Current Journal of Applied Science and Technology

40(7): 23-29, 2021; Article no.CJAST.67070
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Comparative Study between Modified Solar Dryer and Open Sun Drying for Drying of Onion Slices

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Authors' contributions

This work was carried out in collaboration among all authors. Author PS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors EM, KCR and GSK managed the analyses of the study. Author BB managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2021/v40i731324
Editor(s):
(1) Dr. Rodolfo Dufo Lopez, University of Zaragoza, Spain.
(2) Dr. Chien-Jen Wang, National University of Tainan, Taiwan.
(3) Dr. Elena Lanchares Sancho, University of Zaragoza, Spain.
Reviewers:
(1) Kiran Devade, Pune University, India.
(2) Dinesh Acharya, Tribhuvan University, Nepal.
Complete Peer review History: http://www.sdiarticle4.com/review-history/67070

Original Research Article

Received 10 February 2021
Accepted 20 April 2021
Published 28 April 2021

ABSTRACT

Solar greenhouse drying is a method of removing moisture from the food material in which drying medium is solar energy which is easily available and low in cost for farmers. The solar energy is decreases in the monsoon months in comparison to non-monsoon months. The decrease in the solar energy results in lower temperatures in the solar greenhouse dryer. The aluminium foil which has 88% reflectivity, reflects the radiation inside solar greenhouse dryer and heats the air inside dryer and maintains heat for longer times. Aluminium foil was applied on eastern, western and southern walls of the dryer and the parameters *viz;* temperature and relative humidity were recorded in both modified solar greenhouse dryer, solar greenhouse dryer and ambient conditions. Assessment of temperature in ambient condition, solar greenhouse dryer with and without modification showed the maximum temperature difference between solar greenhouse dryer without modification and ambient condition was about 11.5°C whereas 17.5°C maximum temperature difference between modified solar greenhouse dryer and ambient condition. The dryer was able to

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reduce moisture content of onion from initial moisture content of 679 per cent dry basis to 5.7 per cent in 31 h of drying whereas the traditional sun drying was able to reduce moisture content of onion from initial moisture content of 679 per cent dry basis to 29 per cent in 31 h of drying time. The results showed a considerable advantage of solar dryer over the traditional open sun drying method in term of drying rate and less risk for spoilage.

Keywords: Solar dryer; onion; temperature; moisture.

1. INTRODUCTION

Onion (*Allium cepa L*.) is one of the main crops under Allium family, cultivated mainly in the tropical countries since long time. Besides imparting a characteristic taste and flavour to food, it also has significant therapeutic values [1]. Because of its hypocholestrolemic, thrombolytic and antioxidant properties, onions are useful in the treatment of cataracts, cardiovascular disease and cancer [2]. Onion is noted for its pungency, which is caused by a volatile oil called allyl-propyl disulphide. Onion contains vitamin B, a trace of vitamin C and also traces of iron and calcium. Since raw onions increase the levels of high density lipoproteins, they help to lower cholesterol levels. Onions help in controlling coronary heart disease, thrombosis and blood pressure.

Onion is one of the important vegetable crops grown in India. Globally, India ranks second after china in onion production, with a share of around 14%. Maharashtra ranks first in onion production with a share of 28.32% during 2019-20. Onion production in Andhra Pradesh was 267.15 Lakh tonnes during 2019-20. Though, there is great potential for the state of Andhra Pradesh in the cultivation of onion crop, farmers often incur losses due to low prices during the glut, lack of sufficient market outlets and other infrastructure facility in the marketing system. The storage losses of onion in India ranges from 30 to 60% due to various factors such as physiological weight loss (25-30%), rotting due to fungal diseases (10-15%) and sprouting of bulbs (10- 15%). Drying is the most commonly used preservation technique and dehydrated onion can be used in many processed or ready to eat foods in place of raw onion. This has several advantages such as convenience of transportation, storage, preparation and use [3]. Dehydrated onion is also used as a flavouring additive in several products in food industries such as meat products, sauces, soups, salad dressings, pickles and other snack items [4].

Sun drying is the most popular onion preservation techniques used around the world [5]. However, sun drying necessitate a longer drying period and a higher processing temperature, affected by frequent weather fluctuations making it difficult to preserve product moisture content and quality due to airborne dirt and dust [6]. New and innovative techniques or modifications that increase the drying rate and enhance the product quality have achieved considerable attention in the recent past. To make Solar greenhouse dryer more efficient, some modification is being incorporated in the conventional greenhouse dryer. Generally, thermal losses take place in the solar greenhouse dryer namely through the walls and ground of the dryer. In order to minimize the heat loss from the dryer, study is being carried out using aluminium foil on eastern, western and southern walls. The objective of the work was aimed to compare modified solar dryer with open sun drying for onions.

2. MATERIALS AND METHODS

2.1 Study Location

The experiment was conducted at the section of Agricultural Engineering, ICAR-Indian Institute of Horticultural Research, Hessarghatta, Bangalore North District, Karnataka. It is situated on the latitude of 13°58′ North, longitude of 78° east and at an elevation of 890 meters above mean sea level which is considered as the heart of the Mysore Plateau (a region of the larger Deccan Plateau) of Karnataka.

2.2 Description of Solar Greenhouse Dryer

A gable roof even span type solar tunnel dryer having a floor area of (6x3m) was designed for drying onion flakes. The height of solar dryer was 2.7m which was convenient height for a person to enter into the dryer and carry out the operations such as loading and unloading of the material to be dried. the center length of the dryer was 3.3m. The solar tunnel dryer was a

galvanized iron framed structure and oriented in north-south direction. The structure was covered with ultra violet stabilized polythene sheet of 200 micron size. Two fresh air inlets, each of 0.6 x 0.3m were installed at the rear side of the dryer and at 0.15m height from the ground level for entry of fresh air. Two each of 50 watt axial flow exhaust fans were fitted (9''diameter) at the front side of the dryer at 2 m height from the ground level, for easy escape of moisture ladden air from the dryer, for obtaining higher drying rate. The structure was raised on concrete floor. Five platforms were fabricated to place the products filled in plastic tray. Each platform had a dimension of 2.7m x 1m x 0.96m (lxwxh). Four platforms were kept inside solar tunnel dryer and one was used for open sun drying of product. the platforms were fitted with nylon caster wheels for mobility.

2.3 Modifications in Solar Greenhouse Dryer

In order to reduce the heat loss from the solar greenhouse dryer, aluminium foil was used on eastern, western and southern walls of solar greenhouse dryer. Aluminium foil with reflectivity of 88% was selected for the study and applied on both eastern and western sides of solar greenhouse dryer. For southern wall, an aluminium foil sticked thermocol frame was used. Reflectivity of aluminium foil reflects the sunlight and reflected sunlight heats the air in the solar dryer which helps in the improving the heat and its retention in the solar greenhouse dryer.

The parameters, temperature and relative humidity were recorded in solar greenhouse dryer with and without modification as well as in ambient conditions for two days. The parameters measured to study and analyze the microclimate inside the solar tunnel dryer. The instrument used for the present investigation was data logger for recording the hourly temperature and relative humidity during the drying period, electronic weighing balance for weighing the onion samples and hot air oven to determine the initial and final weights of the samples.

2.4 Operation

Freshly harvested onions were procured from local market of Bengaluru district in Karnataka state. Onions with moisture content 87.08% (w.b) were peeled, rooted and cut into slices of 2-4 mm thickness using manual slicer and spreaded with 500 g in 56 trays, 28 trays were kept on drying platforms under ambient conditions and another 28 trays were placed on platforms inside the dryer. Weights of the sample were taken in every one hour from 9 AM to 4 PM for the first day of drying and for the second day weights were taken in every 2 h from 8 AM to 4 AM as the slow weight reduction in the samples.

3. RESULTS AND DISCUSSION

The result Table 1 showed that maximum temperature difference between solar greenhouse dryer without modification and ambient condition was about 11.5°C. Table 2 showed that maximum temperature difference between modified solar greenhouse dryer and ambient condition was 17.5°C higher than the maximum temperature difference between solar greenhouse dryer without modification and ambient condition. Fig. 5 showed the temperature difference values of modified solar greenhouse dryer (9-17.5°C) were higher than solar greenhouse dryer without modification (6-11.5°C) through out the 8h i.e., from 9.00 AM to 4 PM for 2 days [7].

Fig. 6 showed that the final moisture content of onion slices at the end of the two day was lower in the modified solar greenhouse dryer than that in the ambient condition. This was because of the raised chamber temperature and relative humidity of the open air. The dryer was found to dry the products to safe storage moisture content of 6 per cent (d.b%) for long period in two days drying which is not obtainable in the open air sun drying in two days. The dryer was able to reduce moisture content of onion slices from initial moisture content of 679 per cent dry basis to 5.7 per cent in 31h of drying whereas the traditional sun drying was able to reduce moisture content of onion slices from initial moisture content of 679 per cent dry basis to 29 percent in 31h of drying.

3.1 Ambient – Open Sun Drying

The greatest moisture reduction was observed to have occurred between 11.00 AM to 3.00 PM daily when the solar intensity and drying air temperature was the greatest. The samples dried in the modified solar greenhouse dryer were clean and of high quality with no contamination through dust or insect and did not change

colour while those under open air sun drying showed changes in colour indicating signs of deterioration in quality. It was concluded that the modified solar greenhouse dryer increased the drying rate significantly. Hence, modified solar greenhouse drier was found to be technically and economically suitable for drying of onion slices under the specific conditions.

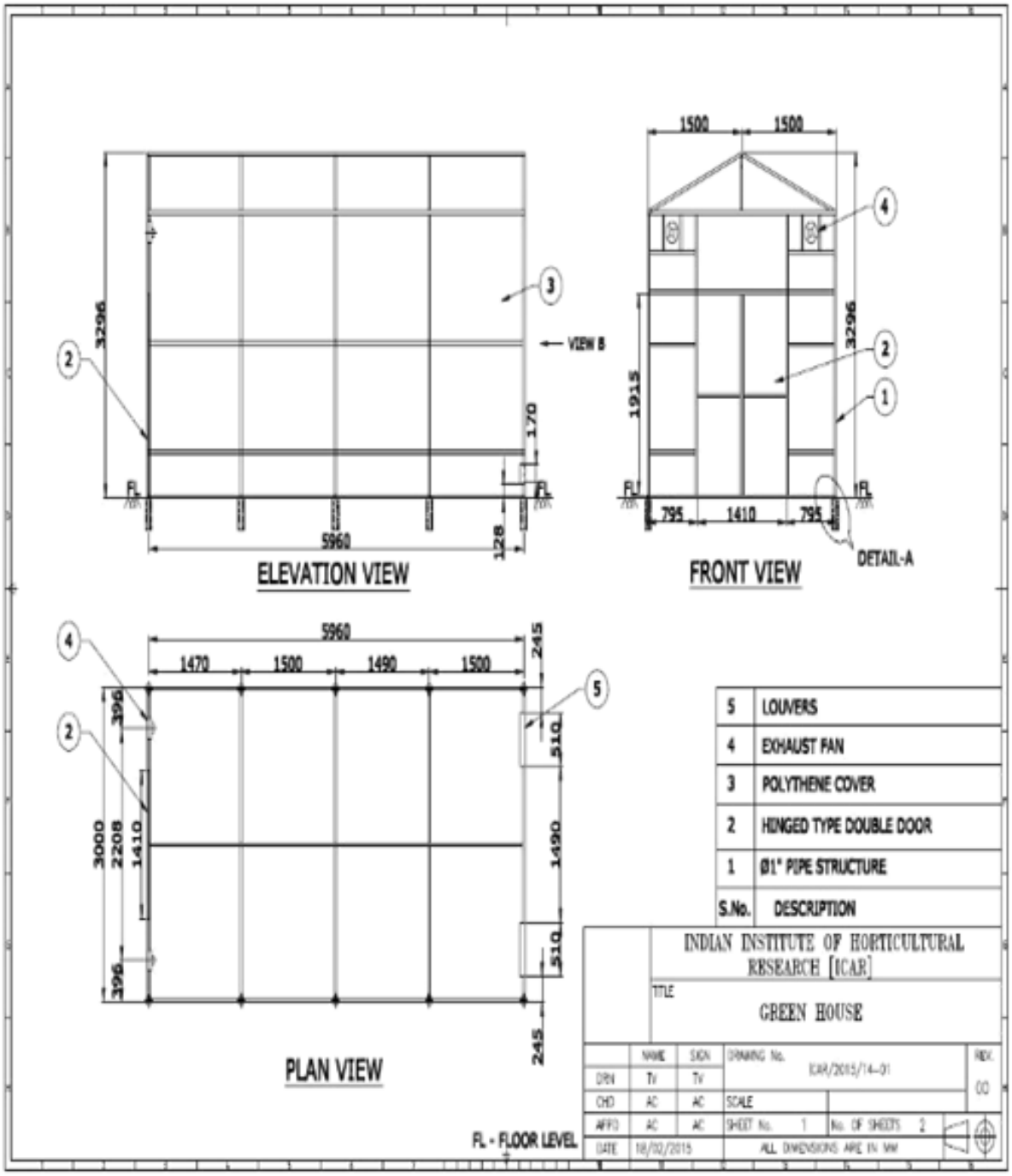

Fig. 1. Structural details of solar greenhouse dryer

Fig. 2. Modified Solar greenhouse dryer using aluminium foil on eastern, western and southern walls

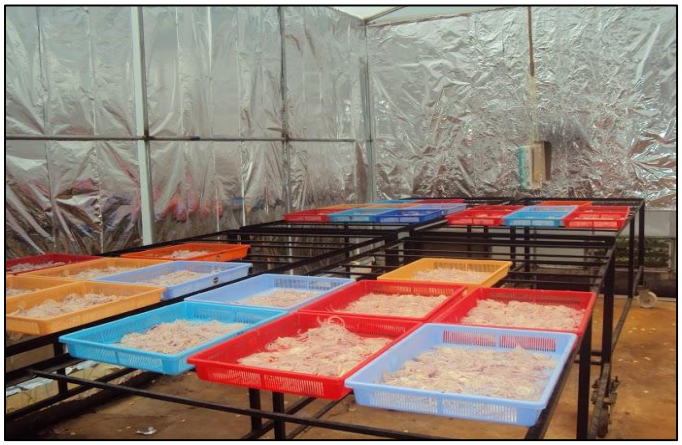

Fig. 3. Onion slices placed inside the modified Solar greenhouse dryer

Fig. 4. Onion slices placed at ambient condition

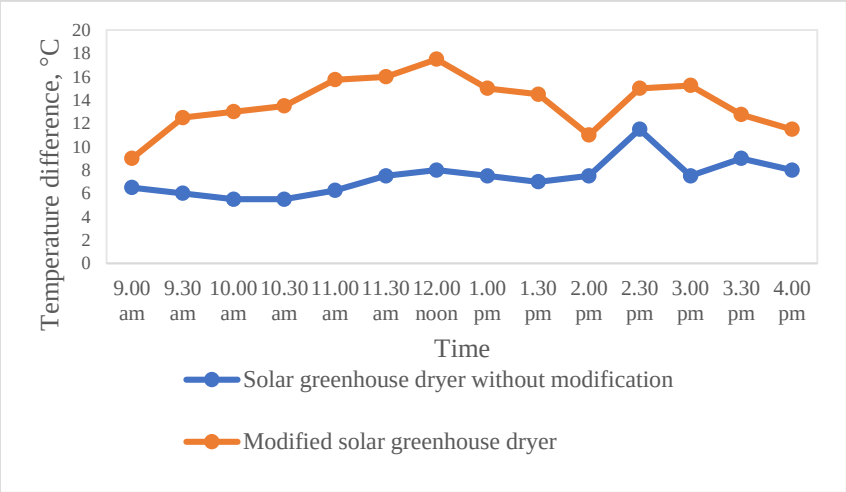

Fig. 5. Temperature difference values of solar greenhouse dryer with and without modification

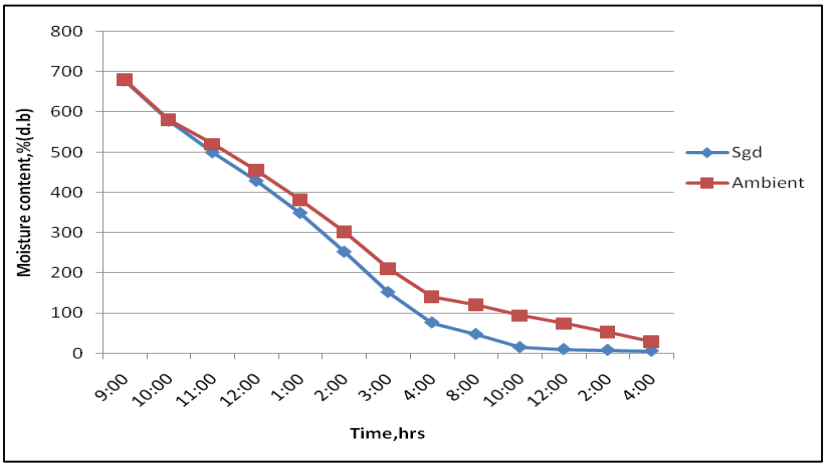

Fig. 6. Drying curve for modified solar greenhouse dryer and ambient condition
Sgd - Modified solar greenhouse dryer

Table 1. Average readings of temperature inside the solar greenhouse dryer without modification and ambient condition

Time	Temperature (°C)		Temperature difference (°C)
	Solar dryer without modification	Ambient condition	
9.00 am	31	24.5	6.5
9.30 am	32	26	6
10.00 am	33.5	28	5.5
10.30 am	32.5	27	5.5
11.00 am	35	28.75	6.25
11.30 am	35.75	28.25	7.5
12.00 noon	37.5	29.5	8
1.00 pm	38.5	31	7.5
1.30 pm	37	30	7
2.00 pm	39	31.5	7.5
2.30 pm	42.5	31	11.5
3.00 pm	35.5	28	7.5
3.30 pm	37.5	28.5	9
4.00 pm	35.5	27.5	8

Table 2. Average readings of temperature inside the modified solar greenhouse dryer and ambient condition

Time	Temperature (°C)		Temperature difference (°C)
	Modified solar greenhouse dryer	Ambient condition	
9.00 am	37	28	9
9.30 am	42	29.5	12.5
10.00 am	42	29	13
10.30 am	42	28.5	13.5
11.00 am	44.5	28.75	15.75
11.30 am	45.5	29.5	16
12.00 noon	47.5	30	17.5
1.00 pm	48	33	15
1.30 pm	46	31.5	14.5
2.00 pm	45	34	11
2.30 pm	46.75	31.75	15
3.00 pm	46.5	31.25	15.25
3.30 pm	43	30.25	12.75
4.00 pm	41.75	30.25	11.5

4. CONCLUSION

The result of the dehydration of onions in modified solar greenhouse dryer showed that the onions in modified solar dryer dried faster than the natural open sun drying method with drying temperature of up to 48°C. Onions dried under the modified solar dryer gives high quality products and time savings than open air sun drying. The results showed a considerable advantage of solar dryer over the traditional open sun drying method in term of drying rate and less risk for spoilage.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/67070