Date canning: a new approach for the long time preservation of date

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Abstract Dramatic growth in date (*Phoenix dactylifera* L.) production, makes it clear to apply proper methods to preserve this nutritious fruit for a long time. Numerous methods have been used to gain this goal in recent years that can be classified into non-thermal (fumigation, ozonation, irradiation, and packaging) and thermal (heat treatment, cold storage, dehydration, jam etc.) processing methods. In this paper these methods were reviewed and novel methods for date preservation were presented.

Keywords Date · Shelf-life · Preservation methods · Canning

Introduction

Date fruit (*Phoenix dactylifera* L.) is one of the nutritious foods and is cultivated and found in the Canary Islands and northern Africa, the Middle East, Iran, Pakistan, India, and California. This fruit is usually brown berry. It is rich in carbohydrates,

minerals, vitamins and contains high amounts of dietary fibers. These nutrients can promote human health in every aspect. Due to these properties the production of date has increased during the last 30 years, however by this increase the amount of lost dates also has increased and reached to near 30 % of annual production in the world (Besbes et al. 2009), for example this amount is approximately 20 % in Iran (Niakousari et al. 2010). The production of date in Iran as the 3rd world producer of date was 1,016,610 t in 2011 (FAOSTAT 2011). Many of 1,500 varieties of date palm are cultivated in some limited regions of the world. In Iran, there are 400 cultivars including: Astamarkan, Shahany, Zahidi, Mozafati, Barhi, and Kabkaab.

Usually, date fruit has been classified into four main maturity stages, i.e., kimri, khalal, rutab, and tamer. Although the date fruit at tamer stage is self-preserving because of its low moisture and high sugar content, date at khalal and rutab stages are very sensitive and perishable due to their high moisture content. In these stages the nutritional values are higher than tamer stage so the consumers prefer rutab.

The spoilage of fruits by insects, microorganisms, color deterioration and chemical changes during storage is a serious problem especially during hot and humid tropical conditions (Mohammadzai et al. 2008). A first major concern after harvest is insect infestation that causes great deals of fruit losses. Among the potential pathogenic bacteria, *Escherichia coli*, *Staphylococcus aureus*, and *Bacillus cereus* have been identified in date fruits together with lactic acid bacteria, yeasts, *Aspergillus flavus*, and *A. parasiticus* (Aidoo et al. 1996).

Several processing techniques may be useful for controlling and preventing date losses (Barreveld 1993). In general, we can classify these methods into non-thermal processing techniques including fumigation, irradiation, Modified Atmosphere Packaging (Table 1) and thermal processing methods including heat treatment, dehydration, cold storage, and jam (Table 2). Among these methods fumigation is very common and is the first choice for producers.

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Table 1 Non-thermal methods have been used for date preservation so far

Treatment method	Processing condition	Advantage	Ref.
Fumigation	Reldan: 15 g/m ³ of storerooms for 12 h at 15 °C Hydrogen phosphide: 1.5 to 2 g/m ³	Fast in action, cost benefit	Barreveld 1993
Ozonation	4,000 ppm of ozone in 1 h for insects and insect eggs 8 ppm for 180 or 240 min for fungal species	No residual components, minimum damage to the product	Al-Ahmadi et al. 2009; Niakousari et al. 2010
Irradiation	0.3 and 0.9 kGy for 32.15 and 96.46 min 0.5 kGy 0.6, 0.9 and 1.8 kGy in temperature room	No nutritional problems, no insects	Al-Kahtani et al. 1998; Azelmat et al. 2006; Barreveld 1993
Packaging (MAP)	85 % CO ₂ +3 % O ₂ +12 % N ₂ 75 % CO ₂ +12 % O ₂ +13 % N ₂ 34 % CO ₂ +37 % O ₂ +29 % N ₂ 10 % CO ₂ , balance air 20 % CO ₂ , balance air 30 % CO ₂ , balance air 20 % CO ₂ , balance N	Prolonged shelf-life	Al-Eid et al. 2012; Dehghan-Shoar et al. 2010

Non-thermal processing of date

Sorting and cleaning Because of the variability in the ripening process of different cultivars, ripening time also differs. There are wide variations in their final appearance, therefore it is important not to mix different cultivars of dates with each other. Because of the shape, stickiness, and softness of the date fruit it is practically impossible to sort it out mechanically, therefore it is done manually. On the other hand with sorting the dates by eye, more factors can be controlled. In manual processing the color, texture, size, moisture and blemishes are the main factors which are needed to be checked (Barreveld 1993). The damaged and infested dates are removed by workers while they are moving on the belt.

Dates may be contaminated by insects (and their dead bodies) and dust during harvesting and handling, therefore they should be cleaned to raise their marketability. Different methods have been used till now, like dry cleaning and mechanical washing with water. Dry cleaning is done by moving the dates over mechanical shakers, slowly rotating cylinders, or passing the dates over rotating soft brush. The danger of

microbial builds up necessitates frequent changing and cleaning of brushes. A complete washing unit consists of an inclined feeding belt made of coarse screen which takes the dates to the enclosed washing tunnel where they are subjected to strong water sprays. During this process the dates are turned around by the water sprays for a complete wash from all sides (Barreveld 1993). It is not recommended to use detergents, because they may be absorbed by the date flesh and cannot be removed later. Moving on the belt, the dates will pass under a strong air blast which removes the adhering water from the date surface to prevent any microbial contamination.

Fumigation Insect infestation in store products may be controlled effectively by fumigation. Over the past 100 years, fumigation has been the most effective method of pest control in store dates. Up to nine different chemicals have been used as fumigants, but currently, only chlorpyrifos-methyl (Reldan) and phosphine are considered safe for use in date preservation and food industries (Yubin and Ajit 2007). Reldan can kill insect in all the stages of its life. With regard to fumigation by gases, two types can be distinguished: at atmospheric pressure

Table 2 Thermal methods have been used for date preservation so far

Treatment method	Processing condition	Advantage	Ref.
Heat treatment	Pasteurization at 60–65 °C Boiling in water for 10 min	Artificial maturation, promoting the enzymatic inversion, eliminating the tannin and increasing the level of total phenolic and total flavonoids compounds	Allaith et al. 2012; Barreveld 1993
Cold storage	−18±2 °C for 6 months −18 °C for 6 and 10 months −18 °C, −35 °C and −50 °C	Reducing the activity of chemical and biological reactions	Al-Yahyai and Al-Kharusi 2012; Ashraf and Hamidi-Esfahani 2011; Sidhu 2008
Dehydration	65 °C and 40 % humidity 70 °C and air velocity of 1.5 m ² /s	Cost benefit	Barreveld 1993; Falade and Abbo 2007

and under vacuum. The penetration of the gas in the vacuum method is more intense, the time of treatment is reduced and more affected by the time of evacuating the air than dispersion of the gas, but the investment costs are much higher. Fumigation at atmospheric pressure can be subdivided in fumigation in temporary enclosures, like under the tarpaulin or plastic and in a permanent storeroom space equipped for fumigation with airtight doors, and circulation and exhaust fans. The practical, average dose of effective fumigation of dates has been reported as 15 g/m³ of storerooms for 12 h at 15 °C. If the processing temperature is lower, the amount of gas has to be increased (25 % for every 3 °C drop) but can be reduced when time of treatment is increased (Barreveld 1993). The fumigant phosphine has provided an important replacement to methyl bromide in several situations, but phosphine has one important disadvantage, it requires an exposure period of 5 days or longer, which makes it unsuitable for quarantine fumigation (Yubin and Ajit 2007). Compared to the use of methyl bromide, which is fast in its action, the use of hydrogen phosphide is slow and it will take at least 48 h before the gas has fully developed. On the other hand, the application is very simple and also suitable for small containers like airtight bags and small storerooms without the need for special equipment, and where the time factor is not important. The effective dosage for the fumigation of dates is 1.5 to 2 g/m³ of storage space (Barreveld 1993).

Using malathion and methyl bromide are common among producers, but many stored-product insect species have developed resistance to malathion. Many of the chemical pesticides used to protect dates from insect activity are threatened by environmental legislation. Methyl bromide depletes the ozone layer and has been classified as a class I ozone-depleting substance and is being phased out by 2015 worldwide (UNEP 2012).

Ozonation Ozone is a triatomic molecule (O₃) and a very reactive form of oxygen. It is commonly produced in nature by interactions of molecular oxygen (O₂) with chemicals, electric discharges during lightning, or short ultraviolet (UV) radiation from the sun. The use of ozone as an effective sanitizer has been increased among many of food industries. The limited solubility of ozone in water can be advantageous, and the gaseous state of the sanitizer may have beneficial implementations in food processing (Yousef et al. 2011), although ozone decomposes to a number of free radicals, no residual components are left on products when decomposition is complete (Novak and Yuan 2007). The relatively indiscriminate attack of organic compounds by free radicals from ozone decomposition inactivates both microorganisms and insects while conjointly resulting in self-depletion. In association with foods, many organic components are reactants as well, resulting in self-depletion of ozone and reduced biocidal effectiveness (Khadre et al. 2001). So an important

consideration in the use of ozone is to involve the minimum concentration of ozone necessary to decrease microbial concerns while minimizing damage to the food being treated (Novak and Yuan 2007).

Twenty four different kinds of foods including cereal grains, cereal grain powders, peas, beans and whole spices of foods were treated with 0.5 to 50 ppm ozone (gas phase) at 10 °C for 1 h. Riboflavin was stable during treatment, with over 90 % retention of vitamin B₂ in all food samples, even with treatments of 50 ppm ozone. Thiamin decomposition was detected in some food samples of flours and spices treated with 50 ppm ozone. Losses amounted to up to 40 % in products with high surface areas, but minimal losses (~10 %) were seen in whole grain and bean products (Rice 2012). Extensive use of ozone (110–120 ppm) will chemically destroy a variety of amino acids (Rice and Gomez-Taylor 1986), but there is no evidence that the use of ozone at levels suggested for food preservation will cause any destruction of amino acid (Rice 2012).

Long term inhalation studies with animals show that ozone is not a systemic poison, nor is it carcinogenic (National Toxicology 1994). With more than 100 years of ozone application in a variety of commercial- industrial manufacturing and processing plants, there has never been a death reported from exposure to ozone (Rice 2012).

The effectiveness of ozone on insects (Indian meal moth (*Plodia interpunctella*) and sawtooth grain beetle (*Oryzaephilus surinamensis*)) was evaluated (Niakousari et al. 2010). In this study insects in their different stages of life (adults and larvae) were exposed to the ozone, the mortality of 50 % obtained by 2 h exposure of 1,200 ppm. This rate exceeded to 100 % mortality by 1 h exposure of 4,000 ppm of ozone. The results showed that there is an inverse relationship between the concentrate of ozone and time. The insect eggs were strongly resistant against almost all of chemical and physical treatments and only 20 % of them were destroyed by 4,000 ppm of ozone during 1 h. Processed eggs for 2 h with 2,000 and 4,000 ppm of ozone resulted in killing 50 and 80 % of eggs, respectively. These results showed that ozone has an initial problem in being able to penetrate through the insect egg, reducing its ability to inactivate eggs completely at deeper levels. The other aspect of using ozone is how it affects the sugar content of date. In a study by Niakousari et al. (2010) the total and invert sugar contents in the control and ozonized dates did not change significantly ($P < 0.05$). There was a steady increase in mortality of larvae and adults of *O. surinamensis* reaching 100 % at 30 ppm ozone delivered in 6 h (Al-Ahmadi et al. 2009).

The growth of most test fungi significantly decreased on exposure to 4 ppm ozone for 120 min and steady drop in growth rate achieved on dose elevation to 8 ppm accompanied with extending the exposure time, ozone concentration of 8 ppm was lethal for all fungal species, when the exposure time extended to 180 or 240 min.

Irradiation Food irradiation is the application of ionizing radiation, in the form of x-rays, gamma rays, or accelerated electrons, to improve the microbial safety, delay the maturation and prolong the shelf life of food products (Sommers and Fan 2011). Only these ionizing rays are authorized to be used in food irradiation applications. This physical treatment is used on more than 60 food types in over 40 countries worldwide (FSAI 2006). Radiation is an energy form traveling through space (radiant energy) in a wave pattern and can either be naturally occurring (e.g., from the sun or rocks) or produced by man-made objects (e.g., microwaves and television sets). The frequency or wavelength of the energy waves produced by different sources distinguishes the different types and functionality of radiation, with high-frequency radiation of UV, X-rays, and gamma-rays posing the most significant risk to human health. Gamma ray, electron beam, and X-ray sources are used for a variety of industrial processes. Gamma radiation is preferred because it can penetrate deeply, whereas e-beams penetrate food to a depth of only 3.80 cm. X-rays are capable of irradiating thicker items, but the process is extremely expensive and energy intensive. Large amounts of food would have to be irradiated to make it affordable (Riganakos 2010). The ^{60}Co almost always used for the irradiation of foods.

The effect of irradiation on the nutritional quality of food is similar to, and in some cases less than that for some other preservation methods. Only minor changes are observed in the level of some vitamins (B_1 , C, A and E), while carbohydrates, fats and proteins remain largely unaffected by low or medium doses. However, nutritional changes in food due to irradiation are dependent on factors such as the temperature, radiation dose, packaging environment and storage (FSAI 2006).

The toxicological aspects of food irradiation have been studied more extensively than for any other food preservation techniques (Wilkinson and Gould 1996). So the International Project in the Field of Food Irradiation (IFIP) was created in 1970 with the aim of worldwide research program on the health safety of irradiated food. The research program included long-term animal feeding studies, short-term screening tests, and the study of chemical changes in foodstuffs irradiated with a dose of up to 10 kGy (Diehl 1999). The Joint FAO/IAEA/WHO Expert Committee also evaluated the Wholesomeness of Irradiated Food (JECFI). This committee concluded in 1980 that the irradiation of any food commodity up to an overall average dose of 10 kGy presented no toxicological hazard and no special nutritional or microbiological problems (WHO 1981).

In a study dates were infested by 20 *O. surinamensis* adults per replicate (Single infestation), and 20 *O. surinamensis* and 20 *Tribolium castaneum* adults per replicate (mixed infestation); then the dates were irradiated by a ^{60}Co source at 0.3 and 0.9 kGy for exposure times of 32.15 and 96.46 min. Radiation at these doses for 2 days after infestation led to a complete control without causing any damage to the irradiated dates in the single and mixed insect treatments. After 45 days

of infestation and following irradiation, regardless of the dose, no live insects were detected in the single infestation treatment. In mixed infestation, a dose of 0.9 kGy was sufficient to cause 100 % mortality, but five adults of *O. surinamensis* were found alive in one replicate of mixed infestation treatment when a dose of 0.3 kGy was applied (Al-Kahtani et al. 1998). One hundred percent mortality occurred in the most resistant development stages of the insects by 0.5 kGy irradiation; 0.25 kGy is enough and effective for preventing the development of insects (Barreveld 1993).

Irradiation is very effective on the microbial content of processed products especially in bacteria (Jay et al. 2005). Total bacterial counts reduced in irradiated dates but the reduction in yeasts and moulds was not remarkable (Al-Kahtani et al. 1998; Azelmat et al. 2006).

Dates were irradiated with doses of 0.6, 0.9 and 1.8 kGy and stored at room temperature ($18 \pm 4^\circ\text{C}$) for 4 and 8 months; the chemical aspects of dates were analyzed immediately after irradiation and storage times. The results indicated that there were no significant differences in dry matter, total lipids, glucose and fructose contents amongst the treatments. The treatment led to an increase in titratable acidity immediately after irradiation. The protein composition of dates was not affected by irradiation and post-irradiation storage. The results of carbohydrate analysis for dates as a function of irradiation dose and post-irradiation storage demonstrated that immediately after irradiation there were no differences in total sugar amounts between irradiated and non-irradiated dates. These amounts increased gradually with increasing storage time for all the samples. For starch content, the results show that irradiation did not induce significant changes after irradiation but 4 months storage showed a significant reduction in the starch content; however this reduction was for both the irradiated and non-irradiated dates (Azelmat et al. 2006). Mohammadzai et al. (2008) irradiated dates with 20, 50, 100, 200 and 300 krad and packed the samples in blue, green, yellow, black and white polyethylene bags and stored them for 6 months. In proteins, the decrease is higher in the first 3 months, whereas in the last 3 months no prominent difference was noticed. The maximum protein decrease was recorded for control samples in the blue packaging. Minimum decrease (2.32–1.4 %) was recorded in samples in white and yellow packaging, at doses of 300 and 200 krad, respectively. The results of fat contents clearly indicate that packaging and radiation doses up to 300 krad do not affect the contents (Mohammadzai et al. 2008). Fructose, glucose and total sugars were significant ($p \leq 0.05$) reduced immediately after irradiation; this could be due to the formation of some radiolytic products of carbohydrates (Al-Kahtani et al. 1998).

Packaging Modified atmosphere packaging (MAP) is defined as ‘the packaging of a perishable food products in an atmosphere which has been modified so that its composition is

other than that of air' (Mullan and McDowell 2003). The principle of MAP is replacement of air in the package with a fixed gas mixture. Once the gas mixture is introduced, no further control of the gas composition is exercised, and the composition will inevitably change (Sivertsvik et al. 2002). MAP treatment potentially can reduce respiration rate, metabolic heat production, browning, decay and product sensitivity to ethylene (Kader et al. 1989).

A negative correlation was reported between the CO₂ concentration and survival of the insects in Sayer date as well as mould and yeast by applying MAP technology (Al-Eid et al. 2012; Dehghan-Shoar et al. 2010). The mechanism of this reduction may be due to the reduction of intracellular pH and disturbance of cellular metabolism.

Because of the presence of CO₂ and its solubility in fruit shelf, pH value decreases in MAP system (Dehghan-Shoar et al. 2010). Storage temperature may affect the pH value among the samples; so that in higher temperature more decrease was seen in pH value in Sayer dates than CO₂ elevation. As a consequence of the increase in CO₂ content, sugar crystallization decreased because fruit maturity and evaporation decreases in this treatment (Dehghan-Shoar et al. 2010). MAP-treated dates had an insignificant weight loss during the storage. Dates treated with CO₂ at levels of 20 % or below demonstrated reduced ripening signs including firmness retention, higher sensory scores and a 'yellowed' colorings compared with non-treated ones (Al-Eid et al. 2012).

Thermal processing of date

Heat treatment Thermal processing is one of the conventional preservation methods which assures processed foods to be safe and shelf-stable (Ramaswamy and Chen 2002), so by giving time at a specified temperature to the food it can be ensured that the products do not pose a public health problem (Holdsworth 2004).

Since the destruction of nutrients during the thermal process is dependent on (1) time-temperature treatment used as the basis of the process and (2) rate of heat transfer into the product, losses range from 0 to 91 %, depending on the nutrient and product may occur. Non-enzymatic (Maillard) browning, as the sugars react with certain amino acids to create an indigestible complex is the consequence of heat treatment. Some nutrients such as vitamin C are destroyed by heating (Lund 1988).

Heat treatment of dates may have some beneficial effects on date fruit. The presence of insects on any stage lessens the quality of date; activity of enzymes and growth of microorganisms have the same effect, so the aim of applying this treatment is destroying insect life, reducing the microbial count and decreasing enzyme activity. Complete sterilization

of date is impossible due to the damage of date shelf therefor a partial pasteurization at 60–65 °C is enough to prolong the shelf life of date (Barreveld 1993). Other benefits of this treatment are artificial maturation, promoting the enzymatic inversion and eliminating the tannin. On the one hand because of incomplete ripening of fruits on the other hand the threats of early rains cause to apply heat treatment. The optimal temperature for Deglet Nour is 35 °C and for other cultivars is about 50 °C (Barreveld 1993).

Boiling the dates in water for 10 min significantly increased the level of the total phenolic and total flavonoids compounds but caused significant losses in anthocyanin content (Allaith et al. 2012). By reviewing several articles on the effect of heat treatment on the phenolic content of different fruits and vegetables (Al-Farsi et al. 2005; Dewanto et al. 2002; Chumyam et al. 2013; Manzocco et al. 1998; Cheng et al. 2006; Randhir et al. 2004; Ahmed and Ramaswamy 2006; Saad et al. 2013), it can be concluded that the level of phenolic acids increase due to chain-breaking effect of heat treatment; additionally the breakdown of cell walls and hydrolysis of linkages between bound acid and lignin or arabinoxylanes cause the release of phenolic acids. Boiling of dates for long time may facilitate the leakage of anthocyanins during the extraction.

Cold storage By applying low temperatures mainly for preservation and extension of shelf life of fresh or processed foods, reducing the activity of microorganisms, enzymes, and chemical and biological reactions occur. Generally below 4 °C no insect activity takes place, however at these levels insects will not necessarily be destroyed (Barreveld 1993). Increase in moisture content, reduction in sugars, and pH but decreases in tannins of rutab date occurred during storage at -18 ± 2 °C for 6 months (Sidhu 2008). A significant reduction in seed and flesh weights of dates was observed at -18 °C storage for 6 and 10 months (Al-Yahyai and Al-Kharusi 2012). Tissue damages during storage at temperatures above -18 °C was severe due to crystallized solute inclusions, at -18 °C was moderate and at -35 to -50 °C was negligible (Ashraf and Hamidi-Esfahani 2011).

Dehydration The term dehydration refers to the removal of moisture from a material with the primary objective of reducing microbial activity and product deterioration (Ratti 2001). Since the moisture content of the fresh date fruit is high (about 60 %), drying is a common and traditional method to prolong its shelf life. The recommended temperature and relative humidity for drying of soft dates are 65 °C and 40 % (not more than 60 %) which avoid quality loss and case hardening (Barreveld 1993). However, Falade and Abbo (2007) concluded that, it would be possible to attain faster drying by increasing the temperature up to 70 °C and air velocity of 1.5 m²/s (Falade and Abbo 2007).

Date jam Jams may have originated as an early effort to preserve fruit for consumption in the off-season. Originally, jam production relied on the native pectins of incorporating fruit for gel formation. Fruit was cooked with sugar, extracted acids, and pectins, and if the proper balance of the sugar level, pH, and pectin content were achieved, a satisfactory jelly was obtained (Baker et al. 2005). Date fruits, having high sugar contents, are very suitable for jam manufacture. The rutab-stage date fruits have an appropriate quantity of the pectin required for jam preparation (Suad and Jiwan 2005).

A good jam can be prepared when the sugar content is 65 %, the pectin is 1 % and the pH is about 3.0 to 3.2 (Suad and Jiwan 2005). Besbes et al. (2009) cooked second-grade date fruits of Deglet Nour, Allig and Kentichi cultivars to produce date jam. Brix was adjusted at 65 % and the pH was adjusted to 4.0 ± 0.1 with a citric acid solution at the end of cooking. Then jars which contained jam sterilized at 90 °C for 15 min. By this treatment total sugar, protein and dry matter decreased; total dietary fiber and total phenolics increased (Besbes et al. 2009).

Pickle Pickling consists of both controlling some and encouraging growth of other microbes (not harmful to humans) in order to reach a situation in which the product is both preserved from microbial deterioration and remains edible. The types of date pickles are as follows: relishes, brine pickle, fruit pickle, fresh pack pickle, and pickles-in-oil. Date fruits at the kimri and khalal stages of maturity are suitable for making pickles and chutney. The ample amounts of sugars and other nutrients of kimri-stage fruit make it suitable for producing good quality pickles. The duration of the pickling process varies from prolonged fermentation for brine pickles to very limited fermentation for fresh-pack pickles or no fermentation (Suad and Jiwan 2005). In this method dates are packed in an acidified sugar solution and immediately pasteurized (Barreveld 1993).

Jelly Jelly is similar to jam except that a clear fruit extract is used to obtain a transparent final product. For jelly making, a clarified date juice: sugar ratio of 1:1 is used, and the finished product has total soluble solids content of around 73°Brix and a pH of 3.57, with a shelf life of up to 6 months at room temperature (Suad and Jiwan 2005). The process consisted of mixing and boiling 60 kgs of date juice (42°Brix) and 48 kgs of sugar with 350 g of pectin and pH adjusted to 3.4 with citric acid, to a level of 68°Brix. The product was hot filled in jars and pasteurized for 10 min at 90 °C (Barreveld 1993).

Date syrup The date syrup is a clarified and concentrated liquid that is extracted from date fruit. It is produced through-out three major stages: extraction, clarification and concentration. The procedures of producing date extract are as follows:

- Hot water: water ratio of 1:3 (w/w) at 90 ± 5 °C for 90 min.
- Pectinase/cellulase enzymatic extraction: the date fruit pulp was blended with 3 times of distilled water and the pH value was adjusted to 6.0 ± 0.2 before the addition of enzyme preparations. Pectinase enzyme was obtained in already available liquid form, but in the case of cellulase, 250 mg of enzyme powder was dissolved in 100 ml distilled water before use (or 50 U of pectinase and 5 U of cellulase). Pectinase and cellulase enzyme preparations were added at the rate of 1 % for each; on a date pulp weight basis. The mixture of date pulp, water and enzyme preparations was mixed carefully and incubated at 40 ± 2 °C for 90 min (or during the 120 min at 50 °C) with a continuous shaking. At the end of the incubation period, the mixture was autoclaving using 15 psi steam pressure for 10 min to stop the enzyme activity (Abbès et al. 2011; Al-Hooti et al. 2002). The pulp was preheated to 45 °C and divided into different parts of enzyme treatment. The pectinase enzyme was pipetted (0.05 and 0.1 ml / 100 g pulp) into the date pulp. The enzyme treated pulp was incubated at 45 °C for 30–150 min. After clarification, treated date pulp was pressed in a hydraulic press for extracting the juice. The date juice yield was measured and recorded as weight/weight of pulp. The juice was heated to 85 °C for 60 s to inactivate the added enzyme and cooled (Kulkarni et al. 2010).
- Microwave extraction: the date fruit pulp was blended 3 times with distilled water and then, the mixture was mixed carefully and the extraction was carried out at 90 ± 5 °C for 30 min in microwave oven in which the emitted frequency of radiation was 50 Hz.
- Ultrasonic extraction: the date fruit pulp was blended 3 times with distilled water and then, the mixture was mixed carefully and the extraction was carried out at 30 ± 5 °C for 30 min in ultrasonic device (Entezari et al. 2004).

At the end of extraction by using the tested previous procedures individually, the mixture was centrifuged ($10,800 \times g$) at 30 ± 5 °C for 25 min. Then the supernatant was collected. The percentage of date syrup extraction with hot water, enzymatic extraction, microwave and ultrasonic extraction were 38.94 %, 83.10 %, 77.52 % and 83.96 %, respectively (Ganbi and Hassan 2012). Therefore, it seems that ultrasonic and enzymatic extractions are efficient methods to apply for juice extracting.

After extraction clarification is carried out to improve the quality of the extracted juice, so active carbon, resins, enzymes and filter aids are used to reach this effect (Barreveld 1993). The date juice is mixed carefully with 0.5 % activated carbon granules at ambient temperature (35 ± 5 °C) followed by filtration (Al-Farsi 2003). The clarified juice with a Brix level of 20–25 may be concentrated, preferably under vacuum, to avoid as little as possible heat-induced changes in the

materials and to be able to use energy saving multi-stage evaporation. With regard to physical stability experience has shown that below 70°Brix the possibility of crystallization is remote. A most common density of date syrup is 75°Brix at which level it is self-preserving and crystallization only occurs after prolonged storage (Barreveld 1993). Date syrup is a good source of dietary fiber, total phenolics, and antioxidant activity that can take into account as an inexpensive source of natural antioxidants (Al-Farsi et al. 2007).

Date paste Producing date paste is another way of preserving of this fruit and making it available for the food industry throughout the year. In this regard, pitted tamer date fruits are steamed for 3 min at 10 psig or soaked for 5 to 15 s in water at 95 °C. The low pH of 5.4 is necessary for improving the shelf life of this product by adding citric acid or ascorbic acid. The final product may be used as a sucrose replacer in ice cream and bakery products (Suad and Jiwan 2005).

Date canning

Thermal processing is a suitable method to prolong the shelf life of fruits, especially date fruit, which has some benefits, including: artificial maturation, destroying insects, reducing the microbial load, inactivation of enzymes (e.g. pectinase), and reducing tannin. Schematic representation of manufacturing procedures for canned date was shown in Fig. 1. The temperature above 100 °C (sterilization temperature) is not proper for sanitization of date due to its destructive effect on the shelf. Therefore by choosing a proper combination of time

and temperature, that is the art of thermal processing, and by resolving deficiencies a safe product can be produced. This canned product which has all the benefits of the thermal processing method may extend the shelf life of date fruit because of its reliable packing and may preserve the sensitive fruit shelf.

Conclusion

Growth in date production in recent years, makes it clear to apply proper methods to preserve this nutritious fruit for a long time. These methods can be classified to non-thermal (fumigation, ozonation, irradiation, and packaging) and thermal (heat treatment, cold storage, dehydration, jam and etc.) processing methods. Methods like fumigation and irradiation have some limitations due to consumer acceptability. In MAP and cold storage the investment costs are much higher. Dehydration decreases the quality of the final product. Therefore it is needed to re-engineer the product design by using the art of formulation to prolong the shelf life of date. It seems more studies on thermal processing especially heat treatment are needed to investigate the effect of various pHs and Brixs as well as heating range and duration on the final product. The type and shape of packaging are important to protect the sensitive shelf of date.

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Fig. 1 Schematic representation of manufacturing procedure for canned date

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