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SIMPLE DESIGNING AND FABRICATION OF HOT-AIR DRYER FOR INDUSTRIAL AND LABORATORY PURPOSES

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Abstract

Purpose of the study: The primary purpose of this experiment is to design, fabricate, and test the efficiency of a low-cost hot-air dryer. This type of dryer will help remove the maximum percentage of the moisture from fruits, rice, etc., so that they can be stored for longer times with high nutritional contents.

Methodology: Diameters, length of the column, and mesh size were calculated. The length and width of the pipe were taken as 35 cm 15 cm, respectively. For the purpose of fabrication, metal pipes were selected, welding equipment was used which joins by the fusion of the materials, then some wet particles were put in the mesh for testing, air is blown in the upward direction with high velocity, solid particles blow up in the air, and hot air will remove the moisture of the wet particles in the vapor form after a fixed time mesh was removed and the dried particles were weighed.

Main Findings: The drying process mainly depends on air temperature, velocity, and time. It was found that the food gets spoiled with the high temperature, velocity, and time; this leads to a lower nutritional value. It can dry 1000 kg of particle for 10 hours with 4433.2875 kg of flow air per hour when the temperature driving force for the heat transfer in flow systems is 80.75 can dry 1000 kg of particle for 10 hours with 4433.2875 kg of flow air per hour and the temperature driving force for heat transfer in flow systems is 80.75℃.

Applications of this study: This design type can dry 50 grams of wet particles with 25.4975 kg /s of air when the system's flow temperature is about 45.874℃. The main applications of the design and fabrication presented in this research work are that it will replace some of the costly drying equipment like rotating tray air dryers

Keywords: hot-air dryer, tray air dryer, fabrication, mesh plate, nutritional value, moisture

INTRODUCTION AND LITERATURE REVIEWS

Drying is one of the most common and important method used for the preservation of food. In this process, there is the removal of moisture (Vega-Mercado et al., 2001; Jarayamanan et al., 2006) from a body by evaporation, and for this hot-air dryer is the most commonly used method. If the drying process has not completed, because of the high relative humidity, the growth of the microorganisms (Abonyi et al., 2002) will take place, and the quality of the product gets deteriorated (Kumar et al., 2015). Drying the food products in the open sun in a thin layer is one of the traditional drying methods. It is simple, economical, but in this method, drying was uncontrollable, non-uniform, sometimes rain, rodents, birds, insects, etc. can also affect the dried quality. Therefore, drying (Wu et al., 2004) helps reduce the weight, microbial activity, and deterioration and extending the product shelf life.

In the year 2008, Ajao et al. fabricated and tested a motorized direct low-temperature crop dryer made up of mainly wood and double-layered transparent glass, which functions as a solar collector. Ikejorfor and Okonkwo, in 2010, designed a solar dryer with adjustable airflow rates and a heat storage unit with a drying chamber. The drying chamber was made up of three detachable perforated metal screens to spread the products. It was also covered with a transparent material to allow direct solar radiation on the products. Several published articles discuss different types of dryers, their principles and operations (Bansal et al., 1987; Kumar et al., 2015; Nindo et al., 2003).

Chua et al. (2003) have discussed in their review (Chua et al., 2003) about the low-cost drying technologies for rural farming areas where raw materials and labor are readily available. They proposed that the suitable dryers (Kaleemullah et al., 2005; Schofield et al., 1962) must be of low costs, easy to construct and fabricate with natural materials (Bacelos et al., 2009) available, easy-to-operate, the maintenance must be easier. Behera et al. (2017) designed and fabricated a solar dryer for fisherwomen's sustainable livelihoods. Fisherwomen used to dry fish in clear unhygienic conditions. Such a solar dryer has been designed and fabricated by Behera et al. (Behera et al., 2017) considering system parameters such as inlet temperature of air, humidity, moisture carried by air per minute, and outlet temperature of the air.

Olaniyan et al. (2012), designed a column dryer for paddy rice (Delele et al., 2015) and carried out a preliminary test on the dryer which showed (Olaniyan et al. 2012) that it was able to reduce the moisture content of paddy rice samples from 22.36 % to 13.37 %. Thus, the dryer performed satisfactorily, powered by a 1.0 hp single- phase electric motor, the dryer has a production cost of USD 375 including labor and the cost of electric motor. Silverio et al. (2015) designed a novel rotary dryer for drying fertilizer. They made a comparison of its performance with conventional air- dryers. They found (Silverio et al., 2015) that the drying rate in the deigned hybrid roto-aerated dryer was up to 18-fold higher than that found in the best configuration of the conventional rotary dryer (Arruda et al., 2009; Yeole et al., 2013). This research works is targeted to design, fabricate, and test the efficiency of the hot-air dryer that can be easily used in industries, homes, and laboratories.

METHODOLOGY

Designing of the hot-air dryer

Following are the main equipment required for the designing of the hot-air dryer:

(1) Welding equipment: It is used to create a joint on a work piece. Basically, it joins metals or thermoplastics by the fusion process, which is different from lower temperature metal-joining techniques such as brazing and soldering, where the base metal does not get melted. So, a filler material is often added to the joint to form a pool of molten material (the weld pool) which further cools to form a powerful joint, in addition to heat, pressure can also be used to produce a weld.

(2) Hot Air pump: It works by applying power to the dryer, the motor starts spinning the fan, which in turn draws air in through the air inlets at the sides of the dryer. The main driving force to heat the air is from a coiled wire on an insulating board, and this air is pulled inside the dryer. The wire is made of such a material that is a poor conductor of electricity, so when an electrical charge is sent through it, it becomes hot instead of conducting the charge. When air is drawn into the dryer, it is forced through the barrel of the dryer and travels through the heating element. So in this way, the case is shaped.

Fabrication of the hot-air dryer

Following are the main steps are required for the fabrication of the hot-air dryer:

Firstly, a metal pipe is selected for the fabrication, it is cut in length 35 cm, and width 15 cm (while cutting eye protection and gloves must be taken for the safety), the diameters, length of the column, and the mesh size was calculated. Then test was then performed by placing the weighed number of wet particles in the mesh and then putting it in the column. After this, switched the hot air device, and air is allowed to flow through a column in an upward direction with the velocity greater than the settling rate of the particles. It was observed that the solid particles would be blown up and become suspended in the air stream and the hot air will start to heat the wet particles, and so the moisture inside the particles will get removed by hot air and will convert into vapor where it moves up, and through a thin pipe, it can be recovered. After 1 hr or 45 min, the column to be cooled for 30 min, the mesh was removed, and the dried particle/sample was weighed.

RESULTS AND DISCUSSION

Because of the presence of the enzyme- polyphenol oxidase, some fruits (Chang et al., 2006) are darken up when exposed to the air. So, to avoid such darkening, the fruits are treated with sulfur compounds known as sulfites, which can cause potentially severe allergic reactions in sensitive individuals. Thus there is the need for the type of dryer so that the fruits etc. can be dried any without the use of chemicals or preservatives.

Drying apple test

A fresh and clean apple was cut in four pieces, with each having different thicknesses (0.2, 0.3, 0.4, and 0.5 cm), weighed, and put in the mesh of dryer without the addition of any chemicals. Then it was put in a hot air device at 45.874 ℃ of temperature in the flow system for one hour (figure 1). After one hour, pieces were taken out (figure 2) and weighed to calculate the percentage of moisture removed from each piece. The results of the test shown below in table 1.

Figure 1: Apple pieces placed into dryer

Figure 2: Apple pieces after drying

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Table 1: % of moisture removed from apple pieces

Pieces (slices)	1	2	3	4
Thickness (cm)	0.2	0.3	0.4	0.5
Start weight (g)	1.552	1.744	1.77	4.342
End weight (g)	0.221	0.257	0.261	0.728
Difference (g)	1.331	1.487	1.509	3.614
% moisture removed	85.76	85.26	85.25	83.23

Table 1 shows that the rate of moisture removal is faster in pieces 1, 2, and 3 because their thickness is less than the fourth piece, so their weights are also different. It must be noted that no color difference was observed for the pieces before and after drying. Figure 3 shows the relationship between thickness and moisture removed in one hour.

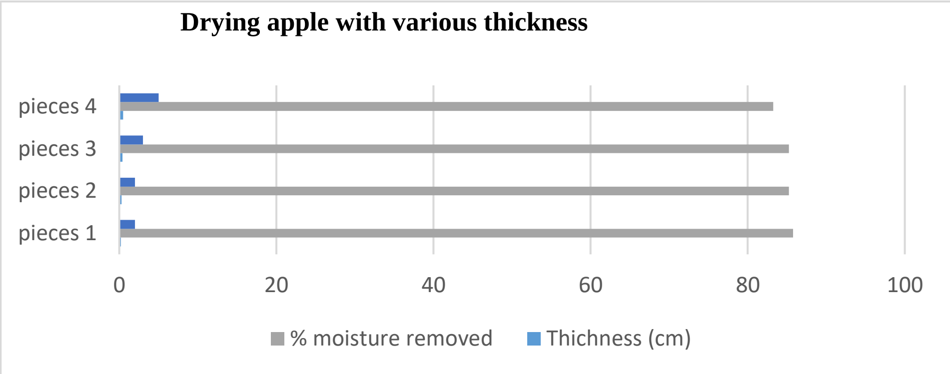

Figure 3: Relationship between apple thickness and percentage moisture removed

Drying rice test

50 g of rice was taken and divided into two parts. Part-1 and Part-2 were kept in the hot-air dryer at 45.874 ℃ temperature in the flow system for one hour, and 30 min, respectively (figure 4), and moisture removed from each part was calculated. The results obtained are shown in table-2.

Figure 4: Drying rice test

Table 2: percentage of moisture removed from rice parts

Part	1	2
Start weight in (gram)	50.025 g	50.036 g
End weight in (gram)	44.554 g	46.536 g
Removed moisture	10.936%	6.99%
Time	1 hour	30 min

The percentage of natural moisture in the rice taken was 12%, but after drying the rice part-1 and part-2, for 1 hour and 30 minutes, the percentage of moisture removed was obtained to be equal to 10.936% and 6.99% respectively. Figure 5 shows a relationship between the time and percentage of moisture removed for the two rice parts.

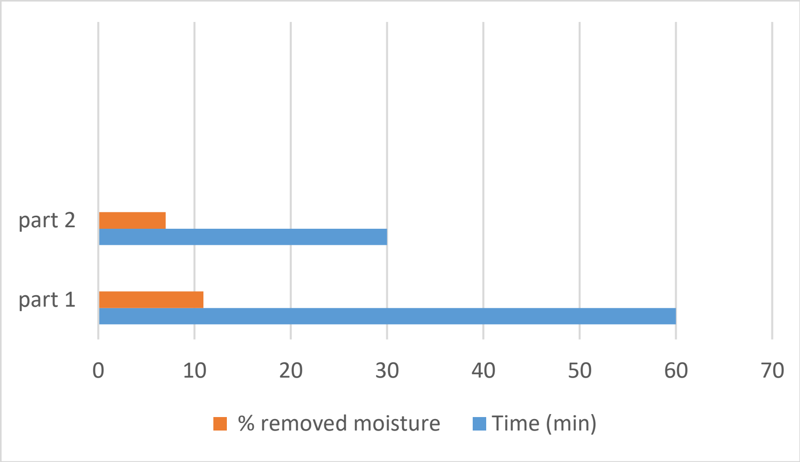

Figure 5: Relationship between the time and percentage of moisture removed

Drying rice test with 32.872% of moisture:

50 g of rice was weighed, and 100 ml of distilled water was added to it, left for one day. Next day water was removed, and the percentage of moisture was observed and then put it into the hot-air dryer, left for one hour, then taken out and weighed to get the percentage of moisture removed, results for this test are shown in the table 3.

Table 3: percentage of moisture removed from rice with 32.872% of moisture

Start weight (gram)	50.025
Weight with moisture (gram)	66.56
End weight (gram)	38.047
% moisture before drying	32.872
% removed moisture	42.84

Table 3 clearly shows that the end weight observed was less, mainly due to the removal of moisture and the weight before and after drying was also different because approximately 9.968% of natural moisture was removed during drying.

CONCLUSION

Based on the results discussed, it is clear that the drying process mainly depends on the air, temperature, velocity, and time. For example, if there is an increase in the temperature and velocity, the food will get more deteriorated, leading to a high loss of nutritional values. In the same way, if food is kept for greater time in the dryer, the nutritional value will be decreased as was seen in the case of drying ice with 32% moisture, here it was observed that the percent moisture before drying was 32.872%. The percent of the moisture removed was 42.84 %, so the rice was broken. Similarly, in the case of fruits, it was concluded from the results that the best cutting size was 0.4 cm; when it was dried for 40 – 45 minutes, at 45.874 ℃ of temperature, almost 85% of moisture was removed. This research can become the most significant replacement of some highly expensive drying equipment's such as rotating tray air dryers because the mesh plate used here can function as a heat exchanger. Its velocity is the same as that of rotating tray air dryer, i.e., 1 -2 m/s. If the system's flow temperature is about 45.874℃, this design could dry grams of wet particles with 25.4975 kg /s of air.

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