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Design, Fabrication and Testing of A Direct type Solar Dryer

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ABSTRACT: Solar energy is one of the sustainable and renewable sources of power that encouraged various researchers from all over the world. To overcome the wastage, drying is an excellent method to preserve the food grains, fruits and vegetables. For drying, conventional drying system is sun drying which is free and a renewable source of energy. The use of solar dryers can eliminate these limitations significantly and enhance the productivity of farmers towards better revenue earned. Since India and especially in the Northern regions receives a high amount of sunlight, these solar dryers can prove very fruitful.

The dimensions of the box taken were 30 in × 30 in × 14in. With conventional drying the ambient temperature recorded as 36°C with a moisture loss of 20 g. But with this solar dryer, the recorded average ambient temperature of 37°C had internal temperature of 40°C which removed 18 g of moisture. Through this inspection it was found out that the solar dryer not only effectively and quickly manages to dry food products but also preserves their quality in terms of taste, texture and smell. Solar dryer is a lot more efficient in drying food products and it also prevents loss of quality in terms of taste, colour, smell etc.

KEYWORDS: Ventilation, Solar dryer, Convection current, Absorption.

I. INTRODUCTION

For human being, food is a basic need after air and water. It is biggest hurdle to manage the balance between food production and its immediate consumption [1]. To overcome this barrier, drying is an excellent way in which food such as grains, vegetables and fruits are preserved for some time.

Solar dryers are devices that usesolar energyto dry substances, especially food. Solar dryers use the heat from sun to remove the moisture content of food substances. The solar dryer consists of a box made up of easily available and cheap material like galvanized iron, brick, and plywood. Top surface of the dryer is covered by transparent single and double-layered sheets. The inside surface is coloured black to absorb the incoming solar radiation. Since the box is insulated, the inside temperature of the box is raised. The air is ventilated through the small holes at the top of the box. As the inside air gets warm, it rises by thenatural circulation process and removes the moisture from the fruits, vegetables, and the crops placed in trays inside the box [2]. To fill the vacuum, fresh air comes in by a forced draught process. An important feature of solar drying devices is the size of the solar collectors. Depending on the quantity of goods to be dried, collectors must have the capacity to provide sufficient quantities of hot air to the drying chamber. Collectors which are too small in proportion to the amount of food to be dried will result in failed attempts and spoiled food. The principal of solar dryer is presented in Figure 1.

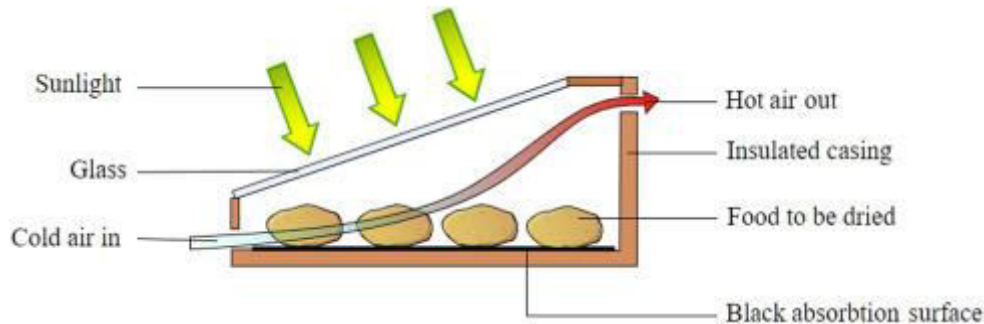


Fig 1 – Principle of solar dryer [3]

II. SIGNIFICANCE OF DRYING IN INDIAN CULTURE

Drying of food grains in the fields by exposure to sun has been very common in India since ancient times. The industrialization in the present century created a demand for controlled drying of many agricultural products such as tobacco, wood, peaches, resins, etc., since such products retain the flavour, quality and appearance thus having better sale prospects. Such products could be dried in peak season and made available for consumption throughout the year. Coal, oil or firewood are usually used in such conventional industrial dryers. The present energy crisis compels one to think of use of alternate sources of energy and the population free. Abundant and readily available solar energy seems to be the only answer.

Traditional methods of food drying are to place the foodstuffs in the sun in the open air. This method, called sun drying, is effective for small amounts of food. The area needed for sun drying expands with food quantity and since the food is placed in the open air, it is easily contaminated. Therefore, one major reason why sun drying is not easily performed with larger quantities of food is that the monitoring and overview becomes increasingly more difficult with increasing food quantities. In contrast to sun drying, where the food is exposed directly to the sun, the solar drying method uses indirect solar radiation.

The principle of the solar drying technique is to collect solar energy by heating-up the air volume in solar collectors and conduct the hot air from the collector to an attached enclosure, the meat drying chamber. Here the products to be dried are laid out. In this closed system, consisting of a solar collector and a meat drying chamber, without direct exposure of the meat to the environment, meat drying is more hygienic as there is no secondary contamination of the products through rain, dust, insects, rodents or birds. The products are dried by hot air only. There is no direct impact of solar radiation (sunshine) on the product. The solar energy produces hot air in the solar collectors. Increasing the temperature in a given volume of air decreases the relative air humidity and increases the water absorption capacity of the air. A steady stream of hot air into the drying chamber circulating through and over the meat pieces results in continuous and efficient dehydration. Sreekumar and Rajarajeswari [4] experimented on direct type solar dryer to dry Tapioca, apple tomato, pineapple, onion. The maximum temperature difference was achieved 32°C and drying duration of onion, tomato, tapioca, apple and pineapple samples dried in solar drier was 4, 4, 5, 6, 6 hours respectively. Puello-Mendez et al. [5] tested the direct type solar dryer on Cocoa beans. Solar dryer with plastic roof reduced the moisture content from 58.0% to 7.0% in 4 d whereas 4 d was taken by direct solar dryer. Agarwal et al. [6] reviewed the various types of dryer and concluded that the direct type dryer has significant performance and self-sustainable as compared to other dryers.

Benefits of using a solar dryer:

- i. It offers high intensity of heat
- ii. It retains heat even on a rainy day
- iii. Continuous drying
- iv. Economical
- v. Hygienic drying process
- vi. Preserves taste, texture and quality of food product

III. CONSTRUCTION AND WORKING

3.1 Materials used for Construction: The materials used for the construction of the solar dryer are described below.

MDF sheets: Medium density fiberboard (MDF) is a composite product used in many home and professional projects, such as furniture, cabinetry, flooring and even speaker boxes due to its smooth finish, machinability, strength and consistency. All MDF is made using a process similar to that of particleboard: wood fibers, mixed with resin, are compressed and heated to form durable panels. Under the MDF umbrella, however, are a few other types beyond the “regular” MDF that are made especially for certain applications. MDF sheets is used as they are lighter, sturdy and easy to handle. They are better used for construction of the cabinet.

Stainless steel net: Stainless steel net is used on a wooden frame to put the food products on. It makes easier to remove the products after they are dried.

Tarpaulin sheet: Tarpaulin sheet is used to seal the chamber which transmits the entry of sunlight.

Temperature meter: It is used to measure temperature differences.

Weighing scale: A device used to measure weight differences which shows how much moisture has been removed.

Wooden planks: Wooden planks are used to construct the upper and lower frame for platform and tarpaulin sheet.

3.2. Construction of the dryer

The construction of this solar dryer is in the form of a box covered with a tarpaulin sheet, operating on natural convection. The body is made up of MDF sheets with holes drilled on the opposite sides to facilitate air ventilation. The box is painted black on the inside to enhance heating due to radiation. There is an upper frame made up of wooden planks with tarpaulin sheet attached on the top to enhance passage of sunlight. Internal frame is also made of wooden planks with stainless steel net attached. This platform is used to place food products.



Fig 2 – Final assembly of the solar dryer

3.3. Working procedure

Conventional sun drying: Food products are sliced into the form of chips and initially weighed. These chips are then put into direct sunlight on a plate. After all the moisture has been removed, the chips are weighed again and time required is noted.



Fig 3 – Sun drying of Banana



Fig 4 – Sun drying of Potato



Fig 5 – Sun drying of Onion

Drying using solar dryer: Food products are sliced into the form of chips and initially weighed. These chips are then put into the drying chamber of the solar dryer. After all the moisture has been removed, the chips are weighed again and time required is noted.



Fig 6 – Drying with solar dryer of Banana



Fig 7 – Drying with solar dryer of Potato

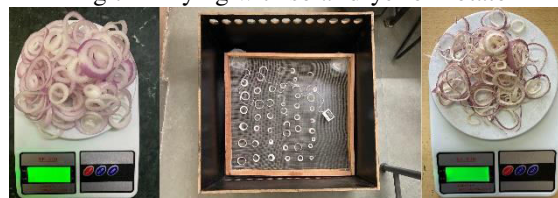


Fig 8 – Drying with solar dryer of Onion

IV. RESULTS AND DISCUSSION

The solar dryer is operating well in clear sunny conditions. The food products are easy to dry, take significantly less time, and the quality of the products is preserved. The taste, texture and smell of the chips is maintained in a better condition when dried using a solar dryer. This solar dryer is exceeding the expectations, and can be manufactured easily. This device can be used for a small – scale home based dry food products packaging business. Testing of this solar dryer is done in two situations. The temperature readings are taken in a time span of 15 minutes each. The results are as follows: -

Drying directly under the sun:

- Food products used were Potato, Banana and Onion.
- The average ambient temperature was 36.16 °C.
- The average weight of moisture removed was 20 g.

Drying using a solar dryer:

- Food products used were Potato, Banana and Onion.
- The average ambient temperature was 36.65 °C.
- The average internal temperature was 37.75 °C.
- The average weight of moisture removed was 20 g.

The total cost while preparing this direct solar dryer is ₹3516 which is very less than the total cost of the present market rate. The cost per unit mentioned in above table of the equipment is according to the market price but if it was manufactured then the rate shall be much lowered.

Table 1 – Bill of Materials

S.No	Material	Cost
1.	Stainless steel net	₹ 216
2.	MDF sheets	₹ 1450
3.	Angle and screws	₹ 100
4.	Adhesive	₹ 140
5.	Tarpaulin sheet	₹ 850
6.	Paint	₹ 100
7.	Temperature meter	₹ 340
8.	Digital weighing scale	₹ 320
9.	Total	₹ 3516

V. CONCLUSION

Overall, after designing, analysis to validate testing conditions and finally fabricating this research paper successfully helps manufactures of solar dryers to reach their goal with minimum cost constraint, minimum weight and a tool that can withstand various atmospheric conditions. This research has discussed all the aspects of the ‘Direct Solar Dryer’ in details. It can be concluded that the design of the solar dryer as per the initial specifications is successfully carried out. As referenced before, the usage of the solar dryer makes it easy to dry food products and can help in generating income on a small scale. Improvement can be made by adding solar panels and exhaust fans to improve the drying efficiency. It ought to be noticed that food products dried in this version of the device still do not have the best appearance physically. But as stated earlier, the addition of certain equipment and heating elements can solve this problem and keep the project affordable. Around there, there's as yet potential for development. This design is beneficial for women in rural areas where there is an abundance of open area and bright sunlight so they can easily make spice powder by drying. Also the cost of existing commercial solar dryers is very costly and not affordable by the common people, so this prototype will be a helping hand to them in the pricing sector.

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