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Experimental Analysis of Solar Dryer

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Abstract

Agro-commodities are most commonly dried in open air. For easy usage, low cost dryer in clear and rainy day was the need by many farmers. Present study was intended to study, fabricate and test the solar dryer for drying fruits and vegetables. A model was designed for drying chillies and potatoes by direct solar energy in line with auxiliary drying chamber. Proposed method of drying is comparatively fast and clean. Dried chilli and potatoes may be directly used. Performance analysis is carried out for the developed model, results were satisfactory.

Keywords: Solar dryer, agriculture products, solar dryer, absorber plate, toughened glass, baffles, exhaust pipe, drying cabinet

INTRODUCTION

In recent years there is a large growth in utilisation of solar energy. There will be a scarcity of fossil fuel resource in the coming days; there fore there is huge demand for alternative power source. Moreover solar energy is abundant naturally available energy in most of the places in India, and it is available in both direct and indirect forms. Solar energy applications are largely divided into two categories: direct conversion to electricity via solar cells (electrical applications) and indirect conversion. The second group is thermal applications. Solar heating, solar cooling, solar drying, solar cooking, solar ponds, solar distillation, solar furnaces, solar thermal power generation, solar water heating, solar air heating, and so on are examples of the latter. A full description, basics, and earlier work on solar dryers and solar air warmers are offered as a crucial component for the indirect and mixed modes of sun dryers [1].

A solar air heater is a type of energy collector that uses sun insolation captured by an absorbing substance to heat air. Solar air heating is a renewable energy heating technology that is used to dry agricultural goods effectively and efficiently. An absorber material, sometimes with a selective surface, collects solar energy and converts it to air via conduction heat transfer in a simple solar air collector. This heated air is then ducted to agricultural goods such as chilies, grapes, and potatoes [7-8].

However, if products are not protected from rain, wind-borne dirt and dust, and bug, rodent, and other animal infestation, they may be considerably harmed and lose food quality in the dried stage. Products may have an adverse economic influence on both domestic and international markets. Some of the problems associated with open-air sun drying can be handled by employing a solar dryer, which includes a collector, a drying chamber, and, on occasion, a chimney. [2] Solar technology has been recommended regularly for the dried fruit business, both to reduce energy costs and to economically accelerate drying, which would boost final quality

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dried grapes, okra, tomato, and onion. They concluded that drying time was significantly reduced, resulting in higher product quality in terms of colour and reconstitution properties. They also believe that sun drying facilities are more cost effective for small farmers than oil or gas fuelled dryers, especially in excellent weather. Solar dryers utilised in agriculture for food and crop drying, as well as industrial drying operations, may prove to be the most energy-saving technology [3]. It not only saves energy, but it also saves time, takes up less space, improves product quality, increases process efficiency, and protects the environment. Solar dryers overcome some of the most significant disadvantages of conventional drying. Solar drying can be used to supplement or replace artificial drying systems, reducing the amount of fuel energy required overall. Controlled drying of grains provides a number of advantages, including improved product quality, storage capacity, and cleanliness, reduced waste, and improved time and space transportability [4].

A source of thermal energy to evaporate the water and a supply of air to carry away the water vapour generated are necessary to dry items. To control food drying, we use fuels such as electricity, natural gas, or coal. Energy engineers are exploring for alternative energy sources due to the scarcity of fossil fuels and the various environmental challenges associated with their use. Solar energy is the best solution or alternative energy source. Solar energy is free, clean, and abundant. Solar dryers, which heat the air in a flat plate solar collector and then transmit it via a drying chamber/cabinet, are an improved technique of using solar energy [5].

PROBLEM IDENTIFICATION

The capacity of the heat absorber plate to absorb and retain more heat from the sun is critical to the performance of flat plate collectors. The heat absorbed by the flat plate collector is determined by both the thermal characteristics and the design of the heat absorber plate. Heat absorber plate material is crucial in heat absorbing performance because of its thermal characteristics. However, the fundamental issue of heat loss in the collector has been decreased with the use of superior insulating material [6].

WORKING METHODOLOGY

In the hot and dry climate of Hubballi, Karnataka, India, a solar dryer with indirect natural and forced convection is created to demonstrate its performance. The system consists of a flat plate collector and a drying chamber with four shelves and a chimney. The collecting and drying chambers are 2m x 1m and 1m x 0.5m in size, respectively. Between the absorber plate (G.I sheet) and the toughened solar glass, six 50cmx3cmx7cm baffles are fitted. The solar glass and absorber plate are 10cm apart. Green chilies, red chillies, and potatoes were used in the trials. It takes 7 hours to dry. The collector is tilted at 25° to the horizontal and directed south-north. In the month of April 2023, ambient temperature and weight were monitored hourly for drying of green chilies, red chillies, and potatoes. The current study's findings reveal that drying time is shortened and final product quality is improved. Figure 1 depicts a block schematic of the experimental setup.

Objectives

The project is conducted with the following objectives to be achieved:

- To evaluate the performance of the prototype using some common agro-commodities with different loads (quantity) and drying modes.
- To shorten the drying time comparatively with open sun drying.
- To assess the solar dryer’s performance.
- To protect the food from dust and insects etc, to get hygienic food. By drying in a closed cabinet.
- To decrease the operating cost in comparison to conventional dryers (using electricity, gas or kerosene etc)
- To store dried agro-products for longer periods of time.

Experimental Setup

The flat-plate solar collector was always inclined and oriented to collect the maximum amount of solar radiation throughout the desired season of use. The finest stationary orientation in the northern hemisphere is straight south, whereas the best stationary orientation in the southern hemisphere is due north. As a result, the solar collector in this place is inclined at 25^0 degrees to the horizontal and aimed south. which is the best advised orientation for stationary absorbers. This tilt is also designed to enhance air circulation. The experimental setup is depicted in Figures 2 and 3.

Material Properties

Components of solar dryer (Table 1)

1. Solar flate plate collector
   - Solar toughened glass
   - Absorber plate(G.I. sheet)
   - Baffles
   - Stand for collector
2. Drying chamber
   - Trays
   - Exhaust pipe
3. Chimney pipe

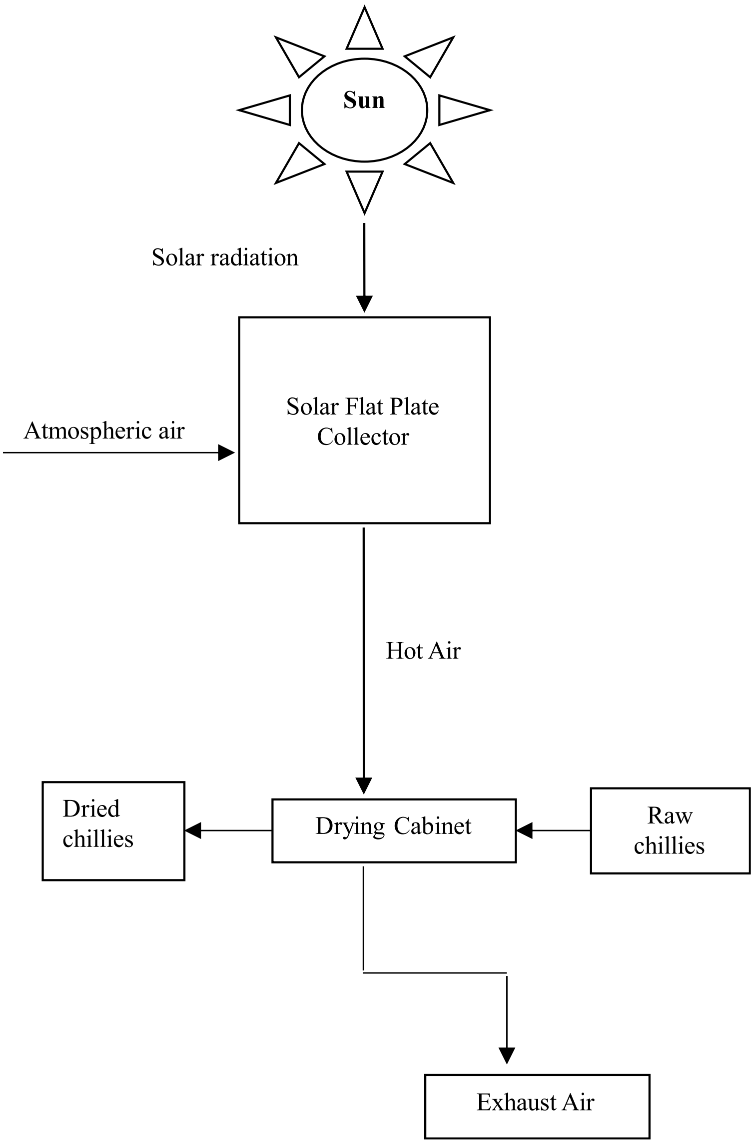

Figure 1. Block diagram of experimental set up.

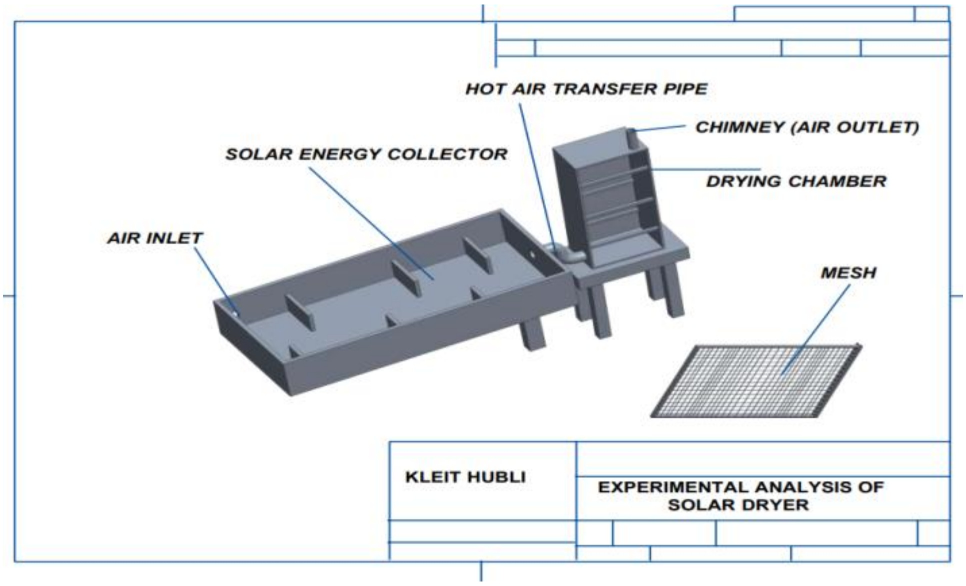

Figure 2. CAD Diagram of solar dryer.

Figure 3. Experimental setup.

Table 1. Specifications of solar dryer components.

Sl No.	Components	Material	Dimensions	Quantity
1	Solar Collector	Plywood	Length = 2000mm Width = 1000mm Height = 150mm	1
2	Drying Chamber	Sheet metal	Length = 400mm Width = 500mm Height = 500mm	1
3	Pipe	Aluminium	Length = 3000mm Diameter = 2mm	
4	Absorber Plate	GI Sheet	Length = 2000mm Width = 1000mm Thickness = 1mm	1
5	Toughened Glass	Solar toughened glass	Length = 2000mm Width = 1000mm Thickness = 5mm	1

ANALYSIS OF SOLAR DRYER

From the above graph we concluded that at the time of 12:30pm to 3:00pm having the highest temperature (Table 2).

Moisture content determination of red chilli:

$M_{wb} = (M_i – M_f) / Mi\ 100$

M_{wb} = Moisture on a wet basis
M_i = sample's starting mass
M_f = sample's final mass

M_{wb}= (250-65) / 250 × 100
= 0.74 × 100
M_{wb}= 74%

Therefore, after the experimental analysis the product green chilli got decayed. So, drying of red chilli can be advised (Figures 4-9)

Moisture content determination of potato:

Mwb = (Mi - Mf) / Mi 100

Mwb = Moisture on a wet basis
Mi = sample's starting mass
Mf = sample's final mass

M_{wb}= (250-60) / 250 × 100
= 0.76 × 100
M_{wb}= 76 %

As a result, moisture content may be estimated, and boiled potato can be dryed rather than drying potato is advised (Figures 10 and 11).

Table 2. Variation of ambient temperature with respect to time.

Sl. no	Time	Ambient Temp in ºc		
		Day 1	***Day 2***	***Day 3***
1	9:00am-10:00am	26	24	24
2	10:00am-11:00am	27	29	29
3	11:00am-12:00pm	31	33	32
4	12:00pm-1:00pm	34	35	35
5	01:00pm-2:00pm	36	36	37
6	02:00pm-3:00pm	39	39	40
7	03:00pm-4:00pm	35	37	38

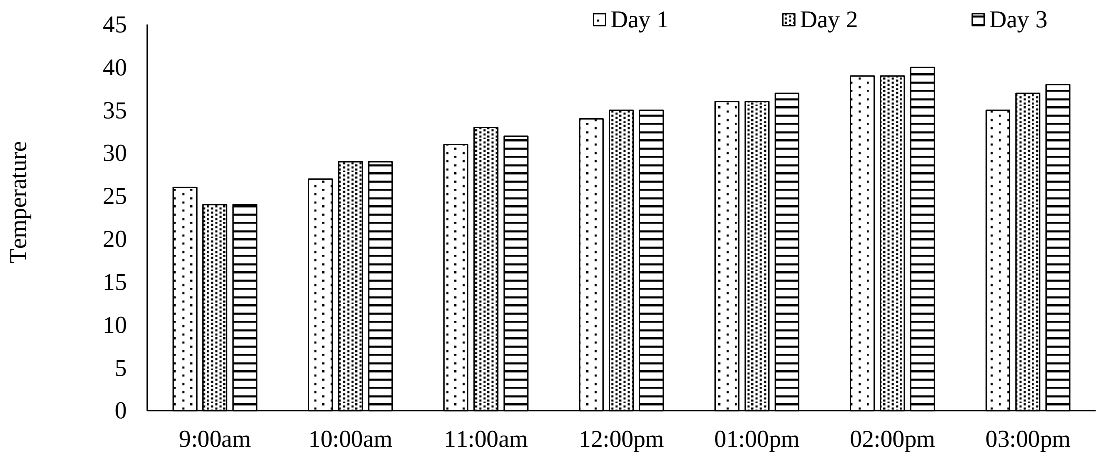

Figure 4. Plot of Time v/s Temperature.

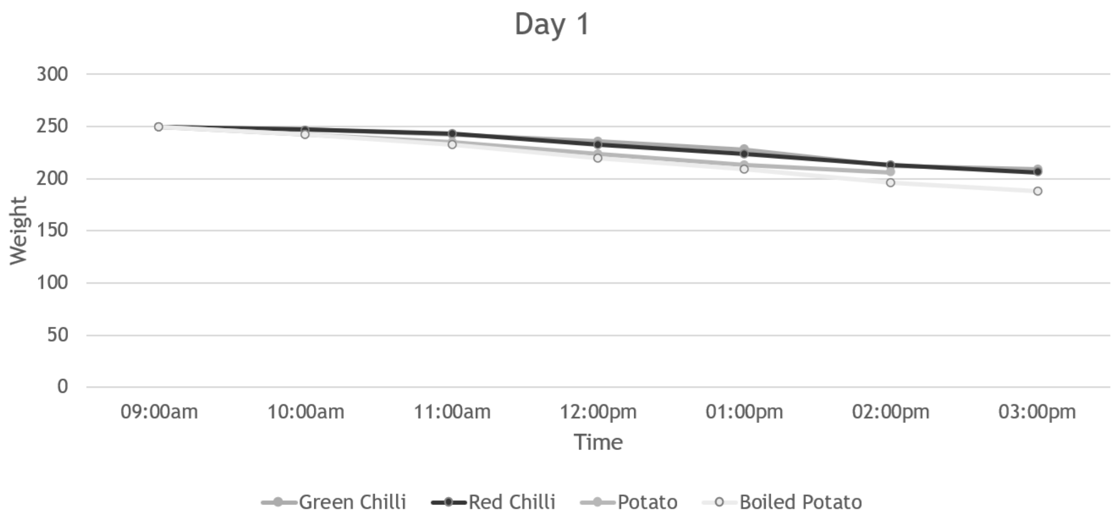

Figure 5. Variation of ambient temperature and weight over time, Day 1.

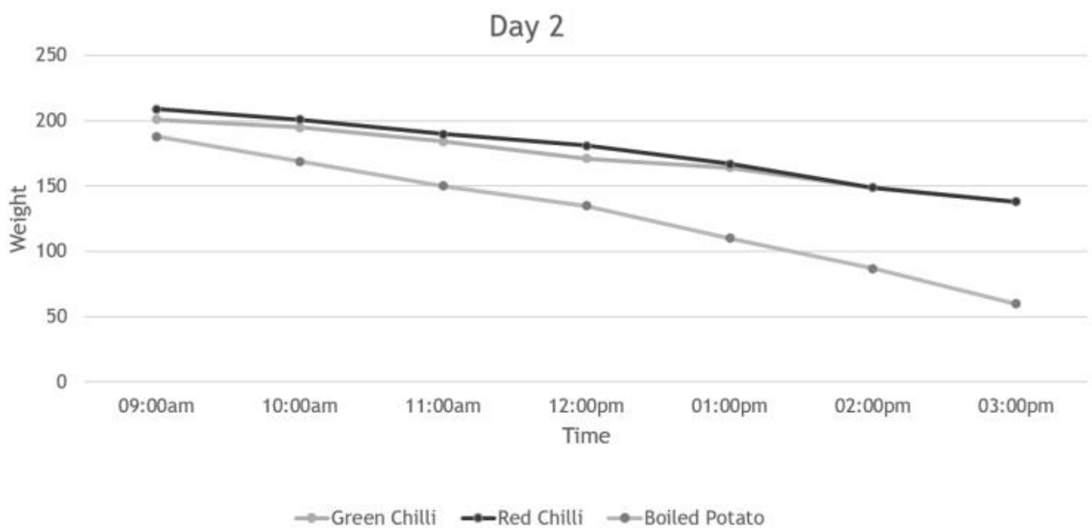

Figure 6. Variation of ambient temperature and weight over time, Day 2.

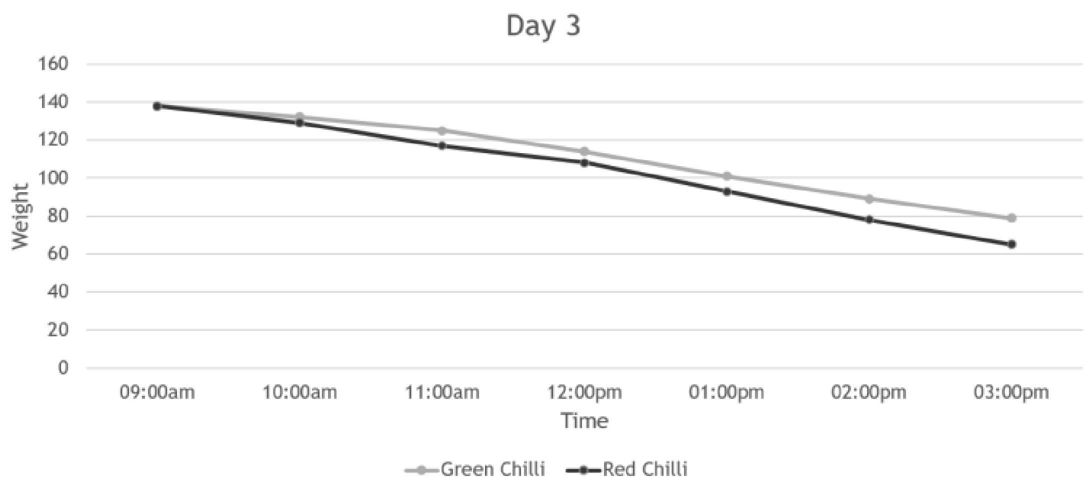

Figure 7. Variation of ambient temperature and weight over time, Day 3

Figure 8. Initial and final view of green chilli.

Figure 9. Initial and final view of red chilli.

Figure 10. Initial and final view of boiled potato.

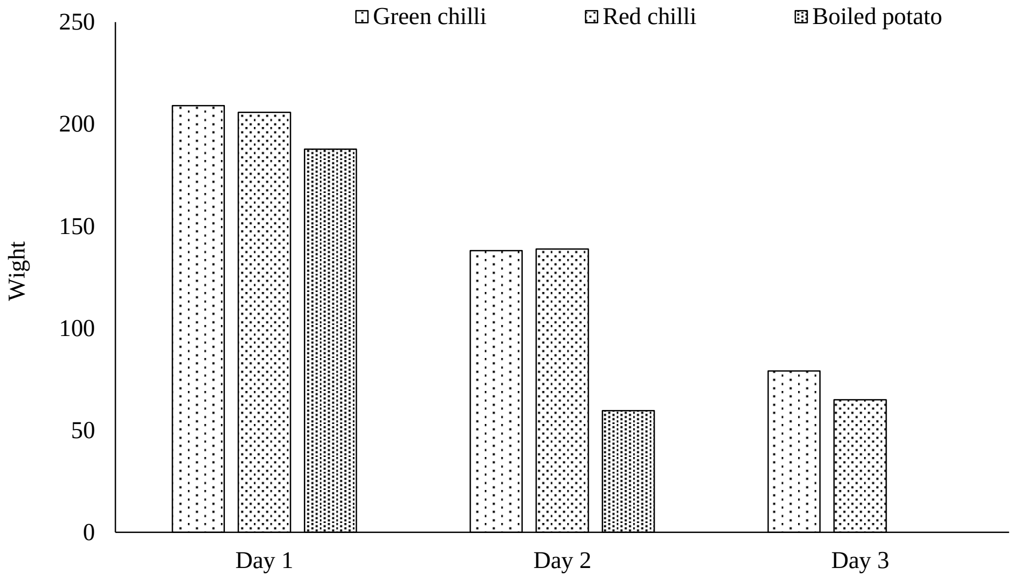

Figure 11. Plot of Day v/s Weight.

Future Scope

The present work leaves a wide scope for future investigators to explore many other aspects of solar dryer. Some recommendations for future research include:

- To generate and evaluate the concepts of the solar dryer by benchmarking the prototype of this dissertation work or by evaluating the uncertainties of the prototype and also, by trying to make the dryer integrated with temperature indicators for each chamber. So that maximum heat control is made possible.
- In winter season the agro-products can be dried through forced convection.
- To design a solar dryer used for drying food products of higher quantity i.e.,>1Kg.
- Double slope passive solar dryer can be fabricated to attain higher efficiencies.
- Thus, the result so obtained in this work can be taken as a database for future investigation related to this kind of work.

RESULT AND CONCLUSION

Result

The tests were carried out on chiles and potatoes. It takes 7 hours to dry. The collector is tilted at 25° to the horizontal and directed south-north. During the experiment, ambient temperatures and weight were measured hourly for drying green chilies, red chilies, potatoes, and boiling potatoes from April to May. The temperature rose by a maximum of 15-20 degrees Celsius. The collector's hot air enters the drying cabinet through a 51 mm diameter chimney pipe at the bottom. Chilli moisture content was lowered from 100% to 24%. The current study's findings reveal that drying time is shortened and final product quality is improved. The outcomes are depicted visually. The graph, which is a line chart, depicts the relationship between time of day and temperature. The graphs depict the relationship between weight and time of day using data from the preceding tables. It has been discovered that drying the same quantity of goods using natural convection takes less time than traditional drying. Natural convection dried the green chilies in three days, reducing the weight from 250 g to 79 g, however the experiment failed since the crop died. In comparison, the same number of red chiles were dried by natural convection over three days, reducing the weight from 250 g to 65 g. The potatoes were dried in one day by natural convection, reducing the weight from 250 g to 206 g, however the process failed due to the development of black spots. The weight of the same number of boiling potatoes dried by natural convection for two days was lowered from 250 grammes to 60 grammes. Agricultural products are dried to a moisture content of 20-25%. Natural convection drying is faster than traditional drying.

Red chilli

- The weight reduction of red chilli can be concluded from 250gms (Initial weight) to 65gms (Final weight). And the percentage of weight reduction of red chilli is obtained as 26%.
- The moisture content of red chilli is obtained as 74%.

Boiled potato

- The weight reduction of boiled potato can be concluded from 250gms (Initial weight) to 60gms (Final weight). And the percentage of weight reduction of boiled potato is obtained as 24%.
- The moisture content of boiled potato is obtained as 76%.

CONCLUSION

A solar air drier is ideally suited to the drying process. One of the most important potential applications of solar energy is sun drying of agricultural items. Agricultural product post-harvest losses may be drastically reduced by using well-designed sun drying systems. The indirect mode forced convection solar dryer offers a high drying speed and quality when compared to other types of solar dryers. The projected solar air drier with a collector size of $2m^2$ dries agricultural items from 100% to 24% moisture content under ambient conditions throughout the harvesting season from April to May. Experiments were conducted using a solar air heater, which had a maximum temperature rise of 20°C. Natural convection drying takes less time than standard drying. As a result, natural convection is favoured over conventional drying for drying agricultural products.

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