PROCESSING OF VEGETABLES IN A SOLAR DRYER IN ARID AREAS

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Abstract

When the production is high, the farmers have to sell the material on the same day of harvesting at very low price as high moisture content of fresh vegetables leads to rapid deterioration in the quality of the product because of the growth of micro flora insect infestation etc. Therefore, there is a great loss to the farmers. But this loss can be minimized by dehydrating the material up to safe moisture content that can be achieved by improvement in processing techniques, the important part is drying. Fortunately India is blessed with abundant solar energy. Therefore, solar dryers seem to be good substitute for mechanical dryers. Optimally inclined surface receive 22.8 % more solar radiation as compared to horizontal surface. Therefore, optimally tilted solar dryer has been used for this study. The tilt of solar dryer is adjusted once in a fortnight as per elevation of the Sun. Different types of vegetables were also dried. Vegetables were cut into pieces and loaded in optimally tilted dryer in direct and indirect mode. The initial moisture content of the tomato 95.8 %, spinach 95.7 %, carrot 93.4 %, onion 89.9 %, turmeric 87.6 %, coriander 89.7 %, okra 94.0 %, fenugreek 89.9 %, Mint 89.7 %, was reduced to 2.2 %, 2.4%, 2.6%, 5.9 %, 1.3%, 4.7%, 5.0 %, 0.8%, 2.0 %, respectively within 2 to 4 days of exposure in solar dryer. It takes 20 % more time in drying of vegetables in In-direct mode. The efficiency of the dryer was found to be 17.95 %. The use of solar dryer will be a great boon for farmers.

1. Introduction

Direct sun drying method has been practiced since ancient time and it is still being widely used in developing countries. Although this method of drying is cheap yet it is associated with the problems like contamination by foreign materials by dirt, dust and wind blown debris and insect infestation as well as uneven drying. During rainy season, the material can not be dried to desired safe storage moisture and the material also may get wetted. Fortunately India is blessed with abundant solar energy. The arid parts of India receive maximum radiation i.e. 7600 – 8000 MJm^{-2} per annum, followed by semi arid parts 7200 – 7600 MJm^{-2} per annum and least on hilly areas where solar radiation is still appreciable i.e. 6000 MJm^{-2} per annum. Therefore, solar dryers seem to be good substitute for mechanical dryers. Solar dryers are of three types natural, forced convection type and mixed mode Performance of the natural convection solar dryer is very good during the summer but it is very poor during winter in northern parts of India and takes longer time for dehydration of fruits and vegetables because its absorbing surface is horizontal and so receive much less radiation compared to optimally inclined surface. Solar radiation received at Jodhpur on horizontal surfaces and optimally inclined surface is shown in Table 1. From Table 1, it is clear that solar radiation received on an inclined surface is 69.73 % more than a horizontal surface during the month of December and an inclined surface receives 43.8 % and 22.76 % more radiation than a horizontal surface during the winter season (October – March) and round the year, respectively. Therefore, optimally tilted solar dryer has been used for this study. The tilt of solar dryer is adjusted once in a fortnight as per elevation of the sun.

Table 1. Mean daily solar radiation (MJ m^{-2}) on horizontal and optimally inclined surfaces

	Solar radiation (MJ m^{-2})		
Month	Horizontal surface	Inclined surface	Increase over horizontal surface (%)
January	16.6	26.10	57.23
February	19.6	27.65	41.07
March	23.0	26.16	13.74
April	25.5	26.02	2.04
May	26.6	26.60	0.00
June	24.9	24.90	0.00
July	21.1	21.10	0.00
August	19.5	19.67	0.87
September	21.5	23.09	7.39
October	20.5	26.05	27.07
November	17.3	26.70	54.33
December	15.6	26.42	69.36
Mean	21.0	25.04	22.76

2. Design

The solar dryer based on the natural convection operation principle mainly consist of a rectangular box made of galvanised steel sheet (22 gauge). A glass roof (area 1.0 m^2) made of clear window glass (4mm thick) is provided at the top of box and a layer of dried pearl millet stems insulation is provided at the base. The drying material can be kept on two trays made of stainless steel angle frame and stainless steel wire mesh. These trays can be placed on angle iron frame in the dryer through an open able door provided on the rear side of the dryer. Five partitions are also provided in each tray so that the vegetables can be stacked even on inclined plane. Six plastic pipes are fixed in the front wall of the dryer just below the trays to

introduce fresh air at the base. Two tapered slits are made on sidewalls of dryer for escaping the hot moist air from the drying chamber. A overhang over these slits protects the material from rain and wire mesh in these slits safe guards against flies and squirrels. An adjustable iron angle stand is provided to keep the dryer at optimum tilt in accordance with latitude and season of operation. In this dryer, the material can be loaded in drying trays to a maximum depth of 5 cm. The optimally tilted solar dryer is shown in Fig. 1.

2.1 Direct mode

For operating the solar dryer in direct mode, the material is directly exposed to solar radiation. Cold air enters through the ventilation holes beneath the trays, gets heated and takes the moisture out through the slits. This dryer as such works in direct mode.

2.2 Indirect mode

For operating the dryer in indirect mode, a blackened aluminium sheet is inserted just above the slits and below the glass cover of direct type dryer so that the drying trays always remain in shade. The aluminium sheet is painted with black board paint, which has high solar absorptance as well as high thermal emittance.

Thus the unit used for direct mode of drying can also be used for indirect mode of drying by simply inserting a blackened aluminium sheet between the slit and glass cover of direct type dryer.

(A) Direct mode

(B) In-direct mode

Fig. 1 Optimally tilted solar dryer

3. Performance

A series of experiments were conducted to study the comparative performance of solar drying system for dehydrating chillies, mint, tomatoes and coriander leaves in direct and indirect mode. For experimental study, both direct and indirect type solar dryers were used. Both the dryers were kept facing due south and loaded with equal quantity of materials. These units were kept at optimum tilt in accordance with latitude and season of operation. Air temperature inside the dryer at the centre of the drying trays and ambient air temperature were recorded hourly. Solar radiation on glass planes of dryers were also measured hourly during the drying trials. The initial and final moisture content of the product was determined by random selection of samples which were cut into small pieces if necessary, weighed by accurate scale with a degree of accuracy of 10^{-5} gm and then oven dried. During the experiment, all the drying trays were weighed at a regular interval of 2 or 3 hours. These experimental observations were continued until the product acquired a constant weight i.e. it attained its equilibrium moisture content. Moisture content of materials was computed from the difference in these weights.

Different types of fresh vegetables (Fig.2) were also dried . Vegetables were cut into pieces and loaded in optimally tilted dryer in direct and indirect mode. The initial moisture content of the tomato 95.8 %, spinach 95.7 %, carrot 93.4 %, onion 89.9 %, turmeric 87.6 %, coriander 89.7 %, okra 94.0 %, fenugreek 89.9 %, Mint 89.7 %, was reduced to 2.2 %, 2.4%, 2.6%, 5.9 %, 1.3%, 4.7%, 5.0 %, 0.8%, 2.0 %, respectively within 2 to 4 days of exposure in solar dryer. It takes 20 % more time in drying of vegetables in In-direct mode. Fig 3. depicts dried vegetables in direct and indirect mode.

The efficiency of the solar dryer was obtained by the following relation:

$$\eta = \frac{M\,L}{A \int_0^{\theta} H_T \, d\theta}$$

Where

A Absorber area, m^2

H_T Solar radiation on dryer plane, $J\ m^{-2}\ hr^{-1}$

L Latent heat of vaporisation, $J\ kg^{-1}$

M Mass of moisture from the product evaporated, kg

θ Period of test, hr

η Efficiency of the solar dryer

The efficiency of the dryer was found to be 17.95 %. The use of solar dryer will be a great boon for farmers in the developing countries. The farmers can dehydrate vegetables when these are available in plenty and at low cost. Dehydrated vegetables can be sold in the off season when prices of vegetables are high and farmers can generate more income. The use of solar dryer will be a great boon for farmers in the developing countries.

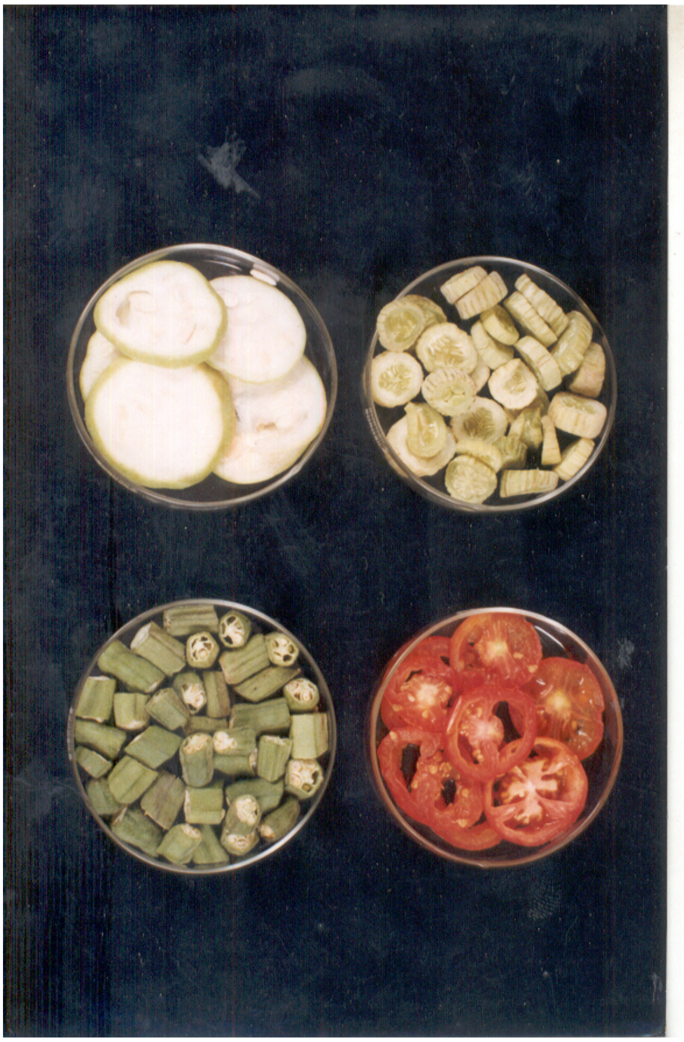

Fig. 2. Fresh vegetables

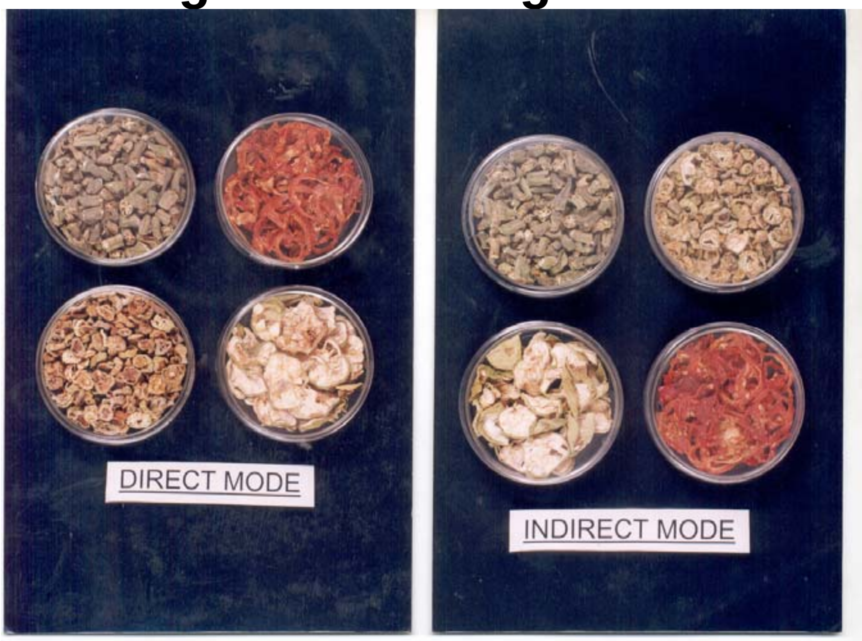

Fig. 3. Dried vegetables

4. Conclusion

A optimally tilted type solar dryer can be used both in direct and indirect mode for dehydration of fruits and vegetables. Vegetables were cut into pieces and loaded in optimally tilted dryer in direct and indirect mode. The initial moisture content of the tomato 95.8 %, spinach 95.7 %, carrot 93.4 %, onion 89.9 %, turmeric 87.6 %, coriander 89.7 %, okra 94.0%, fenugreek 89.9 %, Mint 89.7 %, was reduced to 2.2 %, 2.4%, 2.6%, 5.9 %, 1.3%, 4.7%, 5.0 %, 0.8%, 2.0 %, respectively within 2 to 4 days of exposure in solar dryer. It takes 20 % more time in drying of vegetables in In-direct mode. The farmers can dehydrate vegetables when these are available in plenty and at low cost. Dehydrated vegetables can be sold in the off season when prices of vegetables are high and farmers can generate more income. The use of solar dryer will be a great boon for farmers in the developing countries.