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MODIFIED PARABOLIC SOLAR COLLECTOR HOT-AIR TRAY DRYER

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***Abstract*— The present work deals with the performance evaluation of an active indirect solar dryer integrated with a parabolic dish collector to dry Indian high quality onion. The system mainly consists of a parabolic collector which is provided with is provided with an insulator made of plywood with air gaps and aluminum foil wrapping, and a drier consisting of five trays where the onions are dried. The flow of hot air through the tray is maintained using an exhaust fan positioned at the bottom of drier. The fan exhausts the moisture extracted from the product to make the flow of air without any localization. From the analysis it is found that the parabolic dish collector generates a maximum temperature of 40'C and dries 3 kilograms of onions 4 to 6 hours of a day. Thus, hot air from the parabolic dish concentrator reduces moisture content of onions.**

I. INTRODUCTION

Drying is one of the methods used to preserve food products for longer periods. The heat from the sun coupled with the wind has been used to dry food for preservation for several years. Drying is the oldest preservation technique of agricultural products and it is an energy intensive process. High prices and shortages of fossil fuels have increased the emphasis on using alternative renewable energy resources. Drying of agricultural products using renewable energy such as solar energy is environmental friendly and has less environmental impact. Different types of solar dryers have been designed, developed and tested in the different regions of the tropics and subtropics. The major two categories of the dryers are natural convection solar dryers and forced convection solar dryers. In the natural convection solar dryers the airflow is established by buoyancy induced airflow while in forced convection solar dryers the airflow is provided by using fan operated either by electricity/solar module or fossil fuel. Solar thermal technology is a technology that is rapidly gaining acceptance as an energy saving measure in agriculture application. It is preferred to other alternative sources of energy such as wind and shale, because it is abundant, inexhaustible, and non-polluting. Solar air heaters are simple devices to heat air by utilizing solar energy and it is employed in many applications requiring low to moderate temperature below 80°C.

The increasing cost of fossil fuels affects the costs of various production processes and encourages the use of renewable energy to reduce fuel costs. Among all renewable energy sources, solar energy is unique due to its enormous amount of energy, low cost and high potential [1,2]. Sun drying is the traditional way of reducing the moisture content in fruit and other products and is still popular in developing countries [3]. Drying was an important step in the postharvest process and is one of the oldest techniques for preserving agricultural products [4]. Although open sun drying is a simple and effective method, much of the heat generated from solar energy is wasted to the environment, resulting in a low drying efficiency [3].

The two common types of solar collector dryers are (a) cabinet dryer and (b) chimney type solar dryer. The cabinet dryer has a solar collector integrated inside the dryer. Solar radiation is transmitted through the top and absorbed on the blackened interior surfaces under the product drying tray. The chimney type solar dryer has the same main components as a cabinet dryer but the solar collector is separate from the dryer. In addition, the chimney at the top of the drying chamber improves air circulation and increases the drying performance of the ventilation inside the dryer. The product being dried is directly heated by the sun and also is exposed to the hot air passing through the solar collector. A chimney type solar dryer generally has a higher temperature in the drying chamber than a cabinet dryer and since a chimney type solar dryer can make use of racks in the drying chamber, it also occupies less space. Therefore, most researchers using solar dryers have chosen to have a separate solar collector.

Solar drying may be classified into direct and indirect solar dryer. In direct solar dryers the air heater contains the grains and solar energy which passes through a transparent cover and is absorbed by the grains Essentially, the heat required for drying is provided by radiation to the upper layers and subsequent conduction into the grain bed. However, in indirect dryers, solar energy is collected in a separate solar collector (air heater) and the heated air then passes through the grain bed, while in the mixed mode type of dryer, the heated air from a separate solar collector is passed through a grain bed, and at the same time, the drying cabinet absorbs solar energy directly through the transparent walls or the roof [5].

Energy is important for the existence and development of human kind and is a key issue in international politics, the economy, military preparedness, and diplomacy. To reduce the impact of conventional energy sources on the environment, much attention should be paid to the development of new energy and renewable energy resources. Solar energy, which is environment friendly, is renewable and can serve as a sustainable energy source. Hence, it will certainly become an important part of the future energy structure with the increasingly drying up of the terrestrial fossil fuel. However, the lower energy density and seasonal doing with geographical dependence are the major challenges in identifying suitable applications using solar energy as the heat source. Consequently, exploring high efficiency solar energy concentration technology is necessary and realistic. [6][7]

Solar energy is free, environmentally clean, and therefore is recognized as one of the most promising alternative energy recourses options. In near future, the large-scale introduction of solar energy systems. directly converting solar radiation into heat, can be looked forward. However, solar energy is intermittent by its nature: there is no sun at night. Its total available value is seasonal and is dependent on the meteorological conditions of the location. Unreliability is the biggest retarding factor for extensive solar energy utilization. Of course, reliability of solar energy can be increased by storing its portion when it is in excess of the load and using the stored energy whenever needed. [8]

Onion is agriculture produce, very commonly used in culinary preparations since ancient times. Onion adds a delightful taste and flavor to food products. It also evidenced as a decent medicinal compound. Onion contains hypo-cholesterolemic, thrombolitic, and antioxidant. These therapeutic compound make onion useful for cataract, cardiovascular illness, and cancer, as quantified by Nuutila et al. [9] and Vidyavati et al. [10]. Indian dark red onion is indeed old species in the onion group. These onions have a similar flavor, like regular yellow onions with less tenderness and meaty. Anthocyanin produces deep purple outer skin and reddish flesh. Also, high levels of the antioxidants anthocyanin and quercetin make these onions are more effective in cancer pugnacious than white species [11]. Red onions exhibit higher antioxidative traces than yellow and white onions. Red onions are potential health food and suitable for humanoid nutrition [12].

Onion, which is primarily used as a seasoning ingredient in several countries, is one of the most popular vegetables containing various beneficial chemical compounds such as fibers, vitamins, organic acids, phenolic compounds, and other antioxidants. Phenolic compounds in onion comprise gallic acid, ferulic acid, protocatechuic acid, quercetin, and kaempferol [13], with gallic acid and quercetin being important compounds that have antiallergic, antioxidant, anti-inflammatory, antihyperglycemic, anti-lipid peroxidative, and antimicrobial properties [13][16].

Drying is one of the postharvest treatments for onion; for this process, water content is removed by introducing heat. Harvested onion contains high moisture content of >80% that can be reduced to 10% or below by drying, which in turn increases storage life. Nevertheless, excessive drying can affect the stability of phenolic compounds and lead to the degradation of antioxidant compounds in onion [14]. Furthermore, drying can reduce vitamin C, color, and other ingredients because of the introduction of excessive heat. In certain cases, in terms of energy usage, drying is inefficient [14][15]. At present, convective drying is mostly used for onion drying. To minimize energy cost, convective method via direct sun drying can be an alternative; however, it takes long drying time and is weather dependent because it requires ambient air conditions. At relatively high humidity (such as in wet season), products cannot be completely dried because of sorption isotherm characteristics [16].

In general, onion bulbs are purchased from traditional markets for direct use as a food seasoning. However, many consumers are gradually adjusting to the use of sliced or powdered onion for the flexibility these onions forms offer [17]. The use of dehumidified air as a drying medium could shorten the drying time of onion bulbs and preserve their bioactive compounds [18].

Relative air humidity close to 0% or air moisture content (MC) of up to 0.1 ppm and temperatures in the range of 10–40°C could potentially enhance the driving force for moisture transfer from the onion surface to the drying air. Hence, the drying time could be shortened, and heat could be utilized more efficiently [19] applied air dehumidification as a drying medium to reduce the free moisture on the surface or outer layer of fresh onion bulbs to approximately 12%. In this state, fresh onions can be preserved from germination during storage. Results showed that dehumidified air can significantly reduce the drying time at drying temperatures ranging from 40to 50°C.

The current work aims to evaluate the effect of recycled exhaust air on the thermal efficiency of onion slice drying. Ambient air was heated to a certain temperature before feeding to the drying chamber, and then the exhaust air exiting the dryer was recirculated and mixed with incoming fresh air to minimize heat utilization [20]. The thermal efficiency of this system was estimated under various drying conditions and compared with the results of standard drying without a recycling system.

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II. MATERIAL AND METHOD

Collector (Air Heater): The heat absorber (inner box) of the solar air heater was constructed using well-seasoned woods painted black. The solar collector assembly consists of air flow channel enclosed by transparent cover (glass).

The Drying Chamber: The drying cabinet together with the structural frame of the dryer was built from well-seasoned woods which could withstand termite and atmospheric attacks. An outlet vent was provided toward the upper end at the back of the cabinet to facilitate and control the convection flow of air through the dryer. Access door to the drying chamber was also provided at the back of the cabinet. The roof and the all wall of inside chamber are covered by aluminum foil paper, which provided additional heating.

Drying Trays: The drying trays are contained inside the drying chamber and were constructed from a double layer of fine wire mesh with a fairly open structure to allow drying air to pass through the food items.

III. EXPERIMENTAL METHOD

In the current research a modified parabolic solar collector Hot air dryer to dry food material. It's covered with a glass to raise the temperature of ambient air up to drying temperature of food material. We covered chambers inside part with aluminum foil paper to maintain temperature. The drying chamber consists of plywood and has hopper and wood the dimension of chamber are 50*24. The exhaust fan is fixed to control and study the effect of air flow rate on a drying. Five trays are fixed which can dry 5 kg of material. It also help in drying due to force convection. In our research high quality onion is use as food material. The slices of onion are kept on tray for drying . A periodic monitoring of moisture removal done by waving onion in every half an hour.

4. ENVIRONMENTAL METHOD

Data were installed to record the ambient air temperature and relative humidity inside and outside the drying chamber, the test were performed from 9:00 am to 3:00 pm.

The air velocity flow into drying chamber is 33.51 m/s.

For the drying chamber inlet temp. is 40`c and outlet temp. is 37-38 `c , however drying chamber inside maintained temp. is 40`c.

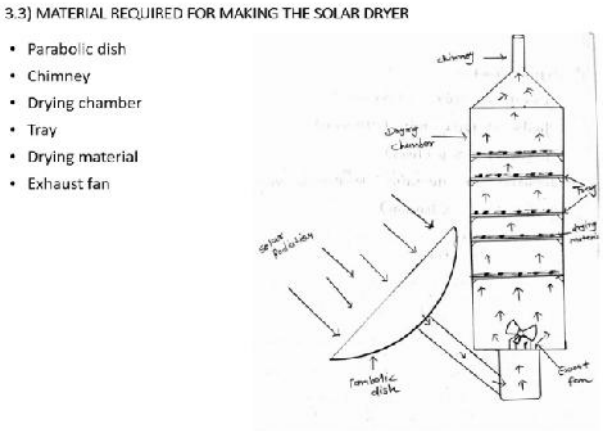

Fig. 1. Specifiation and Schematic for experimental setup

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DRYING EFFECTIVENESS

A. Drying rate: The drying rate is the amount of moisture to be removed over the drying time. The drying rate was used to indicate whether the water evaporation capacity of the dryer was faster or slower than traditional sun drying. The drying rate of a sample was calculated using the following equation.

$$DR = \frac{m_d(M_i - M_f)}{t}$$

WHERE, DR = DRYING RATE (GWATER/H)

MD = THE MASS OF DRY ONION (GSOLID)

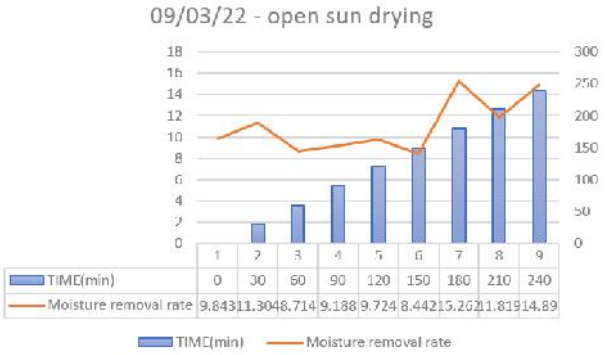
MI = THE INITIAL MOISTURE CONTENT OF ONION (GWATER/GSOLID)

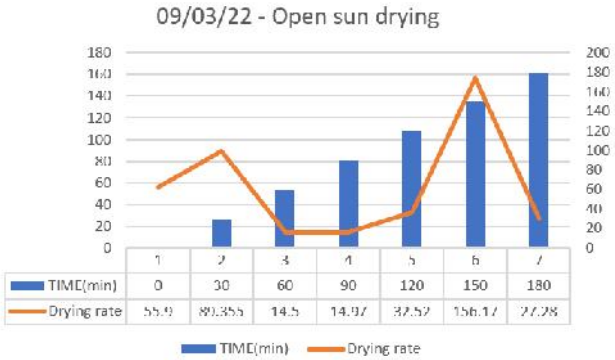
MF = THE FINAL MOISTURE CONTENT OF ONION (GWATER/GSOLID)

T = THE DRYING TIME (H)

IV. RESULT AND DISCUSSION

OPEN SUN DRYING





This two line charts illustrate the moisture removal and drying rate according to time, in this both we time is increase gradually in period of thirty minutes. Firstly we are discuss about moisture rate, it started with small rose and after that it slightly fluctuated, but suddenly in afternoon at 1:00 o`clock it has jump and increase the moisture rate. Furthermore, it has fall and after again rose.

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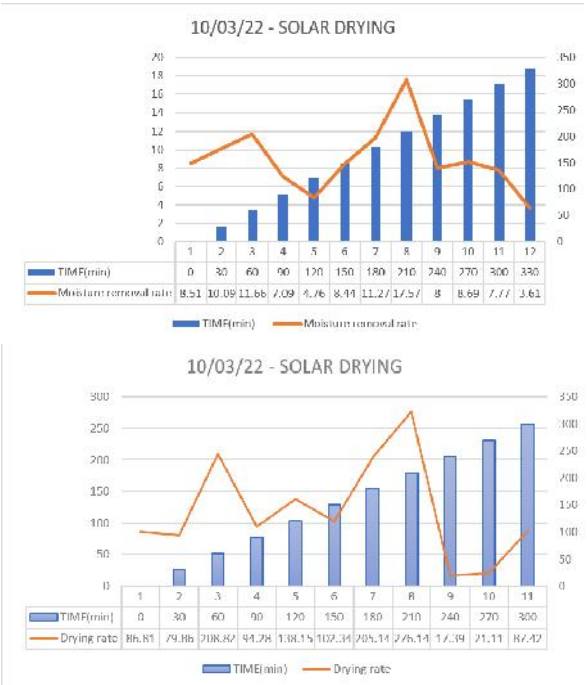
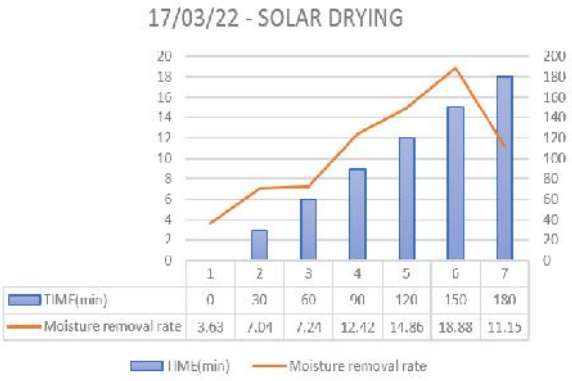
In contrast, drying rate is stood at above 50 and finish at below 30. It started with incline but eventually after 30 min it is dramatic fall, next step it has slightly rose and dramatically increase and reach close below 80 it saw the major difference during the afternoon and after that it has decrease.

SOLAR DRYING



This both graph illustrate that time is gradually increase with period of 30 min and comparatively moisture removal rate is also rose after 30 min it has drastically decrease, after 120 min it has boom and reach highest pick up point in afternoon, because after 12:00 o`clock temperature is shoot up. Although after major moisture remove it has decline and slightly rose again, and it has decrease and reach lowest point. However, drying rate is very fluctuated and highest point is 276.41 and lowest point is 17.39. in this both graph describe that afternoon time is very comfortable for drying.

V. SOLAR DRYING



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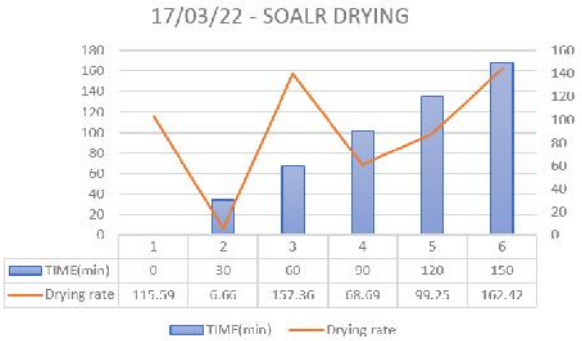
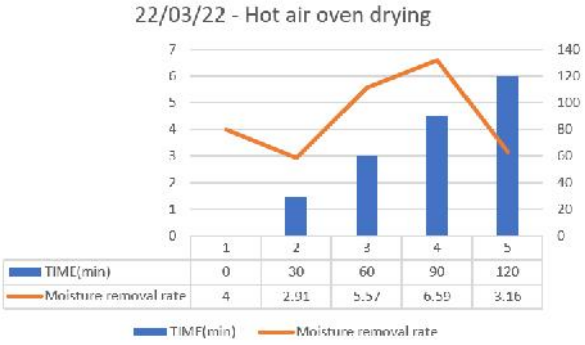
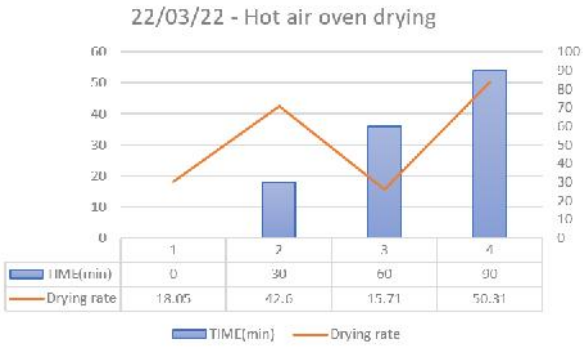


Firstly if we describe the moisture removal rate it has saw drastic increase until 12:30 o`clock and reach the highest point. In contrast, drying rate has fluctuated.

HOT AIR OVEN DRYING





This line graph depicts that for moisture removal rate is has fall in first step after that it has increase drastically and decrease, comparatively in drying rate is fluctuated. This method is done in hot-air oven but it has not much give as expected result.

VI. CONCLUSION

To conclude and offer our opinion, drying is one of the method used to preserve food for longer period. open-sun drying method is gave good result but there some drawbacks. In open-sun drying method there are kind of risk for prevent the drying material, there are maybe fungus and bacteria problem. For the hot-air oven drying is not gave expected result comparatively our modified solar collector hot-air tray dryer is give high efficiency. However it was not much expensive and require man-power.

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