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Fabrication of Solar Dryer for Green Drying of Herbs From Easily Available Material

Dr.S. M. Mowade[1], Sudhir R. Thool[2], Sanket D. Dhawane[3], Mukesh Narnaware[4], Mayur Aasre[5]

[1] .*Professor & Head,Department of Mechanical Engineering, SRPCE,Nagpur*
[2345]*Students, Department of Mechanical Engineering, SRPCE, Nagpur*

Abstract: *Most of the agricultural product contains high moisture of about 25-80%. This value of moisture content is very much higher than the required for long preservation. Due to this moisture content bacterial & fungal growth is very fast in green herbs. Bacteria & enzymes may spoil the foodstuff & reduces the nutrient content in it. Moisture content of green herbs at a certain level slows down the bacterial, enzymes & yeast effect. Therefore it is necessary to reduce the moisture content in foodstuff for its long preservation. Drying is one of the major food processing operations. The main objective of drying is to remove free water from fruit and vegetables to the extent where micro-organisms do not survive so that dried green herbs can be stored for longer period without rotting and deterioration in the quality of the product. They can be constructed from locally available materials at a relatively low capital cost and there are no fuel costs.*

Keywords: *Enzymes, yeast effect, Deterioration.*

I. 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 problems like contamination by foreign materials by dirt, dust and wind-blown debris and insect infestation as well as uneven drying. Fortunately India is blessed with abundant solar energy arid parts of India receive max radiation i.e. 7600-8000 MJ/m2 per annual, followed by semi-arid parts 7200-7600 MJ/m2 per annual and least on hilly areas about 6000 MJ/m2 per annual. Therefore solar dryer seem to be good substitute for mechanical dryers which run on electricity and fossil fuels as India is already facing energy generation problem. Farmer can't afford such kind of mechanical dryer as they are costly.

In order to overcome such kind of problem idea of indirect type forced convection solar dryer comes, where air is first heated and then passes over the green herbs in drying chamber in order to carry out moisture.

Solar dryer have some advantages over sun drying when correctly designed they give faster drying rates by heating the air to 10-30oC above ambient, which causes the air to move faster through the dryer, reduces its humidity and deters insects. The faster drying reduces risk of spoilage, improves quality of the product and gives a higher output throughout. However care is needed to prevent too rapid drying, which will prevent complete drying and would result in case hardening. Solar dryer also protects foods from dust, insects, birds and animals. They can be constructed from locally available materials at a relatively low capital cost and there are no fuel costs. Thus, they can be useful in areas where fuel or electricity are expensive, land for sun drying is in short supply or expensive, sunshine is plentiful but the air humidity is high. Moreover, they may be useful as a means of heating air for artificial dryers to reduce fuel cost.

a)The Scope and Objectives

For Almost all the natural products including selected herbs for the studies like Tulsi, Karela, Neem, Carry leaf, Amla etc amongst other herbs need to be dried Green to retain their actives for better effectiveness. Hence there is a big demand for dryers to produce dried material that will remain green after drying. The market size being huge and with good availability of solar radiations, solar dryers could emerge as a cost effective and energy efficient alternative for such applications. The objective of this research work is to carry out "Performance investigation of solar dryers for green drying of some herbs"

II. Problem Identification

Drying products makes them more stable and in the case of food allows them to be stored safely for long periods of time. Safe storage requires protection from the growth of molds and other fungi most difficult of the spoilage mechanisms to detect and control. The types of loss generally caused by fungi are:

- Reduction in the germination rate of seed.
- Discoloration, which reduces value of foods for many purposes.

• Development of mustiness or other undesirable odours or flavours.
• Chemical changes that render food undesirable or unfit for processing.
• Production of toxic products, known as mycotoxins, some of which can be harmful if consumed.
• Total spoilage and heating, which sometimes may continue to the point of spontaneous combustion.
Considerable losses may occur during natural sun drying due to various influences such as rodents, birds, insects, rain, etc. The quality of dried products may also be lowered significantly. Over drying and contamination by dust and insect infestation are typical for natural sun drying. The resulting decrease in product quality may cause the products not to be marketable.

III. Construction And Working Of Solar Dryer

A) Materials and Components

Material specification of the various parts and assembly used to fabricate the solar vegetable dryer are as follows:

a) Collecting Tank

The collecting tank (shown in fig.3.1) is the important part of the system. It is made of tin having rectangular dimensions 900 mm x 700mm x 300mm and is open from the top side of it. It has rectangular cross section having a cage placed over it of dimensions 300mm x 60mm at its lower side to provide air inlet. It also has the exhaust outlet of diameter 100 mm. on the opposite side where the blower is fixed. A four column stand is fixed on its bottom to fix the aluminium sheet on the top of the column.

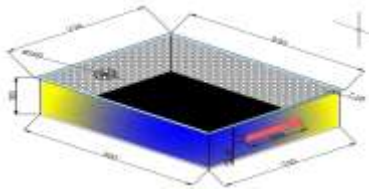

Figure3.1: Collecting tank

b) Blower (CPU Fan):

It is a CPU fan having 7 blades runs at 2500 rpm, which is placed at the top side of the solar radiation collecting tank. The blower is run directly by solar panel, which runs on 12V, 0.5 amps current. Its purpose is to suck and transfer the heated air through the pipe to the wooden box. It also used for exhaust purpose. The hot air from the wooden box is then exhausted to atmosphere.

c) Glass

It is mainly used for allowing the radiation from sun to enter the solar radiation collecting tank. The dimension of glass is 930 mm x 730 mm and thickness of 5 mm. It is placed above the heat collecting plate at about 100 mm height on the collecting tank for free circulation of air coming from inlet. It provides packing to the collecting tank so that heated air cannot be leaked from anywhere else other than the blower outlet.

d) Pipe

The flexible rubber pipe of diameter 8 cm and is used to connect the solar radiation collecting chamber and wooden box. The pipe passes the heated air from the blower to the wooden box where foods are kept. The pipe provides the flexibility so that solar radiation collecting chamber and wooden box stand can move independently.

e) Mild Steel Stand

The M.S. Steel dryer chamber is placed on the adjustable and removable stand made of mild steel. When the inclination is changed according to the month, so the height of wooden chamber is vary according to it. Hence the M.S stand is made to vary its height according to it.

Figure3.2: Drying chamber stand

f) M.S. Steel Dryer Chamber

The dryer box made of M.S. Steel, is used in the distributive flow solar dryer for receiving the heated air from the blower at the bottom and storing the green herbs on the shelves inside it and provided with circular vent at the top to pass-out the exhaust air. It is square in shape having dimension 1040mm X 520 mm. and width of 460 mm. It is designed to provide a space for storing various food items and other eatables. The eatables can be placed or withdrawn using the door provided.

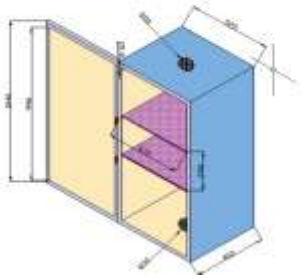

Figure 3.3: Drying chamber

g) Shelves:

The Shelves are made inside the wooden box with the help of support provided at both ends of for proper placement of eatable items. Shelves are made of thin steel net with small meshes so that the air can easily circulate inside the box. Total 2 shelves are placed inside the box having capacity of 2 to 2.5 Kg at a time.

h) Insulation

Thermocol is generally used as insulating materials which can be used to reduce heat losses from solar dryer. The insulation material is stick on the outer surface of the solar radiation collecting tank with the help of fevicol and covered with black color plastic tape and also used inside the wooden box to reduce heat loss. The thermocol has low thermal conductivity 0.035 (w/m°C), density 16 (kg/m³) and also has stability at high temperature.

i) Solar Panel

As the name suggest solar dryer is used for drying green herbs using solar radiation by heating air. But air is to be circulated via blower which requires power .Solar panel provides energy to run the blower. It has rating of 50 Watts, 12 Volts and 1 Ampere. Solar panel is placed over the wooden box and connected via electric wire to the blower.

j) Black Paint

The solar radiation collecting tank is painted black (black paint containing (5%) black chromium powder to increase its absorbing capability) along with heating plate except glass. The purpose of doing this is to generate the concept of black body radiation.

B) Construction

The experimental set-up of an indirect forced/ natural convection solar dryer consists of a flat plate solar air collector, drying chamber and four drying trays. The schematic diagram of the experimental set-up is shown in 3.4

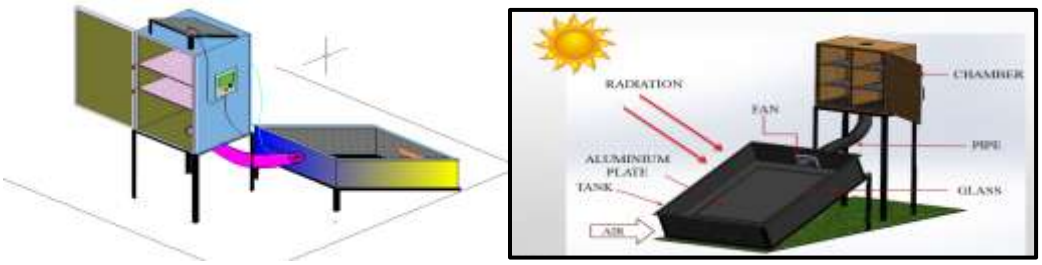

Figure 3.4: Cad Model

Table No. 3.1: Details of drying chamber

Sr. No.	Parameters	Values
1	Length	1040mm
2	Width	460mm
3	Height	520mm
4	Material	M.S. Steel (2 mm thick)
5	No. of Shelves	2
6	Volume of drying chamber	248.78m^3

Table No. 3.2: Details of solar collector assembly

Sr.No.	Parameters	Values
1	Length	1531 mm
2	Width	1074 mm
3	Height	308mm
4	Absorber plate	0.1 mm Aluminium/GI Steel/Copper Sheet
5	Absorber Area (Ac)	1.23 x 0.76 m^2
6	Surface treatment	Black paint coating
7	Glass	Clear glass of thickness 6 mm
8	Insulation	Thermocol
9	Frame	Made of Mild Steel
10	Collector slope (β)	Adjustable of 21.09°, 25°,35°,45°
11	Airflow area (at inlet and outlet)	668.50x105mm
12	Distance between cover and absorber plate	101.30 mm
13	Blower	100mm dia., 2500rpm CPU fan

IV. Experimentation

a) The detailed procedure for the test run is as under:

1) For Solar drying of various types of herbs, seven to eight types of herbs like Neem (Sweet and bitter), Spinach, Methi, Karela, Chilli, Coriander, Tulsi, Amla Sour and sweet (Broken and chips), Potato (chips) and Green peas should be selectedone by one on each day of experimentation.

2) Before starting of experimentation any one crop was selected and its weight is measured on weighing machine for proper selection of crop in proportion.

3) The experiment was conducted according to location at Nagpur, Central India (latitude 21°06' N and Longitude 79°03'E) and the orientation of the solar collector has been fixed towards the south direction, inclined at an angle of 31°.

4) Air velocity or flow rate of air at the inlet position of the drying chamber was measured by anemometer.

5) Humidity, Temperature of collector plate, ambient temperature and dryer chamber (box) temperature was recorded during experimentation using hydrometer and thermocouples (which are already placed inside heat collector chamber, air and dryer).

6) During experimentation time of drying, length of day and date of experimentation was recorded during experimentation.

7) At the end of experimentation weight of dried crop is measured and difference of Weight and dry crop is calculated, to evaluate moisture loss during experimentation.

8)Similar experiments were repeated by changing collector plate material. Initially GI Steel sheet, then aluminium and then copper plate were used during experimentation.

9) Fig.5.1 Shows experimental setup during experimentation and Shows products/ green herbs dried during experimentation.

Fig. 5.1.Experimental Setup

Figure 6.2: Samples of Green Herbs dried using Solar Dryer (Neem (Sweet & Bitter), Karela, amla before and after drying, Chilli, Bher before and after drying

a) Dryer Efficiency Calculations

$$\eta_d = \frac{\Delta M * L}{I_c * A_s * t}$$

Where (L) is the latent heat of vaporization of water (KJ/Kg), (ΔM) is difference of the mass of the crop before and after drying, Ic is global heat flux in W/m2, Surface Area of the heating plate (As), m^2 and (t) is the time of drying in sec. For effective four hours duration.

$$\frac{0.58 * 2257 * 1000}{793.95 * 0.9348 * 3600 * 4}$$

=0.0887 i.e. 8.87%

% moisture Loss (PML)

PML is calculated using relation

$$(\%\mathbf{ML}) = \left(\frac{\boldsymbol{M_{ci} - M_{co}}}{\boldsymbol{M_{ci}}}\right)$$

Where, Mci= mass of crop sample before drying and Mco = mass of crop sample after drying.

Material	Mass of crop before drying	Mass of crop After drying	Moisture Loss	% of Moisture Loss, %M=ML/Mci	Time
	$\mathbf{M_{ci\ in\ Kg}}$	$\mathbf{M_{C0\ in\ Kg}}$	ML in kg	%M	hrs
Neem_ bitter	1	0.42	0.58	58	6
Neem _sweet	0.8	0.33	0.47	58.75	6
Spinach	1	0.32	0.68	68	6
Methi	1	0.26	0.74	74	6
Tulsi	0.55	0.21	0.34	61.8182	6
Karela	0.73	0.33	0.4	54.7945	6
Karela	0.75	0.38	0.37	49.3333	6
Chilli	0.828	0.486	0.342	41.3043	6
Chilli	0.75	0.455	0.295	39.3333	6
Coriander	0.927	0.182	0.745	80.3668	6
Amla Sour(Broken)	0.525	0.166	0.359	68.381	6
Amla Sweet (Broken)	0.365	0.162	0.203	55.6164	6
Amla(Chips)	0.73	0.3	0.43	58.9041	6
Potato(chips)	1	0.652	0.348	34.8	6
Green Peas	0.9	0.4	0.5	55.5556	6

V. Conclusions

Under this experimental investigation of thermal performance of solar dryer gives the temperature difference of atmospheric air and drying chamber of solar air heater of near about 10 to 17 ^{0}C on a moderate sunny day. It is suitable dryer for producing hot air of space heating and agricultural drying applications.According to test carried out, it is clear that the aesthetic look is maintained in solar force convection drying than in solar natural convection drying or in open sun drying.It was considered that the food in the solar dryers were, almost without exception, of high quality. However for the food dried in the open sun drying, a possible health hazard might exist because of the relatively large numbers of flies which were attracted into the food. Solar-dried food was judged to be of higher quality than those dried in the open sun drying.

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