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Review

Technologies for the development of new value-added foods from dates and their processing by-products

Research highlights

- Innovative approaches to the value addition to date fruits and their processing by-products have been reviewed
- New processes (e.g., ultrafiltration and hydrothermal treatments) to obtain differentiated date ingredients are shown
- The use of date fruits and their processing by-products as natural sources of value-added active compounds is also presented

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Review

Technologies for the development of new value-added foods from dates and their processing by-products

Alex López Córdoba

Universidad Pedagógica y Tecnológica de Colombia, Facultad Seccional Duitama, Escuela de Administración de Empresas Agropecuarias, Carrera 18 con Calle 22, Duitama 150461, Boyacá, Colombia. alex.lopez01@uptc.edu.co. ORCID: 0000-0003-2434-5743

Abstract: The changes in consumer preferences and the increasingly competitive global market have demanded that food entrepreneurs engage in innovative value-added activities. The date is a delicatessen fruit known by its content of active compounds (e.g., dietary fiber and antioxidants) and its biological activity which has a vast potential in the design of new products such as bioactive ingredients, sugar substitutes, dietary supplements, functional foods, among others. In the current paper, innovative approaches to the value addition to date fruits and their processing by-products have been reviewed from recent high-quality scientific works. New processes such as ultrafiltration and hydrothermal treatments are shown as a useful alternative to obtain differentiated date-based ingredients (e.g., fiber concentrates, sap syrups, and date powders). Moreover, the use of date fruits and their byproducts as natural sources of value-added active compounds in the preparation of dairy, meat, and bakery and cereal products is also presented.

Keywords: Value addition; Functional Foods; *Phoenix dactylifera*; Innovation; Differentiation

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1. Introduction

Date palm (*Phoenix dactylifera* L., Family Arecaceae) is one of the oldest and most important fruit crops in the arid and semi-arid regions of the world such as the Middle East and North Africa region (Ghnimi et al. 2017). In these areas, date fruits have played an essential role as a food security crop and provide a valuable support economic development. The date palm has the advantage of survives under harsh conditions, such as high levels of soil salinity, extreme drought, and heat (Yaish and Kumar 2015).

The world production of dates rose 8.166.014 t in 2017 (FAOSTAT 2019). Although Egypt (1.590.414 t), Iran (1.185.165 t), Algeria (1.058.559 t), Saudi Arabia (754.761 t), and Iraq (618.818 t) are the central producing countries (FAOSTAT 2019), date palm production has extended to United States of America, Central and South America (Mexico, Peru, Chile and Colombia), Southern Europe (Spain) and Australia (Rivera and Johnson 2013; Sirisena et al. 2015).

The number of date varieties grown globally exceeds 2000, but the two most widely known in the international market are the Medjool and Deglet Noor (Ghnimi et al. 2017). The rest of the date varieties sold in the international markets are generally referred to as "common dates," especially in the EU market (Mbaga 2015). Unfortunately, a large number of excellent date varieties are not well known outside their countries of production as there is no internationally agreed system for their identification and classification (Ghnimi et al. 2017).

Date palm is considered a multipurpose palm because it is a source of multiple nonfruit and fruit products. However, it has not been fully exploited as yet. Date fruits are known for their differenced nutritional value and functional properties (Khalid et al. 2017). They are widely available in the global market, especially at the ripe stage Tamar, and are consumed fresh, dried, or in various processed forms such as jam and jellying (Ghnimi et al. 2017). Unfortunately, it is estimated that about 30% of the total production of dates is lost during

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harvesting, picking, storage, commercialization and technological transformation due to the incidence of physical, physiological, and pathological disorders and to insect infestation (Abbès et al. 2011; Lobo et al. 2013). Therefore, several strategies have been proposed in order to valorize hard dates, as well (Tang et al. 2014; Mrabet et al. 2015).

In addition to date fruits, palm trees offer several other derivatives (such as leaves, trunks, and seeds), which are used for many traditional and industrials activities like roofing, fencing, basket making, and animal feeding (Makhlouf-Gafsi et al. 2016). Date palm sap could be directly consumed as a juice or fermented to obtain alcoholic beverages. The waxes of the leaf have important pharmacological properties such as wound healing, anti-inflammatory, antibacterial, antiviral, hepatoprotective, and antitumoral effect (Khelil et al. 2016). The current paper provides information concerning the advances in the development of new value-added products from date fruits and their industrial exploitation. Several recent high-quality scientific works were reviewed, and new technologies for the value addition to date fruits are presented. As far as the authors are aware, several works are dealing with the composition and the biological activity of different date cultivars (Ghnimi et al. 2017). However, the development of value-added foods from date has been little discussed.

2. Date fruit development

Figure 1 shows the stages that take place during the development of the date fruit. Several studies had discussed the physical and chemical development of dates as they pass through these stages (Baliga et al. 2011; Ghnimi et al. 2017). Date fruits is commonly consumed in their last three development stages (i.e., Khalal, Rutab and Tamr).

The fruits are also classified according to their moisture contents at fresh Tamr stage into soft (> 30%moisture), semi-dry (20–30% moisture) and dry cultivars (<20% moisture)

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(Ghnimi et al. 2018). In soft cultivars (like Hillawi, Abada, Amhat, Barhi, Bentaisha, Halawy, Hayani, Honey, Khadrawy, and Medjhool), almost all sucrose is converted into invert or reducing sugars (glucose and fructose) during ripening (Lobo et al. 2013). Dry date cultivars (like Badrayah, Bartamoda, Deglet Beida, Horra, Sakoty, and Thoory) contain a relatively high proportion of sucrose. Semi dry-date cultivars include cultivars such as Amry, Dayri, Deglet Nour, Khalas, Sewy, and Zahidi. Both dry and semi-dry dates retain a good amount of sucrose on full ripening, in addition to the reducing sugars (Lobo et al. 2013).

3. Composition and biological activity

The date fruit is composed of an edible flesh (or pulp) (85-90%) and a single seed (10-15%) (also called kernel, stone, pit, or pyrene) (Figure 1) (Ghnimi et al. 2018; Kamal and Sami 2018).

The composition of date fruits depending on the cultivar, stage of maturity, and agro-climatic conditions. Table 1 shows the estimated composition of date pulp and seeds of some of the most popular date varieties in the global market. Date pulps contain easily digestible sugars (70%), mainly glucose, sucrose and fructose; dietary fibers and contain fewer proteins and fats (Table 1) (Baliga et al. 2011; Ghnimi et al. 2017). They also contain vitamins like riboflavin, thiamine, biotin, folic, and ascorbic acid that are essential for the body (Baliga et al. 2011; Aslam et al. 2013). The pulps are rich in iron, calcium, cobalt, copper, fluorine, magnesium, manganese, potassium, phosphorus, sodium, copper, sulfur, boron, selenium and zinc (AL Juhaimi et al. 2014; Al-Farsi et al. 2018).

When compared to the pulp, date pits contain a higher quantity of protein and fat and are also high in dietary fiber (Table 1) (Baliga et al. 2011; Bouhlali et al. 2017). They have many other benefits, such as vitamins, minerals, carotenes, and other chemicals that may prevent cancer and heart disease (Bouhlali et al. 2017; Laghouiter et al. 2018). Date palm seeds

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contain 5–12% oil with the predominant of oleic acid followed by linoleic, lauric, palmitic, and stearic acids (Laghouiter et al. 2018).

Date pulp and seeds are rich in value-added metabolites such as phenolic acids, flavonoids, tannins, anthocyanins, and carotenoids (Di Cagno et al. 2017; Ghnimi et al. 2017). Several works are dealing with the role of these compounds on the health benefits associated with date fruit (Table 2) (Taleb et al. 2016; Al-Alawi et al. 2017).

4. Value addition to date fruits

4.1. Dried dates

Drying of fresh dates is necessary because it contains high moisture which limits the shelf life. Moreover, several consumers show a preference for fruits at the dry and semi-dry stage, probably because of lower astringency, sweet taste, and easy storability

Drying consist in the reduction of the moisture content of the date fruits. Sun-drying is a traditional way of preserving dates (Al-Farsi et al. 2005). However, some of their antioxidant constituents are lost during this process (Al-Farsi et al. 2005). Air drying is another process used for the decreasing of the water content of date fruits (Al-Awaadh et al. 2015). Al-Awaadh et al., 2015 studied the effects of different air-drying conditions on date fruits color and texture. Drying assays were performed at different temperatures (50°C, 60°C, 70°C, and 80°C,) and air velocities (0.5, 1.0, and 2.0 m/s). It was stated that to minimize changes in the date fruits color and texture, the optimal drying conditions are temperatures ranging between 60 and 70 °C using a air velocity of 2 m/s. Juhaimi, Özcan, & Uslu, 2017 studied the effect of microwave (360, 540 and 720 W) and conventional drying (70, 90 and 110 ºC) on the antioxidant activity, the polyphenol content and the mineral profile of date pulp. Both dehydration methods caused a reduction in the phenolic compounds amount, although the antioxidant activity of the date flesh was not affected.

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136 4.2. Date paste

137 Date paste is one of the most popular date products in several countries. It is prepared
138 based on pitted and minced dates and is mainly consumed as paste, but also it is used as an
139 important ingredient in bakery and confectionery industries for cookies, sweetbreads, and
140 candy bars (Sánchez-Zapata et al. 2011; Al-farisi and Lee 2014). Moreover, date paste could
141 be used as a texture modifier and also as an stabilizer of lipid-rich foods or emulsions
142 (Sánchez-Zapata et al., 2011).

143 Date paste is rich in sugar (sucrose, fructose, and glucose), dietary fiber, and phenolic
144 compounds (Table 3) (Sánchez-Zapata et al. 2011; Martín-Sánchez et al. 2014; Ben Mya et
145 al. 2017). Moreover, this product has reported low pH (6.0) and water activity (0.58)
146 (Sánchez-Zapata et al. 2011).

147 Date paste can also be enriched with date seeds to improve their dietary fiber and
148 phenolic compounds content. Al-farisi & Lee, 2014 proposed an innovative process to
149 obtaining date paste enriched with dried and roasted seed powders with good sensory quality.

150 Most recently, dried date paste has been proposed as a useful carrier for probiotic strains
151 such as *B. coagulans* BC4 (Marcial-Coba et al. 2019). This interesting approach could be
152 useful to the development of new functional snacks containing probiotic bacteria.

153

154 4.3. Date juice and syrup

155 Date syrup (or dibs) is one of the most important derived date fruit product. Date-syrup
156 mainly contains sugars, such as sucrose, fructose, and glucose (Abbès et al. 2015). Moreover,
157 this contains proteins, lipids, pectin, salts, and minerals (Abbès et al. 2015). Date syrup is
158 also an important source of natural antioxidant compounds (Al-Mamary et al. 2014).

159 The date syrup could be used as an ingredient of a broad amount of food products. Also,
160 date syrup has been proposed as a tablet binder (Alanazi 2010).

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To the preparation of the date syrup, date pulp is blended with water and heated at 100 ºC between 5 and 30 min. The produced juice is filtered and centrifuged. Finally, the supernatant is concentred to 80 ºBrix by heating. The syrup could be crystallized and could be a product named as date-set-syrup (Al-Farsi et al. 2018).

Raw date syrup is frequently subject to clarification/discoloration steps in order to remove off-color compounds and increase the extraction yield, reducing sugars soluble dry matter and titrable acidity of the products (Abbès et al. 2011). The treatment of the syrup with hydrolytic enzymes (e.g., pectinase and cellulase) has proved to be a useful way to increase the recovery of soluble solids of date syrups (Abbès et al. 2011, 2013, 2015). To remove off-color compounds, such as polyphenols, activated carbon is used for its high adsorptive capacity, and sufficient pore size distribution (Ahdno and Jafarizadeh-Malmiri 2017). Ahdno and Jafarizadeh-Malmiri 2017 developed a sequenced enzymatically pre-treatment and filter pre-coating process to decrease turbidity and darkness intensity of date syrup(Figure 2).

Date palm sap is one of the popular derivatives of date palm trees (Makhlouf-Gafsi et al. 2016, 2018). This derivative has steadily gained attention and importance in the development of date syrups. To the preparation of the date sap syrup, exuding saps are collected by a traditional tapping method from male and female date palms, filtered through a fine cloth and concentrated by heating at 100 ºC to 74 °Brix or with a rotary vacuum evaporator, at 60 °C. The date palm sap syrups have been produced at laboratory scale and characterized in terms of their physicochemical, rheological, microstructure, and thermal properties (Makhlouf-Gafsi et al. 2016). Furthermore, their content of bioactive compounds has been evaluated finding a high content of polyphenolic compounds and a potent antioxidant, antimicrobial, and cytotoxic activity (Makhlouf-Gafsi et al. 2018). The ultrafiltration process also has been evaluated as a positive alternative to concentrate and separate the date sap syrup (Makhlouf-Gafsi et al. 2016, 2018). It has been found that ultrafiltration allows retaining sucrose through

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187 tubular membranes decreasing its content in the corresponding syrups and increasing the
188 amount of reducing sugars. This contributes to a reduction of the syrup crystallization
189 phenomenon. Moreover, the ultrafiltration process caused retention of pectin, which affects
190 significantly the rheological properties of sap syrups (Makhlouf-Gafsi et al. 2016).

191 4.4. Date powders

192 Date powders constitute a useful dosage form of date components into several food
193 formulations, for instance, as a sugar replacer (Barimah et al. 2015; Ben Mya et al. 2017). To
194 their preparation, macerated dates are put on trays and dried down to less than 5% moisture
195 by air drying or freezing drying. The dried dates are ground and sold in various screen sizes
196 (Suresh et al. 2013; Jridi et al. 2015).

197 Date powders have also been obtained from date processing by-products such as date
198 pits. Suresh et al., 2013 studied the thermal properties and the chemical composition of date-
199 pits powders. The pits were removed from dates variety Khalas in the Tamar maturity stage,
200 cleaned, freeze-dried, and grounded (Suresh et al. 2013). Date-pits powders showed a high
201 content of crude fiber (33.9 g /100 g date-pits powder) and their polyphenol contents ranged
202 from 21 to 62 mg gallic acid equivalents (GAE)/g date-pits depending on the extraction
203 conditions (solvent and temperature). A. Ahmed, Arshad, Saeed, Ahmed, & Chatha, 2016
204 working with roasted date-pits powders reported crude fiber contents around 9 g /100 g
205 roasted date-pits powders and polyphenols content between 8 and 12 mg GAE/g. Gökşen et
206 al., 2018 determined the proximate compositions, dietary fiber contents, and the
207 technological properties and bile acid binding capacity of the date seeds powders of three
208 cultivars (Safawi, Suhgai, and Mebruum). Date seeds powders showed high total dietary fiber
209 contents (85.6–87.4%), where the insoluble and soluble dietary fiber contents were in the
210 range of 82.1–84.4% and 2.8–3.5%, respectively. Besides, it was suggested that hydrophobic
211 interactions between dietary fiber fractions and bile acids lead to high bile acid binding

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212 capacity of date seeds powder. Binding of bile acids and increasing their fecal excretion has
213 been hypothesized as a possible mechanism by which dietary fiber lowers cholesterol
214 (Gökşen et al. 2018).

215 The lactic acid fermentation of date fruits has also been proposed as innovative
216 biotechnology to achieve functional dietary supplements. Di Cagno et al., 2017 investigated
217 selected autochthonous lactic acid bacteria for the manufacturing of freeze-dried powder
218 from fermented date fruits puree. Fermented date fruits puree resulted enriched in γ-amino
219 butyric acid, conjugated linoleic and linolenic acids, and insoluble dietary fibers. Besides,
220 lactic acid fermentation allowed the highest concentration of phenolic derivatives with high
221 human bioavailability.

222 4.5. Date fiber concentrates

223 Dietary fiber concentrates from date have been considered functional ingredients. It has
224 been obtained from secondary dates applying hydrothermal pre-treatments that allow for the
225 extraction of soluble compounds to the liquid phase, leaving a fibrous material as a solid
226 fraction (Mrabet et al. 2015). Steam explosion treatment has been proposed for the
227 manufacturing of date fiber concentrate. In this process, the material is treated with high-
228 pressure saturated steam (10- 40 kg/cm^2/ 180-240 ºC) for a few minutes, and then the pressure
229 is swiftly reduced, causing the materials to undergo an explosive decompression (Figure 3A).
230 In order to reduce the pressure and the processing costs, others pre-treatment processes have
231 been developed based on steam treatment but without explosive decompression (Figure 3B)
232 (Mrabet et al. 2015). In the novel system, a lower range of pressure and temperatures (3-9
233 kg/cm^2 and 140-180 ºC) is applied for a longer period of time (15-90 min). Mrabet et al.,
234 2015 applied for the first time both thermal pre-treatment systems based on steam technology
235 (steam explosion treatment and steam treatment) to secondary date varieties from Tunisia, in
236 order to obtain new date fiber concentrates with antioxidant properties. The recovery of fiber

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concentrate was similar for both processes and also their chemical composition. Also, the date fiber concentrates had very high antiradical activity (230–580 mmol Trolox/kg of fiber concentrate). Date fiber concentrate exhibited a pleasant chocolate/coffee flavor and therefore was proposed for their incorporation in dairy or bakery products. More recently, Mrabet et al., 2017 developed a new date fiber concentrate rich in dietary soluble fiber through enzymatic hydrolysis (Viscozyme® L) in order to increase their prebiotic effect. The fiber concentrates were rich in gluco- oligosaccharides and manno- and xylo-oligosaccharides that are considered as emerging prebiotics.

4.6. Date oils

The date-pit oil is commonly extracted using n-hexane in a Soxhlet apparatus or ultrasound-assisted solvent extraction (Al-Kharousi et al. 2016). Date palm seed oil contain saturated and unsaturated fatty acids, where the oleic acid is the major fatty acid (39.7–49.7%) (Golshan Tafti et al. 2017; Al Juhaimi et al. 2018; Laghouiter et al. 2018). Pentadecanoic, palmitic, heptadecanoic, stearic, arachidic, behenic, palmitoleic, cis10-heptadecenoic, cis11-eicosenic, linolenic, cis11,14-eicosadienoic, cis-11,14,17-eicosatrienoic have also been found in date seed oil (Habib et al. 2013). Date seed oil is also rich with phenolics compounds including hydroxytyrosol, protocatechuic acid, gallic acid, tyrosol, caffeic acid, p- coumaric acid, 3,4-dihydroxyphenylacetic acid and oleuropein (Laghouiter et al. 2018). β-Carotene has been reported as the most occurring carotenoid in several date seed oil varieties. Moreover, the date seed oils depicted considerable concentrations of vitamin E and vitamin K1 (Habib et al. 2013). Besides of its valuable chemical composition, date pits oil had reported a good oxidative and thermal stability; thus, it could be used for cooking and frying in culinary and industrial applications (Al-Kharousi et al. 2016; Golshan Tafti et al. 2017). Acid value, peroxide value, and p-anisidine value of

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1.4 mg KOH/g oil, 3.3 meq/ kg oil and 0.6, respectively were reported for fresh date-pit oil by Al-Kharousi et al., 2016.

5. Development of food products with ingredients derived from date

5.1. Fruit and vegetable products

Date fruits have been proposed as a positive alternative to conventional fruit in jam and jelly production. These products have been prepared from date paste and date syrup, respectively (Benali et al. 2015). Benali et al., 2015 demonstrated the feasibility of natural jelly from three Algerian raw materials, namely date syrup, lemon juice, and orange albedo powder, using response surface methodology combined with central composite design. The cooking temperature and cooking time were found to be the most influent factors on textural properties of the final jelly. Moreover, these authors reported that to reach textural properties of commercial jellies, the temperature of the cooking process and the heating time of the initial fruit mixture had to be fixed at 155 °C and 10 min, respectively.

Fruit bars also constitute an excellent vehicle for date bioactive compounds. Parn, Bhat, Yeoh, & Al-Hassan, 2015 developed fruit bars by utilizing date paste as a sugar source. Date paste was boiled under stirring for 10 min and then was added of milk powder, margarine, citric acid and common salt. The pulp mixture obtained was boiled, and continuously stirred until 75 ºBrix and then poured into greased, non-sticking trays and cooled to room temperature (25 ºC). Finally, the fruit bars were cut and packed. Date fruit bars had a high content of crude protein, carbohydrates, and fat being a good source of energy. Moreover, the bars had suitable textural characteristics.

5.2. Meat products

The incorporation of date into meat products has proved to be an easy and economical strategy to develop healthier products with improved physicochemical and sensory properties

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(Elleuch et al. 2008; Sánchez-Zapata et al. 2011). Sánchez-Zapata et al., 2011 developed date paste-added bologna sausage finding that when date paste was added at 10 and 15%, it results in a more adhesive and less hard, chewy, and cohesive product than the control (Sánchez-Zapata et al. 2011).

Martín-Sánchez et al., 2013 evaluated the viability of using date paste in a campagne type pork liver pâté, as an inexpensive source of sugars, dietary fiber, and natural antioxidants. Liver pâtés, with high amounts of fat and iron, are sensitive to oxidative deterioration. Thus the addition of a date paste which is rich in natural antioxidants was proposed to increase the product quality. The incorporation of 10% date paste protected the product against lipid oxidation during refrigerated storage. Moreover, pâtés with date paste were greatly accepted by consumers, and trained panelists, the mix of sweet and salty tastes, together with a good texture was agreeable (Martín-Sánchez et al. 2013).

5.3. Dairy products

There is an increased number of scientific and clinical evidence supporting the health benefits of fermented milk products. El-Nagga & Abd ElTawab, 2012 studied the effect of the addition of date syrup on the physicochemical and sensory properties of two fermented dairy products (zabady and biogarde). Buffalo's milk (3.0% fat) was heated to 90 ºC/15 min, then concentrated date syrup was added at different levels (1%, 2%, and 3%) at 50 ºC, rapidly cooled to 42 ºC. To the preparation of zabady, the blends were inoculated with *Lactobacillus delbruekii* subsp. *Bulgaricus* and *S. thermophilus*. In the case of biogarde, active starter cultures of *B. bifidum, Lb. acidophilus* and *S. thermophilus* were used. Date syrup-added fermented milk had better flavor, appearance, and body textures. Moreover, they were good sources of lysine, histidine, threonine, and leucine + Isoleucine (El-Nagga and Abd ElTawab 2012).

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Dairy products have also been fabricated from date processing by-products. Trigueros, Sayas-Barberá, Pérez-Álvarez, & Sendra, 2012 proposed a strategy to the sustainable use of date blanching water for reconstituting skim milk powder and producing low-fat yogurt. Date blanching water was found to be a source of phenols and flavonoids as well as organic acids and sugars, that confer interesting antioxidant, sensory and physicochemical properties to the yogurt (Trigueros et al. 2012). Jridi et al., 2015 obtained syrups and powders from by-products of three Tunisian date varieties (Deglet Nour, Kentichi and Allig) for their incorporation in different formulations of dairy desserts. Date syrups and powders were used as natural sweetening agents and source of coloring and flavoring compounds. Moreover, they were able to act as thickening aids due to their high-water holding capacity attributed to their content of insoluble fibers and polysaccharides. The incorporation of the date by-products improved the polyphenol content and the antioxidant activity of the dairy desserts (Jridi et al. 2015).

5.4. Cereal and bakery products

Breakfast cereals are defined as foods obtained by swelling, grinding, rolling or flaking a cereal grain. They are the most popular breakfast choice eaten by school-aged children. Although breakfast cereals are a good source of vitamins and minerals, antioxidants, phytoestrogens, and fiber, many breakfast cereals contain high levels of sugar (Khehra et al. 2018). Recently, Aljobair, 2018 fabricated corn and sorghum flakes using date syrup in place of sugar. The products showed a high nutrient content and exhibit good sensory acceptability, except for the dark color of the flakes.

Bakery products constitute a major food staple in the world. The use of date syrups as a sugar substitute in bread formulations has been studied for many years ago. Also, date dietary fiber concentrate is a beneficial ingredient to bread making because it offers health benefit and improves the bread yield due to their high water absorption capacity (Borchani et al.

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2011). Bchir, Rabetafika, Paquot, & Blecker, 2014 examined the effect of the incorporation of apple, pear and date fiber from cooked fruit by-products of "Liège syrup" manufacturing on wheat bread dough performance and bread quality. Date and apple fiber concentrate-enriched dough showed higher water absorption, stability, and dough yield. The crust of the bread enriched with date fiber had a darker color characterized by a low lightness (Figure 4).

Mrabet et al., 2016 developed muffins enriched with date fruit fiber concentrate obtained after a steam pre-treatment. The muffins containing date fiber concentrate showed higher dietary fiber content and antioxidant activity than the unfortified muffins. They also showed good sensory acceptability, similar to that of the product without date fiber concentrate.

5.5. Sauces

Mayonnaise is an oil-in-water emulsion based on of egg, vinegar, oil and spices (especially mustard). This is probably one of the most widely used sauces or condiments in the world today. Oil is the major ingredient contributing to the viscosity and body of mayonnaise. Mayonnaise is commercially prepared using soya bean, cottonseed, sunflower, and corn oils. Basuny & AL-Marzooq, 2011 used date pit oil to replace conventional oil in producing mayonnaise. It was found that mayonnaise containing date pit oil was superior in sensory characteristics as compared with control manufactured from corn oil.

5.6. Ethnic date-based products

The term ethnic foods refers to the cuisine of a country, which is socially and culturally accepted by people that live outside of that country (Karizaki 2017). The date is one of the most common ingredients of Iranian national cuisine. Iranian people consume an average of 7 kg of dates per year. Date-pilaf, egg-date, and date-pastry are the most popular date-based products consumed by Iranian people. These products are generally prepared in the home, or small (noncommercial) operations (Karizaki 2017).

6. Conclusions

There is an increased number of scientific and clinical evidence supporting the biological activities of date palm fruits. Thus, date palm fruits and their processing byproducts can be used as a source of several bioactive compounds such as antioxidants and dietary fiber for the development of new value-added date-based foods. Several emerging technologies have been explored at laboratory scale for the manufacturing of high valued added date-based ingredients. Between them, the ultrafiltration and the lactic acid fermentation have shown important advantages. However, the use of these at the industrial level is also in its start-point. Interactions between the scientific community and agri-food industries are highly necessary to the transfer of scientific knowledge currently available in the literature in order to commercialize innovative date-based foods.

Conflicts of Interest: The authors declare no conflict of interest.

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 doi:10.20944/preprints202105.0555.v1

596 Table 1. Chemical composition (g/100 g dry weight basis) of date pulp and seed of some of the most popular date varieties

Varieties	Origin	maturation stages	Fruit part	Dry matter	Sugars	Protein	Fat	Ash	References
Deglet Noor	Tunisia	Tamr	Flesh	75.6 ± 0.05	79.1 ± 0.80	2.10 ± 0.10	-	2.50 ± 0.04	(Elleuch et al. 2008)
Medjool (or Madjool)	Mexico	Tamr	Flesh	82.86 ± 0.80	71.16 ± 1.09	3.47 ± 0.11	0.74 ± 0.19	2.36 ± 0.03	(Salomón-Torres et al. 2018)
Alligh	Tunisian	Tamr	Flesh	73.1 ± 0.80	72.8 ± 0.27	3.02 ± 0.13	-	2.52 ± 0.01	(Elleuch et al. 2008)
Barhee Zahidi	Pakistan	-	Flesh	89.5 ± 0.39	73.72±2.65	4.60±0.18	2.08±0.07	1.91±0.07	(Awan et al. 2018)
Khalas	Oman	Tamr	Pit	93.3	46.1	5.3	10.4	0.4	(Suresh et al. 2013)
Sukkari	Iraq	-	Flesh	87.43 ± 0.33	78.32 ± 0.98	3.00 ± 0.18	0.65 ± 0.09	2.30 ± 0.20	(Siddeeg et al. 2018)
Safawi	Saudi Arabia	-	Pit	-	-	5.42 ± 0.19	8.14 ± 0.24	0.81 ± 0.04 5.56	(Gökşen et al. 2018)
Mebruum	Saudi Arabia	-	Pit	-	-	5.56 ± 0.17	6.99 ± 0.08	0.97 ± 0.02 5.60	(Gökşen et al. 2018)
Shugi	Saudi Arabia	-	Pit	-	-	5.60 ± 0.22	7.19 ± 0.16	0.95 ± 0.01	(Gökşen et al. 2018)

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 doi:10.20944/preprints202105.0555.v1

598 Table 2 Health benefits associated with date fruit

Health benefits	References
Antioxidant activity	(Al-Mamary et al. 2014; Zhang et al. 2017)
Anti-inflammatory activity	(Taleb et al. 2016; Zhang et al. 2017)
Anti-tumor activity	(Zhang et al. 2017)
Antihemolytic activity	(Bouhlali et al. 2016)
Antibacterial activity	(Bouhlali et al. 2016; Taleb et al. 2016)
Antileishmanial activity	(Albakhit et al. 2016)
Antimutagenic properties	(Baliga et al. 2011)
Antiviral activity	(Jassim and Naji 2010)
Hypolipidemic effect	(Khan et al. 2018)
Antidiabetic effects	(Ahmed et al. 2017)
Anti-angiogenic properties	(Taleb et al. 2016)
Wound healing	(Abdennabi et al. 2016)
Antifungal activity	(Boulenouar et al. 2011)

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601 Table 3. Chemical composition of date paste

Component	Average ± standard deviation (g/100 g fresh weight)
Proteins	2.12 ± 0.02
Fats	1.35 ± 0.25
Moisture	34.73 ± 1.16
Ash	1.75 ± 0.42
Total sugars	53.00 ± 1.03
Total dietary fiber	7.00 ± 0.15
Insoluble dietary fiber	4.04 ± 0.04
Total phenolic content	225 ± 22 (mg GAE/100 g fresh weight)

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605 **List of Figures**

621

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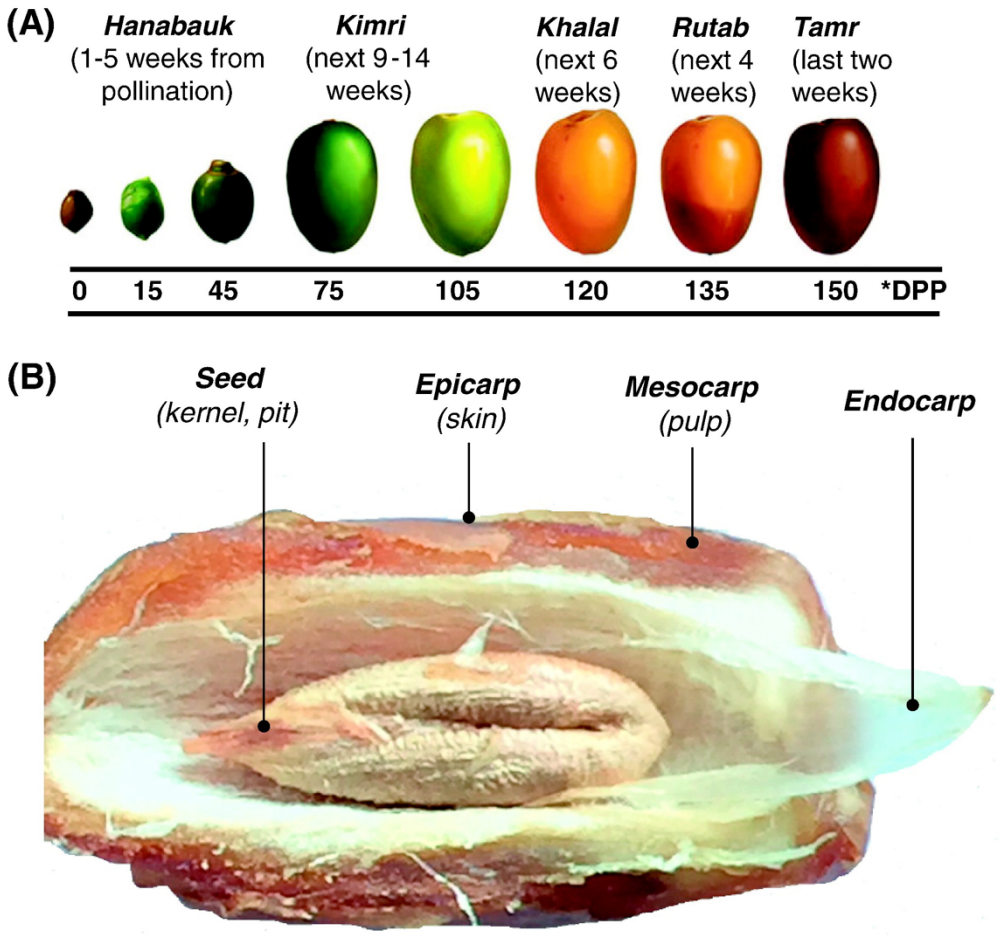

622 Figure 1 (A) Different fruiting stages of date palm according to days post-pollination.
623 Reprinted with permission from Al-Mssallem et al., 2013; (B) The anatomy of the date fruit
624 at Tamr stage showing the epicarp, mesocarp, endocarp, and seed. Reprinted with permission
625 from Ghnimi et al., 2017

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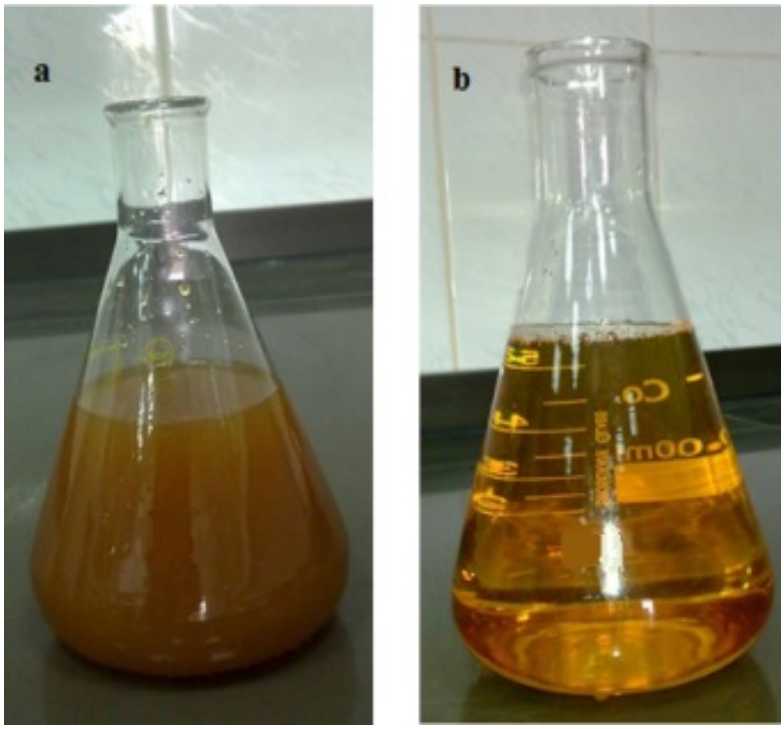

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628 Figure 2 Raw date syrup (a) and clarified date syrup using optimum conditions

629 obtained for enzymatically pre-treatment and filter pre-coating processes (b).

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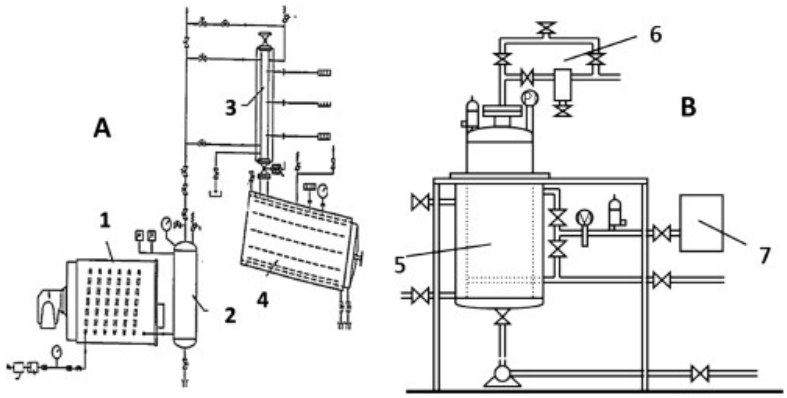

Figure 3 Diagrams of hydrothermal treatment reactors. Subfigure A: Steam explosion reactor (SET). Subfigure B: Steam reactor (ST). 1.- Steam generator. 2.- Steam accumulator. 3.- Reactor chamber (2 L capacity). 4.- Expansion chamber. 5.- Reactor chamber (100 L capacity). 6.- Cooler. 7.- Steam accumulator. Reprinted with permission from Mrabet et al., 2015

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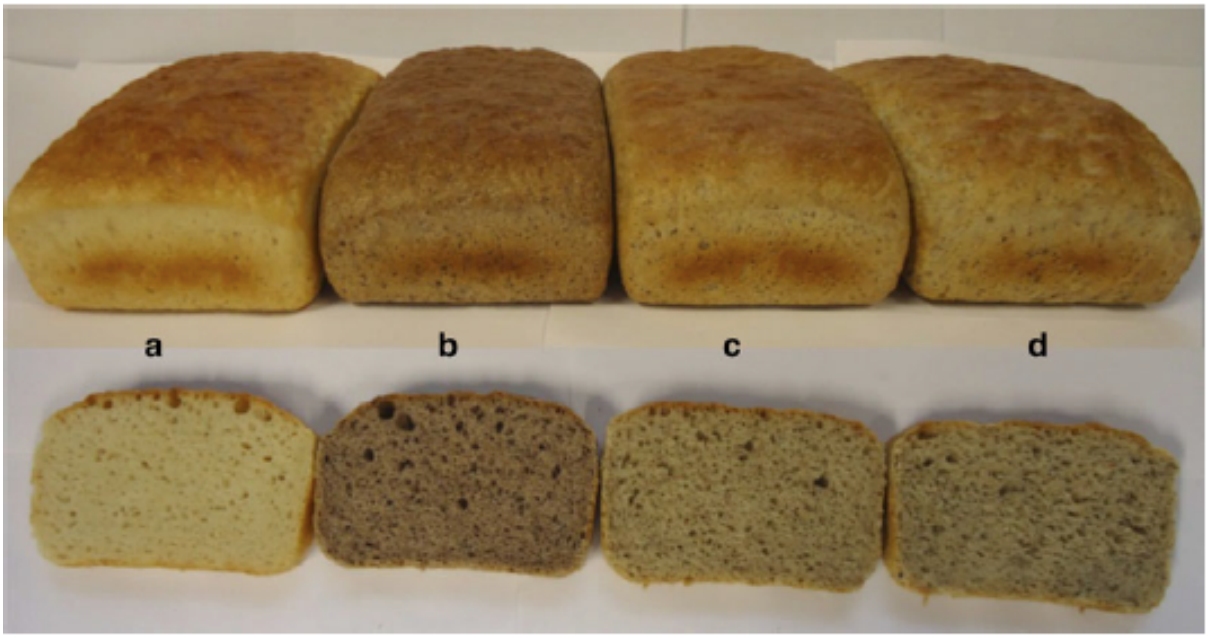
640 

641 Figure 4 Effect of flesh fiber concentrates on external appearance and internal structure of
642 bread: control (a), date fiber (b), pear fiber (c) and apple fiber (d). Reprinted with permission
643 from Bchir, Rabetafika, Paquot, & Blecker, 2014

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