Drying of Tomato Using Indirect Solar Dryer at Controlled Temperature

ISSN (e) 2520-7393
ISSN (p) 2521-5027
Received on 2nd Mar, 2019
Revised on 2nd April, 2019
www.estirj.com

Zain ul Abideen[1], Dr. Shaheen Aziz[2], Engr. Aisha Kausar[3] Hafiz Anees Rehman[4]

[1,2,3] *Department of Chemical Engineering MUET, Jamshoro, Pakistan*
[4]. *Department of Chemical Engineering Quaid e Awam, Nawabshah , Pakistan*

Abstract: Drying is an ancient and traditional way for preserving the food. An active method used worldwide to preserve the food is Solar Drying. Solar energy is present in nature in large quantity and is cost effective and thus appropriate for drying to get good yield, Due to their ability of locally manufacturing and existing they saves transport, time and cost. Solar dryer can be designed and fabricated locally in various sizes starting from small ones to big ones as demanded to dry the food, agricultural products and different items The tomato was dried in four days and remaining weight of sample at fourth day was 130 gm. While, the dryer can developed for industrial scale to save the capital cost. Food businesses would be influenced to use this solar dryer along with old techniques for making it efficient.

Keywords: *Solar energy; Drying; Indirect solar dryer; Food Drying; Moisture Removal*

1. Introduction

Solar energy played a vitol rule in fulfilling the energy needs of the ancient man. As the generation has evolved from time to time the use of solar energy has also improved from early ages. From ancient times men have preserved fruits and vegetables to preserve for hard days. These tools introduced new methods, however by this time the accumulative request for nutrias, economical natural food plus their rising demand for tolerable financial gain, are transfer star drying to the face as a valuable various for excess product. This food recover family nutrition as a result of fruits and vegetables contains high numbers of minerals, vitamins and fiber, and the sugar patients can use edible fruit prepared while not using sweat could be the health alternative as a replacement of desert [1,4,7].

Drying with in the sun is extremely cost-effective in merely scattering produce on an appropriate surface and allow it to dry in the sun, however someone is required to be at home for the entire period of drying to look after livestock plus take away the turn out if the climate suddenly changes & becomes unclean, or once it showers. The food which we spread over open air is of poor yield due to the exposure of food to bacteria, flies and sand, dust [5].If we compare the food which is dried directly in sunshine, this technique needed money and time to dehydrate fruits and vegetables box frame lined with flexible material [6]. The advantage of solar dryer is that it has rapid dry air which do not contaminate the food while in exposure to sunshine it has moisture in air which can tarnish the quality of the food and flavor as well [7]. This technique has a more convenient and rapid factor that inner temperature of the equipment is more than the outside, hence it has low risk spoilage due to the rapid speed of drying, the product was also much cleaner, safer, free from bacteria, it also has no labor cost and in rainy weather the material to be dried can be kept free from moisture and contaminations. [8].

2. Related Work

We designed and fabricated an Indirect forced convection solar dryer and its performance was checked while using the small apple slices in large quantity. The dryer has been designed indigenously using locally available materials for construction and it is cost effective. The product placed inside the drying chamber is allowed to heat with heated air passed through separate solar collector. Some well created baffles are installed in indirect forced convection solar dryer from which solar energy is passed which was absorbed earlier in the collector. The temperature inside the drying chamber and the solar collector was much higher than the ambient temperature during most hours of the daylight, which was useful for better drying. The relative humidity inside the drying chamber was also less during different time. Percentage of moisture loss and mass of water removed in the drying chamber was higher compared to open sun drying. Higher crude protein and dry matter contents in the solar dried green apple slices also indicate that the solar drying is better than sun drying. The indirect forced convection solar dryer which is well fabricated and designed will be very useful for drying the agricultural products and food items in rural areas because it is very cost effective and easy to handle [9].

Corresponding author Email address*: 10muet41@gmail.com*

"Food drying was a very simple and ancient skill as told by Kerr, Barbara a known solar cooker designer and Living expert. It only required a large open area where Air can easily pass and sunshine is easily available to dry the food by spreading all the pieces. Sunshine is a must requirement because it helps the air to get dry and dehydrates the food. An old tradition still used in the world to dry the food is to spread it over the roof or take the food in the basket and let it expose to open air. Beside all this many other arrangements are being used such as spread the food over large thin stick and place it over the fire to dehydrate it, Meanwhile many other type of dryers are also available in the market. But Barbara holds his choice with the downdraft system. United States food and drug agency advised after its study and experiments that dried food is far better than canning and under freezing food. She gave a report study that freezed and canned food has no texture and flavor [10].

Markus, Häuser and Omar Ankila (2010) stated the conventional sun drying gives poor yield because the food is spread in open air and is open to all the insects, birds, rodents, bacteria, dust particles and many more. Fouling, infection with germs, creation of mycotoxins, and contamination with disease-causing microorganisms were the product. They state that the drying apparatus used in industrial nations overcomes all of these difficulties, but regrettably was not very well matched for use in rising countries for it required considerable money and a well-developed structure [11].

Ong KS (1986) designed a modern type of solar crop dryer. It has a flat-plate of conservative type associated to a dehydrating chamber. The solid which is to be dehydrated is retained on the upright stack of trays in the dehydrating chamber. Bottom end of the accumulator is exposed to the ambient air coming from outside the system. Air is heated up by the solar heat falling on the accumulator. The hot air moves upward and gives the discharge in the ventilation chamber. By all the above procedure the air is distributed via natural convection. The rate of flow of air can be improved by connecting a tall stack to the dehydrating chamber, or we can use a up went duct directly attached to the dehydrating chamber to increase the rate of the dehydration [12].

Pangavhane DR, Sawhney RL, Sarsavadia PN (1999) designed and fabricated a multipurpose purely natural convection solar dryer for the drying of agricultural products such as fruits and vegetables. Solar air heater installed in the dryer along with plenum chamber, chimney, connectors and drying chamber. Solar air heater has a dimension of 2.47 m 0.73 m 0.03 m through which hot air is passed. The U shape corrugations acted as absorbent that was painted in black has a top surface for the air passage of size 1800 mm 730 mm. The dimension of drying chamber was 350 mm, 350 mm, 700 mm, made of 500 mm alloy sheet insulated with nonconductor. Five punched plates were set at a distance of 9 mm from one another. Grapes were dehydrated inside the appliance, similarly in the open sun for analysis of the dryer. Grapes were pretreated before drying all these into a solution of 20% industrial dipping oil and a pair of 2.5% K_2CO_3. The solar-dehydrated grapes were found higher than the preserved grapes. The drying time was reduced to just about partial within the solar dryer related by open sun drying. This technique is used for drying numerous agricultural products like grapes and tomatoes [13].

Hydari A, Suharwadji Haen I (1981) established solar dryer for onion drying. The plastic-covered drying chamber (20000gm ingredient) measured 1200 mm, 1200 mm, 3500 mm high and contained seven trays unfold 30 cm separately. There are three black flat metallic plate-type air heater were coupled with the drying section on other sides. Filling and delivery were done on the fourth side. Every dryer restrained 1200 mm wide 3500 mm long 20 cm deep and delivered by elastic packing. Products displayed that the solar dryer compact their common range of drying days next 10 to 3 with a traditional weight loss of 22% as related complete around 35% using the school outside open air methodology. [14].

Van Eckert M (1998) designed and fabricated a solar dryer and many other i.e. 90 dryers were tested during 1996-1997 as part of GTZ project. The amount of the dryer is a pair of 2000 mm, 800 mm, drying size 18–22 kg of garden-fresh mangoes per day within the Kenyan weather, leading to roughly 0.50 kg/day of dried product. The temperature was ranged up to 40C above the ambient temperature. The dryer was proved to be technically reliable cautiously viable, and socially satisfactory by the Kenyan individuals. It was suggested that dark frame solar dryers are more suitable on behalf of minor scale drying due to its effectiveness and environment friendly convection [15].

ZOELLNER, et al (2010) designated solar dehydration system, to dehydrated the yearly growth of 10000kg of apples and extra fruit product, they arrange alternate ways of project managing to elude the well-known disasters of the conventional and lavish practical aid plans convoyed with vast groups [16].

3. Methodology

3.1 System working

The purpose of dryer is to supply the heat product more available below the ambient temperature, thus rises the vapor pressure of the moisture sufficiently detained with in crop and decrease the relative humidity of the air and increases its moisture carrying capacity while ensuring the sufficient low moisture content [17].
The solar dryer considered in our research is simple and cheap. Here the product is placed on trays or shelves in the

drying chamber. Solar radiation is not incident directly on the food [18].

Our principle here is that; Black substance absorbs more heat than any other materials, Warm air is always lighter than cold air and, Air flows from higher pressure to low pressure. Air is allowed to flow through the heating chamber which is placed tilting at certain angle. Preheated air warmed during its flow through the heating chamber is ducted to the drying chamber to dry the product [19].

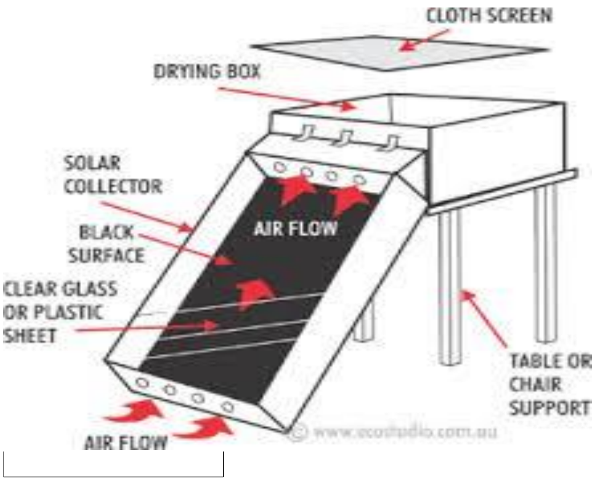

Figure.1. Indirect Solar Dryer

Our principle here is that;
Black substance absorbs more heat than any other materials, Warm air is always lighter than cold air and, Air flows from higher pressure to low pressure. Air is allowed to flow through the heating chamber which is placed tilting at certain angle. Preheated air warmed during its flow through the heating chamber is ducted to the drying chamber to dry the product [19].

Our design consists of following parts:

a) Solar Collector
b) Drying chamber.
c) Air exhaust.
d) Tray capacity.

4. Results and Discussion

After drying of tomato and their results of different tests performed are given below. 4.1 Drying of Tomato through Dryer.

Fig.2. Tomatoes before drying

Tomato sample of 1000 gm were dried from 17 to 20 July 2018 at 50ºC maximum temperature of dryer. The tomato was dried in four days and remaining weight of sample at fourth day was 130 gm

The complete data along trend presented below:

- After Tomato sample of 1000gm were dried from 21 to 24 July 2018 at 50ºC maximum temperature of dryer.
- Cut of was set at 51ºC.
- The Tomato was dried in four days.
- The last weight that weighted was 130 gm.

Fig.3. Tomatoes after drying.

Table.1 First Day Drying Tomatoes

Tomato Sample						
Time	Ambient Temperature	Humidity	Wind Speed KM/HR	Dryer Temperature	Before Drying Product Weight	After Drying Product Weight
8:00	32C	56	24	32C	1000 gm	710 gm
9:00	33C	50	28	40C		
10:00	36C	45	31	41C		
11:00	37C	41	32	44C		
0:00	38C	44	32	46C		
13:00	39C	58	34	47C		
14:00	38C	56	31	47C		
15:00	36C	54	32	45C		
16:00	35C	53	29	44C		
17:00	33C	52	25	43C		
18:00	30C	51	31	41C		

After 1st day drying of tomato, we took total 1000g of tomatoes for the experiment and placed them under solar dryer to check about the evaporation by natural sunshine i.e. solar drying. 290g of moisture evaporated and the net weight of tomatoes remains 710g.

Table.2 Second Day Drying Tomatoes

Tomato Sample						
Time	Ambient Temperature	Humidity	Wind Speed KM/HR	Dryer Temperature	Before Drying Product Weight	After Drying Product Weight
8:00	32C	56	24	32C	710 gm	490 gm
9:00	33C	50	28	40C		
10:00	34C	45	28	42C		
11:00	35C	41	32	44C		
0:00	38C	44	32	45C		
13:00	39C	52	32	47C		
14:00	38C	56	31	47C		
15:00	37C	54	33	44C		
16:00	36C	53	29	44C		
17:00	34C	52	25	43C		
18:00	32C	51	31	42C		

After 2nd day drying of tomato, we took total 710g of tomatoes for the experiment and placed them under solar dryer to check about the evaporation by natural sunshine i.e solar drying. 220g of moisture evaporated and the net weight of tomatoes remains 490g.

Table.3 Third Day Drying Tomatoes

Tomato Sample						
Time	Ambient Temperature	Humidity	Wind Speed KM/HR	Dryer Temperature	Before Drying Product Weight	After Drying Product Weight
8:00	32C	56	24	32C	490 gm	290 gm
9:00	33C	50	28	40C		
10:00	34C	45	28	42C		
11:00	35C	41	32	44C		
0:00	38C	44	32	45C		
13:00	39C	52	32	47C		
14:00	38C	56	31	47C		
15:00	37C	54	33	44C		
16:00	36C	53	29	44C		
17:00	34C	52	25	43C		
18:00	32C	51	31	42C		

After 3rd day drying of tomato, we took total 490g of tomatoes for the experiment and placed them under solar dryer to check about the evaporation by natural sunshine i.e solar drying. 200g of moisture evaporated and the net weight of tomatoes remains 290g.

Table.4 First Day Drying Tomatoes

Tomato Sample						
Time	Ambient Temperature	Humidity	Wind Speed KM/HR	Dryer Temperature	Before Drying Product Weight	After Drying Product Weight
8:00	31C	56	24	32C	290 gm	130 gm
9:00	32C	50	28	38C		
10:00	34C	45	28	41C		
11:00	35C	41	32	43C		
0:00	37C	44	32	44C		
13:00	38C	52	32	45C		
14:00	38C	56	31	45C		
15:00	37C	54	33	44C		
16:00	33C	53	29	43C		
17:00	34C	52	25	42C		
18:00	32C	51	31	41C		

After 4th day drying of tomato, we took total 290g of tomatoes for the experiment and placed them under solar dryer to check about the evaporation by natural sunshine i.e. solar drying. 160g of moisture evaporated and the net weight of tomatoes remains 130g. The experiment took place for 4 days continuously and 87% moisture evaporated from the system which is quit astonishing and cheap.

Conclusion

The designed solar dehydrator is active type solar dehydrator that proved efficient on experimental basis. The 1000 gm tomatoes was dried in this dryer within 4 days each respectively which was hygienic and safe with nutrients means the experiment is ideal for large scale use. The tomatoes were dry without any pre- treatment instead of wash and cutting into pieces. Quality and color of tomatoes is also not damaged. Temperature control system prevented vegetables from burning and cooking during peak sunshine hours.

References

[1] Scanlin, D., 1997. Indirect, Through-Pass, Solar Food Dryer. Home Power. February.

[2] El-Sebaii, A.A. and Shalaby, S.M., 2012. Solar drying of agricultural products: A review. Renewable and Sustainable Energy Reviews, 16(1), pp.37-43.

[3] Bharadwaz, K., Drying of agricultural products using forced convection indirect solar dryer.

[4] Scanlin, D., 1997. Indirect, Through-Pass, Solar Food Dryer. Home Power. February.

[5] El-Sebaii, A.A., Aboul-Enein, S., Ramadan, M.R.I. and El-Gohary, H.G., 2002. Experimental investigation of an indirect type natural convection solar dryer. Energy Conversion and Management, 43(16), pp.2251-2266.

[6] Kendall, P. and Allen, L., 1998. Drying Vegetables: Food And Nutrition. Colorado State University Cooperative Extension Service Publication, Colorado, USA. Kerr, Barbara: [1999] A Review Of Solar Food Drying; 1999 - Kerr, Barbara. The Sustainable Living Center. 3310 Paper Mill Road, Taylor, Arizona 85939 USA

[7] Häuser, Markus and Ankila, Omar: [2010] Morroco Solar Dryer Manual; Centre de Développement des Energies Renouvelables (CER) Office Regional de Mise en Valeur Agricole du Haouz (ORMVAH) Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH 2010.

[8] Ayensu, Akwasi: [2009] Dehydration Of Food Crops Using Solar Dryer With Convective Heat Flow; Dept. of Physics at the University of Cape Coast, Cape Coast, Ghana.

[9] Kaustav Bharadwaz, Debashish Barman , Debottam Bhowmik ,Zunaid Ahmed, [2007] design, fabrication and performance evaluation of an indirect solar dryer for drying agricultural products.

[10] kerr, barbara: [1999] a review of solar food drying; 1999 - kerr, barbara. the sustainable living center. 3310 paper mill road, taylor, arizona 85939 USA.

[11] Häuser, Markus and Ankila, Omar: [2010] MORROCO SOLAR DRYER MANUAL; Centre de Développement des Energies Renouvelables (CER) Office Regional de Mise en Valeur Agricole du Haouz (ORMVAH) Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH 2010

[12] Ong KS , [1986] The State-of-art report on solar drying in ASEAN countries. RAPA Publication: 1986/27, FAO, Bangkok

[13] Pangavhane DR, Sawhney RL, Sarsavadia PN (2002) Design, development and performance testing of a new natural convection solar dryer. Energy 27:579–590.

[14] Hydari A, Suharwadji Haen I (1981) Application and future prospect of onion solar dryer. In: Proceedings of regional Asia and Pacific workshop on the applications of solar energy in agricultural and post harvest activities, Bandung, Indonesia.

[15] Van Eckert M (1998) Mango drying: a tree product value and income generating enterprise in rural areas, ITFSP internal paper # 19. Nairobi, Kenya.

[16] Zoellner, et al: [2010] Solar Drying Of Apples In Neapl; 2010 Institute C for Thermodynamics, Technical University Munich, Germany

[17] Ajit K. Mahapatra, et al: [2009] Parameter Sensitivity Analysis Of A Directly Irradiated Solar Dryer With Integrated Collector 2009; Department of Agricultural Engineering, School of Engineering, University of Zambia, P.O.Box 32379, Lusaka, Zambia..

[18] Soomro, Muhammad Saleh [2003] Design, Fabrication Ang Performance Evaluation Of An Agro-Dryer For Drying Agro-Commodities. PhD thesis, Sindh Agriculture University, Tando Jam.

About Authors

1. Zain Ul Abideen ME Chemical Engineering Solar Energy.

2. Dr Shaheen Aziz Professor Muet Jamshoro.

3. Engr Aisha Kousar Lecturer Muet Jamshoro.

4. Hafiz Anees Rehman Lecturer Quaid e Awam. Nawabshah.