RESEARCH PAPER
J. Food Sci. Technol. Nepal, Vol. 8 (18-22) 2013
ISSN: 1816-0727

Grape Dryer Using Infrared Radiation : An Experimental Study

JOSHI SNEHAL SANTOSH* and JOSHI SANTOSH VISHNU[2]

[1]Department of Applied Sciences & Maths, K.K.Wagh Institute of Engineering Education & Research, Amrut Dham, Panchavati, Nashik, Maharashtra, India-422003
[2]Department of Electronics and Communication Engineering, K.K.Wagh Women's Polytechnic, Amrut Dham, Panchavati, Nashik, Maharashtra, India-422003.

* Corresponding author: **ss.sci@gmail.com**

Preserving fruits by drying is an important operation continued from prehistoric period. Infrared radiation can be used for grape drying purpose. It is unique process and distinctly different from conventional or natural drying. The infrared radiations accelerate drying process with a better control to achieve uniform drying, reduced drying time and ultimately improved product quality. Besides, it requires less floor space and compact system are the additional advantages. In this paper existing natural grape drying process is modified with suitable enclosure containing IR radiators and allied system. Appropriate sensors are used to measure parameters like humidity, temperature and weight of sample. Experimental analysis done with the help of dryer proves the uniform drying of the grapes with the help of infrared radiation. The original color of grapes is better conserved as the drying takes place at low temperature. The drying time is reduced to a significant level as compared to natural drying process.

Keywords : Grape drying, infrared radiation, temperature and humidity controller

Introduction

In India different types of fruits and vegetables are available in various regions of the country. All these agricultural products grows in different seasons and in a particular area only. These agricultural products are used by people all over India and abroad. India produces 1.2 million metric tonnes of grapes, which makes a share of 1.83 percent of the world production and 3 percent of the total fruit production in the country. India has achieved the highest productivity of 20 tonnes/ha in the production of table grapes. Presently in India about 78 percent of grape is used for table purpose, nearly 17-20 percent is dried for raisin production, while 1.5 percent is used for juice and only 0.5 percent is used in manufacturing wine. (Oulkar, 2012). Hence, it requires a proper preservation as agricultural products are always prone to spoil.

Direct consumption of grapes is a major share, and once harvested it should be consumed within a short span time. Also during the bumper harvest , traders intentionally slow down the process of buying grapes and under such circumstances, since the crop is prone to spoilage, the farmers are left with no choice but to sell at throw away prices (Panghavane,2009). Hence, it is required to utilize it within a short interval of time either in the form of production of raisins as a dry-fruit for direct consumption or some amount of grapes are diverted for wine or champagne production as only few factories are existing for this purpose.

Raisins are produced by different techniques all over the world. But the time required for the process of drying and quality of raisins produced is different by different techniques. United States of America, Afghanistan, Iran, Turkistan are the major exporters of raisins. In American golden bleached process, grape bunches are dipped in either potassium carbonate or sodium hydroxide solution for few seconds (Osman *et.al*., 2008). These processed grapes are washed with normal water. This operation produces cracks on the surface of the gapes so that the moisture can easily come out of the cuticle during drying process.

In Afghanistan, natural shade drying process is very popular as it is easy and cost effective. It gives results in three to four weeks. In Australian, cold dipping process is used where the grape clusters are dipped into potassium carbonate and ethyl oleate for few minutes (Osman *et.al.,* 2008). During processing cracks are generated on the grapes, thus the grapes are ready for further processing. In India, natural drying methods such as shade drying and sun drying are used for raisin making (Horticulture Crops, 1993). But this process have few drawbacks:

1. The drying process is carried out manually and do not have any control.
2. The uniform spreading of grapes on mesh and cleaning of surrounding area is done manually.
3. The area required to dry the grapes is very large, thus misutilization of the valuable agricultural land. The investment on space and infrastructure is very large and cannot be afford by small farmer.
4. The drying process is long lasting of about 15 to 20 days.
5. Quality of raisins is not uniform.
6. The drying process is not possible in adverse weather condition.
7. Continuous monitoring is required to control the birds from eating grapes.
8. Dust from external environment degrades the quality of product.
9. Mechanical dryer cannot control the temperature and humidity during drying process.

To overcome all these difficulties the automation of drying process is needed. (Gawade *et.al*., 2003). The paper explains the prototype model of grape dryer developed for study of effect of infrared radiation on grapes and to produce the raisins without changing its nutritional value and natural color with optimized dehydration system. The developed dryer ensures the drying in poor weather condition due to enclosed chamber with controlled environment using automation process that is suitable for raisin production. The time required by the dryer is few hours in comparison with natural drying (Pangavhane,2009). Raisins have large market worldwide and can boost the economy of farmers. The returns are much higher than those obtained by marketing of fresh grapes and hence farmer's profitability can be increased by increasing raisin production.

Material and Methods

Experimental Set Up

Figure 1 gives the sketch of the dryer. It consists of drying chamber which is designed in such a way that inlet air can be uniformly blown through the grapes placed in tray with the help of two exhaust fan. Stainless steel trays with 1mm spacing mesh is used. The tray is placed on digital weighing machine to monitor the weight of grapes during the drying process. The infrared radiations are used to dry the grapes. A bank of infrared LEDs is used as IR radiation. The bank of LEDs is constructed on printed circuit board The LEDs are arranged in a 12×12 matrix. The intensity of infrared radiation can be changed by changing the order of array of matrix. More the intensity of light , more will be the rate of evaporation from berries. The temperature near the grapes is controlled by changing the distance between the LED bank and the tray inside the chamber. These IR radiations deeply penetrate the grapes to make the dehydration fast. Humidity inside the drying chamber is monitored and controlled by the speed of inlet fan and outlet fan.

Temperature sensing

For temperature sensing, current source sensor AD590 has been used. It has a resolution of 1μA/ K, by using channel one of LM324 the current signal is converted to voltage signal as well as amplified according to the resolution required and is fed to the analog channel zero (AN0) of the analog to digital converter in the micro-controller.

Humidity sensing

In the dryer humidity sensor (Honeywell PHS-220) having a resolution of 33 mV/ %RH with a range of up to 95 % RH works on supply voltage of 5 V dc. The output is amplified for increasing resolution and is fed to micro-controller.

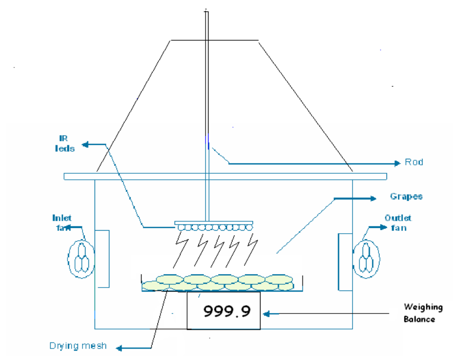

Figure 1. Experimental set up of dryer

Sample preparation

Berries were separated from the grape bunches. It is dip into fresh water. Rinse and clean it properly. Throw the used water. Take again 500mL fresh water and add 10 g of NaOH and ethyl oleate , stir it until gets dissolved. Dip the berries into the solution for 2 min. It removes the waxy layer on the berries and develops minute cracks on the surface of skin through which moisture gets evaporated and the drying is speeded up (Oulkar, 2012). Grapes were rinsed with fresh water. Now the grapes are ready for processing. Collect all berries and put into mesh which is inside the chamber.

Experimental procedure

Drying is the removal of moisture from the substance. Many moisture measurement techniques are available but most of them are off-lline. The moisture contents of a substance is expressed in terms of either moisture contents on wet basis (MCWB) or moisture contents on dry basis (MCDB). But the moisture content on dry basis is always preferred. As moisture is removed, weight loss takes place in substance to be dried . The weight loss of substance is directly proportional to moisture removal. Moisture level of 12 to 15% in the product gives a dry and hard feel the product, while 15-18% may give a feel of wet and soft product. Therefore, a moisture level of 15-16.5% is an appropriate range keeping in view the softness of the product, organoleptic qualities including mouth feel, protection from microbial spoilage and production from chemical changes. (Oulkar, 2012). Drying of grapes is done by creating a moisture gradient within and outside the product, the higher the gradient faster is the rate of drying.

As the IR source is on, the energy is transfer from IR source to berries, the moisture comes out of the berries through the cracks generated during chemical treatment. Therefore, humidity inside the chamber will increase. This humid air is replaced by fresh air using fans. The temperature inside the chamber will increase due to IR radiation and hence the rate of evaporation through berry will increase ,thus drying takes place. The weight of the berries will be reduced due to loss of water.

Theoretical Considerations

As shown in Figure 2 when the IR radiation is imparted on the processed grapes the water molecules inside the grapes gets heated. Due to the capillary action taking place inside the grapes, the water molecules are coming towards the surface. Water vapor leaves the surface of the grapes and increases the humidity of the chamber. Through inlet fan fresh air is coming in and the humid air is removed out of the chamber. As the moisture is removed from grapes, it shrinks. The pressure inside the grapes increases thereby creating a pressure gradient. In this way the drying process continues till it removes the desired moisture. Both over drying and under drying are harmful for agricultural products. Over drying causes discoloration due to caramelization and reduction in nutritional value. On the other hand, under drying or slow drying results in deterioration of food quality due to fungal and bacterial action. The grape skin ruptures for drying air temperature at 80°C. The raisins produced due to their sticky surface are not considered to be of good quality. In the first phase (60 % of total drying time) the drying rate is faster. While in the second phase (40 % of total drying time) the drying rate is slowed down due to thick collapsed cuticle and IR heat plays a very important role in penetrating the heat and remove the moisture in the second phase (Joshi *et.al*., 2007). The relative humidity for drying should be maintained between 12 to 18%. Relative humidity less than 12% would loose the smooth texture of skin of raisin, which will result in poor quality raisins (Ladaniya *et.al*.,2005). It is advantageous to monitor and control the temperature (less than 50°C), humidity (12 to 18%) and air flow inside the chamber.

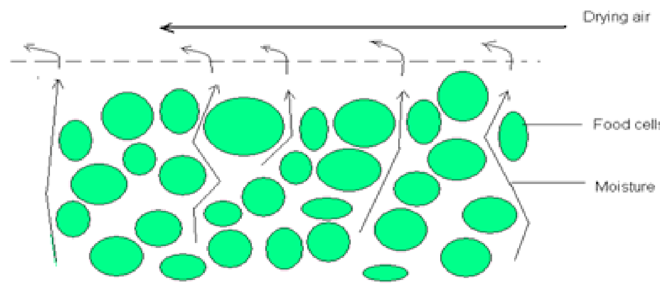

Figure 2. Movement of water from the food while being dried

Experimental measurements

The temperature inside the enclosure produced by IR radiation was sensed by using solid state temperature sensor (PT-100) . Increase in temperature accelerates the rate of evaporation of water from berries, hence water in the form of vapor is coming out of berries increasing humidity inside the enclosure which is sensed by capacitive humidity sensor. As this humidity inside the enclosure is more than the reference humidity which is set using microcontroller, the speed of fan is changing accordingly. The process of humid air removal from enclosure takes place until the weight of product reaches to 30% of its original weight. As the moisture is removed from berries weight of berries reduces. It is sensed by load cell . When the weight reaches to 30 % of its original weight, the system is shutdown automatically.

The dryer is tested for 2 kg of grapes to study the optimum period required to dry the grapes without losing its nutritional value and natural color. During drying the distance of IR source from the grapes , the humidity and temperature inside the chamber are varied. The grapes used for experimentation was Thomson Seedless. After preparing the sample by chemical process the temperature and relative humidity maintained inside the dryer was 30°C and 12%. The speed of fan was maintained at 2500 RPM. Table 1 gives the observations of dependence of processing time on the weight of grapes with the change in the distance of IR source from grapes. Fig. 3 shows it graphically.

Table 2 gives the effect of speed of fan on drying time by keeping the temperature 29°C and relative humidity 18% and distance 08 cm of grapes from the source. Fig. 4 gives the graphical representation.

Table 1. Parameters variation

No. of LEDs	Distance from source (cm)	Time for processing (Hrs.)
144	10	22
144	08	20
144	05	16

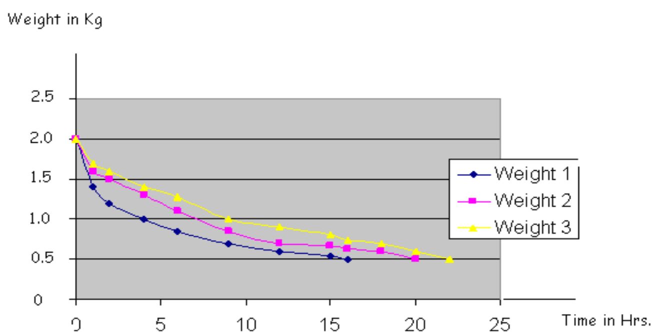

Figure 3. Effect of distnce from the source on weight loss during drying

Table 2. Parameters variation

No. of LEDs	Distance from source (cm)	Speed of Fans (rpm)	Time for processing (h)
144	08	1250	22
144	08	2500	16

Results and Discussion

Moisture removal rate is high in early stage of drying. It is observed that approximately 60 % moisture is removed in 30% of total drying time. In early stage of drying process, more water is coming out of cutical and converted into vapor which are removed by fresh air. Hence continuous removal of moist air takes place using fans and moisture level in the grape is maintained at 15-18% . Thus the drying time is reduced to 16 to 22 hours against 15 to 20 days required by natural drying process.

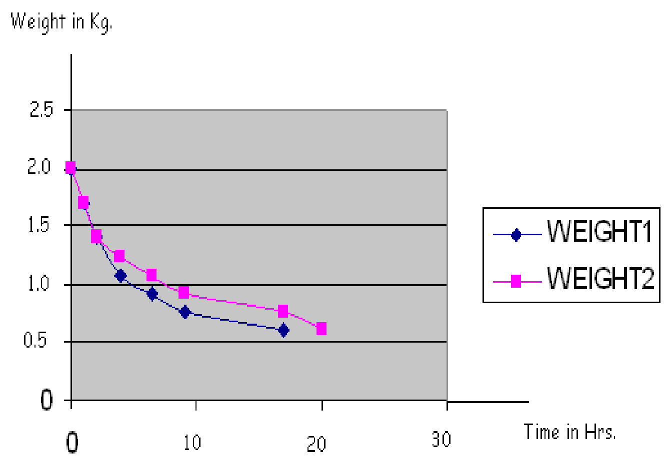

Figure 4. Effect of speed of the fan on weight loss during drying

Number of LEDs are 144. Approximately power consumed by LED bank is 15 Watts. Also two fans consumed 80 Watts power. So total power consumed during processing by the dryer is 1600 watts (approx).

The drying rate was optimized further by keeping the fan speed initially to compensate for faster drying rate and keeping the fan speed low during the slow drying rate later . The drying phases were judged by the weight criteria. As the speed of fans are increased, the processing becomes faster.

It is also observed that more the distance of the IR source from the grapes the more will be the processing period. Thus the dryer is found out to produce green raisins with soft texture and natural taste.

Conclusions

The study has clearly brought out that the dryer produces soft raisins with low power consumption and reduced drying time around 16 to 22 hours as compared to natural drying of 15 to 20 days. The green grapes have chlorophyll contents which are not destroyed during the drying process as it is being carried out at low temperatures (ambient temperatures + 3 to 4°C).

Acknowledgement

I take this opportunity to express my deep sense of gratitude to the Director, BCUD, Pune University, Pune, Maharashtra, India, for sanctioning me the grant of Rs.

2 Lakhs for this research project. I am also thankful to the Principal and Management of K.K.Wagh Institute of Engineering, Education and Research, Nashik, for their continuous encouragement and support during the project work. I am also thankful to all those who have extended their direct and in-direct help and co-operation during the project.

References

Chhada, K.L. S.D., Shikhamani, (2011). The grape – improvement , production and post-harvest management, Malhotra Publishing House, New Delhi, India.

Elepano, A. R. and Satairapan, K. T. (2001). A solar biomass dryer for pineapple. A paper presented at 51th Phillipines Society of Agricultural Engineers National Convention, Cebu City.

Gawade, B.J., Jadhav, M.S. and Nimbalkar, C.A. (2003). Effect of different methods of raisins making from giberelic acid treated Thomson seedless grapes on quality of raisins in storage. *Journal of Soil and Crops*, 13 (1):101-107.

George, S.D., Cenkowski, S. and Muir, W.E. (2004). A review of drying technologies for the preservation of nutritional compounds in waxy skinned fruit ASAE

The society for Engineering in Agricultural,

Food and Biological Systems, Paper Number: MB04-104.

Goyal, N.C. and Khetan, R.K. Monograph of Electronics Design principles.

Ismile, O., Keyf, S., Beyribey, B. and, Corbacioglu, B. (2008). Effect of dipping solutions on air-Drying rates of the seedless grapes. *Food sci. Technol. Res.*,14(6),547-552.

Jambhale, A.S. and Barradekar, B.V. (2008). Microwave drying system with high-tech phase controller: a modified applicator. World Academy Science, Engineering and Technology, 46.

Joshi , S.V. and Vasvi, S.N. (2007). Microcontroller based grape dryer .

Ladaniya, M.S., Wanjari, V. and Hahalle, B. (2005). Marketing of grapes and raisins and post harvest losses of fresh grapes in Maharashtra Indian. *J. Agric.Res.* 39(3):167-176.

Oulkar, D.P. (2012). Fate of agrochemicals during processing of grapes to raisins, *shodhganga.inflibnet.ac.**in**/bitstream/10603/4096.*

Panghavane, D. R. (2009). Comparative drying performance study of natural convection solar dryer with traditional grape drying methods.