# Development of Solar Dryer of Fruits and Vegetables Incorporated by Evacuated Tube Collector

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***Abstract –*** An indirect type forced convection solar dryer is fabricate with the components like evacuated tube collector, drying chamber and blower. The performance of the designed drier is evaluated by carrying drying experiments with copra at Coimbatore district Tamilnadu, India. A short survey of these showed that applying the forced convection solar dryer not only significantly reduced the drying time but also resulted in many improvements in the quality of the dried products. Solar drying of copra is carried for forced convection and is compared with natural convection solar drying. The temperature of the drying chamber ranges from 49ºC to 78ºC for natural and forced convection while the ambient temperature ranges from 28ºC to 32ºC. Initial moisture content of copra ranges from 51.7% to 52.3% and the final moisture content obtained about 7 to 8%. The forced convection solar dryer takes less time than the natural convection solar dryer to attain the equilibrium moisture content. Solar drying copra obtained was free from smoke, dust, bird and rodent damage.

***Keywords:*** *Forced Convection, Evacuated Tube Collector, Moisture Content.*

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## I. INTRODUCTION

Safeguarding of organic products, vegetables, and nourishment are key to keeping them for quite a while without decay in the nature of the item. The number of procedure advancements have been utilized on a modern scale to protect sustenance items; the critical ones are canning, frigid, and drying out. Among these, drying which is reasonable for creating nations with low-temperature and less warm preparing offices. It offers a best and viable method for safeguarding to lessen misfortunes amid postharvest and balance the deficiencies in supply. Drying is a straightforward procedure of expelling dampness from an item with a specific end goal to achieve the harmony dampness content and is a vitality escalated operation. The fundamental goal of drying separated from developed stockpiling life can likewise enhance the quality, simplicity of taking care of, further handling and is most likely the most seasoned strategy for sustenance safeguarding honed by mankind. India remains as the third position on the planet for biggest coconut-delivering nation. Copra is one of the major conventional items handled from coconuts. Crisp coconut contains a dampness substance of around 52% (wet premise), which ought to be lessened down to around 7% by drying with a specific end goal to think the oil content. On a normal, 5–7 coconuts are fundamental to deliver 1 kg of copra, in spite of the fact that this relies on upon the evaluation of item. The customary techniques followed in India are sun and oven drying. They create low quality copra furthermore require some investment to accomplish the harmony dampness content.

In oven drying, smoke has direct contact with the coconut and result as fantastic copra is not delivered because of smoke stores may frame polycyclic sweet-smelling hydrocarbons in the copra [1]. Sun drying takes around 7 days and if the climate is stormy the copra acquired will be tainted with growths which deliver a dark rotten item. Also sun drying requires more space, is work concentrated and there can be create low quality copra from stores of earth and clean. Likewise, microorganisms can bring about rancidity, expand the corrosive substance, and lessen the measure of oil removed from the item bringing about low-quality coconut oil. The oil separated from low quality copra likewise requires extra refinement to meet global principles. A few exploratory and hypothetical studies have been accounted for on the improvement of different sorts of sunlight based driers for drying farming items [2].

Drying assumes a noteworthy part in which the free water atoms are evacuated leaving the vital bound water particles. The old technique used to safeguard nourishment is regular sun drying. Yet, characteristic sun drying has numerous impediments, for example, uncontrolled drying, tainting by winged creatures, bugs and clean, climatic misfortunes and so on. The nature of the item is observed to be less and can't be sent out. It additionally requires more work and the procedure is observed to be moderate.

The principle target of the present work was to enhance the nature of copra created in a constrained convection sun based dryer. Yet, it has been accounted for that the proficiency of emptied tube gatherer is high when contrasted with the productivity of level plate authorities. Notwithstanding, the some exploratory works have been tackled sunlight based cleared tube dryers [3].

So an endeavor has been made to plan and build a novel sunlight based dryer with cleared tube authorities and study its execution on copra in the locale of Coimbatore, Tamilnadu, India.

## II. MATERIALS AND METHODS

### A. Measuring Instruments and Devices

A computerized anemometer is utilized to gauge surrounding temperature and wind speed. A solarimeter is a pyranometer of silicon pn intersection kind of measuring gadget used to quantify joined immediate and diffuse radiation. The examples are said something hourly premise utilizing an advanced electronic equalization with an exactness of one milligram. The stickiness of the encompassing air was computed by utilizing psychometric outline with the assistance of measured wet and dry knob temperatures recorded by separate mercury thermometers amid the examinations.

B. Experimental Setup

The circuitous sort constrained convection sunlight based dryer is basically built with four crucial components in particular, the blower, the cleared tube gatherer, the drying chamber and the stack. Fig. 1 demonstrates the segment of the sun powered dryer. The drying chamber is made of stainless steel sheets of thickness 27.5mm and protected on all sides with rock fleece chunk to keep lost warmth. It comprises of two punctured plate as top and base plate to put the item to be dried. It comprises of six cleared tube authorities with a copper header for exchange of warmth to the channel air drying gatherer. The twofold layer glass emptied tube gatherer is around 1.6mm thickness and the crevice between the glass tubes is cleared. Heat misfortune because of convection, conduction and radiation is consequently minimized and it can withstand high temperature because of this innovation. The authority is set along N-S bearing, confronting south in order to track greatest sunlight based radiation amid the day time. The cleared tube gatherer is utilized as air radiator which associated with the drying authority with the assistance of EPDM (Ethylene Propylene Diene Monomer) elastic hose. The hot air from the drying gatherer outlet is associated with the bay of drying chamber. The blower is connected at the bay of the drying authority for directing the test of constrained convection.

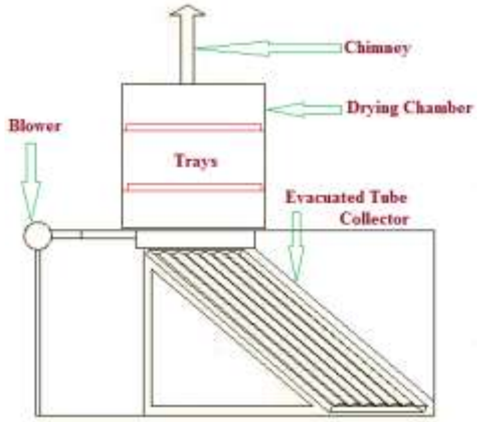


Fig. 1 Indirect type forced convection solar dryer

A. Experimental Procedure

Broken copra's are uniformly spread in the trays and are kept inside the chamber for solar drying. In the designed solar dryer, air is blown into the evacuated tube collector with the help of the external device blower. The solar radiation falling on the collector, the collector gets heated up and transfers heat to the air flowing through the drying collector. This hot air enters the inlet of the drying chamber where copra is loaded in two trays. The moving hot air evaporates the water content (moisture) of the copra under the basic mechanism of removal of moisture from the surface of the product to the surrounding followed by the removal of moisture from inside the product to the surface [4].

The velocity of the air at the tray was adjusted by using a control valve. During the experiments, temperatures at various locations in the solar collector and the drier chamber, ambient dry and wet bulb temperatures were measured at hourly intervals. The relative humidity of air was calculated from measured wet and dry bulb temperatures using a psychometric chart. After the moisture content was reduced to 40%, the copra kernels were scooped from the shells and dried further without shells. Moisture contents were determined by using Eq. (2). Experiments were only conducted during daylight hours. The readings are taken on hourly basis from 10.00am to 3.00pm until copra attained equilibrium moisture content.

D. Analytical Calculation

1) Determination of Moisture Loss Moisture loss of drying product copra every hour using the below formula [4],

ML = Mt - Md (1)

The initial Mt , and final mass Md, of the samples were recorded with the help of electronic balance.

2) Determination of Moisture Content The quantity of moisture present in a material can be represented on wet basis and expressed as percentage.

The moisture content, Mwb, on wet basis was calculated by using Eq. (2).

The procedure was repeated for every one hour interval till the end of drying.

$$M_{wb} = \frac{(M_t - M_d)}{M_t} * 100$$

3) Determination of Drying Rate

The drying rate, DR, should be proportional to the difference in moisture content between material to be dried and the equilibrium moisture content [5].

$$DR = \frac{dM}{dt}$$

Where, dM – Mass loss of the crop dt – Drying time

II. RESULTS AND DISCUSSION

Temperature variations of the designed solar dryer natural circulation for four days on hourly basis from 10.00a.m to 3.00pm during the experimentation for natural circulation are shown in Fig.2.

The maximum temperature of 78o c was observed and average temperature recorded at the outlet of the drying collector was 64 o c. It is observed that the temperature inside the drying chamber is higher during the mid-noon time. The variation of air temperature at outlet of collector with respect to drying time on hourly intervals for different days with forced convection is shown in Fig.3.

The minimum and maximum temperature was recorded during the forced convection is 48o c and 68o c respectively. The temperature variation is due to the change in solar radiation intensity which is measured by using the instrument pyranometer.

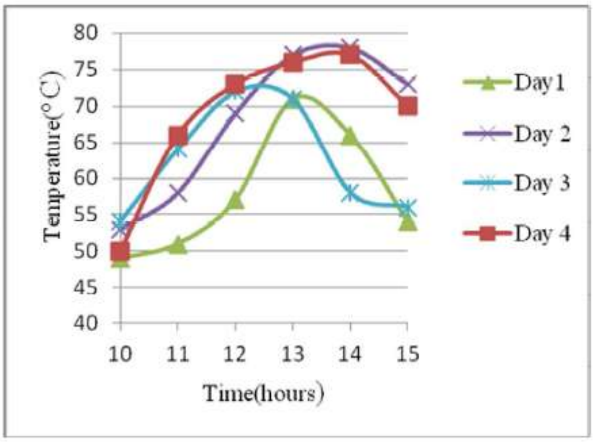


Fig. 2 Variation of Drying air temperature at outlet of collector Vs Drying time for natural convection.

Variation of moisture content with respect to drying time until to reach the equilibrium moisture content for natural circulation which takes four days is shown in Fig. 4. The initial moisture content of the copra around 52% and obtained the final moisture content as 7.1%.

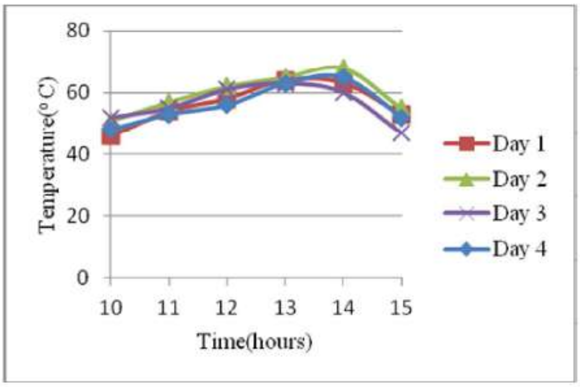


Fig. 3 Variation of Drying air temperature at outlet of collector Vs Drying time for forced convection.

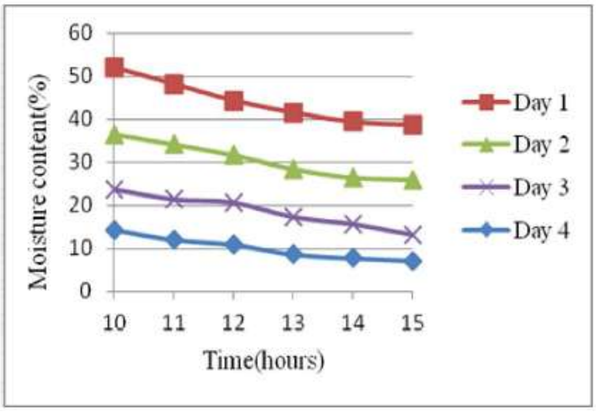


Fig. 4 Variation of Moisture content Vs Drying time for natural circulation.

The variation of moisture content and drying time for forced convection is shown in Fig.5. The drying time taken by the designed solar dryer with forced convection to reach the equilibrium moisture content of copra is less than the natural convection. The initial moisture content of the drying product was 52% and reached the final moisture content as 7.3% which comes under the equilibrium moisture content. The forced convection has been conducted with blower with velocity of 1m/s in the inlet of drying chamber. The moisture content is reduced in the initial stages well as compared to the lower stage to reach the equilibrium moisture content. The drying rate decrease with increase the drying time during the experimental observation.

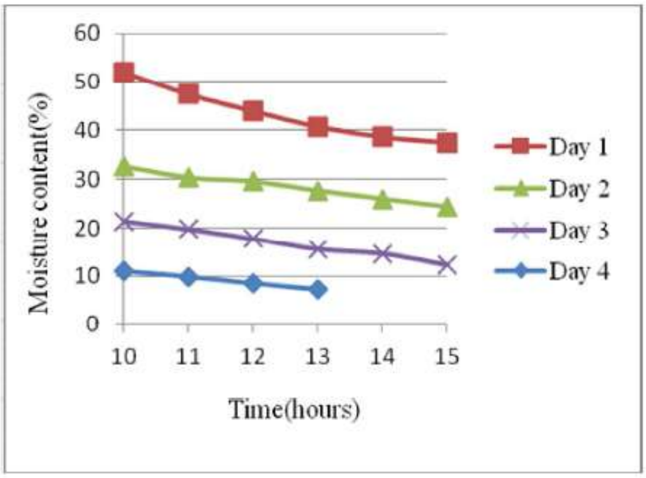


Fig. 5 Variation of Moisture content Vs Drying time for forced circulation.

## III. CONCLUSION

In this experimental study, the drying of copra was investigated under the two different modes as natural and forced convection. The indirect type forced convection solar dryer with evacuated tube collector generates air temperature higher inside the chamber and enhance drying rate thereby reducing the drying time required to dry a product. The time taken by the solar dryer with forced convection to reach desired moisture content is less than the time required in natural convection. As the solar dryer using evacuated tube collector can perform better even during cloudy days and winter season. The designed indirect type solar dryer utilized the more solar thermal energy as a result obtained as reducing the time required to dry the copra and also improves the quality of the drying product.

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