15	31	40	43	42	62	62

tracking of sun is done there is a decrease in both the inlet and outlet mostly in the afternoon. It takes 4 hours lesser on the second day of drying of dry the same amount of potato chips when tracking of sun is done manually.

Variation in drying air relative humidity

Table B3 & B4 shows the hourly in relative humidity of drying air for different days of solar drying of potato chips. From the Table it is noted that relative of drying air increases from morning to noon and then decreases with slower rate. The maximum drying air humidity attained was 74% at 11:15 a.m. on first day of drying without tracking of sun and it was 76% at 12:15 p.m. when tracking of sun is done. Difference between the relative humidity of ambient air and drying air was 12% at 12:15 p.m. when tracking is done. It shows that the relative humidity is in increasing trend in 1st half of drying and in decreasing trend in second half of drying. It was found that when tracking of sun was done manually there was a steep rise in the drying air humidity mostly in the afternoon the same result also reported by Lye *et al.*, (2002).

Quality testing of dried Potato Chips

Organoleptic evaluation of dried product

The samples of product dried in both the method (tracking & without tracking of sun) were given to panel. The result of evaluation by the panel with the help of hedonic scale is presented in Table No.

The test conducted for texture, colour, flavor, appearance, taste and overall acceptability for the product is presented in Table 4.1.

Overall acceptability of Potato chips dried in solar dryer in solar dryer under both the condition was "Slightly liked" by the panel.

Table. Observation and Calculation on Rehydration of Dried Vegetable (Potato Chips)

Time	Initial Dryer Sample (Potato Chips)	Rehydration Ratio (Potato Chips)
Initial	8.0	-
After 5Min.	30.50	3.80
After 10Min.	40.48	4.89
After 15Min.	43.11	4.42

Table. Percent Moisture content of Potato Chips evaporated

Tray No.	Drying Day			
	Initial Wt. (g)	Final Wt.(g)	Moisture evaporated (g)	Moisture content (%w.b)
T_1	450.00	60.00	390.00	81.63
T_2	500.00	70.00	430.00	83.50
T_3	550.00	99.50	450.50	81.50
T_4	600.00	114.50	485.50	80.00

*Initial moisture content of Potato Chips-81.42% (w.b.)

Rehydration ratio of dried Potato chips

The rehydration ratio of dried Potato chips samples. The rehydration ratio determined was 5.44 for solar dried product in case potato. The higher rehydration ratio implies lower solid concentration in the samples and vice-versa. The rehydration ratio for both method of drying was found to be the same. It shows that tracking of sun during solar drying does not have any effect on the quality of dried samples.

Conclusion

In this work we studied the solar drying of sliced potatoes by Tracking and without Tracking methods. The operating condition ensuring a better result was found solar tracking method, Potato chips obtained from drying process at 49°C have the same

Table 4.1. Average score of sensory evaluation

S. No.	Sample	Texture	Colour	Flavour	Appearance	Taste	Overall Acceptability
1	Potato	5	5.5	5.2	5	6.3	6.5

Table. Variation in air Temperature, Relative Humidity inside and outside the dryer at no load

Sl. No.	Sample	Texture	Colour	Flavour	Appearance	Taste	Overall Acceptability
1	Potato Chips	56466	55666	66464	45545	46545	64666

freshness. All the potato chips has been dried in box type solar dryer.

Acknowledgement

Authors greatly acknowledge, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India to provide all necessary facilities for conduction of research trial.

References

Aboltins 2013. A Theoretical study of material drying coefficient. International Scientific Conference Engineering for Rural Development, Latvia University of Agriculture, Jelgava,.

Ahmed, M., Hauser, J.C., Heijnen, C. and Chaudhary, M.A. 2002. Solar drying of fruits and vegetables. *Park-Journal of Agricultue-Research (Park)*. 17(3) : 237-244.

Bakal, S.B., Gedam, K. H. and Sharma, G.P. 2010. Drying characteristics and kinetics of fluidized bed dried potato. *Agricultural and Food Science.* 19 : 127-135.

Bennamoun Lye Belhari Azeddine 2002. Design and simulation of a sola dryer for agricultural products. *Journal of food Engineering.* 59 : 259-266.

Gupta, M. K., Sehgal, V.K. and Arora, S. 2011. Optimization of drying process parameters for cauliflower drying. *Journal of Food Science and Technology.* 50: 62-69.

Garg, H.P. and Krishnan, A. 1974. Solar drying of agricultural products *Annals of Arid Zone* 13(4) : 285–292.

Olawale, A.S. and Omole, S.O. 2012. Thin layer drying models for sweet potato in try dryer. *Agric. Eng. Int: CIGR Journal.* 14 (2): 2060-2069.

Patel, K.K. and Kar, A. 2012. Heat pump assisted drying of agricultural produce-an overview. *Journal of Food Science and Technology.* 49: 142–160.10.1007/s13197-011-0334. pp. 153-158.

Radhika, G.B., Satyanarayana, S.V., Rao, D.G., Raju, B.V. 2011. Mathematical model on thin layer drying of finger millet (*Eluesine coracana*). *Advanced Journal of Food Science and Technology*. 3: 127–131.