

RESEARCH ARTICLE

Performance evaluation of solar tunnel dryer and electric tray dryer for drying date palm fruit (*Pheonix dactylifera* L.) in arid region of Rajasthan

■ Dhairya Gaur, Vijay Raj Singh and J. K. Gaur

SUMMARY

Date palm (*P. dactylifera*, L.) is an important fruit of arid and semi-arid regions. In Western Rajasthan the dates are harvested in the month of July-August but preferred to eat during winter months, so it becomes necessary to dry and store the fruits at least for 4 to 6 months. The use of an appropriate temperature for drying of dates is quite crucial as a higher temperature may encourage case hardening, caramelization and a higher hygroscopicity; whereas a lower temperature would be insufficient to remove significant moisture leading to a clumpy powder. Farmers generally dry the dates in open sun. This traditional uncontrolled drying method is unhygienic and required more time, also weather dependent, so alternate economical methods are being tested in the region by the scientists and the farmers for drying of dates in the form of Pind. The paper deals with the performance of solar tunnel dryer and electric tray dryer installed at the farmer's field in Bikaner district of Rajasthan. The results reveal the drying time of Medjool date palm fruits in solar tunnel dryer and electric tray dryer.

Key Words : Medjool, Dehydration of date fruits, Pind, Open sun drying, Solar tunnel dryer, Electric tray dryer, Drying time

How to cite this article : Gaur, Dhairya, Singh, Vijay Raj and Gaur, J. K. (2023). Performance evaluation of solar tunnel dryer and electric tray dryer for drying date palm fruit (*Pheonix dactylifera* L.) in arid region of Rajasthan. *Internat. J. Plant Sci.*, **18** (2): 98-102, DOI: 10.15740/HAS/IJPS/18.2/98-102, Copyright@ 2023:Hind Agri-Horticultural Society.

Article chronicle : Received : 11.03.2023; Revised : 10.04.2023; Accepted : 27.05.2023

MEMBERS OF THE RESEARCH FORUM

Author to be contacted :

Dhairya Gaur, Bikaner Technical University, **Bikaner (Rajasthan) India**

Email : dhairyagaur413@gmail.com

Address of the Co-authors:

Vijay Raj Singh, Rajasthan University of Veterinary and Animal Sciences, **Bikaner (Rajasthan) India**

Email : vijayrajsingh799@gmail.com

J. K. Gaur, Swami Keshwanand Rajasthan Agricultural University, **Bikaner (Rajasthan) India**

Email : jkgbkn@gmail.com

Date palm (*Phoenix dactylifera* L.) fruits, popularly known as dates are oval-cylindrical shaped edible sweet fruits, 1 to 3 inches long, and about 1 inch in diameter, with colour ranging from dark brown to bright red or yellow, depending on variety. Mature date palms produce 70–140 kilograms of dates per harvest season. On an average, dates contain 21% water, 75% carbohydrates 63% sugars and 8% dietary fiber, 2% protein, and less than 1% fat. It is a high source of energy, as 100 g of flesh can provide an average of 314 kcal. Dates are a good source of antioxidants, mainly

carotenoids and phenolics (Farsi and Lee, 2008). Date palm farming was started in 2007 in India. Date palm takes 4 to 8 years after planting before they bear fruit. Date palm agriculture is practiced in India along the coastal belt from Mandvi to Anjar in Gujarat's Kutch and Saurashtra districts. Rajasthan, Tamil Nadu, and Kerala are among the states that grow it. Date palm cultivated area in India is 12493ha (Jana and Basu, 2019). India is the largest country in import of date palm, importing about 38% of the world market (Indian Council of Agricultural Research). Date palms require hot, dry weather with plenty of sunlight and well-draining soil, so its cultivation is also preferred in the arid region of Rajasthan. Rajasthan grows date palm varieties like Barhee, Khuneji, Khalas, Medjool, Khadravi, Jamli and Sagai. In Rajasthan, the area under date palm is increasing every year and has crossed more than one thousand hectares. The production of date fruits has increased the income of farmers many folds as compared to traditional rain-fed crops. Date fruits are consumed as fresh, while some proportion is processed into various products like Pind, juice, paste, spread and syrup, or used as ingredient in various food products like beverages, desserts, confectionary and baked items (Shahib and Marshall, 2003). When the date palm fruit is matured enough to store without spoilage, it is called Pind or Tamar. Medjool variety is preferred for making Pind. Drying is the cheapest, easiest and most common method of preserving and storing of perishable agricultural products. Date palm fruits contain about 60% moisture, therefore drying of fresh dates is necessary to extend its shelf life (Yahia *et al.*, 2014). Dried dates products are easy to store and highly alternative to market than the freshly harvested products.

Falade and Abbo (2007) investigated that the moisture content of date fruit vary from 60% at the mature to about 25% at the dried stage, safe moisture content for storage of date is between 24% and 25%. Air-drying and rehydration of date palm fruits could be modeled using Fick's diffusion model. It was observed to attain faster drying with increased drying temperature up to 70 °C, after which the drying mechanism changed, probably, due to case hardening. Drying of dates took place entirely in the falling rate period. Basunia *et al.* (2010) designed a 12 meter long by 2 meter wide solar tunnel batch dryer to dry 180-200 kg of freshly harvested dates. Half of the partially air-tight tunnel base was used as the flat plate air heating solar collector and the remaining half as a dryer. The drying air was forced

from the collector region (south side) to the drying region (north side) of the half circular tunnel where the product was to be dried. The drying temperature could easily be raised from 5-300°C above ambient temperatures inside the tunnel at an air velocity of approximately 0.5 m/sec. The moisture content of 190.2 kg of freshly harvested dates was reduced by 32.8% (wet-basis) to a final average moisture content of 18.6% (wet-basis) within two days (20 hours). The results indicated that the drying was faster in solar tunnel dryer than under natural open air sun drying. It was possible to reach the moisture content level for safe storage within less than two days (20 hrs) with a solar tunnel dryer and 5-7 days in open air natural sun drying. The improvement in the quality of dates in terms of color, brightness, flavour, and taste and food value was distinctly recognizable. Sagarika *et al.* (2019) studied drying characteristics of date palm fruits using greenhouse dryer and compared the results with open sun drying. A gable shaped greenhouse with east-west orientation was constructed with 4.5 m length and 3.0 m width. The height of the greenhouse was about 3.0 m approximately. The walls of the greenhouse were wrapped with UV resisted polyethylene sheet. In open sun drying the date palm fruits were directly exposed to solar radiations. The results showed that the time taken to dry date palm fruits in greenhouse dryer and open sun drying was 40 hours and 58 hours, respectively. In an experiment conducted by Ertekina and Ipek (2020), date palm drying process was carried out with four different temperatures of 50°C, 70°C, 90°C and 110°C with two different drying techniques; drying with oven and drying with thermo gravimetric analysis (TGA). The experiment revealed that drying time decreased with increasing drying temperature while the colour of the dried date palm fruit became darker with increasing temperature. The relationship between drying time and drying temperature was worked out in terms of a mathematical model of drying temperature dependent on drying time *i.e.* $DT = 3 \times 10^{-5}(t^2) - 0.0218t + 122.5$ with a regression co-efficient of $R^2 = 1.00$ for drying process with oven. When the palm dried with its shell as a complete fruit, the drying time at 110°C was 360 min. In a study conducted on dates by Hasan *et al.* (2022), a temperature of 70 °C was found optimum for drying of dry and semi-dry fruits in cabinet drying. It was found that dry varieties, such as Barakawi dates, are more suitable for production of a less clumpy date fruit powder. Sansaniwal *et al.* (2022), developed natural convection greenhouse dryer and natural convection indirect solar dryer to study date palm

fruits' drying characteristics in terms of moisture ratio and convective heat transfer co-efficients. At the same time, the thermal performance of drying units was also examined in terms of energy efficiency. The experimental data were fitted in various drying models, of which the Lewis model was found to be best fitted. The experimental errors were analyzed in terms of percent uncertainties. The drying costs of dried date palm fruits under greenhouse dryer and indirect solar dryer were found to be 1 22.37/kg and 1 30.14/kg, respectively.

MATERIAL AND METHODS

The present study was conducted in Bikaner district of Western Rajasthan (Latitude: 27.97485, Longitude: 73.2109) in the month of July 2022 at a farmer's field. The farmer had grown 765 plants of Medjool date palm which were 8 years old. The average production of fresh dry fruits was 85 kg/plant.

Two types of dryers were used in experimentation: 1. Solar tunnel dryer and 2. Electric tray dryer

Solar tunnel dryer :

A solar tunnel dryer with east-west orientation, 40 ft in length and 10 ft width with central height of 8 ft was used (Fig. 1). The structure was made of GI pipe and covered with 150 micron thick UV stabilized polythene sheet. Two fans of 1275 rpm, were also fitted at the top of width walls to regulate the inside temperature and humidity. The structure was large enough for a person to enter. The tunnel space was divided in 32 shells each of 25 kg capacity. The shells were made of 25 mesh cloth for easy circulation of air through the dates. The overall capacity of the dryer was 800 kg per batch.



Fig. 1: Solar tunnel dryer

Electric tray dryer :

An electric tray dryer of 300 kg capacity per batch was used in the experimentation (Fig. 2). It was enclosed insulated chamber and trays were placed on top of each other inside the chamber. The dates to be dried were placed in the trays. The drying process was based on circulation of hot air through the chamber. The heat was transferred through the trays via hot air circulation by an electric heater. The transfer of heat, as well as the proper circulation of the heat, was facilitated by the installed blower fans. Additionally, the equipment had a control panel for temperature control as well as other parameters fixed outside the equipment. In the tray dryer, moisture was removed from the fruits in the tray by a forced convectional heating. Two fans each of 0.75 KW, 415 volts 960 rpm in the tray dryer were used to circulate the hot air at a speed of two to five meters per second. During water evaporation from the surface, there was diffusion of the water from the interior of the fruits by a capillary action. The moisture discharge occurred through the outlet. Drying was continued until the desired moisture content is attained. The heated air was re-circulated with fresh air in selected proportions for optimum drying.

The fresh fruits were harvested on 70 percent maturity and dried in the both dryers. In solar dryer the fruits placed in trays receiving the solar radiations through plastic cover and moisture was removed by forced convection. The solar radiations were available for 9 hours a day for drying. The atmospheric temperature, temperature inside solar tunnel dryer, duration of fan operation in solar tunnel dryer and time taken in drying the fruits with respect to temperature were recorded.



Fig. 2: Electric tray dryer



The temperature in tunnel dryer was fixed as 50^o, 60^o and 70^oC and the corresponding time required to bring the moisture to 23 per cent were noted.

RESULTS AND DISCUSSION

The initial moisture content at the time of harvest was in the range of 57-60 per cent. The final moisture content was kept 23 per cent. The drying time in solar tunnel dryer was more due to gap in the availability of solar radiations. Solar radiations were available for 9 hours a day for drying purpose. The time required for drying at different atmospheric temperature is presented in Fig. 3. The drying of dates took place entirely in the falling rate period. The heat and mass phenomena was based on absorption of radiation and moisture removal by convection. Drying period was worked out to be 3 to

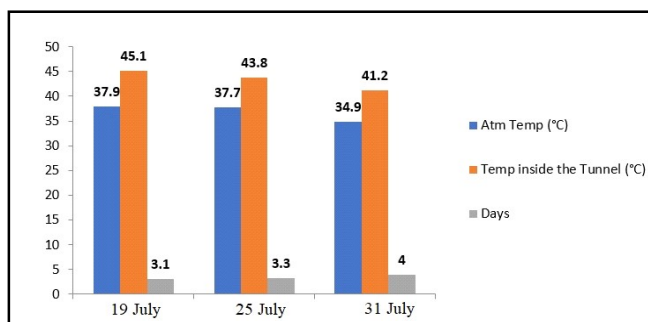


Fig. 3: Drying in solar tunnel dryer (Month-July, 2022)

4 days which was due to drop in temperature after sun set.

In electric tray dryer, the fruits at the top and the bottom dried simultaneously and constant temperature was maintained, so drying was quick and drying time was less as compared to solar tunnel dryer. The drying periods at 50^oC, 60^oC and 70^oC temperatures were 6.3, 6.1 and 5.15 hours, respectively, the same is presented

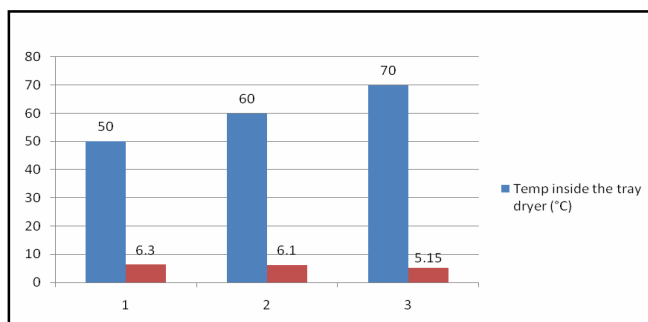


Fig. 4: Drying in electric tray dryer

in Fig. 4. The quality of fruits dried at 50^oC was the best as compared to drying at 60^oC and 70^oC temperatures.

The results reveal that although the time required in solar tunnel dryer was more as compared to electric tray dryer but at the same time the capacity was more and comparatively there was less use of electricity. The initial investment on electric tray dryer was Rs. 3 lakh for 300 kg capacity as compared to Rs. 75 thousand for 800 kg capacity solar tunnel dryer.

In Western Rajasthan fruits of date palm mature one month early in comparison to Gulf countries, so timely drying the dates in the form of Pind is advantageous in the international market.

REFERENCES

- Basunia, M.A., Handali, H.H., Balushi, M.I., Rahman, M.S. and Mahgoub, O. (2010). Drying of dates in Oman using solar tunnel dryer. XVIIth World Congress of the International Commission of Agricultural and Biosystems Engineering (CIGR) Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB) Québec City, Canada, June 13-17, 2010.
- Ertekin, O. and Ýpek, Y. (2020). Modeling of drying processes of dates (*Phoenix, Arecaceae*) with Oven or TGA and microbiological properties of fresh and dried dates, *International Journal of Fruit Science*, pp.1530-1538.
- Falade, K. O. and Abbo, E.S. (2007). Air drying and rehydration characteristics of date palm (*Phoenix dactylifera* L.) fruits, *Journal of Food Engineering*, **79** (2): 724-730.
- Farsi, M. A. and Lee, C. Y. (2008). Nutritional and functional properties of dates: A review. *Critical Reviews in Food Science & Nutrition*, **48**(10), 877-887. <https://doi.org/10.1080/10408390701724264>.
- Hasan, F., Nazir, A., Sobti, B., Tariq, H., Karim, M., Marzouqi, A. H. and Eldin, A.K. (2022). Dehydration of date fruit (*Phoenix dactylifera* L.) for the production of natural sweet powder, *NFS Journal*, **27**:13-20.
- Indian Council of Agricultural Research. <https://icar.org.in/node/5899>
- Jana, H. and Basu, D. (2019). Importance of date palm cultivation in India, *International Journal of Current Advanced Research*, **8** (2) (D) : 17349-17356.
- Sagarika, N., Kapdi, S. S., Sutar, R. F., Patil, G. B. and Akbari, S. H. (2019). Study on drying kinetics of date palm fruits in greenhouse dryer, *Journal of Pharmacognosy & Phytochemistry*, **8**(3): 2074-2079.

Sansaniwal, S. K., Kumar, M., Sahdev, R. K., Bhutani, V. and Manchanda, H. (2022). Toward natural convection solar drying of date palm fruits (*Phoenix dactylifera* L.): An experimental study, *Environmental Progress & Sustainable Energy*, **41** (6).

Shahib, W. A. and Marshall, R.J. (2003). The fruit of the date

palm: Its possible use as the best food for the future, *Int. J. Food Sci. Nutr.*, **54** : 247-259.

Yahia, E.M., Lobo, M.G. and kader, A.A. (2014). Harvesting and postharvest technology of dates, In: Siddiq, M., Aleid, S.M., Kader, A.A. (Eds.), *Dates: Postharvest science, processing technology and health benefits*. John Wiley & Sons Ltd, pp. 105-135.

18th
Year
★★★★★ of Excellence ★★★★★