



Different Drying Methods for Preservation of Dates: A Review

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Authors' contributions

This work was carried out in collaboration between all authors. Author KCSS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NSR and LM helped in collection of data. Author NV analyzed the article and suggested necessary changes. All authors read and approved the final manuscript.

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ABSTRACT

Background: Dates, the staple food in many Gulf countries and they are the fruits with high nutritional values, besides highly perishable, so there is a need for a better preservation technique which will prevent the dates from deterioration and also in the extension of shelf life of dates. Dates, the fruit of date palm provide not only the essential nutrients but also health benefits. They can be consumed by adding in coffee, milk or yoghurt and the dates which are processed can be used as paste, syrup, pickles, jams, and jellies and also used in bakery and confectionary products along with chocolate, coconut, honey, vinegar and other.

Scope and Approach: This article describes the purpose of drying and dehydration of dates and also different drying methods for dates like solar drying, hot air oven drying, vacuum drying, spray drying and drum drying. Keeping the nutritional composition and health benefits of dates in mind

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there is a need to know the different processing techniques which extend the shelf life of dates.

Key Findings and Conclusion: The most common medicinal use of dates and its products is as a tonic, especially for women who are close to delivery and at the postpartum stage. The extent of spoilage in dates is very high when there are unfavourable climatic conditions and prone to coliform attack. This leads to loss of consumer interest and export potential, so in order to prevent these losses drying and dehydration is needed.

Keywords: Perishable; drying; shelf life; drum drying.

1. NUTRITIONAL COMPOSITION

The most important component present in dates is carbohydrates; it may constitute around 78% [1] and provides instantaneous energy or readily available energy to the humans. The region of production and variety can significantly affect the glucose content and total sugar contents by date fruits [2]. The dates are also as excellent source of dietary fibre which ranges from 6.4% to 11.5% based on the varieties [3]. Dates contain both soluble and insoluble fibres [4]. The important components present in dates are cellulose, hemicellulose and lignin about 1.55%, 1.28% and 2.01% respectively [5,6]. The pectin present in dates will accumulate during the growth of fruit and it reaches or attains maximum value before there will be accumulation of sugar and the percentage of pectin content in dates is 0.5% - 0.9% [7,8].

Dates having the very small amount of protein and lipid, but after drying the content will increase because of moisture removal. The fresh dates having 1.50 g/100 g of protein and that of dried dates are 2.14 g/100 g [9]. The lipids are present in very small fractions but they have physiological importance, these are present in the skin dates the lipid content is 0.14/100 g). The seed of the dates contains dietary fibre and small fractions of mannose and maltose and a source of antioxidant [4]. The date fruit contains 4.6 to 15.2% of total weight of date [10,11].

Dates also contain fatty acids in date flesh and seeds. And many important vitamins and minerals and the mineral content vary from 0.1-916 mg/100 g of date flesh [12]. It also contains carotenoids and anthocyanin in small fractions. It has excellent values because it serves as antioxidant, anti-inflammatory, antimutagenic and anticancer agent [13]. Dates are also very much helpful in protecting from chronic diseases including heart diseases. Dates are very much useful in curing abdominal problems because they contain phenolic compounds which are used

as cleaning agents and intestinal problems [14]. Many of the syrups for a sore throat are prepared from dates.

The most common medicinal use of dates and its products is as a tonic, especially for women who are close to delivery and at the postpartum stage. The consumption of dates by women before and after delivery can act as a tonic to strengthen the uterine muscles [15]. Dates not only help in activating the delivery process but may also prevent the post-delivery bleeding due to the presence of some constricting substances. The most important application of dates in the medicinal field is during pregnancy, lactation and reproductive system. The consumption of dates by women that means before and after delivery, acts as a tonic and will strengthen the muscle. It also acts as a remedy for healthiness and night-blindness [16].

2. PURPOSE OF DRYING AND DEHYDRATION OF DATES

Dates have many nutritional and functional values, so there is a need to convert the un-ripened dates into value-added products through the process of drying or dehydration [17]. There is a chance of fungal growth under humid conditions which leads to the quality deterioration of the dates [5]. Dates are most frequently attacked by coliforms and faecal coliforms. The extent of spoilage in dates is very high when there is unfavourable climatic conditions and prone to coliform attack [5]. This leads to loss of consumer interest and export potential, so in order to prevent these losses drying and dehydration is needed [18].

3. DRYING METHODS FOR DATES

Drying is the unit operation which removes moisture from the produce for its safe storage, which will increase the shelf life of the products. Drying is the cheapest, easiest and most common preservation technique, mainly for

perishable products [19]. Nowadays dried products are having good market benefits than the fresh because of their advantages. There are different methods available for drying of dates like sun drying, hot air oven drying, solar drying, drum drying, tray drying etc [20].

3.1 Sun Drying of Dates

The dates were placed on the mats and are exposed to sun for sun drying but due to the traditional sun drying there is a chance of contamination of dates with bird's litter and also there will be a probability for the infestation of dates due to the open environment conditions [21]. In a study made by [21], they procured dates of Aseel variety from Sindh region which were thoroughly cleaned and sorted. A known quantity of dates around 33 kg were the total aerobic count, total yeast count and total mould count and the total coliform count are very high in processed dates during sun drying than that of electric cabinet drying and solar dried dates [21]. Dates were placed on the mats are exposed to sun drying at 35-45°C for 6-7 days. After that the cooled dates were packed and subjected for sensory evaluation and they found that there is a pH of 5.9, acidity 0.25%, moisture 18.4% and total sugar 65.2% [21].



Fig. 1. Sun drying of dates

3.2 Drying of Dates by Solar Driers

(a) The traditional method of solar drying: After harvesting the dates in Algeria, solar drying is done traditionally on the roof of the houses by hanging, such that they are exposed to air. The drying continues for 2 to 3 weeks. It is possible that the final product obtained is dehydrated, but the dates obtained by this method are of very poor quality, as they were exposed to open atmosphere they become hard and dusty without any strong added value.

(b) Drying of dates using solar dryer: Same as the above, they have taken dates of Aseel variety

of 33 kg and were placed inside solar dryer and temperature is maintained up to 65-75°C, after that the dried dates were cooled at 4-5°C for 3-4 hrs and packed in card boxes, the observations observed in solar drying are pH. 6.0, acidity 0.24%, moisture 14.9% total sugar (61.2%) [10].

In a study, they designed a solar drier to undergo drying of dates. The drier works on the principle of forced convection, which consists of 50 trays and the capacity of each plate is 10 kg date each one. The dimensions of the tray are 1.5 m x 1 m, the maximum flow rate of air through the ventilator was 1500 m³/kg. The surface area which is used for drying was 3 m², it can accommodate up to 200 kg of whole produce [22].

(c) Drying of dates using solar tunnel drier: In a study [23], developed a prototype solar tunnel, which is 12 meters long and 2 m wide, it is a batch type drier having capacity of 180-200 kg of fresh dated per batch. The solar tunnel dryer is designed in such a way that the flat plate air heating collector and drying tunnel are fabricated as a single unit. For supporting the transparent plastic cover lightweight aluminium frames were used at the uppermost section of the drier. The entire tunnel setup was planned at the height of 700 mm from the ground surface. A UV stabilized transparent polyethylene plastic cover of 0.2 m thickness was used to cover the entire solar tunnel dryer; such that the dryer becomes almost airtight.

In this method the drying air was passed from south side to north side that means collector region to drying region of half circular plate where the dates were to be dried, the drying air temperatures inside the dryer were 5-30°C above the ambient temperature and the highest temperature recorded was 69°C. The velocity of the air inside the dryer was about 0.5 m/s to 0.6 m/s. a sample of 190.2 kg sample was takes, and subjected for drying it was observed that the is a moisture reduction from 32.8% (wet basis) to 18.6% (wet basis) with two days (20 hrs) by the results obtained it is clear that the drying is solar tunnel dryer is faster than the normal open sun drying techniques. It can also be started that the safe moisture level attained in solar tunnel dryer was two days (20 hrs). But in case of normal sun drying it will take nearly 5-7 days. The quality of dates, colour, flavour etc. was totally different to that of sun dried dates.

The different parts of the solar tunnel drier were (1) Air inlet to the collector, fan, (2) South side wooden cover, (3) Collector part (12 m²), (4) Lightweight aluminium frame, (5) Dryer part (12 m²), (6) Air outlet from the dryer, (7) Concrete block sub-structures, (8) Wooden frame to support bends and base of the tunnel, (9) Metallic wire mesh net over wooden base in the dryer part, (10) Absorber plate.

(d) Drying of dates by different solar driers: A study on dates, by drying the dates in different solar driers. For this study they had taken deglet-nour variety dates, which were very famous in the region of Maghreb. This variety of dates was known as the queen of dates; these were the world's best variety having good export value. As the date fruits were harvested once in a year it is very necessary to give post-harvest treatment treatments like drying in order to protect the dates from both hot and rainy climates and to

reduce the accidents during storage. This study was conducted based on two objectives one was soaking of dates at different temperatures like 20°C, 25°C, 30°C, 35°C, 40°C, 45°C, 50°C and 55°C in distilled water and to see the effect of temperature on the inversion reaction of sucrose. And the second objective of the study was to dry the rehydrated samples in different solar driers.

Three different solar driers were used for carrying out the drying operation, they were (1) natural convective solar drier (2) direct convective solar drier (3) in-direct natural solar drier. The drying was undergone till a moisture content of 0.35 kg/kg dry air was reached. The time taken by natural convective solar drier, direct convective solar drier and in-direct natural solar for drying the product to 0.35 kg moisture/kg dry air was 22h, 11.5h and 2.5h respectively.

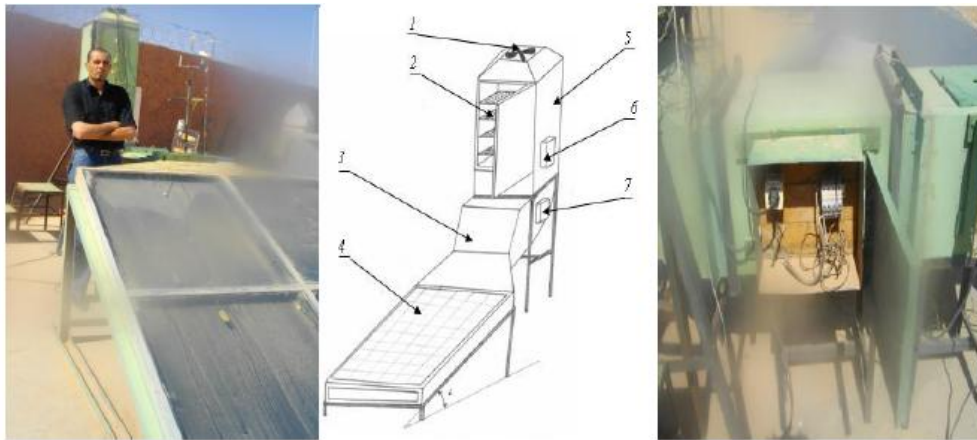


Fig. 2. Solar drier for drying of dates

The components of the drier were 1) ventilator 2) trays 3) collector 4) solar panel along with air 5) cupboard of drying 6) cup board for the ordering of ventilation 7) auxiliary electrical power box

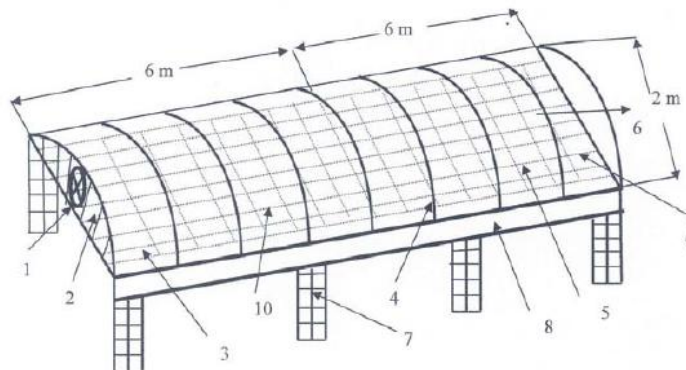


Fig. 3. Solar tunnel drier [23]

4. DESCRIPTION OF THE DRYING SYSTEMS

- Natural convection indirect solar drier (Fig. a): The natural convection indirect solar drier consists of air plane solar system with dimensions of 2×1×0.13 m. The angle of inclination of collector with the horizontal was 16° and it is directed towards south side. The room for drying the dates was entirely made of coated sheet of dimensions 1×0.8×0.8 m and all the external walls are covered with thermally insulated material polystyrene. The drier is provided with a chimney in galvanized sheets of dimensions 1×0.02×0.02 m
- Direct forced convective drier (Fig. b): The direct forced convective drier consists of a drying room and a chimney, the drying room was covered with six glass covers having a thickness of around 4 mm. A metal sheet is placed at front side of the drier corresponds to the door of the drier. The base of the drying room was composed of two different galvanized sheets, these were separated by a layer of polystyrene. one of the sheet was coated with black paint for absorbance of the radiation. The product to be dried was placed on the galvanized grid for

calibration. The chimney of the drier which is in cylindrical shape whose length was 1 m and the diameter as 0.1 m.

- In-direct forced convective drier system (Fig. c): The in-direct forced convective drier system consists of solar collector with simple circulatory system and a normal glass such that the area of the glass was around 2.5 m². There was a galvanised iron sheet which was painted in black for absorption purpose. A 50 mm thermal isolation material was used and was made of polystyrene. The interior walls of the drying room were insulated with polystyrene and the exterior walls were covered with galvanised iron. Air circulation and air exit systems were aspirated by a fan having 1400 rpm. The product was placed on a rectangular galvanised grid.

From the study it was concluded that the soaking of dates at a temperature of 25°C to obtain hydrated dates of 0.5 kg water/kg dry matter. Out of the three driers used for drying of dates, the samples dried in indirect natural convective drier were of good quality with acceptable duration. A good microbiological quality was observed in dates from all the three types of driers.

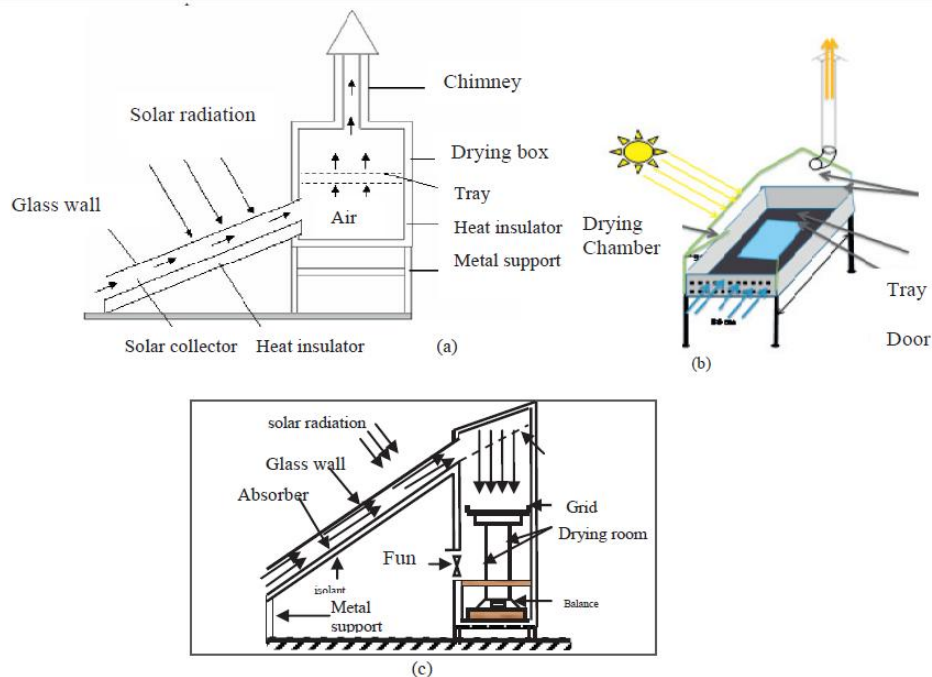


Fig. 4. a) Natural convection indirect solar drier, b) Direct forced convective drier, c) In-direct forced convective drier system. (Samira et al., 2014)

4.1 Vacuum Drying of Dates

Date fruits used for this study were purchased from a local market and stored at a temperature of 6°C. The dates prior to drying were cut into cubes having a thickness around 2.94-3.68 mm. The initial moisture content of the dates was around 14.7-14.89%.

The vacuum (200 mbar) drying was done using a laboratory drier with a vacuum pump. The drying was carried at different temperatures 60°C, 80°C, and 100°C. The loss of moisture in the product was determined using electronic balance at an interval of 15 minutes with an accuracy of 0.001 g [24].

4.2 Hot Air Oven Drying

The dates of Aseel variety, quantity of 33 kg were kept in hot air oven dryer at a temperature of 60°C for 22-24 hrs such that the hot air inside the oven is circulated by the blower, later the dates were cooled 4-5°C and are packed in card boxes. And the observations in processed dates are pH 6.1, acidity 0.26%, moisture 16.2% total sugar 60.3% [21].

4.3 Drying of Dates into Powder Form

Date fruits were highly perishable and were easily effected by the micro-organisms, so the removal of moisture will lead to the safe storage and extension of shelf life of dates. Though there is availability of dates syrup and dates pulp there is a need to develop a free flow dates powder because it can be blended easily into bakery products. The powder obtained from dates can be used as a replacement for added sugar in the manufacturing of several products [25].

4.4 Oven Drying of Dates to Powder

In a study, they made the dates in to paste and the dates paste + carrier agent was dried using a oven drier for 18 hours at a obtain date powder. The physical and thermal properties of the obtained powder were determined and there was no report regarding the nutritional properties of the powder.

4.5 Vacuum Drying of Dates to Powder

In study by Alsenaien et al. [26], the date fruits of khalas variety were procured from national research center for dates in Saudi Arabia. The obtained dates were cut into small pieces; the pieces were dried in a vacuum drying oven at a

temperature of 75±1°C for 24 hours. The obtained dried sample was crushed for 2 minutes in a grinder. The powder was sifted in 0.85 mm openings sieve in order to obtain fine homogenized powder. The obtained powder was stored at a temperature of 4-5°C.

4.6 Spraying Drying of Date Pulp

A study was carried by Manickavasagan et al. [25] in order to produce free flowing powder by using a pilot scale spray drier. The feed stock required for the drying was prepared by removing the seed and the cap of dates and soaking them in water at a temperature of 60°C for 10 minutes. The variety of dates used in this study was Fardh cultivar dates, the most common commercial variety of dates in Oman.

They dried the feed stock by using pilot scale spray drier. They determined the physiochemical properties of the obtained spray dried product and also the powder was to scanning electron microscope in order to know the texture and structure of the developed powder. The different processing conditions of the study were, 2 carrier agents they were malto dextrin and gum Arabic, 2 inlet air temperatures 150°C and 170°C, 2 feed stock flow rates 25 ml/min and 40 ml/min. The carrier agents were added at 0.4 kg per 1 kg of dates pulp. The feed stock prepared for spray drying operation was at 20% concentration. The date powder obtained in all the 8 treatments was subjected for various analysis like moisture content, colour, bulk density, wettability, solubility index, hygroscopicity, SEM analysis and also the determination of total phenolic compounds of the dates powder. The carrier agent has an effect on the gum physiochemical properties of the dates powder, but there was no difference in the phenolic compounds produced by malto dextrin and gum Arabic. The results of the SEM revealed that the dates powder produced from malto dextrin was smooth and spherical in shape but with severe agglomeration, whereas the dates powder produced from gum Arabic was having irregular spheres with small particles with dented surface [27,28].

4.7 Drum Drying of Dates

The drum dryer is a type of drying equipment which works on the principle of direct application of heat to the product in order to remove moisture from the product. The drum dryer is used for drying of liquid foods and pulps. The dates of variety khalas which were taken at

unripe stage and the seed is removed, the date flesh is made into pulp by using the mixer. The pulp obtained is divided into 6 parts, each of 340 g. The drum is operated at 20 rpm, 30 rpm and 40 rpm. Out of total 6 samples, it was observed that the moisture removed from the pulp during the low speeds (20 rpm, 30 rpm) is very high compared to that of moisture removed during the drum at 40 rpm. So the drum drying of dates (as pulp) at low drum speeds is an efficient process

for the moisture removal from dates. The powder obtained from dryer was analysed for moisture, p^h , water activity, colour, and TSS.

The samples obtained from drum drying were dried in a tray drier for 72 hours at a temperature of 65°C in order to bring the samples to safe moisture level. The obtained tray dried samples were analysed for moisture, p^h , water activity, color, and TSS.



Fig. 5. Pilot scale spray dryer [25]

Pilot scale spray dryer 2) Feed tank, Peristaltic pump, 3) Drying chamber, 4) Air filter, 5) Air heater, 6) Control panel, 7) Powder collection from drying chamber; 8-3) Powder collection from cyclone



Carrier gum Arabic



Carrier malto dextrin

Fig. 6. Images of spray dried samples [25]

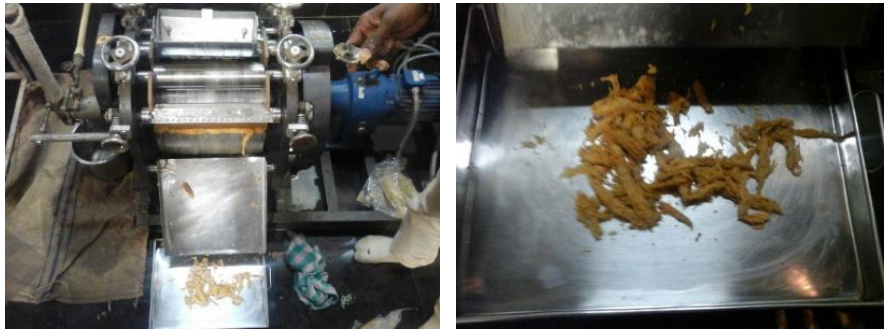


Fig. 7. Drum drying of dates

4.8 Microwave and Freeze Drying of Dates

In a study conducted by İZLi et al. [29] the microwave drying reduced the drying time (16 min) when compared to other methods. The reduction in drying time is due to the drying temperatures in the range of 60°C to 80°C. The phenolic compounds of the dried dates increased to the fresh dates and this might be due to the increased temperatures which leads to greater cell disruption. The freeze drying of dates took more time compared to that of microwave drying. For any quality assessment the colour is most important factor, the colour of dates obtained by freeze drying is very impressive than the fresh dates. The total phenolic compounds also decreased when compared to the microwave drying. The model of [30], gave the best fit for microwave drying and the two term model gave the best fit for freeze drying.

4.9 Convective Drying of Dates

The drying of dates with higher temperatures reduced the drying time. The color of dates compared to that of freeze drying was not much attractive, but the phenolic compounds of the convective dried dates were high. The model of [30], gave the best fit for high temperatures of convective drying.

5. INTENDED USAGE OF DATES AND DATES POWDER

Dates were used in the bread-making process in many bakeries in Saudi Arabia but latest methods were replacing the older methods, so such techniques were disappearing. The date syrup is a very good source of glucose and fructose [26]. The consumption of date syrup was very high in Saudi Arabia. This was used as a

sweetening agent in many foods, the low-quality dates were used as raw material for the production of date syrup [19]. The dates syrup and dates powder were used as a replacement for added sugars in the manufacture of several products mainly in the cookies to increase the nutritional value. Dates play an important role in the traditional medicine manufacturing process, these have an ability to cure the cold, sore throat, fever, abdominal troubles and reproductive problems. The dates of powder can be used in bakeries, such that it will act as both flavouring and blending agent [31,32,33,34].

6. CONCLUSION

Dates were the fruits with high nutritional composition besides highly perishable, so it is essential to prevent the dates from deterioration by using several drying methods available. The most suitable drying methods were solar drying, hot air oven drying, vacuum drying and tray drying. Dates as a powder has several benefits, so the dates were dried into a powder by either spray drying or drum drying techniques. All these drying technologies for dates was to improve the quality attributes and also the shelf life.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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