

FARMERS' PROSPERITY THROUGH SOLAR DRYING OF DATES**N. N. Desai¹, V. M. Modi² and J. K. Patel³**¹Assistant Professor, College of RE and EE, SDAU, S.K.Nagar-385506²Associate Professor, College of RE and EE, SDAU, S.K.Nagar-385506³Assistant Professor, College of Horticulture, SDAU, Jagudan - 382710

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ABSTRACT

*Drying is an essential process in the preservation of agricultural products. Various drying methods are employed to dry different agricultural products. Each method has its own advantages and limitations. Choosing the right drying system is thus important in the process of drying agricultural products. Care must be taken in choosing the drying system. Study comparing traditional drying and other drying methods for the reduction of the drying time and to a significant improvement of the product quality in terms of color, texture and taste. Drying reduces the possibilities of contamination by insects and microorganisms so that product is prevented. An experimental study was performed to determine the drying characteristics of date halves using hot air dryer, solar dryer and open sun drying methods. The date fruits (*Phoenix dactylifera*) are a food of high energy value. It is very popular both nationally and internationally. Date fruits are perishable fruit crop grown in coastal region of Kutchh of Gujarat state. The date fruits are harvested at ripening stage so the fresh fruits have not longer shelf life. The date halves were dried under hot air flow dryer at temperature level of 50, 60 and 70°C under pre-treatment of blanching and un-blanching. The rate of moisture of blanched sample should only 7.5 % reduction at 54 hr drying period while un-blanched sample should 13.9 % reduction at 102 hr. In case of date halves drying, the constant weight of sample was achieved at 56 h of drying period in solar cabinet dryer as compared to 320 h for open sun drying. The moisture content was reduced from 69.5 to 8.7 % (w.b.) under solar cabinet dryer for drying of 56 h, while the moisture content was reduced from 69.5 to 12.3 % (w.b.) under open sun drying for drying period of 320 h. It was found that the highest moisture removal was 67 % for the drying time of 54 h. under hot air flow dryer at 70°C while minimum moisture removal was 63.6 % for drying time of 320 h. under open sun drying method. In hot air flow drying method, the drying rate for date halves was found to be 32.54, 46.37 and 62.03 g/h at temperature level of 50, 60 and 70 °C respectively for blanched samples, while it was 31.56, 45.53 and 60.93g/h at same temperature levels for unblanched samples.*

Keywords : date fruit, drying, product quality, moisture content, hot air dryer, solar dryer

INTRODUCTION

Drying is a heat and mass transfer process resulting in the removal of water moisture, by evaporation from a solid, semi-solid or liquid to end in a solid state. The drying technique is probably the oldest and the most important method of food preservation practiced by humans. The removal of moisture prevents the growth and reproduction of microorganisms which cause decay, and minimizes many of the moisture-mediated deteriorative reactions. It brings about substantial reduction in weight and volume, minimizing packing, storage and transportation costs and enables storability of the product under ambient temperatures (Mujumdar, 1995). During drying many changes take place; structural and physico-chemical modifications affect the final product quality, and the quality aspects involved in dry conversion in relation to the quality of fresh products and applied drying techniques (Saran *et al.*, 2021). Currently

hot air drying is the most widely used method in post-harvest technology of agricultural products. Using this method, a more uniform, hygienic and attractively colored dried product can be produced rapidly. However, it is an energy consuming operation and low energy efficiency, so more emphasis is given on using solar energy sources due to the high prices and shortage of fossil fuels. Solar dryers are now being increasingly used since they are a better and more energy efficient option. The solar dryers could be an alternative to the hot air and open sun drying methods, especially in locations with good sunshine during the harvest season (Pangavhane *et al.*, Sawhney & Sarsavadia, 2002). Among these are lacks of ability to control the drying process properly, weather uncertainties, high manpower costs, large area requirement, insect infestation, mixing with dust and other foreign materials and so on. Solar drying is essential for preserving agricultural products. Using a solar dryer, the drying time can be shortened by about 65% compared to sun

drying because, inside the dryer, it is warmer than outside; the quality of the dried products can be improved in terms of hygiene, cleanliness, safe moisture content, colour and taste; the product is also completely protected from rain, dust, insects; and its payback period ranges from 2 to 4 years depending on the rate of utilization. The most important feature of solar dryers is that the product does not include any kind of preservatives or other added chemical stuffs, which allows its use for people suffering from various allergic reactions from chemical preservatives and other added stuffs. Furthermore, the product is not exposed to any kind of harmful electromagnetic radiation or electromagnetic poles (Tiris & Dincer, 1996). Therefore, solar dryer may become a more convenient alternative for rural sector and other areas in which electricity is scarce and in regular supply. Also, it can reduce crop losses, improve the quality of dried product significantly and is economically beneficial compared to traditional drying methods. Vegetables and fruits are indispensable part of human diet and can be regarded as the fuel for physiological processes. 25-30% of total produce is being wasted during handling from point of production to consumer's plates. This wastage can be effectively reduced by applying appropriate method of processing and preservation. In this regard some of the vegetables have been traditionally processed by drying to extend their storage life well beyond few weeks and make it available in off season.

Date (*Phoenix dactylifera*) is well known for its nutritional contents. It contains 1.9% protein, 70.6% carbohydrates, 2.5% fat, 1.2% minerals and 10% fiber. The dates are considered as prime fruit for their nutritional and therapeutic value. It is required to convert the unripe dates into value added product through a dehydration technique. During conventional sun drying of dates, the unhygienic environmental conditions contaminate the dates with bird droppings and insect infestation. Moreover there is a great chance of fungal growth under high humid conditions. Faecal coliforms is frequently present in traditionally dried dates. The spoilage starts quickly under the influence of unfavorable climatic conditions. It results in a definite wastage of valuable consumable date fruits and minimizes the export potential of the produce. To curtail these losses, the traditional methods of date processing are being replaced by improved techniques. Today, on the global level as well, the production, utilization and industrialization of dates are continuously improving. Keeping in view the growing importance of hygienically processed quality dates. The efficient processing and long-term storage of date requires that the moisture content be reduced to suitable levels by various drying methods.

OBJECTIVE

To study the farmers' prosperity through solar drying of dates

METHODOLOGY

Selection and procurement of raw material

Fresh date palm fruits of variety Zahidi, harvested in the month of June were selected as a raw material. Fresh date palm fruits were procured from Main Date Palm Research Station, S.D. Agricultural University, Mundra (Kutchh), Five samples each of 100 gram were drawn randomly for determination of initial moisture content of fresh date palm fruits. Manual method of sorting was adopted to remove foreign materials, leaves and immature dates, which was followed by water washing operation of date palm fruits. The sample of fresh date palm fruits was selected for study of moisture content. The locally popular and widely cultivated variety Zahidi of date palm fruits was selected for the study. The date palm fruits of this variety are widely consumed, also it contains good amount of protein, fat, carbohydrate, iron, calcium, ascorbic acid and fiber. Zahidi dates are medium sized and distinctively oval in shape. They have pale brown skin and a thick, golden inner flesh that surrounds a single seed.

Preparation of samples for drying

The fully matured fresh fruits of Zahidi variety of date palm fruits were procured from Main Date Palm Research Station, S.D. Agricultural University, Mundra (Kutchh), during the month of June. Leaves and damaged fruits were picked out manually. The pure date palm fruits were then hand washed with clean water and cut into slices by a special kind of knife to separate the date pit and flesh. Fresh date halves are weighed on electronic balance of 200 kg \pm 0.1 g accuracy (Model: Swisser, India). The weighed halves of date palm fruits were soaked in hot water 85°C for 2.0 minutes for blanching because the most of fruits blanching at this temperature range. Blanching stops enzyme actions which can cause loss of flavor, color and texture. The blanched samples each of 5 kg were kept in perforated trays before drying. Other samples without any pre-treatment are taken as control samples. Both the samples were put to dry under three drying methods viz., open sun drying, hot air flow drying at three temperature level of 50, 60 and 70°C and solar cabinet drying.



Open sun drying



Hot air flow dryer



Solar cabinet dryer

Experimental set up

The experimental parameters measured were physiological loss in weight, colour change, texture, temperature, relative humidity and moisture loss of the product. All parameters were recorded at an interval of half an hour initially for first three hours and every one hour there after till four and eight hours of drying. The open sun and solar cabinet drying experiments were carried out during the periods of July under the clean climatic conditions. Solar cabinet dryer and sun drying experiment was commenced at 9:00 hr and continued till 17.00 hr. Hot air flow drying was continue day and night.

Drying analysis

Moisture content was determined as per the following formula and expressed in terms of percentage of moisture content (w.b.).

$$\text{Moisture Content (\%)} = \frac{M_w - M_d}{M_w} \times 100 \dots\dots(3.1)$$

Where,

- M_w = Initial mass of sample, grams
- M_d = Final mass of sample, grams

Relative humidity is the ratio of the partial pressure of water vapor in an air-water mixture to the saturated vapor pressure of water at a prescribed temperature. The relative humidity of air depends on temperature and the pressure of the system of interest.

$$RH = \frac{P_w}{P_{ws}} \times 100 \dots\dots\dots(3.2)$$

Where,

- RH= Relative Humidity,%
- P_{ws} = Saturation vapor pressure, kpa
- P_w =Partial vapor pressure, kpa

The mass of water loss was found by the equation

$$= Mc \frac{W_i - W_f}{100 - W_f} \dots\dots\dots(3.3)$$

Where,

- M_w = Mass of water loss ,kg
- M_c = Mass of product to be dried, kg
- W_i = Initial moisture content (w.b.), %
- W_f = Final moisture content (w.b.),%

Drying rate is the amount of evaporated moisture over time

$$DR = \frac{M_i - M_d}{t} \dots\dots\dots(3.4)$$

Where,

- DR= Drying rate, g/hr
- M_i = Mass of sample before drying,gram
- M_d = Mass of sample after drying, gram
- t = Drying period, hr

RESULTS AND DISCUSSION

Solar radiation intensity and temperature profile

The inside temperature of drying structure was

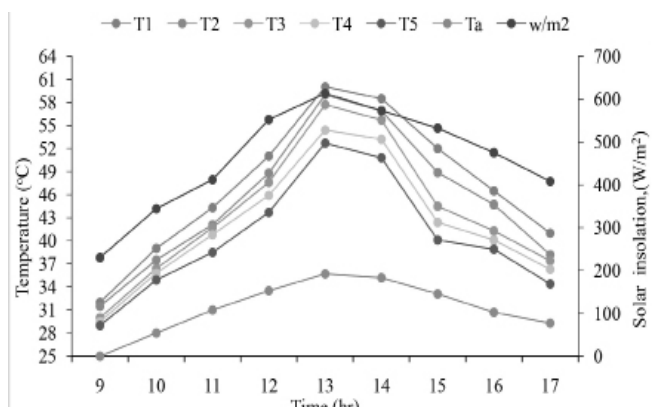


Fig. 1: Solar radiation and thermal profile inside the solar dryer under load condition.

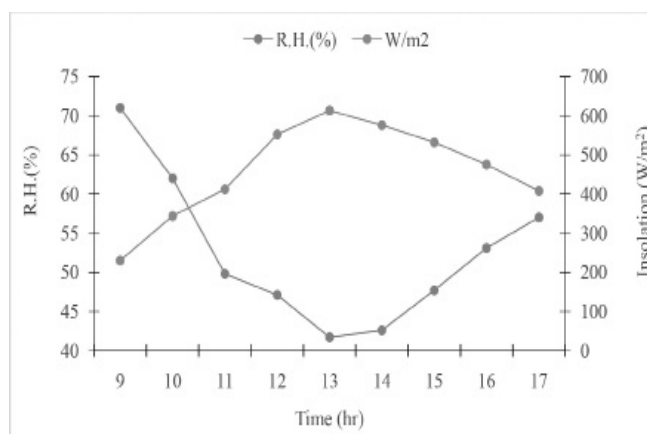


Fig.2 Solar Insolation and Relative humidity Profile

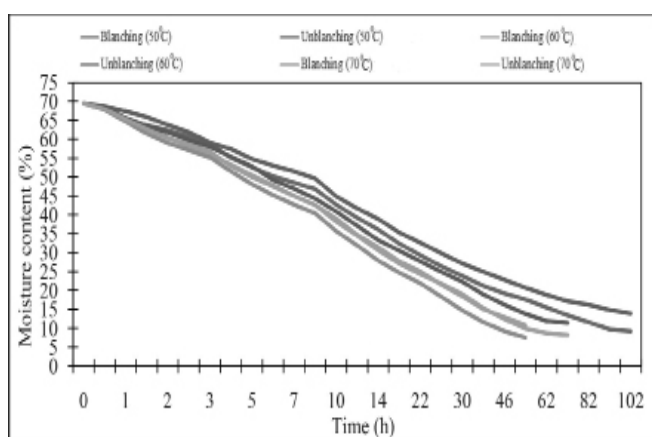


Fig. 3: Moisture content variations for different drying method with drying time

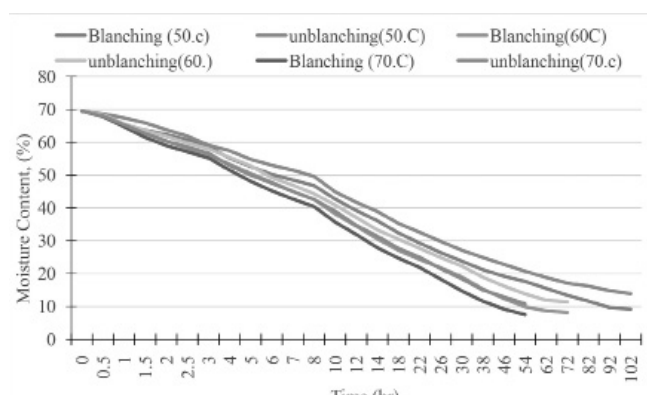


Fig.4 : Moisture content with respect to time under different level of Temperature under hot air flow dryer

measured by RTD sensors using data logger of range 0-100°C ($\pm 0.05^\circ\text{C}$). The test was carried out from time 9.00 a.m. to 17.00. Fig. 1 show the variation of solar radiation intensity and temperature profile inside the solar dryers with time of the day during drying of 5 kg of fresh date slice under load condition. The findings showed that, temperature rises and falls with increasing and decreasing of solar radiation intensity which varies through the day. The maximum value of solar radiation intensity, inside temperature and ambient temperature were measured as 613 W/m², 60^o C and 35^oC respectively at 13:00 pm while minimum values were observed in the morning and end of day at 9:00 am and 5:00 pm respectively. The temperature inside the drying chamber was found to be higher than ambient temperature. A minimum temperature recorded inside the solar cabinet dryer at 9.00 am was 29^oC, with the corresponding ambient temperature of 25^oC. The maximum drying air temperature under solar dryer was found to be 60^o C in the tray T₁ followed by tray T₂(59^o C), tray T₃(57.7^o C), tray T₄(54.4^o C) and tray T₅(52.7^o C). Fig 2 shows the relation between solar intensity and relative humidity.

Fig.3 shows reducing moisture content versus time for the three treatments under different temperature levels. Moisture content at any time of the simulated conditions was determined using equation 3.1. Initial moisture content on wet basis was determined for the date slice samples using equation 3.1, and it was 69.50%. Moisture content at all measurement time was calculated starting from the initial moisture content, thus moisture content trend and behaviour were obtained. Moisture loss rate for blanched and unblanched sample was high in the first 22 hours, reaching as high as 40.2 and 36.9, 45.2 and 41.8, 47.6 and 44.5 % for 50, 60 and 70 °C temperature, respectively. So it was found that moisture loss was maximum in case of blanched sample as compare to unblanched sample. During second day, dropping rate of moisture loss reduced to about 10.1, 11.9 and 12.7% for all the three temperatures, and during the third day moisture loss percentage was even less; reaching 5.8, 4.2 and 1.7% for same level of temperatures. However, an agreement with the finding of this work was found in a convective date drying and modelling study, linear relations

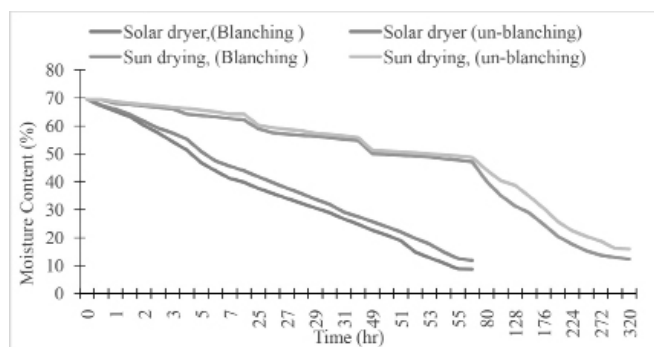


Fig. 5 Variation of Moisture content with respect to time under open sundrying and solar dryer

between moisture loss and time was reported by (Mohamed *et al.* and Morghem, 2016). Also, a linear relation between moisture content and time was reported for drying several other agricultural commodities. In this study, temperature was kept virtually stable. The higher moisture loss was for 70°C treatment followed by 60°C and 50°C.

Fig. 4 shows that the moisture content with respect to time under open sun drying and solar dryer. It was found that loss of moisture was faster in solar dryer as compare to sun drying. The drying time for solar dryer and sun drying were 56 and 320 hrs respectively. The loss of moisture for the solar dryer was 69.5 to 8.7 %, whereas loss of moisture in case sun drying was 69.5 to 12.3 percent. It was also found that blanched sample was obtained less moisture content as compare to unblanched sample in two different drying methods.

Details of different drying tests	
A	Hot air flow dryer at 50°C(Blanch)
B	Hot air flow dryer at 50°C(Un-Blanch)
C	Hot air flow dryer at 60°C(Blanch)
D	Hot air flow dryer at 60°C(Un- Blanch)
E	Hot air flow dryer at 70°C(Blanch)
F	Hot air flow dryer at 70°C(Un-Blanch)
G	Solar drying (Blanch)
H	Solar drying (Un-blanch)
I	Sun drying (Blanch)
J	Sun drying (Un-blanch)

Fig.5 shows that that total drying time was maximum in case of open sun drying and less in case of hot air flow drying method and solar cabinet drying method. It was found that the highest drying rate was 62.03 g/h for the drying time of 54 h under hot air flow dryer at 70°C, while minimum drying rate was found 9.95 g/h for drying time of 320 h under open sun drying method. It was found that the drying rate was 59.45 g/h for drying time of 56 h under solar cabinet

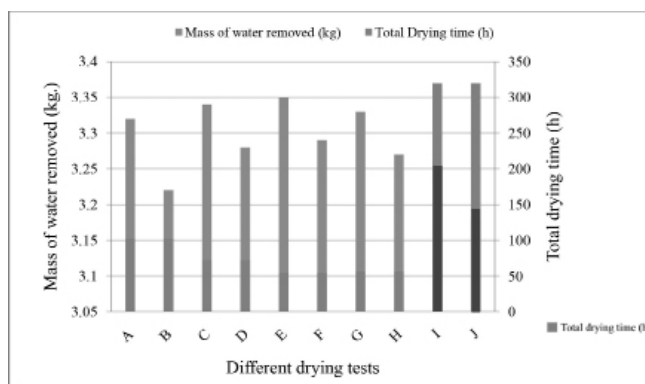


Fig.6 Moisture removal under different drying methods

dryer. So it was found that drying rate was higher in case of solar cabinet and hot air flow dryer as compared to open sun drying.

The drying rate for the different tests performed is presented in Table 1.

Table 1: Drying rate for dates halves

Sr. No.	Drying test	Total Drying time (h)	Drying rate (g/h)
1	Hot air flow dryer at 50°C(Blanch)	102	32.54
2	Hot air flow dryer at 50°C(Un-Blanch)	102	31.56
3	Hot air flow dryer at 60°C (Blanch)	72	46.37
4	Hot air flow dryer at 60°C (Un- Blanch)	72	45.53
5	Hot air flow dryer at 70°C (Blanch)	54	62.03
6	Hot air flow dryer at 70°C (Un-Blanch)	54	60.93
7	Solar drying (Blanch)	56	59.45
8	Solar drying (Un-blanch)	56	58.41
9	Sun drying (Blanch)	320	10.19
10	Sun drying (Un-blanch)	320	9.95

For hot air flow drying, the drying rate for dates halves was found to be 32.54, 46.37 and 62.03 g/h at temperature level of 50°C, 60°C and 70°C for blanched samples, while it was 31.56, 45.53 and 60.93 g/h at same temperature level under un blanched samples. For solar cabinet drying method, the drying rate of dates halves was found 59.45 and 58.41 g/h for blanched and un-blanched samples. For open sun drying method, the drying rate of dates halves was found as 10.19 and 9.95 g/h for blanched and un blanched samples. So it

was found that drying rate was higher in case of solar cabinet dryer and hot air flow dryer as compare to open sun drying.

CONCLUSION

The three drying methods used greatly affected the drying characteristics date halves. The solar dryer was found to be more efficient than the open sun drying. In addition, the samples of solar dryer were completely protected from insects, birds, rain and dusts. The commonly consumed date halves were dried under conventional drying, sun drying and open sun drying. The drying characteristic and time required for drying of date halves was studied and final dry weight of the date halves were estimated. It was found that date halves samples, dried by hot air drying were reported to take minimum time for drying with maximum removal of moisture. The initial first hour of hot air drying and sun drying and initial 6 hours under open sun drying resulted in maximum removal of moisture from date halves. The date halves dried in hot air dryer at 70°C required 54hr drying time.

CONFLICT OF INTEREST

The authors of the paper declare no conflict of interest

REFERENCES

- Mohamed A. Fennir and Mohamed T. Morghem(2016). Moisture Loss of Semidry Libyan Dates at 'Rutab' Stage Evaluated Under Simulated Handling and Transportation Conditions. *Int'l Journal of Advances in Agricultural & Environmental Engg. (IJAAEE)* Vol. 3, Issue 1 (2016) ISSN 2349-1523 EISSN 2349-1531.
- Mujumdar, A. S. (1995). Handbook of industrial drying (second ed.). New York: Marcel Dekker.
- Pangavhane, D. R., Sawhney, R. L., & Sarsavadia, P. N. (2002). Design, development and performance testing of a new natural convection solar dryer. *Energy*, 27(6); 579–590.
- Saran, P. L., Choudhary, R, Solanki, I., and Devi, G. (2015). Traditional medicaments through papaya in northeastern plains zone of India. *Indian Journal of Traditional Knowledge*, 14(4): 537-543.
- Tiris, C., Tiris, M., & Dincer, I. (1996). Energy efficiency of a solar drying system. *International Journal of Energy Research*, 20(9); 767– 770.

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