



PERFORMANCE IMPROVISATION OF CONVENTIONAL GRAPE DRYING METHOD BY INTRODUCING FORCED AIR EXHAUST

¹Mr. Amol Ubale, ²Dr. Dilip R. Pangavhane, ³Dr. Arundhati Warke

¹Assistant Professor, ³Professor

Symbiosis Institute of Technology (SIT),
Symbiosis International University (SIU),
Lavale, Pune-412115, Maharashtra, INDIA.

²Principal & Professor

K..J. Somaiya Institute of Engg. & IT
Mumbai University, Mumbai.

Eastern Express Highway, Near Everard Nagar, Sion (East), Mumbai – 400 022, Maharashtra, INDIA.

Abstract: In present work demonstrates experimentally that if the drying air velocity is kept constant and more than ambient air, drying rate increases by 7%. The natural convection shade drying is compared with the forced exhaust air by using a turbo ventilator fan of 24" diameter. The comparison is made for the 50 kg of the Thomson seedless grapes kept in two different compartments. A part of the grape shade (6'x6'x10') is isolated from sides by using polyethylene film of 6mil thick to avoid direct air flow in horizontal direction. The isolated shade has observed less humidity in night hours by 8-12%. The main focus during the experimentation is kept on maintaining the real time environmental conditions as it was missing in most of the previous research work.

Key words: Air velocity, Drying rate, Turbo ventilator fan, Grape dryer,

I. Introduction

Grapes are one of the most popular and palatable fruit in the world. Drying the grapes produces raisins which have good business value. Drying shades are available nearby the crop cultivation region in India. In the conventional shade drying method it is found that the rate of drying depends upon air temperature and air velocity [1]. Drying of grape either by conventional or non conventional methods produces raisins. Raisins produced either by conventional or non conventional method becomes brownish as the length of drying exceeds more than 15-18 days [2].

The drying period in traditional dryers is around two weeks [2, 3]. Many times due to some or other reasons like cloudy weather or unseasonal showers, the effective days for drying increases which affects the quality of raisins. Hence, it is necessary to reduce the drying time.

In conventional drying of the crops, ambient air temperature and natural wind are taken into consideration as sources of energy and moisture removal. These parameters are disproportionate and unpredictable. In the past literature the main focus is kept on the practical adaptability. Most of the times it is observed that the experiments carried out are under known and controlled environment. But in practice the environment changes with time and hence it generates errors during commercializing of product. The factors affecting the production cost such as skilled labour, availability of raw material, purchases and maintenance must be considered before selecting the dryer. Further the unskilled labour and land requirement depend on the capacity of dryer. The dryer should be designed by considering its versatility to be used for variety of food and adaptable to local conditions [4].

Based on the past literature review and the reported experimental results it is found that because of high temperature the moisture removal rate is high during the day time [5, 6]. However during the night hours the surrounding temperature drops up-to 19°C, which is quite low to remove the moisture from the grapes. Due to this low temperature moisture gets accumulated on the grapes [7]. This increases the load on drying system. For small capacity dryers up to 10 Kg the amount of moisture built up is very less inside the dryer. While in case of large capacity dryer or traditional driers the moisture content inside the dryer is considerably high that increases the drying period.

In view of this modified drying process is presented in this paper. In this process a turbo ventilator fan which works as an exhaust fan is used that removes the moisture content from the dryer. In this modified process changes in the environmental conditions are also considered so as to minimize the errors observed in the conventional methods which help in commercializing the product.

II. Materials and Methodology

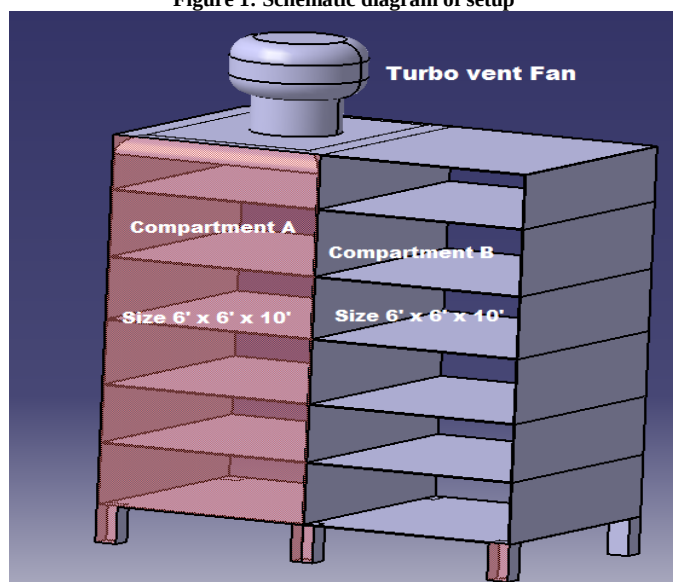
In the present study both forced exhaust and traditional drying systems are compared. Forced exhaust drying system is shown in figure 1. The real time data from experimentation is compared with the traditional drying system data. The data for conventional grape drying based on shade type drying is collected from grape shade at Bavi, Solapur Dist, Maharashtra (INDIA). This place is located at 17° 56' N / 75° 25' E with average air velocity of 1.5-2.2 m/s.

The experimental setup consists of two sections (A and B). Out of which one section (A) having dimension 6'x6'x10' of the conventional grape dryer is covered with 6mil thick polyethylene film so that direct wind contact from side is avoided. Ground clearance of 1.5 feet is kept to have proper ventilation. On the top of dryer shade 12 mil thick polyethylene film is placed with opening for the turbo ventilator fan. A 24" turbo ventilator fan is fixed on compartment "A" which continuously expels the air from dryer and fresh air enters from bottom of the system. In this set up compartment "B" is kept open to the atmosphere which allows air to flow in horizontal direction. In both compartments "A" and "B" Thompson seedless grapes of 25 Kg each are placed on 5 racks respectively. For measuring the moisture content three grapes bunch from each tray are selected at random and tagged for identification. Uniformity in physical shape is ensured by selecting the grapes from the same lot. Spoiled and damaged ones are removed from the bunch to avoid fungal infection. Traditional pre-drying process is carried out such as size sorting, washing and alkali dipping.

To improve water permeability the grapes are pretreated with 2.5% dipping oil and 2% Na_2O_3 . This treatment increases the drying rate [8, 9]. To get better realistic results 50 kg grapes are spread over all racks made up of 1mm thin aluminum alloy mesh equally on both sides. To avoid corrosion aluminum alloy mesh is used. On selected samples weighing is done with a weigh balance of accuracy 1grams (Accuracy of ± 1 grams) is done per hour on each day i.e. morning 7am to evening 7pm [1, 10]. In night hours the readings were taken at 9 pm, 12 pm and next day morning at 4 am and so on. The moisture content/humidity and temperature in the vicinity of each tray is also monitored on hourly basis during day and night hours.

For temperature measurement RTD Pt-100 sensors (accuracy $\pm 0.1^\circ\text{C}$) with microcontroller reading facility having 12 channel selector switches is employed. On each tray one sensor is placed at the centre to measure temperature T_1 to T_{10} and for inlet temperature of air T_{11} is fixed at the bottom of all trays measuring with T_{12} placed near to turbo vent fan. Air velocity is measured for all reading with anemometer (accuracy 0.1m/s).

Figure 1: Schematic diagram of setup



III. Results and discussions

Experimental data is collected during the day time from 7am to 7pm at various location and all racks. Temperatures, relative humidity and air velocity in all racks from T_1 to T_{10} and ambient air temperatures T_{11} & T_{12} is measured on hourly basis. During night hours the reading of humidity, temperatures and air velocity are taken at specified time intervals. The grape bunches are kept without removing the berries from bronchi. It is assumed that the weight of the bronchi is very small (it is around 2-5% of total berries weight and moisture content of is around 40% on weight basis) as compared to the weight of the all berries hence the moisture content of bronchi is neglected. Three bunches of the grapes nearly weighing same, are selected from each tray and averaging is done for finding the moisture ratio and drying rate. The initial mass ' M_o ' (Wb) and the final mass ' M_i ' (Wb) is measured by weighing balance. The samples are recorded at an interval of 1 hour for entire testing period of nine days. The moisture content on wet basis (M_w) is given as [2, 4, 7, and 11].

$$\text{Moisture content, } M_w = \frac{M_o - M_1}{M_o} \quad (1)$$

$$\text{Moisture ratio, } MR = \frac{M - M_e}{M_o - M_e} \quad (2)$$

Where, MR (dimensionless ratio) is the moisture ratio, M (Wb) is moisture content at any time (t in hrs.) M_e is the equilibrium moisture content (Kg of water/Kg of dry matter)

$$\text{Drying rate, } DR = \frac{MR}{Dt} \quad (3)$$

Where Dt is time in hrs. at given interval.

Figure 2 to 4 show the day 1, 5, 9 data for relative humidity versus temperature for entire day at specified time intervals in compartment "A" and "B".

Figure 2: Relative humidity Vs air temp in Comp A & B for Day 1

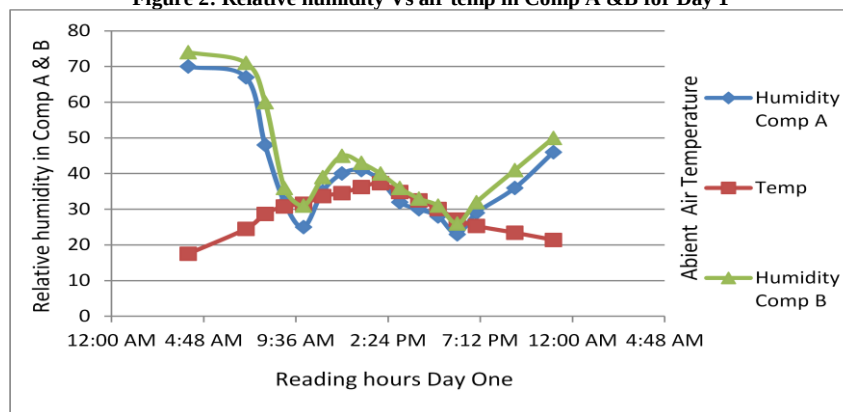


Figure 3: Relative humidity Vs air temp in Comp A & B for Day 5

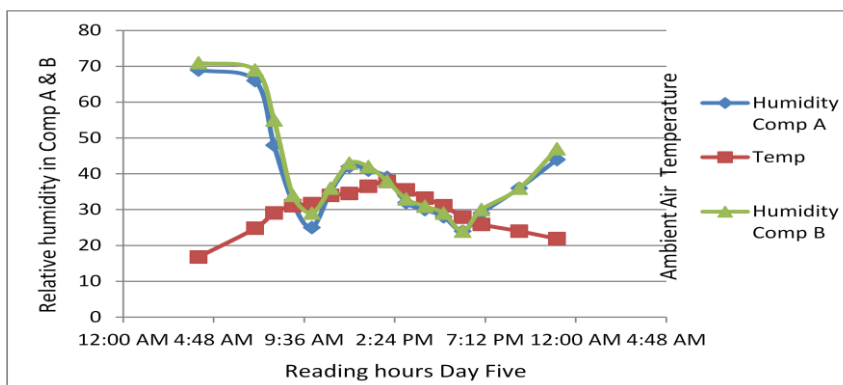
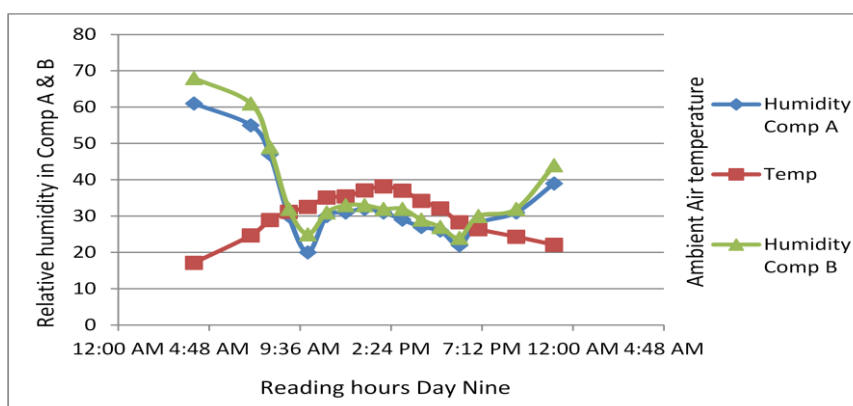


Figure 4: Relative humidity Vs air temp in Comp A & B for Day 9



It is observed that there is no significant change in the temperature (1°C to 1.5°C) from first day to ninth day. The relative humidity in compartment "A" is decreasing from first day to ninth day (RH 70% to RH 61%). This

is due to the decrease in moisture content of the grapes. Further during night time relative humidity is less in compartment “A” as compare to compartment “B” (for example, RH 46% to RH 39% in compartment “A” and RH 50% to RH 44% in compartment “B” at 4 am.) This is because the exhaust fan is removing the humid air from compartment.

Figure 5: Moisture removed Vs Drying Time

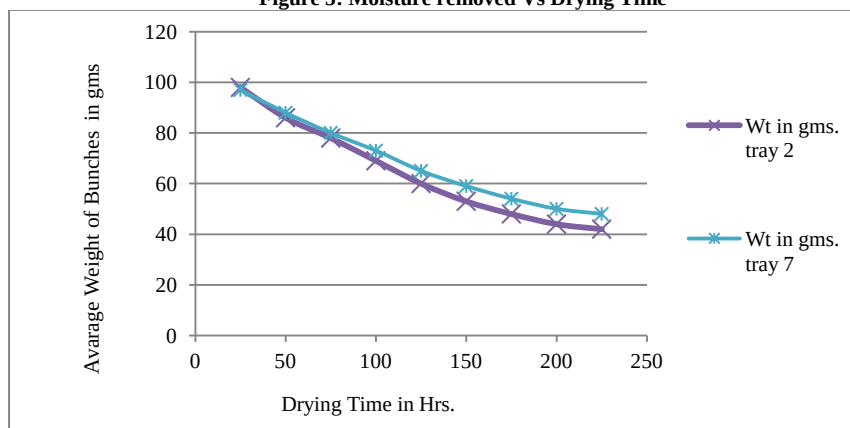
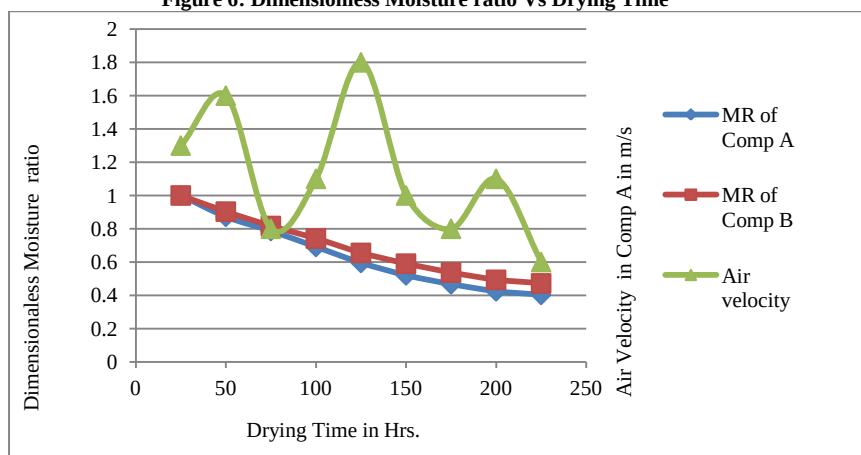
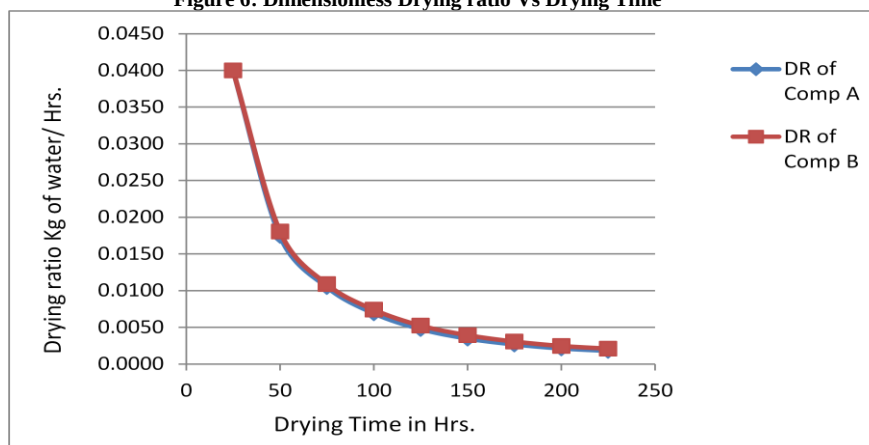


Figure 6: Dimensionless Moisture ratio Vs Drying Time



Highest humidity is observed in rack number 2 and 3 from bottom on either side, hence grape bunches are selected from these racks for comparing the total moisture removed from grapes with drying time. In compartment “A” it is noticed that moisture is removed at faster rate i.e., moisture ratio is 5-7% more than compartment “B”.

Figure 6: Dimensionless Drying ratio Vs Drying Time



A small but noticeable difference in drying ratio is observed in either side of compartments. The difference of 1.8 grams to 2.1 grams per hour is observed. For finding out the drying kinetics various mathematical models

like Newton, Page etc [2, 5, 7, 9, 11, and 12]; are tested with certain modification. These models show best results for thin layer drying phenomenon. The researchers have developed mathematical models for thin layer drying. The deep layer drying model for grapes could be a promising research area where lot of scope and gap are observed in the literature. Finding the deep layer best fitted model for grape drying can be developed in future.

IV. Conclusions

This study is carried out at preliminary stage to study in depth, the analysis of grape drying by forced convection method. The performance of the modified drier is found to be satisfactory. It is observed that forced convection for grape drying reduces the drying period. It is also noticed that moisture removal rate is increased by 7% than the conventional method and due to turbo ventilator fan the night hour drying rate is increased from 1.8 grams/hrs to 2.1grams/hr.

V. References

- [1] Pangavhane Dilip, Sawhney R.L.- Design, development and performance testing of a new natural convection solar dryer, *Journal of Energy*, July2000;27:579-590.
- [2] Pangavhane Dilip - Comparative drying performance study of natural convection solar dryer with traditional grape drying method, *International Journal of Energy*, Vol-3, July2002; 13-22.
- [3] Fadhel A.- Study of Solar Drying of Grape By Three Different Processes. Pre. at conf. of Desalination and The Environment, Santa, Italy May2005.,535-541
- [4] Azad E, Design and experimental study of solar agricultural dryer for rural area *Journal of Energy*, Vol. 10; Sept. 2008.
- [5] Enayat M.M, El- Ghetany H.H. Modeling and experimentation of the equilibrium moisture content of Solar dryer, *Journal of Energy*, Vol. 11; Aug 2009.
- [6] Ahme, L., Prothon, F., and Funebo, T. Comparison of drying kinetics and texture effects of two calcium pre-treatment before microwave-assisted dehydration of apple and potato. *International Journal of Food Science and Technology*, 2003(38): 411–420.
- [7] Enayat M.M, El- Ghetany H.H; Equilibrium moisture content and latent heat of vaporization of grapes, 37th Intersociety Energy Conversion Engineering Conference, 2002
- [8] Pangavhane DR, Sawhney RL, Sarsawadia P. Effect of various dipping pretreatment on drying kinetics of Thompson seedless grapes. *Journal of Food Engineering* 1999;39:211–6.
- [9] A. Midilli and H. Kucuk, Mathematical Modelling of Thin Layer Drying of Pistachio by Using Solar Energy, *Energy Conversion and Management*, Vol. 44, N°7, pp. 1111 - 1122, 2003.
- [10] Ahme, L., Prothon, F., and Funebo, T. Comparison of drying kinetics and texture effects of two calcium pre-treatment before microwave-assisted dehydration of apple and potato. *International Journal of Food Science and Technology*, 2003(38): 411–420.
- [11] Ndukwu M.C. “Effect of Drying Temperature and Drying Air Velocity on the Drying Rate and Drying Constant of Cocoa Bean” *Agricultural Engineering International: the CIGR Ejournal*. Manuscript 1091. Vol. XI., April, 2009.
- [12] T.Y. Tunde-Akintunde and A.A. Afon. “Modelling of Hot-Air Drying of Pretreated Cassava Chips”. *Agricultural Engineering International: the CIGR Ejournal*. Manuscript 1493 Vol. August, 2009.