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Drying of white onion slices in modified solar greenhouse dryer using aluminium foil and black mulch sheet

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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 and black mulch sheet which is best absorber and emitter of heat radiation were used in the solar greenhouse dryer to heat the air and maintains heat for longer time. Combination of alternate strips of aluminium foil on two sides, aluminium foil on south wall and black mulch sheet on the floor of the dryer were used to modify the dryer for conducting experiments 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 19.5 °C maximum temperature difference between modified solar greenhouse dryer and ambient condition. The dryer was able to reduce moisture content of onion from initial moisture content of 669.23 per cent dry basis to 4.2 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 669.23 per cent dry basis to 26 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, white onion, temperature, moisture

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 alternate strips of aluminium foil on two side walls, aluminium foil on south wall and black mulch sheet on the floor of the dryer. The objective of the work was aimed to compare modified solar dryer with open sun drying for onions.

Materials and Methods

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.

Description of solar greenhouse dryer

A gable roof even span type solar tunnel dryer having a floor area of (6 x 3 m) was designed for drying onion flakes. The height of solar dryer was 2.7 m 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 3.3 m. 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 0.3 m were installed at the rear side of the dryer and at 0.15 m 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 2.7 m x 1 m x 0.96 m (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.

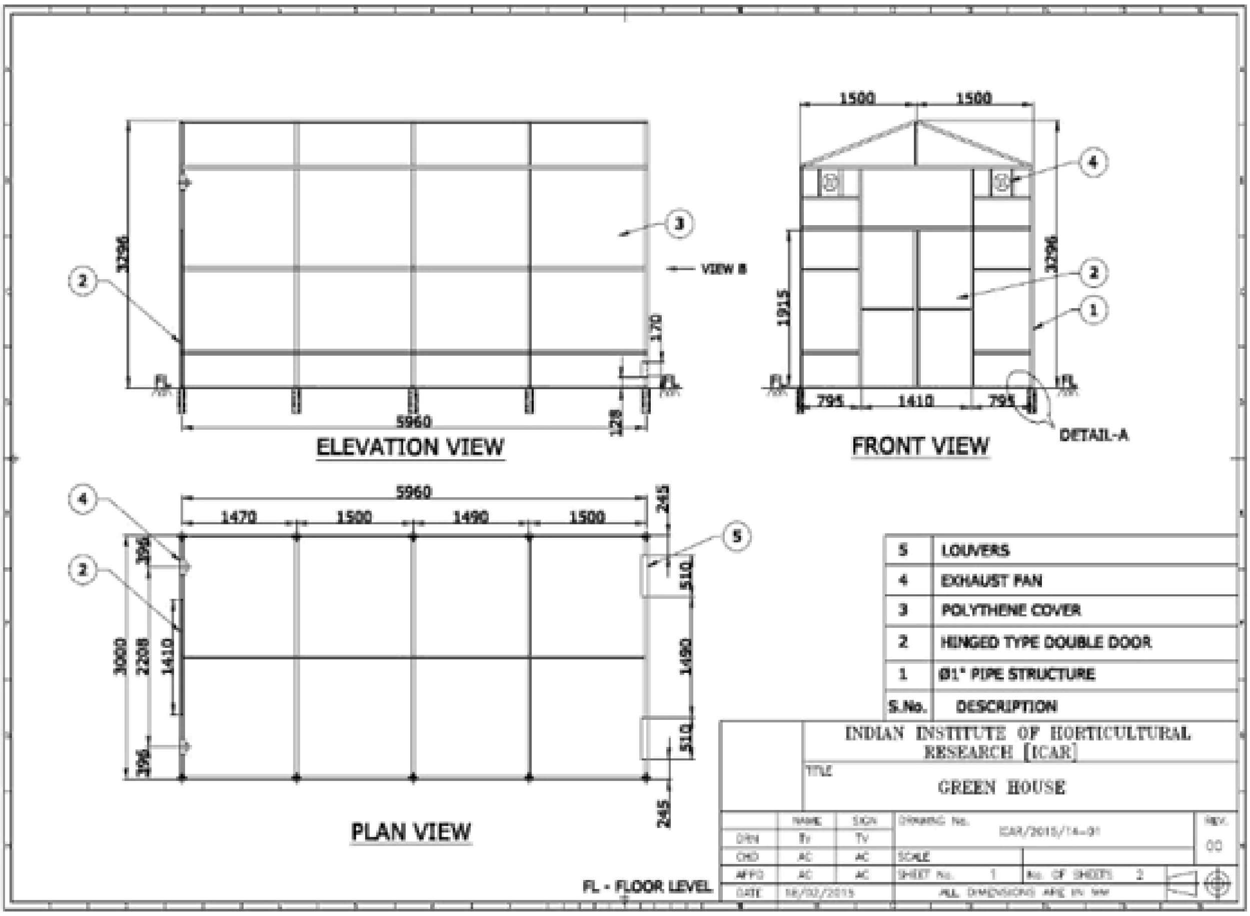

Fig 1: Structural details of solar greenhouse dryer

Modifications in solar greenhouse dryer

In order to reduce the heat loss from the solar greenhouse dryer, alternate strips of aluminium foil on two side walls, aluminium foil on south wall and black mulch sheet on the floor were used. Aluminium foil with reflectivity of 88% was selected for the study and applied as alternate strips on both eastern and western sides of solar greenhouse dryer. For southern wall, an aluminium foil sticked thermocol frame was used. The black mulch sheet which is best absorber and emitter of heat radiation was spread on the floor of the dryer.

Reflectivity of aluminium foil reflects the sunlight and reflected sunlight heats the air in the solar dryer and also black sheet used on the floor retains the heat 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.

Operation

Freshly harvested white onions were procured from local market of Bengaluru district in Karnataka state. Onions with moisture content 87% (w.b) were peeled, rooted and cut into slices of 2-4 mm thickness using manual slicer and spread with 500 g in 72 trays, 36 trays were kept on drying platforms under ambient conditions and another 36 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.

Fig 2: Modified Solar greenhouse dryer using alternate strips of aluminium foil on eastern & western walls, aluminium foil on southern wall and black mulch sheet on the floor

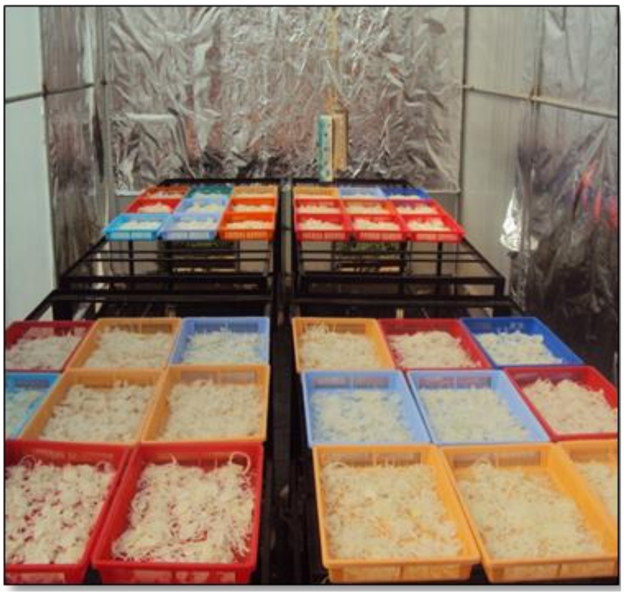

Fig 3: Onion slices placed inside the modified Solar greenhouse dryer

Fig 4: Onion slices placed at ambient condition

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 19.5 °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 (12-19.5 °C) were higher than solar greenhouse dryer without modification (5.5-11.5 °C) throughout the 8 h i.e., from 9.00 AM to 4 PM for 2 days [7]

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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	39.5	26	13.5
9.30 am	39.5	27	12.5
10.00 am	43.75	28.75	15
10.30 am	45.5	28	17.5
11.00 am	48.5	29	19.5
11.30 am	48	29.5	18.5
12.00 noon	46	30.25	15.75
1.00 pm	43	30.5	12.5
1.30 pm	44.5	32.5	12
2.00 pm	46.75	34	12.75
2.30 pm	46.75	32	14.75
3.00 pm	45.75	31.75	14
3.30 pm	43.75	30.5	13.25
4.00 pm	44	30.5	13.5

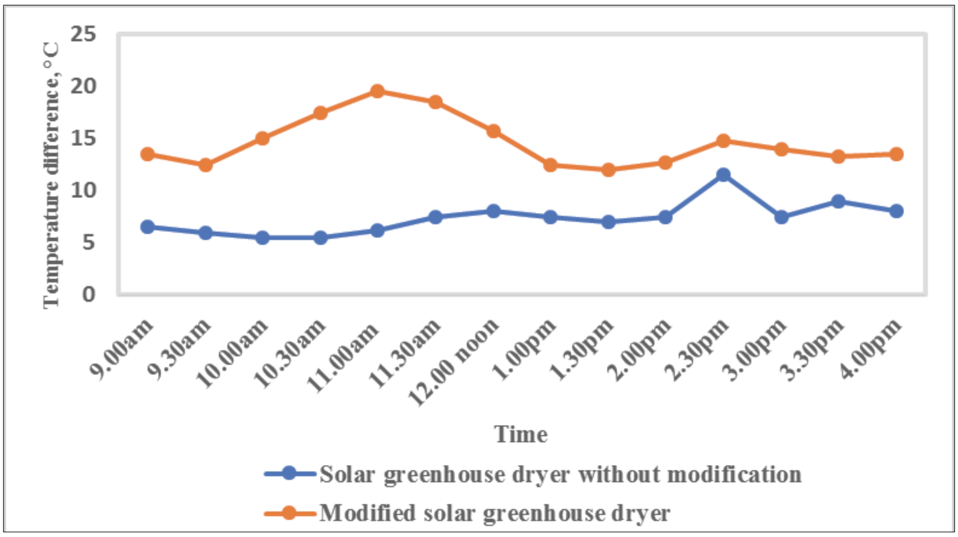

Fig 5: Temperature difference values of solar greenhouse dryer with and without modification

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 4.2 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 669.23 per cent dry basis to 4.2 per cent in 31 h of drying whereas the traditional sun drying was able to reduce moisture content of onion slices from initial moisture content of 669.23 per cent dry basis to 26 percent in 31 h of drying.

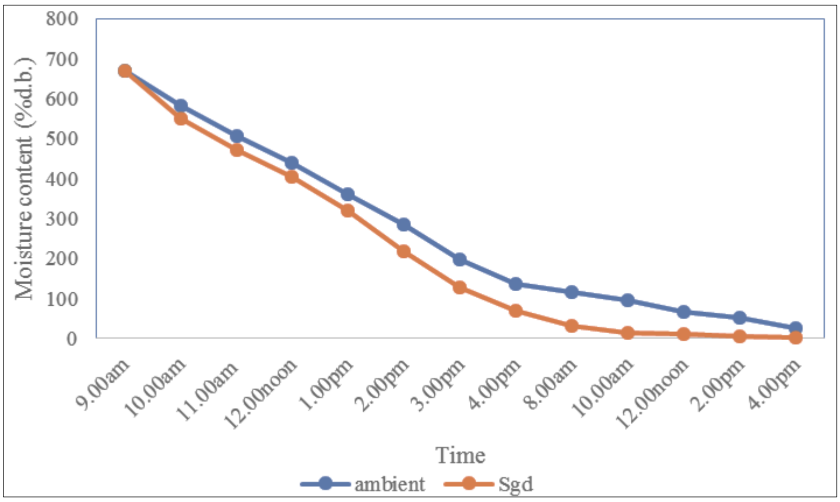

Fig 6: Drying curve for modified solar greenhouse dryer and ambient condition Sgd - Modified solar greenhouse dryer

Ambient – Open sun drying

(a) Dried onion slices inside the modified solar greenhouse dryer

(b) Dried onion slices outside the solar greenhouse dryer

Fig 7: White onion slices after drying

The greatest moisture reduction was 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 (Fig. 7). 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.

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 48.5 °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.

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