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PERFORMANCE COMPARISON OF MOISTURE REMOVAL IN DIRECT SOLAR DRYERS

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Abstract- *Food is one of the most essential fundamental elements for human. It is quite impossible to fulfill everybody's demand of food because of the rapidly growing population of the world. Food preservation is the alternative way to overcome this problem. It is performed by artificial mechanical drying process or by open sun drying process. The first one is more expensive and has adverse effect on environment, while the second one is cheaper and little effect on the environment. As solar energy is an ample and endless energy source, so the conversion of heat energy from sun may be the wisest medium for food-stuffs drying. In this paper, design of a direct solar dryers, and the methodology of the performance investigation of the dryer is described. The objective of the research was designing and investigating cheap, yet, efficient solar dryers for food-stuffs drying at rural areas of Bangladesh.*

Keywords: Solar dryer, Direct solar dryer.

1. INTRODUCTION

Drying is the process of withdrawal of water content from the product by the application of heat and the removal of the released vapor by the air flow around the system. [1]. Drying (or dewatering) is done to obtain the required moisture level. It necessary is to reduce the moisture level of foodstuffs because they have in general a moisture level greater (approximately 25– 80%, in case of agricultural crops around 70%) than those which are well-suited for preservation for a long time. Bythe reduction of water content of foodstuffs to a certain altitude; decrease the effects of molds, enzymes, yeasts, bacteria. In this way foodstuffs can be stocked and preserved for a very long period without adulteration. Another type of drying processis the reduction of moisture until foodstuffs has no water content at all. Dried foodstuffs, can be re-watered and can obtain its basic status [2]. Solar dryers arerelatively cheaper and have higher efficiency. Some solar dryers don't need the application of electrical power or fuel [3].Principal objective of this project is to design a low cost, yet effective solar dryer for drying food. In order to achieve this vital objective, two sub objectives of this project are set: (a) designing and fabricating different types of direct solar dryers. (b) analyzing the drying performance of each dryers separately and compare their performance. Prospective advantages of the proposed dryer will be:

1. Only energy used here is solar energy so cost of fossil fuel and electricity is reduced.
2. The dryer is constructed with wood and glass which makes it cheaper and easier to build.
3. The quality of drying food is good as the performance of the dryer is good.
4. Solar dryer is covered with glass so foods are totally protected from dirt, sudden rain fall in short any kind of contamination.

2. LITERATURE REVIEW

Developingcountries today are facing serious trouble to resolve their food issues for the entire nation as the population is increasing rapidly. This alarming rate of increase in population is directly effecting on food chain stability. The equity between food and population can be maintained by reducing food losses during the harvesting period. On the other hand increasing the food production in rural areas is not easy. In order to solving this issue, drying is becoming the main processing system used to preserve foodstuffs in areas where sunlight is available most of the time [3]. Crop drying is the oldest method for preservation of foodstuffs. The aim of drying is to reduce moisture level from food product so that it can be stored a long time. A survey shows that 20% of the world's total grain is lost after production because of improper handling and poor application of post-harvest management. Grains normally have a moisture level between 18% and 40% and by drying is brought down to a level of 7% to 11% [4]. In a direct-type solar dryer the drying case is built from 1 cm-thick wood and the walls are insulated by glass wool. The leaned wall in the front is glasscoveredfor sunlight to pass through. The rear side has holes to taking out the exhaust air by a fan. The bottom of the front wall can redirect hot air from the solar collector into the cabinet by a centrifugal blower [3].

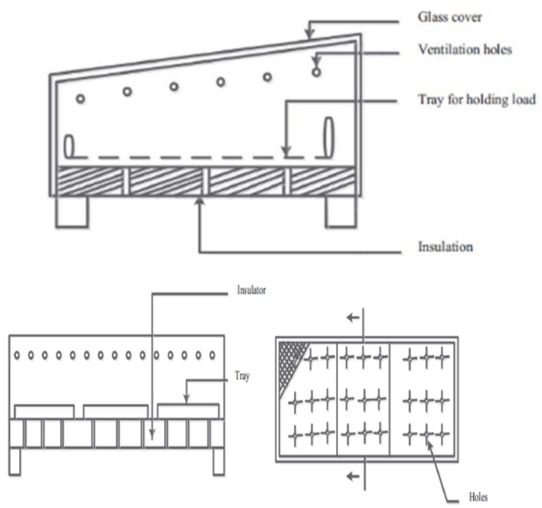


Fig. 1: Direct-type solar dryer [3].

Direct solar dryer is a rectangular box divided intoparallel sections of same size lengthwise. The dryer is covered by glass to produce aconsiderable effect against UV light, thus decrease products photo-degradation. The parts inside the dryers are painted black. As the heating of air inside the box is done by natural convection process so a uniformappreciable air flow through the chamber [5].

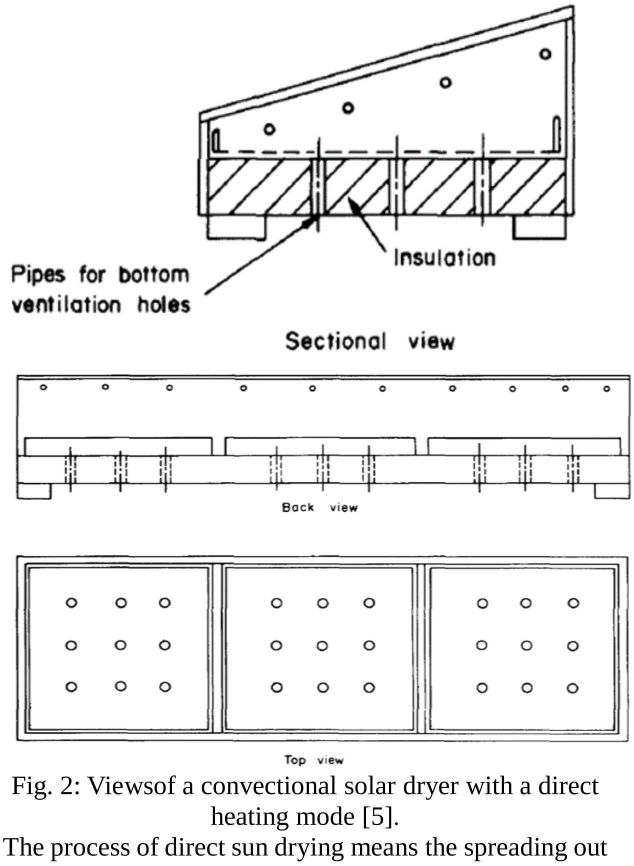


Fig. 2: Viewsof a convectional solar dryer with a direct heating mode [5].

The process of direct sun drying means the spreading out of the stuffs in layers in large outdoor exposed surfaces, till desired moisture level is reached. The surface has gotconcrete built basement with polyethylene covers. As the drying rate is not high so the crops must remain in drying condition for usually 10–30 days, depending on the outdoor condition [2].

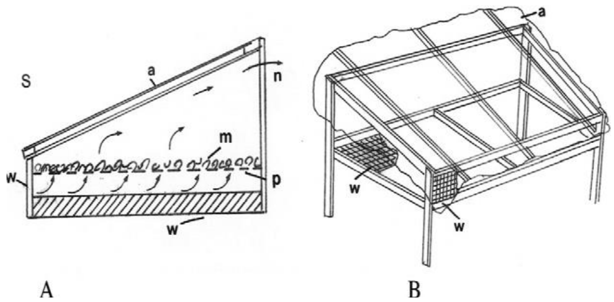


Fig. 3: (A) Greenhouse type solar dryer. (B) Wire basket type solar dryer [2].

3. METHODOLOGY

The first step of our work will be designing and fabrication of the direct solar dryer. Then performance testing in outdoor condition along with data collection and analysis will be done. And the last one is to collect and analyze the data and propose modification.

Fig. 4: Working procedure

3.1 Problem Statement

In Bangladesh mainly fruits and vegetables are involved in the drying process. In villages this is done by directly exposing the products to the Sun, without any external energy source. But contamination is a major issue. For solving this issue solar dryers have been designed and fabricated for small- to medium-scale drying operations. The main problems, however, are (1) to determine the most efficient and cheapest design according to the needs of the users, and (2) promotion among the real users.

3.2 Design of the Proposed Direct Solar Dryers

At first the design of direct solar dryers needs to be formulated by solid works software. The chamber in the left is induced draft chamber (chamber-1), the middle one is v shape (glass) chamber (chamber-2) and the right one is natural draft chamber (chamber-3).

Fig. 5: Different shapes of proposed 'Direct solar dryers'.

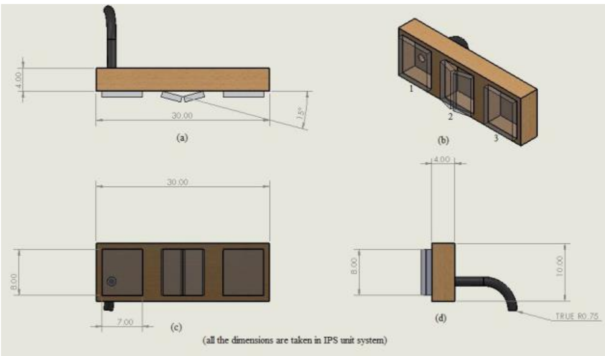
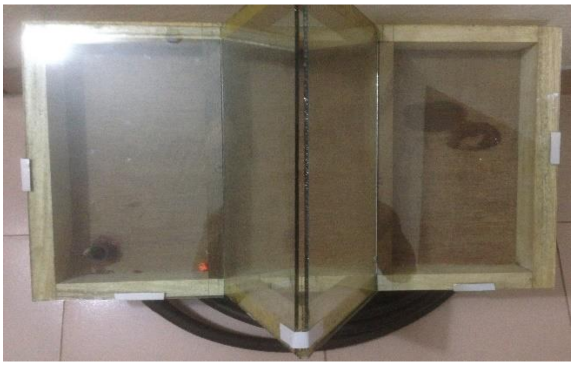


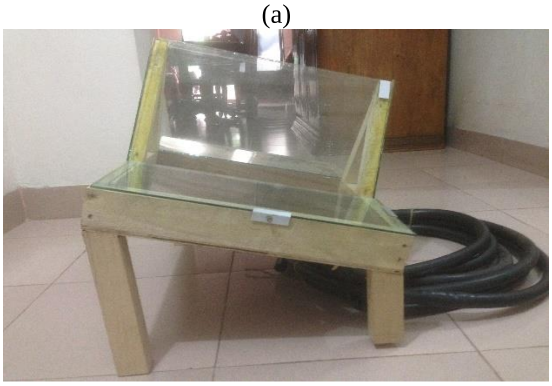
Fig. 6: (a) Top view (b) 3D view (c) front view (d) side view of proposed solar dryers

3.3 Fabrication of the Dryers

The current project is an experimental investigation. The direct solar dryer has three chambers of different shape. A pipe line has been attached with the bottom hole of chamber-1 from roof top to the ground for making induced draft and pipe line is fully air tight. Chamber-2 has been made as like as attic space type (v-shaped) structure in the top portion that two glasses can inclined with each other and there is small space is the upper portion of the v-shaped structure for ventilation. The chamber-3 is a general chamber causing natural draft. The total experimental setup is covered by glasses. The total experimental setup is located at roof top of my residence. For this drying performance investigation some food samples was used such as apple, banana, grape-fruit.



(a)



(b)

(c)

(d)

Fig. 7: (a), (b), (c), (d) Different views of the direct solar dryer.

3.4 Data Collection

Usually the data was collected daily. However, if there was continuous rain, the data collection was stopped. For each Chamber 9 data was collected for 3 samples. There was 3 pieces for each sample. However, the data collection technique was revised and corrected therefore the data was accepted. The data was taken from the 17th June 2018 to 7th August 2018. The data was further modified in such a way that the data was averaged per sample per instance of data collection. The dehydration rate (gm/gm) and average dehydration rate (gm/gm) was calculated from data of each chamber as shown in table. After fabricating the dryer, dehydration rate was measured thrice a day at 11:30am, 2:30pm and 5:30pm.

Fig. 8: Views of experiment performed in direct solar dryers.

4. RESULTS AND ANALYSIS

The data was collected from 17th June 2018 to 7th August 2018. Then the data was taken three times in a day such as 11:30 am, 1:30 pm and 5:30 pm. After analyzing the data the dehydration rate over two time periods such as before 2:30 pm and after 2:30 pm the performance of each chamber can be compared. Banana, apple and grape-fruit were taken as the food samples.

Table 1: Dehydration rate of fruits in three different direct solar dryers

Fruits	Dehydration rate (%)		
	Induced draft chamber	Attic space type chamber	Natural draft chamber
Grape-fruit	44.2%	35%	38.6%
Banana	43.2%	33%	36.9%
Apple	35.7%	30.8%	33.3%

Thedehydration rate of grape-fruit is 44.2% in which 24.1% dehydration is occurred before 2:30 pm and 20.1% dehydration is happened after 2:30 pm in the induced draft chamber. Apple has got a total dehydration rate of 35.7% in the same chamber in which 19.6% dehydration is completed before 2:30 pm and 16.1% dehydration is occurred after 2:30 pm. For banana dehydration rate is 43.2% in where 22.5% dehydration is completed before 2:30 pm and 20.7% dehydration is completed after 2:30 pm. After analyzing the data of induced draft chamber it has observed that the drying rate of grape-fruit is the largest among the samples. Dehydration rate of banana is lower than grape-fruit but higher than apple. In addition, total dehydration rate of induced draft chamber is 41.03% in which 22.07% is occurred before 2:30 pm and 18.96% is completed after 2:30 pm.

In v-shaped glass (attic space) type chamber dehydration rate of grape-fruit is 35% out of which 19% dehydration is occurred before 2:30 pm and 16% dehydration is happened after 2:30 pm. Apple had a total dehydration rate of 30.8 % in this chamber in which 16.4% dehydration is completed before 2:30pm and 14.4% dehydration took place after 2:30 pm. Banana got a dehydration rate is 33% in where 17.9% dehydration is completed before 2:30 pm and 15.1% dehydration is completed after 2:30 pm. After analyzing the dehydration rate of the samples of v-shaped glass (attic space) type chamber it is also seen that the dehydration rate of grape-fruit is the highest among these samples and it is 35% .Dehydration rate of banana is lower than grape-fruit but higher than apple. And lastly total dehydration rate of attic space type chamber is 32.94% out which 17.77% is before 2:30 pm and 15.17% is after 2:30 pm.

In natural draft chamber, the dryingrate of grape-fruit is 38.6% out of which 20.9 % dehydration is occurred before 2:30 pm and 17.7% dehydration is happened after 2:30 pm. Apple obtained atotal dehydration rate of 33.3% in this chamber in which 18% dehydration is completed before 2:30 pm and 15.3% dehydration is occurred after 2:30 pm. For banana dehydration rate is 36.9% in where 20.3% dehydration is completed before 2:30 pm and 16.6% dehydration is completed after 2:30 pm. The dehydration rate of the samples shows that the dehydration rate of grape-fruit is the highest among these samples. Dehydration rate of banana is lower than grape-fruit but higher than apple. It is also observed that total dehydration rate of natural draft chamber is 36.26% in which 19.73% is before 2:30 pm and 16.53% is after 2:30 pm.

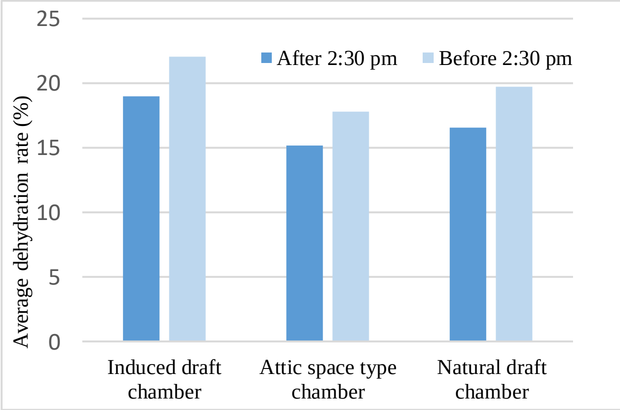


Fig. 9: Variation of average drying rate based on the design of the solar dryer

5. CONCLUSION

Developing countries are facing terrible issues in case of solving their food problems for the entire population because the population is rapidly increasing. This rapid increase of population is directly effectingthe food balance. In order to maintain the correct balance between food and population, reductionof food losses during production time is necessary. Considering these problem, Bangladesh should look forward on solar dryer to preserve food. So here, we have shown the variation of different technology of food drying. So that people can be able to use best technology to preserve food. Bangladesh may appear as role model for preserving food in the world. The outputs of this research are:

1. The drying rate is highest in induced draft chamber, medium in natural draft chamber, and lowest in attic shaped type chamber.
2. The rate of drying is higher before 2.30 pm and becomes lower with time.
3. The rate of drying for apple is lowest, banana has the medium drying rate, grape-fruit has the highest drying rate.

So as a result people will know induced draft chamber direct solar dryer is cheapest and most efficient.

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