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Performance Analysis of Hybrid Solar Dryer (Review Paper)

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Abstract- Solar crop drying is an inexpensive and effective way to preserve food ingredients, especially in developing countries where fuel and electricity are expensive or unavailable. Some tropical fruits are difficult to transport and store, which increases their chances of spoilage. Without access to fuel and large drying systems, preserving fruit for later use is challenging or not possible for the rural farmer. Developing a low-cost, easily assembled locally and low-maintenance fruit drying system will improve access to the off-season and distant markets. A mathematical model of a hybrid solar drying system was developed and validated through experimental testing to design and optimize drying systems for use in developing countries. The prototype drying system consisted of a transpired solar absorber, drying chamber and blower. In this research paper, we are reviewing various solar dryers.

Keywords- Solar dryer, drying chamber, heat.

I. INTRODUCTION

Solar dryers can be effectively proven through experiments in many countries used for drying agricultural products on Solar Crop Dryer (SCD). The question before the farmer is what kind of SCD should be adopted.

The drying process use to remove the moisture from a food product so that the food products do not corrode for a long time. [2] The drying process continues until the moisture vapor pressure in the food products is equal to the moisture pressure in the atmosphere [1, 2]. Thus, the removal of moisture from the product into the environment and the rates.

Agricultural food products are dried using solar dryers which is more acceptable due to their low cost compared to conventional and motorized drying systems, mainly in the region where there ismore sunshine during the harvest season. In developing countries, small farmers face food loss when they produce more than 80% of their food products. Farmers from the old edge usually used Open Sun Drying (OSD) to preserve agricultural crops such as grains, fruits and vegetables. Compared to other drying methods, open sun drying is a time consuming process and causes considerable damage to food products.

II. LITERATURE REVIEW

Moussaoui et al. (2021) dried apple slices at four different temperatures (50, 60, 70, 80 °C) and two different airflow rates (150 and 300 m3/h). According to the drying experiments, they found that the total energy consumption was minimum at high temperature and low airflow, while energy efficiency was reached maximum at high temperature high airflow rate.

The effect on quality of dried mushrooms in a medium size solar dryer was studied by Kumar et al. (2013) for various chemical pretreatments of 1.0% potassium metabisulphite, 0.5% potassium metabisulphite, 0.5% citric acid, and 0.2% citric acid solutions and applying 1% potassium metabisulphite gave best quality dried mushrooms.

Another mushroom drying study was carried out by Thakuria (2018) who developed a low-cost mixed-mode solar dyer system. According to this study, the drying performance was improved by integrating water heating system.

Kushwah et al. (2020) designed a hybrid active greenhouse solar drier using an evacuated tube solar collector, pump and heat exchanger for drying mushroom. They carried out mushroom drying experiments in this dryer, which can be used as both FCD and NCD, and investigated the drying behaviour of the mushroom in terms of convective heat transfer coefficient and dehumidification rate. Nutritional quality comparison of solar and oven dried oyster mushroom that treated with different chemical pretreatments and blanching methods was studied by Mutukwa et al. (2019).

According to this study, drying method had no effect on the mushroom nutritional quality, but pretreatments had effect on nutritional value. This study is mainly concerned with (i) the effects of pretreatment applications, and (ii) the effects of different thickness of foodstuff on drying kinetics in three types of solar dryers. Drying experiments were carried out with mushrooms sliced in different thicknesses (0.5 cm, 1 cm and half) in three different solar dryers (NCD, FCD and HPD). Weight loss, moisture content, drying rate and collector efficiencies were calculated, and the results were compared.

In addition, 1 cm mushroom samples were soaked in 1% citric acid solution for ten minutes in order to monitor the drying characteristics of pretreated and non-pretreated products during drying activity. Although there are many studies on mushroom drying (Kumar et al., 2013, Kushwah et al., 2020, Mutukwa et al., 2019, Thakuria, 2018), there is no study examining the mushroom drying behaviour in three different solar dryers according to the above-mentioned effects.

With this purpose, Section 2 of the study will explain the details of dryers, data collection and theoretical background of drying process; Section 3 presents the results of experiments, compares the performance of solar dryers, and discussed drying behaviors of mushrooms in different dryers; and finally conclusion is given.

A wide variety of solar dryers, their designs, details of construction, basic principles and theories regarding the drying of agricultural food are reviewed comprehensively in Fudholi et al., 2010, Fudholi and Sopian, 2019, Kumar et al., 2016, Nukulwar and Tungikar, 2020 and Vijaya Venkata Raman et al. (2012).

Important findings on indirect type solar dryers for agricultural crops have been reviewed by Lingayat et al. (2020), chemical pretreatments; payback period and economic analysis were discussed in their paper.

Nabnean and Nimnuan (2020) conducted experiments on banana drying and compared the drying performances of traditionally sun drying and FCD. They concluded that their experiments with solar dryer are better in terms of both drying time and product quality.

Bhardwaj et al. (2021) have recently introduced a novel FCD integrated with sensible heat storage materials and thermal energy storage installed in solar collector and drying chamber. According to the authors, the effectiveness of the drying setup was improved, and the dryer kept operating for drying medicinal herb approximately 7 h per day after off- sunshine hours.

Mohanraj and Chandrasekar (2009) studied chili drying in a FCD with gravel as heat storage. They concluded that the inclusion of heat storage material increases the drying time by about 4 h per day.

Vijayan et al. (2016) developed a FCD with sensible heat storage, and presented its mathematical model and performance analysis in their study. According to their results, drying process in this dryer was more uniform as compared to open sun drying, and produced a higher quality product.

Singh et al. (2021) designed a new active mode indirect solar dryer that includes an evacuated tube collector for air heating as a solar collector and a DC fan powered with a PV for airflow through the dryer. Open sun drying and solar dryer experiments of fenugreek leaves and turmeric conducted, and the drying performance were compared. Also, life cycle cost analysis and payback period were calculated, in result the study confirmed an economic viability of the dryer.

Shrivastava et al. (2017) examined the behaviour of thin-layer fenugreek drying in a FCD, and compared the drying kinetics of fenugreek that placed on each tray by fitting to various drying models in the literature.

Leon Dharmadurai et al. (2020) conducted a study by adding an external reflector aimed at increasing the energy input to the solar dryer design. Thermal behaviour of this dryer and open sun drying technique was compared. They reported that while the external reflector increased the temperature by 20%, the drying time decreased by 3 days for grapes.The effects of drying air temperature and effects of slice thickness on the drying behaviour of apple slices in a convective dryer was studied by Meisami-asl et al. (2010). The experiment results showed that, increase of drying air temperature and decrease of slice thickness lead shorter drying times.

Ziaforoughi and Esfahani (2016) designed and developed a solar assisted intermittent infrared dryer powered with a PV, and examined the drying parameters of different thicknesses of potato slices at temperatures of 50, 60 and 70 °C. Also, this study revealed a comparison between an intermittent infrared dryer and a solar assisted intermittent infrared dryer in terms of the amount of the energy consumption and the drying time. By using an indirect hybrid solar–electrical FCD,

Zomorodian et al. (2007) introduced a new approach for employing solar radiation as the main source of energy for paddy drying. The drying test rig was designed, fabricated and evaluated. The rough rice solar dryer was a cross-flow and an active mixed mode type with a new and an efficient timer assisted semi continuous discharging system.

The rig consists of six ordinary solar air heaters, an auxiliary electric heating channel, a drying chamber with an electrically rotary discharging valve and an air distributing system. To evaluate the drying system, a local variety of medium size kernel of rough rice was selected to be dried by the dryer. The maximum overall efficiency of drying system was 21.24% (with average drying air temperature of 55 ^{0}C). The maximum capacity of the dryer was about 132 kg of rough rice with initially 27% d.b.

down to 13% d.b. final moisture content in 3 h of drying period.

Several solar-assisted heat pump dryer have been design, fabricated and tested. Hawlader et al. (2008) studied the performance of the evaporator-collector and the air collector when operated under the meteorological conditions of Singapore.

They showed that ‘‘the evaporator- collector efficiency increases with increasing refrigerant mass flow rate. It was also revealed that the efficiency of the evaporator-collector is higher than that of the air collector’’. The maximum efficiencies of the evaporator-collector and the air collector were reported to be 86% and 75%, respectively.

A solar-assisted heat pump dryer was used to dry poplar and pine timbers in heat pump timber dryer were experimentally analyses. Energy and exergy analyses were made for both types of timber and the timber drying performance of the heat pump dryer was evaluated.

Energy analysis was made to determine the energy utilization. Exergy analysis was accomplished to determine of exergy losses during the drying process (Ceylan et al. 2007).

A heat pump dryer was designed, fabricated and tested to evaluate the drying characteristics of various herbs and the dryer performance under various conditions. Fatouh et al. (2006) have been reported thatthe heat pump assisted dryer is recommended for industrial use

The temperature of air in drying process affects the quality, evaporation capacity as well as drying period. In addition, shorted time period is required for higher temperature drying. At higher temperature, pure water vapor pressure becomes higher; therefore, the difference between water vapor partial pressure and pure water vapor pressure becomes higher. This pressure difference is the driving force of water evaporation to the air.

III. CONCLUSION

Drying of food is needed to prevent food losses between harvest and consumption, and to ensure long term storage of food. The process of drying food using solar energy is one of the most common applications for food preservation.

With the use of solar dryers that provide a hygienic and controllable environment for drying, the products can be dried quickly without being affected by seasonal variables, resulting in good quality dried products.

From the review done by us, it can be said that in order to make better use of the main energy in the solar dryer, it is necessary to make it hybrid.

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