Development of a Compact Solar Vegetable Dehydrator

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ABSTRACT

Agricultural products, such as, vegetables are generally perishable and are difficult to store. Drying is one method to reduce the increase their shelf life. Dehydrators use different type of energy as per availability and requirement. Solar dehydrators are more popular since they use renewable solar energy. In this paper such a domestic passive solar dehydrator is designed and analysed for its utility and effectiveness. The dehydrator is designed for converting the perishable agricultural products into powders so that it can be stored and used for longer time. It is designed in two parts. The first part work as a solar energy collector and the second part works as the dehydrator. The heat from solar radiations is imparted to the air in the solar collector. This hot air is used in dehydrator foe drying agricultural products. The experimentation has been performed for different temperatures and flow velocity of air varying for different vegetables depending on their moisture content and time required to remove the moisture. It is observed that drying at different temperature is required for different vegetables to convert them into powder. The taste and colour of the powder produced are found to be good. Therefore, it is suitable and affordable even for farmers with lesser quantity of products.

Keywords: Vegetable drying, Solar Dehydrator, Solar Energy Collector, Vegetable dehydrator.

1 Introduction

Nowadays the problems faced by the farmers and society are storing of vegetables for a long period and maintenance. Storing of such vegetables for long time may results in rottening /damage of vegetables. This we have seen many cases regarding onions and tomatoes in many villages. On the other hand, there are so many vegetables and fruits which are only available in a particular season only. Drying is excellent way to preserve food and solar drying/dehydration can be considered as appropriate food preservation technology for sustainable development. So, if we are able to make them dry and prepare their powders which involve the removal of moisture from agricultural produce, so that they can be safely stored for longer period of time. The solar dehydrator system utilizes solar energy to heat up the air, which can be further used for drying any food substance. This will help in reducing wastage of agricultural produce and helps in preservation of agricultural produce which can be used for long period of time. In this concept, based on the limitations of the natural sun drying such as exposure to direct sunlight, rottening of vegetables lack of proper monitoring, and the escalated cost of mechanical dehydrators, a solar dehydrator was therefore developed to overcome these limitations. Solar dehydrators are specialized devices in which one can control the drying processes as per requirement of the product. Also, it helps in protecting the agricultural product from damage by insects, pests, rodents, rain and dust and thus reduces loss of product. Comparatively, the solar dehydrators can generate higher temperatures than dryers; maintain the relative humidity as per requirement. In addition, it acquires less space, less time and relatively inexpensive compared to artificial solar drying method. Thus, solar dehydration is a better alternative than artificial mechanical solar drying. Different types of the solar dehydrator constructions details are discussed [1] by Kenneth D. Hoyt. Preservation of food items are discussed in detail by Morais et al. [2]. Solar dehydrators are discussed by

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different researchers [3-4)]. Comparison of solar dehydrator and solar-assisted heat pump dehydrator is done by Yahya [5].

2 Methodology and Construction

The dehydrator is designed in this work is composed of solar collector (air heater) which includes black body for effective heating and solar drying chamber containing rack of two trays both being integrated together. The suction pump is mounted before collector for controlling the velocity of air. The air allowed through air inlet is heated up with the help of temperature regulator which is being used for ambient temperature required for sufficient drying in solar collector and channelled through the drying chamber where it is utilized in drying for removing the moisture content from the product. It is designed such that it can be used for making the powder of dried vegetables to preserve the products for long period. This is also very convenient for farmers to increase their revenue and to decrease their wastage.

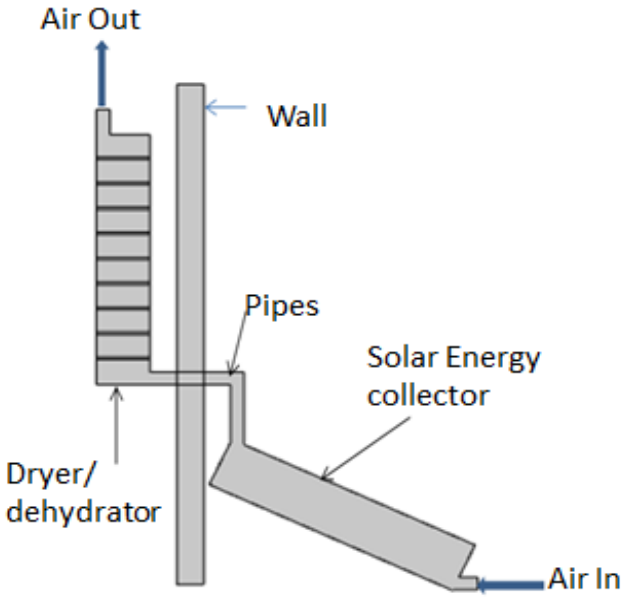

Figure 1 *Set up used for vegetable drying*

2.1 Materials and Methods

The following materials were used for the construction of the domestic passive solar dehydrator.

- Wood is used as the cover/casing of the dehydrator and solar energy collector
- Glass material is used for the transparent cover which permits shortwave solar radiations to enter into the solar energy collector
- Metallic sheet of thickness 2-3 mm painted black is used as absorber plate for absorption of solar radiation.
- Wooden frames are used for constructing the trays.
- Nails and spanners as fasteners used in fabrication work of dehydrator compartment and collector container.
- Pipes of suitable for passage of air from collector to dehydrator.
- Insect net at air inlet and outlet - to prevent foreign particles like insects from entering into the system.
- Hinges and handle for the dehydrator's door for opening and closing for placing or removing trays.

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- Suction Pump and Temperature Regulator for controlling the air flow rate.
- Paint (black) for applying on black absorber surface.
- Mesh for trays, where vegetables are placed in dehydrator.

2.2 Solar Dehydrator Components

The dryer or dehydrator chamber is made up highly polished wood which consist of drying trays. Proper quality mesh is used for trays while container is made of wood. Since wood is a non-conductor and it can be fabricated to a proper smooth surface, it is used for container. Smooth surface finish help in reducing the radiation heat losses. Glass sheet is used for cover plate. Being transparent it allows the solar heat short wave radiations to be transmitted into the solar energy collector. The glass cover is arranged at an angle which helps in preventing dust and rain water from entering into the collector. The bottom surface of the container is painted with black colour, which helps in absorbing heat radiations. The short wave heat radiations, which enter through transparent glass cover and hits on the bottom of collector. The radiations hitting on the bottom surface gets reflected but are long wave radiations and get trapped in the container. The air in the collector container gets heated up by absorbing the heat. The trays are arranged in dehydrator such that hot air passes across them transferring the heat to the vegetable matter placed in the tray, thereby dehydrating them.

2.3 Working of Solar dehydrator

In this system we connect two containers which are made of plywood with the help of pipes. The upper surface of solar energy collector is covered with glass cover and at the bottom we are placing the black body which is acts as a heat absorber. In dryer we are arranging trays in which we will place slices of vegetables to for drying in trays made of mesh. The suction pump and temperature controller are located on the pipe which connects the two containers. The suction pump/blower is used for temperature regulation by controlling the air flow velocity which will be entering through the solar energy collector. The function of temperature controller is to adjust the temperature of air in the dryer, which will require for sufficient removal of moisture from slices of vegetables which are to be dried. After sufficient removal of moisture we are allowed to make the powder of those vegetables by crushing or grinding operations. We finalize the quality of that powder by putting the parameters such as velocity of air, temperature of air, time required for drying and moisture level before drying and after drying the vegetables.

Figure 2 *Solar energy collector*

Figure 3 *Tray used for drying*

The fig.1 shows the schematic of the solar dried used for drying the vegetables. The first compartment is used as a solar energy collector from where the hot air is taken to dehydrator compartment through the interconnected pipe for drying the vegetables. Figure 2 shows the construction details of solar energy collector used for heating the air required for drying the vegetables. The trays used for drying the vegetables are shown in figure 3.

3 Results and Discussion

In this study, we try to convert three vegetable products like onion, potatoes and tomatoes. Figure 4 and figure5 shows the dried vegetables and the powders produced after their drying. Table 1 shows the temperature before and after drying the vegetables. It can be observed that the colour and texture of the powder produced are good.

Figure 4 *slices of Onions Potato and Tomato for drying*

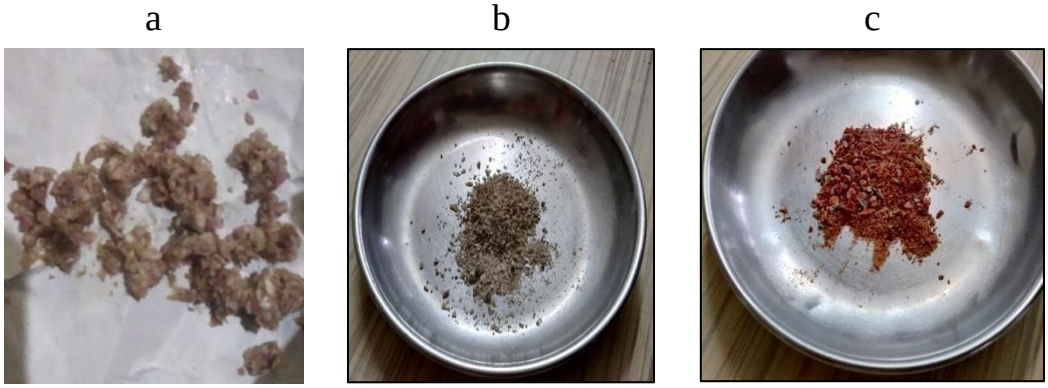

Figure 5 *Dried a) Onion, b) Potato and c) Tomatoes powders*

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Sample vegetable	Time required for in hours	Temperature in degrees used for dehydration	Quality of Product
Onion	3.5	70	Good
Tomato	4	75	Good
Potato	4	76	Good

4 Conclusions

A low cost and efficient solar dehydrator, which can be used by an average farmer, is designed and used for drying the vegetable products and produce vegetable powders. The experimentation has been performed for different temperatures and flow velocity of air varying for different vegetables depending on their moisture content. Following conclusions are inferred from the above discussions

1) The solar dehydrators can be used for drying the vegetables and producing their powders.
2) The dehydrator raises the ambient air temperature in the solar collector as per requirement to a considerable high value for increasing the drying rate of agricultural crop.
3) The solar energy collector can be placed outside the house while the dehydrator can be placed in the house, which helps them in their safety
4) Compared to conventional solar dehydrator, capital cost is less and construction is simpler.
5) Vegetables can be very well dried and converted into powders, whereby they can be made available in all seasons and which also helps in reducing the loss of farmers.

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