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Performance of Cabinet Type Solar Dryer for Drying Apple Slices

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Abstract: Huge amount of food is wasted every year due to lack of proper storage and preservation. Amount of moisture in food affects growth and activities microbial such as bacteria and fungi. Basis of drying is reduction of moisture from food and preventing growth and activity of microbial. Here solar drying was performed for slices of apple in cabinet type of solar dryer at Pune, India (18.58N, 74E) in first week of June 2022. Study was conducted for active and passive case. For active case fan was operated by solar PV panel. It was found that drying was faster in active case than in passive case.

Index Terms **- Solar energy, solar Dryer, Cabinet type dryer, active dryer, passive dryer, apple drying.**

I. INTRODUCTION

Around 15% of the world population is undernourished. The increase in world population will further disturb existing population-food imbalance. Reduction in the food losses occurring throughout food production, harvest, post-harvest, and sell is one of solutions to fight food shortage [1].

A food is source of energy for human and animals. Content of food like water, fat, carbohydrates, protein etc are also food for microbial. To prevent growth of microbial, various preservation methods are used for different food depending on their properties. Food preservation methods are used to retain food quality and prevent them from deteriorating. The preservation process will prevent the development of microbial such as bacteria and fungi. Drying is one of method of food preservation since ancient time. In absence of sufficient moisture, growth and activity of microorganism is reduced. Drying reduces weight of product thus transportation cost is reduced [2].

In absence of proper food preservation huge amount food is wasted. Open Sun drying of vegetable, animal products and fruits is the most widespread method of food preservation in Asian and African countries due solar irradiance being very high for the most of the year. There are some drawbacks relating to the traditional open drying method i.e., spreading the crop in thin layers on mats, trays or paved grounds and exposing the product to the sun and wind. These include poorer quality of food caused by contamination by dust, insect attack, enzymatic reactions and infection by micro-organisms. Non-uniform and insufficient drying also leads to deterioration of the crop during storage. Close drying using solar energy is called solar drying. In solar drying higher temperature is achieved due to green house effect than open sun drying. Thus solar drying is faster. Food is enclosed in the dryer and therefore protected from dust, insects, birds and animals, and chances of food contamination get reduced. The dryers are water proof and the food does not therefore need to be moved when it rains. [3]

Drying contains two steps, i) heating of the product from the heating source ii) mass transfer of moisture from the interior of the product to its surface and from the surface to the surrounding air. Drying consist of the extraction of moisture from the product by heating and the stream of the air around it to carry away the released vapour. The objective of a dryer is to supply the product with more heat than is available under ambient conditions, thereby increasing sufficiently the vapour pressure of the moisture held within the crop and decreasing significantly the relative humidity of the drying air and thereby increasing its moisture carrying capacity and ensuring sufficiently low equilibrium moisture content. In solar drying, solar-energy is used as either the sole source of the required heat or as a supplemental source. The air flow can be generated by either natural or forced-convection. The heating procedure could involve the passage of preheated air through the product or by directly exposing the product to solar radiation or a combination of both. Water starts to vapourise from the surface of the moist product when the absorbed energy has increased its temperature sufficiently for the water vapour pressure of the product moisture to exceed the vapour pressure of the surrounding air. Loss of moisture from the surface is replenished by diffusion from the interior. Solar-energy drying systems are classified as i) active solar-energy drying systems (forced-circulation solar drying systems); and ii) passive solar-energy drying systems (natural-circulation solar drying systems).[4]

A number of studies have reported about the drying behaviour of apples using different drying methods. A longer drying performance can be obtained by placing a thermal energy storage unit in the dryer. Presence phase-changing paraffin wax in the solar air collector increases thermal efficiency and sustainable drying. [5]

Benefits of drying are, i) it permits the long-time storage of food without deterioration ii) it helps to continuous supply of the product throughout the year and advantage of higher price after harvesting season can be taken. iii)it reduces transportation cost. [7]

II. SOLAR DRYER

Solar dryers use the heat from sun to remove the moisture content of food substances. Main components of dryer are a) solar air heater, b) drying chamber and c) chimney. The schematic of indirect solar dryer studied in this study is shown in Figure 1. In indirect solar dryer food article is not directly heated, but first air is heated and air then in turn heats food article. In passive case, natural draft is created using chimney circulated naturally by buoyancy force. Present system uses both passive and active system. For active system air flow is forced by electric fan placed on top of chamber. This fan is operated by PV panel. Performance of dryer is studied for active and passive cases separately.

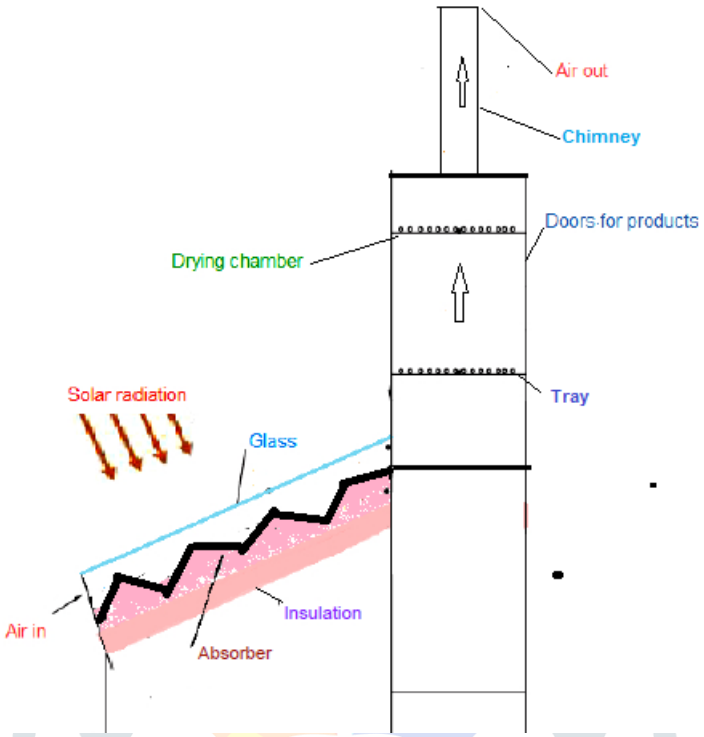

Fig. 1 Indirect solar dryer

Solar air heater:- Here the solar radiation is absorbed in absorber plate of aluminum which is painted black and heat is transferred to air flowing between glass and collector plate. At bottom side of corrected is insulated. To promote turbulence collector surface in step form.

Drying chamber:- Here trays containing food article are kept for drying. Here baffle is provided to create turbulence. Tray having mesh to allow movement of air is provided. Figure 2 shows view of drying chamber.

Fig. 2 Drying Chamber

Chimney: - This is part in located on the top of the drying chamber to increase the air flow in the system by natural draft. Photograph of system is shown in figure 3. Body of solar air heater and drying chamber is made up of plywood.

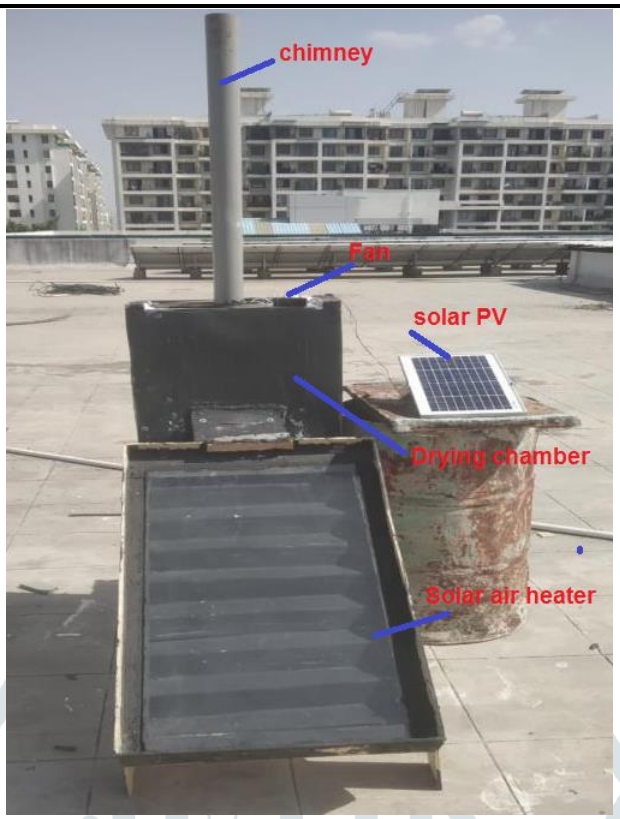

Fig. 3 Experimental setup (Pune, India)

III. PARAMETERS AFFECTING DRYING

The factors affect the air heater efficiency such as collector dimensions, type and shape of absorber plate, glass cover, inlet temperature, wind speed, humidity, air path, and height of the channel. Among all, the glass cover collector, the absorber plate shape factor, and air path are the most important parameters in the design of any type of air heater. [6]

The present study aims at seeing effect of active and passive system in cabinet type solar dryer. Here performance of system was in active case and passive case was studied separately for drying Apple slices. Temperature, relative humidity and mass of apple were measured. For temperature and relative humidity measurement digital sensors were used.

Fig. 4 i) Temperature sensor ii) sensor for relative humidity

IV. RESULTS AND DISCUSSION

Following readings were taken at Pune, Indian (18.58N, 74E). Slices of apples were made with thickness 2 mm to 3mm. Slices were dipped in lemon juice for 15minuite.

i) Temperatures
ii) Relative humidity
iii) Mass of sample

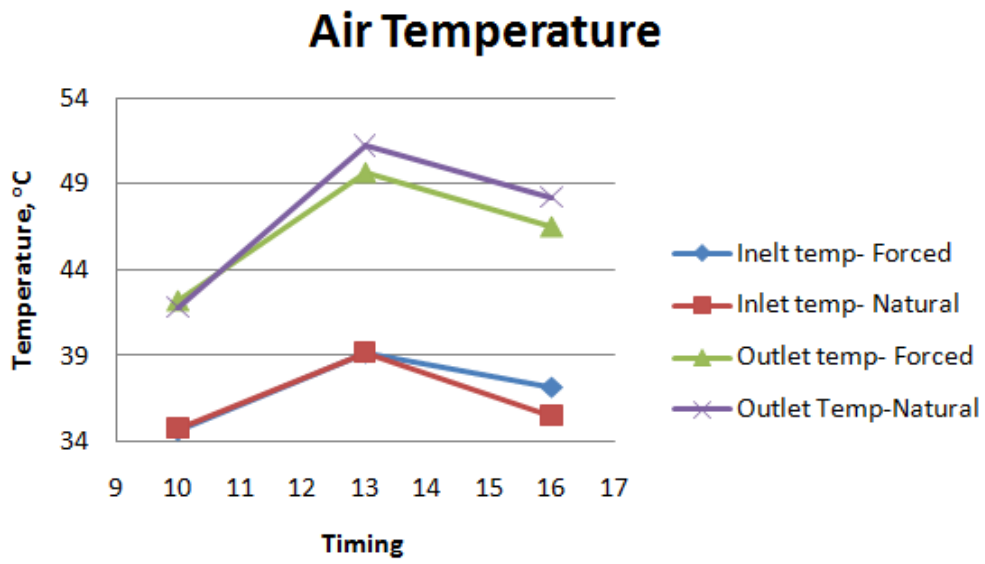

Fig. 5 Inlet and outlet temperature for Natural and Forced draft

Fig. 6 Drying of apple slices: (A) before drying; (B) after drying.

Table 4.1: Percentage moisture removed after drying apple slice

Variable	Active case - day 1	Active case - day 1	Passive case- day 1	Passive case - day 1
Percentage moisture removed	65.1	71.4	64.7	62.5

Figure 5 shows variation of inlet and outlet temperature for active and passive case. Figure 6 shows photos of apple slices before and after drying for a day. About 60% humidity is removed in a day from apple in sunny day. Table 4.1 shows percentage moisture removed from apple slices. It is observed that moisture removal rate is higher in forced draft.

IV. Conclusions

Following coclusion can be drawn from present study,
i) Apple slices can be dried using solar dryer.
ii) Performance of active solar dryer is better than passive solar dryer.
iii)Taste of apple slice after drying is delicious.

V. Acknowledgment

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