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FABRICATION AND COMPARISON OF WHEAT DRYING IN SOLAR DRYER AND NATURAL DRYER

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ABSTRACT - *With ever-growing population, the food grain production will increase to meet the demand of people. Therefore, quality maintenance of the food grain is the primary concern. India produces over 200 million tonnes of food grains annually. There is need of post production management system to match with the increasing production rate. Drying is the primary need of crop's post production system. Many food preservation techniques like cold storage, drying etc., have been evolved out over the years to tackle the storage loss. Hence, sustainable methods for food preservation are the need of an hour. Solar drying is one of the best choices in this context. Comparative study of wheat between a fabricated solar dryer and conventional drying was made in the present study. It has been done to evaluate the quality characterisation of the sample (wheat) to select appropriate drying method. Temperature of the sample both in solar dryer and conventional dryer with respect to time were tested at regular intervals. Humidity of the air was also recorded. Proximate principles such as moisture content, protein, fat, carbohydrate and energy of wheat were analysed for both sun dried and natural dried samples.*

Keywords: *food grains, wheat, solar dryer, temperature, moisture etc.,*

I. INTRODUCTION

Solar drying has been considered as one of the most promising areas for the utilization of solar energy, especially in the field of food preservation. Open sun drying is the most common method employed in tropical countries for the drying of agricultural products, food stuffs, etc. The method is simple, as it does not involve any costly equipment. The product to be dried is spread under sun, and the moisture evaporates from it over a course of time. Even though the process is simple, it suffers from disadvantages such as dust contamination, insect infestation, microbial contamination and spoilage due to rains. Product dried in this way is unhygienic and sometimes unfit for human consumption.

Solar drying can be most successfully employed as a cost-effective drying technique. It has got several attractive features. For example, energy is available at free of cost and can be harnessed in the site itself. Controlled drying is also possible by this method, and it enhances the quality of dried product. Solar drying systems must be properly designed in order to meet particular drying requirements of specific crops and to give satisfactory performance with respect to energy requirements.

A wide variety of solar dryers have been designed by many researchers. Drying conditions for different products will be different, and hence, the solar dryer should be designed for their particular requirement. A good design can help in producing high-quality products and hence bring good returns to the farmers. India receives good amount of solar radiation in the range of 4–7 kWh/m^2-day around 300–330 days in a year. Thus, it is one of the most promising sources of energy. Unlike fossil fuels and nuclear energy, it is an environmentally clean source of energy.

The objective of this paper is to design and construct solar dryer using locally available materials and to evaluate the performance of the solar dryer by analysing the moisture content and nutrient composition of solar dried and natural dried wheat.

II. EXPERIMENTAL METHODS

A. Materials and Methods

The schematic diagram of the solar dryer used in the study is shown in Fig.1

Figure 1. Solar dryer

B. Design Consideration

1. Temperature - The minimum temperature for drying food is 30°C and the maximum temperature is 60°C, therefore. 45°C and above is considered average and normal for drying food materials.
2. The design was made for the optimum temperature for the dryer. T_0 of 60°C and the air inlet temperature or the ambient temperature T1 = 30°C (approximately outdoor temperature).
3. Efficiency - This is defined as the ratio of the useful output of a device to the input of the device.
4. Air gap - It is suggested that during sunny days, in solar dryer a gap of 5 cm should be created for air vent (inlet) and air passage.
5. Dryer Trays - Net cloth was selected as the dryer screen or trays to aid air circulation within the drying chamber. The tray dimension is 50 × 50cm of 2.5cm × 2·5cm wooden sticks used as frame.
6. The design of the dry chamber is made use of wooden wall sides and a glass top (tilted) which protects the food to be placed on the trays from direct sunlight.

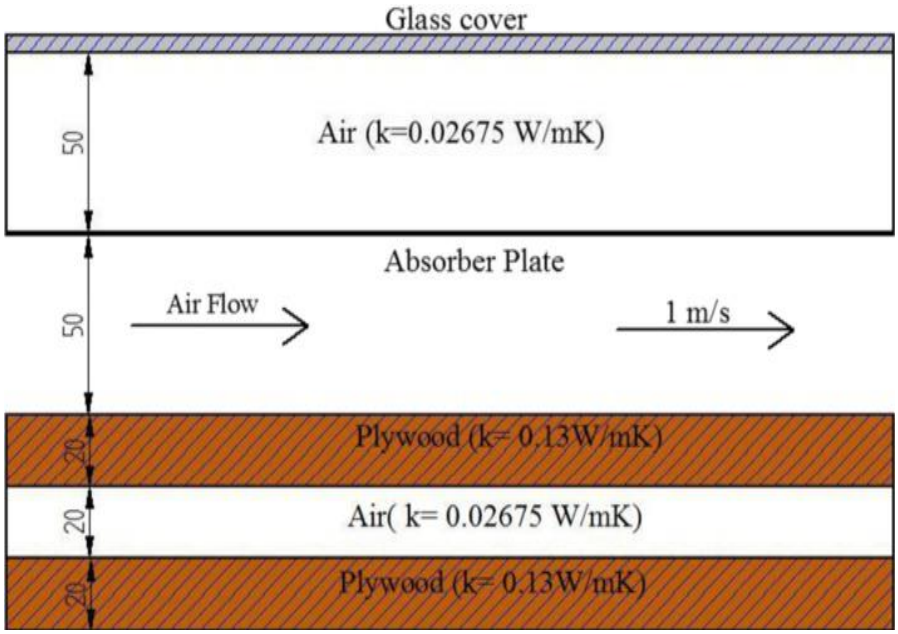

Figure 2. Design of a fabricated solar dryer

C. Methods of drying:

Direct Solar Drying

A portion of wheat was kept in sun between 9 am and 5 pm daily and was dried to constant weight for four days. Direct solar drying is the conventional way of drying the products. In this method the products are directly exposed to the solar radiation and reduce the moisture content to atmospheric air. The air movement is due to density difference. This technique involves the thin layer of product spread over large space to expose to solar radiation. This process takes for a long time until the products will dry to a required level. The surface floor made up of concrete makes applicable for Outdoor direct sun drying. This type of drying method is useful for grains**.**

Figure 3. Conventional dryer

Solar Drying:

Another portion of the sample was dried in the designed solar dryer at the open terrace of Alagappa University, Karaikudi. It is faced on south direction so that the solar radiation will be maximum. The body of the dryer is constructed using the plywood so that the heat loss will be less. There is an air vent (or inlet)in the solar dryer where air enters and is heated up by the greenhouse effect, the hot air rises, passes around the sample, removing the moisture content and exits through the air vent (or outlet) near the top of the shadowed side. The nutritional composition of wheat such as Moisture, energy, carbohydrate, protein and fat were determined by the procedure of Association of official Analytical Chemists (AOAC,1995).

III. RESULTS AND DISCUSSION

Preservation of food by drying is a common practice in different parts of the world and it is used to extend the shelf life of food. Drying allows food to be preserved by removing the moisture in the food, in order to prevent the growth of microorganisms that cause deterioration (Mukhtar, 2009).

A. Moisture Content

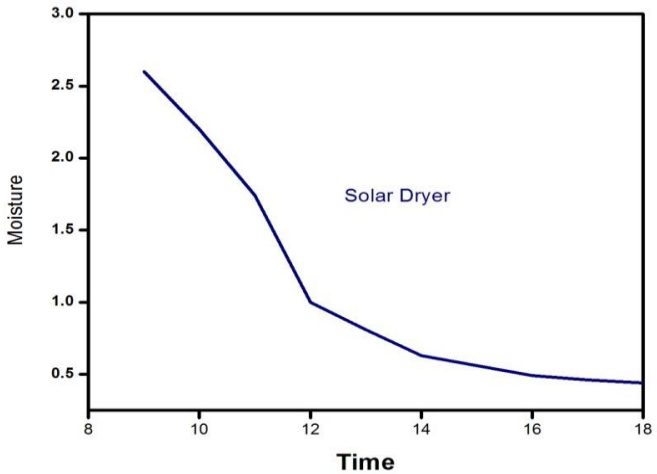

Figure 4. Effect of moisture with respect to time

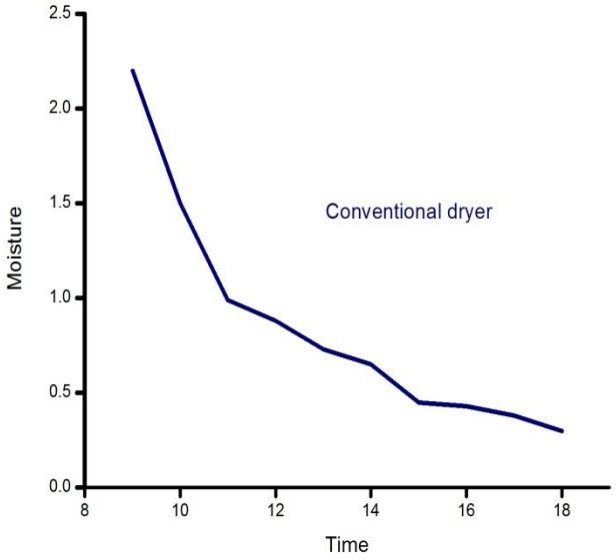

Figure 5. Effect of moisture with respect to time

In this study, the drying methods were capable of removing 80-90% of the moisture in wheat. In this study, it was observed that the moisture content of wheat decreases with time in the experiments due to solar incident radiation. It was found that the drying rate becomes faster at high moisture content. The following graph (4) (5) depicts the hourly basis of moisture content of wheat. It clearly shows that solar dryer exhibits better results in terms of removal of moisture content and the drying process was faster than conventional drying.

B. Moisture removing rate on % dry basis can be calculated using Equation :

$$M_{initial} = \frac{W_w - W_d}{W_w} \times 100 \quad \text{---------- (1)}$$

Where,

$M_{initial}$ is the initial moisture removal rate (%dry basis) ,W_w weight of the wet wheat (g) ,W_d weight of the dry wheat (g).

C. Quantity of heat needed to evaporate the water:

It can be obtained using the following equation , where Q is Amount of energy required for drying process, kJ; hfg = Latent heat of evaporation, kJ/g H2O.

$$Q = Mw \times hfg \text{ ----------(2).}$$

Q=Moisture removed from the product×Latent heat of evaporation

Q=1.0162×2.260kj/ kg

Q=2296.612m^2 kj /kg

During the outdoor usage, the heating of air is achieved from the heat energy of sun rays falling on the solar dryer made of toughened glass. Higher drying temperature results in shorter drying times and the ability to dry to lower its moisture content. Food is not exposed to direct rays of sun, which reduces the loss of colour and vitamins.

The weather conditions such as ambient temperature, incident solar radiation, and relative humidity are the important factors that affect the performance of the solar dryer. For instance, low ambient temperature will increase the convection heat transfer between the whole dryer body and the ambient air increases the heat loss to the surrounding. High incident solar radiation will shorten the time of the drying process due to increase in temperature inside the drying chamber. Ambient temperature and drying air chamber temperature with respect to time is shown in figure 6.

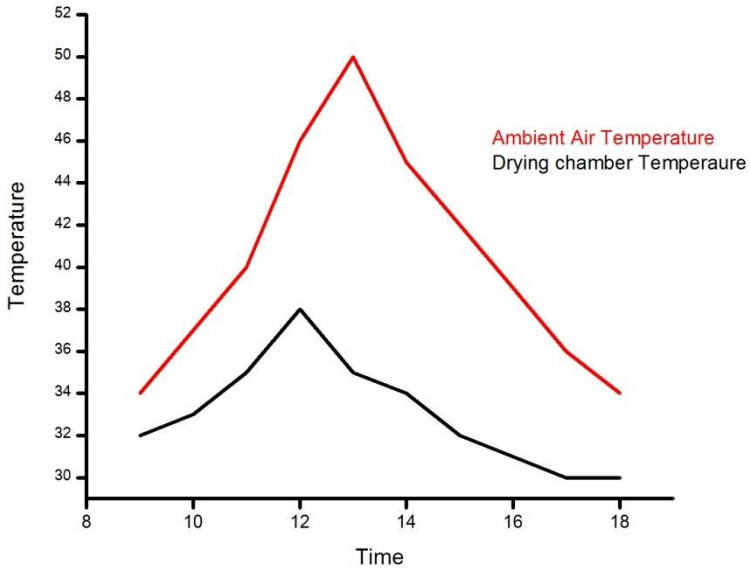

Figure 6. Effect of Ambient air Temperature with respect to time

Similarly ambient air humidity with respect to time is given figure 7. The drying processes were enhanced by the heated air at very low humidity.

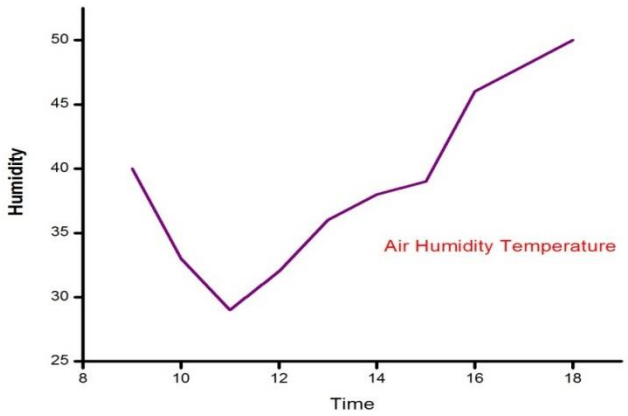

Figure 7. Ambient air humidity with respect to time

It is clear from the figure (8) that temperature increases gradually and slags down as the time passes. The dryer is hotter about mid day when the sun is overhead. The temperature inside the dryer was much higher than the ambient temperature during most hours of the day light. The temperature rises inside drying cabinet for about three hours immediately after 12.00 (noon). This indicates prospect for better performance than open –air sun drying.

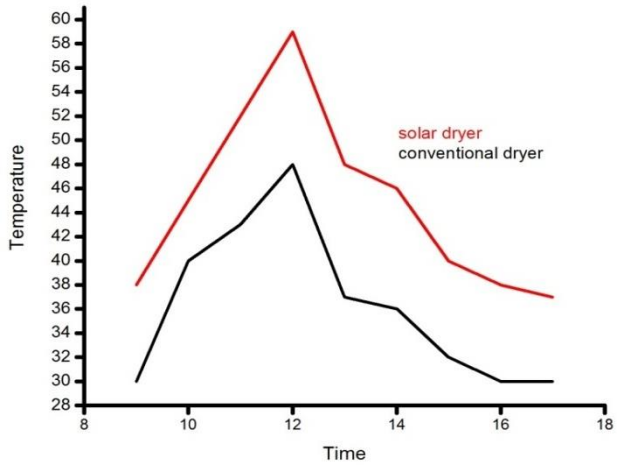

Figure 8. Effect of temperature of solar dryer and conventional drying with respect to Time

Table 1. Proximate principles of solar dryer and conventional dryer

PARAMETER	CONVENTIONAL DRYER	SOLAR DRYER
Protein	13.1g	18.3g
Fat	0.035g	0.115g
Energy	391.25kcal	392.5 kcal
Carbohydrate	70g	96g
Moisture	1.133	5.139

The above Table (1) shows the nutritional composition of wheat both in the conventional dryer and solar dryer. It is very clean that proximate principles of solar dried wheat is rich than conventional dryer. The carbohydrate level of wheat was highest in solar dryer while it was lowering in sundried. Similarly, fat, protein, energy and moisture of the sundried sample were lowered than solar dryer.

Decrease of these macronutrients due to drying may be attributed to the application of heat. Losses of these macronutrients by the application of heat have been reported (Hassan et al., 2009; Agoreyo et al., 2011). Application of heat can be both beneficial and detrimental to nutrients. Heat improves the digestibility of food, promotes palatability and also improves the keeping quality of food, making them safe to eat. Heating process also results in nutritional losses by inducing biochemical and nutritional variation in food composition.

Decrease in protein content of food on the application of heat could be a result of lipid oxidation. Nutrients have been reported to be lost as a result of chemical changes such as oxidation. Lipid oxidation is known to be increase by many factors such as heat, light and radiation. Heat pre-treatment was also reported to decrease to the content of some lipids in Spinach (Cho et al., 2001) due to the application of heat that is capable of destroying them.

IV. CONCLUSION

This paper aimed to study the performance of wheat in solar dryer and natural dryer. It analyzes the moisture content loss during the drying process. Factors that can affect the drying performance namely; the ambient temperature, humidity have been studied. Proximate principles of the sample in solar dryer and conventional dryer were compared well. It is concluded that the more nutrient loss were observed in natural dryer than in solar dryer.

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