

REVIEW ARTICLE

Date-derived industries: A review of common products, manufacturing methods, and leading countries

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ABSTRACT

The date fruit, a nourishing food appreciated worldwide, plays an important role in producing countries' economic and political aspects. Date palms provide numerous products, including date syrup, alcohol, vinegar, date powder, and sugar. This review was undertaken to summarize information about the common date-derived products, the manufacturing methods used, and the leading countries in the date-derived industry. Additionally, the review highlights the future challenges in developing the date industry. The difficulties that accompanied the preparation of this review included the scarcity of modern and reliable information, especially the statistics related to date-derived products from leading countries involved in this industry. This may be due to the incompleteness of such information or the lack of interest in publishing them in reliable scientific sources.

Keywords: Date-derived products; Date palms; Date-producing countries; Manufacturing methods

INTRODUCTION

The date palm (*Phoenix dactylifera*) has been considered a major crop for humans for the past seven thousand years. Dates have gained great importance in the human diet as they contain many essential nutrients, and a steady increase is being observed in their global production (Chandrasekaran and Bahkali, 2013). The date fruit is regarded as a traditional snack usually with coffee or dairy products as part of hospitality in Arab and Islamic countries (Ali et al., 2013; Miller et al., 2003). In addition, the date palm and its fruits have a crucial social and economic role for the inhabitants of oases in the Middle East and North Africa, including their numerous nutritional, medicinal, economic, environmental, and structural uses (Ali et al., 2013).

The Arab countries, in addition to Iran, are known to be the most suitable geographical areas worldwide for date palm cultivation owing to the availability of suitable climatic conditions. The area planted with date palms in the Arab countries accounts for more than 70% of the total area planted with date palms worldwide (El-Juhan, 2010). Date plants are also cultivated in other regions, such as Australia,

Mexico, South America, South Africa, and the United States, more precisely in California, Arizona, and Texas (Al-Alawi et al., 2017). Globally, over 2000 different dates palm varieties have been reported (Ghnimi et al., 2017), with their names differing according to different countries (Ali et al., 2013).

Unfortunately, coupled with data scarcity, the elicitation of statistical data on the local production of dates is fraught with numerous difficulties in most countries. It is important to obtain information about the land area planted with date palms, types of varieties, and annual production for each country. The Food and Agriculture Organization of the United Nations (FAO) helps collect such information from different countries (Johnson et al., 2015; Arias et al., 2016).

In terms of nutritional value, date fruits are rich in nutrients and contain a high percentage of sugars. The date fruit contains essential minerals such as potassium, phosphorous, magnesium, calcium, iron, and zinc (Biglari, Al Karkhi, and Easa 2008; Hussain, Farooq, and Syed 2020). The amount of fiber ranges from 6.4–11 g/100 g of pitted date fruits (Al-Shahib and Marshall, 2002; Al-Farsi et al., 2005). Dates also contain several vitamins, such as retinol, thiamine,

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riboflavin, pyridoxine, cobalamin, and ascorbic acid. Date fruit color varies, depending on the pigment, from yellow to red. These pigments include carotene, flavonoids, and anthocyanins (Al-Alawi et al., 2017; Idowu et al., 2020).

Dates contain antioxidants that have potent health benefits. The common antioxidants found in dates are phenolics (AlFaris et al., 2021), which have favorable health effects on several non-communicable diseases, such as diabetes mellitus, hyperlipidaemia, liver diseases, and autoimmune disease (Dayrana et al., 2014; Barros, 2020; Echegaray et al., 2020).

Economically, date fruits are the most important products of the date palm. They are eaten fresh, dried, and processed. Other parts of the date palm are used in some communities for manufacturing home furniture and building houses. Palm fibers have recently been used to manufacture wood, paper pulp, ropes, and other materials (Arab Organization for Agricultural Development, 2004; Jonoobi et al., 2019).

Most of the harvested dates are consumed directly in the form of Khalal, Rutab, or Tamer packed either by traditional or industrial methods (Hinkaew et al., 2021). Attempts at devising strategies for improving the production of dates have led to modern technologies. The surplus and second-class dates have been converted into derived products for human consumption, such as date syrup, date paste, date jam, vinegar, and liquid sugar, as well as animal feeds (Ashraf and Hamidi-Esfahani, 2011; Ghnimi et al., 2017; Najjar, Stathopoulos, et al., 2020; Sarraf et al., forthcoming). The non-derived products of dates include fresh, mechanically pressed, packed under vacuum, and pitted dates (Ashraf and Hamidi-Esfahani, 2011; Sarraf et al., forthcoming).

Date-derived industries are defined as the industries that transform date fruits into new products that can be used as food directly, such as date paste or a product used as a raw material for another food production, such as date juice. Date-derived products also include non-food products such as medical alcohol (Agricultural Development Fund 2020). The date industry is expected to develop significantly in the future using mechanical food processing techniques to innovate new date-derived products (Sarraf et al., forthcoming).

A previous study explained the technical features of crucial operations of the foremost dates derived industries such as high fructose syrup (HFS), crystalline glucose and fructose, polyols, citric acid, ethanol, vinegar, and baker's yeast (Al Abid, 2009).

Functional applications of date's by-products in food products such as date seed flour hydrolysate (DSFH), date seed flour (DSF), Date seed, Date syrup and powders,

Defatted date seed, Fermented date fruit puree, Date seed oil, etc., were reported (Idowu et al., 2020).

It reported that data processing industries provide a variety of date-derived products such as date-honey, date-syrup, date-jam date dip, date pectin, date-vinegar dietary fiber and syrup are which have a plethora of applications in pharmaceutical and food, and other industries as a gelling agent, a thickener and others (Ramadan, 1995; Al-Hooti et al., 2002).

In this context, in the present review, the prospects of valorization of these date fruit processing by-products and wastes' employing fermentation and enzyme processing technologies towards total utilization of this valuable commodity for the production of biofuels, biopolymers, biosurfactants, organic acids, antibiotics, industrial enzymes and other possible industrial chemicals are discussed (Chandrasekaran and Bahkali, 2013).

The objectives of this review article are to provide a comprehensive overview of date-derived industries in terms of the common products available in the global markets, summarize the manufacturing methods used, and determine leading countries in this promising industrial sector.

A few difficulties plagued the preparation of this review, the primary being the scarcity of modern and reliable information, especially the statistical data related to date-derived products from major date-producing countries. This may be due to the incompleteness of such information or the lack of interest in publishing it in reliable scientific sources.

Common date-derived products

In recent years, considerable interest has been directed towards establishing modern factories for date derivatives to benefit from surplus, low quality, and second-class dates. These factories handle a wide range of products (up to 40) derived from dates through different manufacturing procedures (Barreveld, 1993). The date-derived products that is based on physicochemical properties of dates include date syrup, high-fructose date sugar, and date jams, while those based on biotechnology have citric acid, alcohol (ethanol), vinegar, and bread baking yeast (Najjar et al., 2020; Sarraf et al., forthcoming).

Date-derived products based on physicochemical properties

Date syrup (Date molasses, Dibis)

Date syrup is the concentrated extract of the dissolved solids in pitted date fruits. It is obtained as an incidental by-product when bagged humid dates are heaped for

several months (Aleid, 2013). Additionally, it is produced on different scales by extracting and boiling down juice (El-Sharnouby et al., 2014a,b). The concentration of sugars in dates syrup is approximately 70–85% (Aleid 2013; Aleid et al., 2015), the main being glucose and fructose (Al-Farsi et al., 2007; Kulkarni et al., 2008). It also contains macro-elements such as sodium, potassium, calcium, and micro-elements, with iron content being high (Al-Khateeb, 2008; Aleid, 2013; Aleid et al., 2015), in addition to retinol (vitamin A) and B-complex vitamins. The color of date syrup ranges from golden to dark caramel (Siddiq et al., 2013; Sharnouby et al., 2014a, 2014b). Date syrup is commonly used in bakery products, ice cream, and confectionery production (Aleid, 2011) and serves as a raw material for the production of date liquid sugar (Aleid, 2013; Aleid et al., 2015).

High fructose date sugar

Fructose syrup is used in food and beverage industries at relatively high concentrations. High fructose syrups (HFS) are produced from starchy raw materials, including corn starch, sugar cane, and sugar beet, in addition to rice and dates (Hanover and White, 1993; Vuilleumier, 1993). High-fructose date sugar is a sugary solution with a total solids' concentration of approximately 70–80%, and fructose made up 42%, 55%, or 90% of total sugars, according to international standards (Atiyeh and Duvnjak, 2001a, 2001b; Zhang et al., 2004; Gaily et al., 2010). It is an odorless, transparent, and salt-free liquid. The high fructose date sugar can be used in soft drinks, bakery products, confectionery, and jam production. The limiting factor for producing high fructose date sugar is the price of raw dates compared to the cheaper high fructose corn syrup. This makes the production of high fructose date sugar infeasible in relation to its economic cost (Barreveld, 1993).

Fermentation products from the date

Organic acids

Organic acid products using date sugar include citric, oxalic, and lactic acids (Barreveld, 1993). Date extracts are incubated with certain strains of yeasts, such as *Aspergillus niger*, to produce citric acid (Mehyar et al., 2005; Mostafa and Alamri, 2012). Citric acid is widely used in foods, beverages, and sweets as a flavor enhancer. It is also used in the following industries: dairy products, processed meat, vegetables and fruits, and pharmaceuticals (Radwan et al., 2010). The microorganisms used in acetic acid production from dates are *Saccharomyces cerevisiae*, *Saccharomyces ellipsoidens*, *Acetobacter xylinum*, and *Acetobacter cycendens* (Sokollek et al., 1998; Chauhan et al., 2007; Manickavasagan, 2012).

Alcohol and vinegar

The sugars present in dates are capable of anaerobic fermentation by bread yeast, *S. cerevisiae*, leading to alcohol

(ethanol) (Matloob and Hamza, 2013). The vinegar production is also based on fermenting date sugars using vinegar bacteria *Acetobacter aceti* (Solieri and Giudici, 2009). It is more economical to produce the two products together and separate them at the fermentation unit. Ethanol is an important material with several medical and industrial uses, such as in the pharmaceutical, cosmetics, and food additives industries. Vinegar has many food applications, especially in sauces (Siddeeg et al., 2019).

MANUFACTURING METHODS

Natural date juice

Natural date juice is a drink rich in energy and other nutrients, such as minerals and ascorbic acid (vitamin C). Natural date juice serves as a raw material for manufacturing other date-derived products, such as date syrup and high fructose date sugar (Ramadan, 1995; Al-Hooti et al., 2002; Kulkarni et al., 2010; Bahramia et al., 2011). The brief steps for natural date juice preparation are shown in Fig 1.

Date syrup

To prepare date syrup, pitted dates extracted by water for 20 min at 60 °C. Next, filtration and concentration under vacuum at 55–70 °C to approximately 72–88% of total dissolved solids or 70 °Brix is (Al-Hooti et al., 2002; Al-Farsi, 2003; Ganbi, 2012).

High fructose date sugar

The joint industrial processes between the two production lines of date syrup and high-fructose date sugar include the production of pure natural date juice and the concentration under vacuum. The production of high fructose date sugar found in the production line between the mechanical filtration unit and evaporation under vacuum unit includes

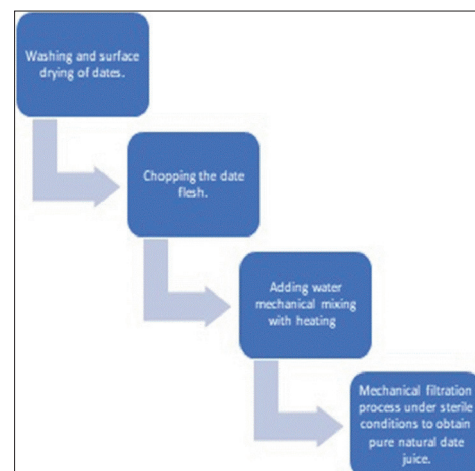


Fig 1. Steps for preparing date juice.

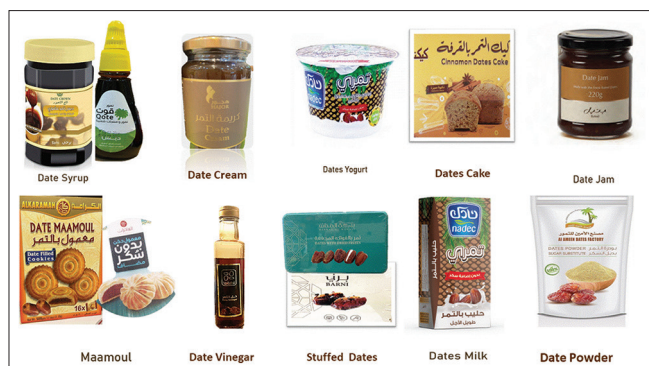


Fig 2. Photograph of some date products from Saudi markets.

four additional units: (1) activated carbon treatment unit for color bleaching, (2) mechanical filtration unit for active carbon separation, (3) ion-exchange unit to produce a colorless transparent extract, and (4) enzymatic treatment unit to convert glucose into fructose (Chaira et al., 2011; Smaali et al., 2011).

Using enzymes to produce liquid sugar

The steps to produce liquid sugar using the enzymes pectinase and cellulase have been described by El-Sharnouby and Al-Eid (2009), which include incubation of the date juice with 1% enzymes at pH 6, 40 °C for 24 h, followed by filtration and concentration to 72 °Brix and storing at 20–30 °C

Thermal extrusion

Thermal extrusion is a promising industrial process in producing and developing high-quality new food products from raw foodstuffs of low or medium quality. In brief, the thermal extrusion process consists of cooking the raw material and pushing the cooked material through an opening to obtain the final product. This process occurs at high temperatures and specific pressure (Ashraf and Hamidi-Esfahani, 2011).

Manufacture of citric acid

The submerged process is the predominant method for producing citric acid using biotechnology, accounting for approximately 99% of the global citric acid production. Date extract is fermented using the fungus *Aspergillus niger*. After the fermentation process, the mixture is filtered and evaporated to obtain a specific concentration of the resulting citric acid (Sokollek et al., 1998; Al-Abid, 2005; Al-Shehri and Mostafa, 2006; Chauhan et al., 2007; Manickavasagan et al., 2012).

Manufacture of alcohol and vinegar

The production process of alcohol followed by vinegar starts with the fermentation stage, using (*S. cerevisiae*) at a temperature of 25–30 °C for 48 h until the alcohol concentration reaches 9–10%. And distillation to obtain

pure alcohol conformed to international standards. After that, the fully fermented juice can be converted into vinegar using the bacteria *Acetobacter aceti*. Next, vinegar's storing and aging process for vinegar is performed to obtain a product with good specifications and develop flavor and color compounds in the final product (Ashraf and Hamidi-Esfahani, 2011).

COUNTRIES LEADING IN DATE-DERIVED INDUSTRIES

Saudi Arabia

The Kingdom of Saudi Arabia is globally ranked as second in the production of dates, with 17% of the total global production (FAOSTAT, 2020). The various regions of Saudi Arabia produces approximately 1,539,755 tons of dates annually. The quantity of exported dates reached 184 thousand tons recently, with 860 million Saudi Riyals. The number of date palms in Saudi Arabia is 31,243,155, covering an area of 107 thousand hectares (National Center for Palms & Dates, 2020). The indicative standard specifications for Saudi dates include 18 varieties of the most famous local dates. According to size and weight, they are classified into excellent, first, and second grades (National Center for Palms & Dates, 2019).

The total number of date factories in Saudi Arabia is 157, while the number of date derivatives factories is 90, constituting 57.3% of the total date factories (National Center for Palm & Date, 2021). The date industry in Saudi Arabia is largely supported by the government industrial programs, where financial support is provided for date factories through the governmental Agricultural Development Fund in long-term loans without profits (Agricultural Development Fund, 2018). Most of the date factories (90%) in Saudi Arabia are engaged in date packaging, and a few of them are involved in the production of date-derived products, such as paste, jam, powder, cream, vinegar, and syrup. Seven products of the date-derived industries in Saudi Arabia are identified, namely, date paste, date syrup, medical solutions, vinegar, medical alcohol, liquid sugar, and citric acid (Fig 2) (Aleid et al., 2015).

Modern production lines are established within large date factories in Saudi Arabia to produce date paste. The pitted dates are exposed to water vapor until a semi-solid paste is obtained. Date paste is frequently used in bakery products, such as Maamoul, and the confectionery industry as a substitute for table sugar (Aleid et al., 2015).

The consumption of date syrup is extremely common in Saudi Arabia as a sweetener for several traditional Saudi foods. Many date factories in Saudi Arabia have produced

lines to produce date syrup commercially (Aleid et al., 2015). The date-derived industry in Saudi Arabia has been facing numerous challenges, including the lack of applied research in this field and the small number of companies specialized in developing and maintaining production lines.

Saudi Arabia offers great opportunities to develop the exports of date-derived products, including increasing production, rising prices of manufactured dates globally, and the substantial governmental support provided to this industry. The local production and imports of the date-derived products for 2016 were 63.3 and 84.9 thousand tons, respectively (Agricultural Development Fund, 2018).

In a study, liquid sugar was prepared from Saudi dates, Rozaiz variety, using pectinase and cellulase enzymes and employing ultrasound technology to ensure maximum extraction of sugars from date juice. The percentage of total dissolved solids reached approximately 75% of liquid sugar, with an improvement in the sensory characteristics of the product. This study revealed that liquid sugar could be obtained from dates as a substitute for sucrose in food applications (El-Sharnouby et al., 2014a). However, several studies have proven the economic infeasibility of establishing factories for liquid sugar production from dates due to the high cost of dates and the low price of imported sugar.

Algeria

Date palm cultivation is considered the cornerstone of agriculture in Algeria. It is the primary source of income for the population in the oases spread in the Algerian desert. The presence of date palms in the oases also provides the appropriate environment for growing a wide range of other crops (Faci, 2019).

According to the FAO, date production in Algeria was estimated at 1.4 million tons in 2019 (FAOSTAT, 2020). Algeria cultivates many varieties of dates, the most important of which is Deglet Nour, making up 49% of the total date production in Algeria and considered the variety with the highest demand locally and globally (Bouguedoura et al., 2008).

The date industry and its derivatives have not reached the full industrial level in Algeria. Date paste is produced for local consumption or export. Date syrup and jam are also produced for consumption by local families using traditional methods. Recently, the manufacture of new products from dates has gained interest (Bouguedoura et al., 2015). There are currently seven-date government factories in Algeria created during agrarian reform and distributed in the main areas, such as Biskra, for the production of dates in the country. The estimated capacity of these

factories is 28,000 metric tons annually. Each factory has units for steam disinfection, sorting lines, ovens for heat treatment, packing lines, and cold stores. Many facilities exist in south-eastern Algeria, such as in Biskra, which has 29 private factories, while in the southwest region, there are no modern packaging factories (Bouguedoura et al., 2015). Juice, vinegar, and sweets are produced from dates in Algeria (Bouguedoura et al., 2015). These products are considered an added value for date varieties with low economic value and suffer from increased wastage. The first industrial production unit of liquid sugar from dates started in Biskra in 2018 (Arab Organization for Agricultural Development, 2019).

To develop date-derived industries in Algeria, attention, and effort can be made in the following areas:

- Encouraging investors to establish date factories and solving productivity and marketing problems.
- Encouraging scientific research on dates and other parts of the date palm for the manufacture of value-added products.
- Exerting efforts to strengthen and activate bilateral agreements to develop the date industry.
- Creating a database on date products to provide periodic statistical information about the number of factories and the quantity of production and exports (Bouguedoura et al., 2015).

A study was conducted in Algeria to extract sugar from Deglet Nour variety in the following steps. Firstly, the chopped date flesh is mixed with distilled water. After that the mixture is filtered to obtain a solution of raw sugar that is evaporated under a vacuum to obtain raw date syrup. Finally, the raw date syrup is dried to obtain crystallized sugar. The sugar produced from dates has physical and chemical properties similar to those of other food sources; therefore, it reduces the cost of sugar consumption from other sources (Mya et al., 2017).

In another study from Algeria, date powder from the H'plowa variety was used in soft drink manufacturing as a substitute for sucrose. Sensory and chemical tests were conducted on these drinks. The results revealed that, compared to soft drinks that were manufactured by using sucrose, using date powder led to an improvement in sensory characteristics, such as flavor and color, as well improvement in the nutritional properties of soft drinks, such as acidity, reducing sugar content, and mineral content (Hariri et al., 2017).

Egypt

The date palm is one of the most important crops in Egypt, which is considered the global leader in date production. The annual date production amounting to

approximately 1.6 million tons is equivalent to 17.8% of the global production (FAOSTAT 2020). Government efforts in cooperation with FAO have been made to increase the export of Egyptian dates (FAO 2019; Abdullah 2018).

Seventeen facilities were involved in the date industry in Egypt in 2005 (Bekheet and El-Sharabasy, 2015). Some of these factories are equipped with modern fumigation, sorting, heat treatment, and packing lines. Other facilities have special units to manufacture date-derived products and the production of date paste, date syrup jams, molasses, and date baking products. Residues from dates like second class date and pitted excluded from the sorting and grading processes. The quantities of fresh dates that have not been utilized can be used as raw materials for the date-derived industries to produce new value-added commodities such as date powder, jam, liquid sugar, baking yeast, alcohol, acetic acid, citric acid, acetone, and animal feed. The residues other than from dates can be used to manufacture wood, paper, and other products (Bekheet and El-Sharabasy, 2015).

A study conducted at the Food Technology Research Institute of the Agricultural Research Center in Egypt led to the production of date powder from date varieties with low economic value or not suitable for export. The value of the varieties was enhanced, especially under the conditions of low prices during the date production season, to counteract the increase in waste caused by the lack of technological methods for cooling, preservation, and treatment. The production of date powder extends the shelf life of dates and facilitates transportation, handling, and storage. Date powder can be used in many food industries, including baked goods, beverages, and date syrup manufacturing, as an alternative to table sugar. Alcohol, vinegar, and baker's yeast can also be produced. (Bekheet and El-Sharabasy, 2015).

Another study was conducted at the National Research Center in Egypt on uses date palm residues from fibers to produce invert sugar using the invertase enzyme. Date palm fibers were incubated with baker's yeast (a source of inverse enzyme) in an aqueous medium at a temperature of 40 °C for 30 min. The carbon dioxide gas released from the enzymatic reaction was used as an activator to break down the surface of cellulose particles to release invert sugar particles. This study showed that inverted sugar could be produced at an annual rate of 6 million kilograms in Egypt by following this method (Mahmoud et al., 2016).

Iran

Date palm is the second most economically important crop in Iran. At the global level, Iran is the third country with

the highest annual date production after Egypt and Saudi Arabia (FAOSTAT, 2020). Dates are widely consumed in Iran because of their cost-effectiveness and easy availability. Many traditional Iranian foods contain dates as the main ingredient (Karizaki, 2017). Statistics show that 55–60% of the annual Iranian production is consumed domestically, and 12–16% is exported, leaving 24–33% as surplus or wasted production (Hajian and Hamidi-Esfahani, 2015).

One of the semi-finished date products in Iran is date paste and date power. To prepare date paste, the pitted dates are immersed in water at a temperature of 90 °C for 30 s. Next, the dates are ground with water to obtain a paste. The date paste is used in bakery products and the confectionery industry. It can be dried until the moisture content reaches 5%. The dried dough is ground into a fine powder to obtain date powder (Karizaki, 2017; Ashraf and Hamidi-Esfahani, 2011; Djaoud et al., 2020;). Date powder is used to manufacture sweeteners and in baby food as a sweetener (Hajian and Hamidi-Esfahani, 2015; Karizaki, 2017).

Date-pastry (*Kolompeh* or *koluche keborma*) an Iranian sweet, is recommended for strengthening the body. It is produced by mixing baking powder, butter, olive oil, groundnuts, and specific spices with the paste of Iranian dates. This food has a desirable sensory quality and high nutritional value (Karizaki, 2017).

Date juice is an important product from the date-derived industry in Iran. It is obtained by mixing dates with an appropriate amount of water and heating the mixture to a temperature not exceeding 50 °C for an hour; the mixture is then filtered to produce date juice. This study indicated that ultrasonic treatment of date juice under appropriate conditions lead to improved product quality and avoidance of health problems caused by microbial contamination (Shalmon et al., 1999).

Dates are an important source of sugar and can be used as a substitute for crystallized sucrose produced from sugar cane and beets in the food industry. Date juice is used in Iran to produce ice cream, sweets, jams, vinegar, and other products (Ehteshami et al., 2017). Additionally, dates are used in Iran to produce liquid sugar, alcohol, and date syrup (Bahramian et al., 2011; Hajian and Hamidi-Esfahani, 2015).

Second-grade or low-quality dates are used to manufacture many date-derived products in Iran. Pitted dates are mixed with water to get rid of unwanted substances. Then, the date juice obtained is used to manufacture most of these products, including liquid date sugar, high fructose date sugar, date syrup, medical alcohol, and vinegar (Hajian and Hamidi-Esfahani, 2015).

However, information about the amount of production, number of factories, and products of date-derived industries in Iran and other countries are scarce. Most of them are from unreliable sources.

Iraq

The history of the date palm in Iraq is incredibly old, and it is believed that Iraq is its original home. Currently, dates are considered among the most important national resources in Iraq. Zuhdi is the most cultivated date variety in Iraq and constitutes more than half of the annual date production in this country, amounting to 4.7 thousand tons in 2020 (Central Statistics Organization, 2020). The date-derived industry in Iraq has been affected by wars in the previous few decades. Iraq had the largest packing and pressing factories for date fruits and their various derived products in the past. The number of pressing factories grew to 250 in 1990; however, this sector had suffered from severe neglect, leading to closing most pressing facilities since 2003 (Khierallah et al., 2015). Currently, no accurate survey is available on date fruit processors in Iraq (Khierallah et al., 2015). Among the date-derived products in Iraq are date syrup, alcohol, and natural vinegar. Other derived products where production has stopped are liquid sugar, yeast, and citric acid (Zabar and Borowy, 2012).

Date-derived industries in Iraq include the manufacture of date paste, which is used in sweets and biscuit production, and the manufacture of liquid sugar from dates.

Date syrup is a common date-derived product, especially in Basra city. Date syrup can be used in many food applications such as in carbonated drinks, sweets, production of citric acid, vinegar, alcohol, and other products from dates. In addition, dates are used in the sweets industry. They are common in Basra due to the availability and quality of dates and the suitability of some of them for sweets manufacturing. Jam is also produced from dates. Date jam can be produced from Khalal (bisr) or ripe date fruits. Date jams have been successfully produced at applied research in Iraq and international companies. Date chips (Tamar Aldin) are produced from clear, filtered date juice to substitute for apricot date chips (Qamar Aldin). Date chips are prepared by concentrating the date extract and adding specific acids and vanilla. The extract is placed in a drying tray exposed to the sun for 3 days. The dried chips are wrapped with aluminium foil and kept at a temperature of 8–10 °C.

Iraq annually produces 30,000 tons of liquid sugar from dates. Liquid sugar is economically important for Iraq, especially in manufacturing soft drinks and concentrated juices. Date kernel coffee can be converted into a good-tasting coffee drink similar to well-known coffee. The production of alcohol (ethanol) from the date was various

renewable agricultural resources, which has received worldwide attention for its use as a biofuel and the other uses of ethanol. The animal feed industry uses low-quality dates, fibers, fronds, and pits to produce animal feed with good nutritional value (Hassan, 2016).

A recent study on the status of date palm cultivation and date production in Iraq has highlighted that the actual number of date factories in Iraq is 6, compared to 150 factories in 2003, in addition to more than 100 small local presses. The date syrup industry is prevalent at the domestic and commercial levels. The previous Iraqi production of liquid sugar, yeast, alcohol (high purity ethanol), vinegar, and animal feed was 30,000 tons, 5400 tons, 2400 tons, 5 million liters, and 15,600 tons yearly, respectively (Al-Thamir, 2017).

Tunisia

Date palm is a vital agricultural crop in the Tunisian oases located in the south of Tunisia, which is characterized by a desert climate and lack of rainfall. The main variety of dates grown in Tunisia is Deglet Nour, which is characterized by its good sensory and nutritional qualities compared to the other varieties (Ismail and Hassine, 2021). Tunisia is an important country at the global level in the production and export of dates. Economically, Tunisia is the first source of exported dates globally, especially the Deglet Nour variety. The export revenue from dates in Tunisia amounted to the equivalent of 200 million Euros in 2018 (Ismail and Hassine, 2021).

The main activities of the date manufacturing facilities in Tunisia include washing, sorting, and packing of dates for local consumption or export. A large quantity of dates is excluded due to their low quality. These dates could be recycled to produce new products rich in sugars and dietary fibers. Several research projects have been launched in Tunisia to produce date-derived products, which include:

- Date juice: Cooking shredded and chopped dates at a temperature of 80 °C for 90 min yields better date juice, which is rich in total dissolved solids, especially sugars, and low in acidity (Chaira et al., 2009; Mtaoua et al., 2016).
- Date syrup is obtained by concentrating date juice at a temperature of 100 °C. It is consumed directly or used in certain food products such as ice cream, jams, sweets, and bakery products. Date syrup is rich in energy and a good source of minerals, amino acids, organic acids, and pigments such as carotene. Moreover, a study used pectinase and cellulase enzymes to obtain date syrup from date juice that is free from turbidity and with a high percentage of total solids (Abbès et al., 2011, 2013; Ismail and Hassine, 2021);
- Studies were conducted to use biotechnology to

produce alcohol and vinegar from Tunisian date juice, where ethanol and acetic acid were produced on an experimental scale (Louhichi et al., 2013; Matloob, 2014; Hamza et al., 2016).

- Two studies used the hydrothermal treatment on low-quality Tunisian dates to obtain dietary fiber concentrates that have antioxidant properties. These dietary fibers can be used in healthy food products, such as baked goods, due to their distinctive flavor (Borchani et al., 2012; Mrabet et al., 2015).
- Tunisia has made efforts to link research with date-derived industries to manufacture these products on a commercial scale, thus imparting Tunisian dates an added value (Hamza et al., 2016; Ismail and Hassine, 2021).

The United Arab Emirates (UAE)

Since the establishment of the Federation in 1971, the UAE government has encouraged date palm cultivation (Kakea and Zayed, 2019). Now, date palm cultivation is spread over the country's seven emirates; in fact, no farm is devoid of date palm trees. The famous date varieties in UAE include Abu Al-Azouq, Anwaq, Barhi, Jabri, and Khalas (Arab Organization for Agricultural Development, 2004).

Dates are considered central to agriculture in the UAE, which exports several dates worldwide. The date-derived industry is one of the most prominent food manufacturing industries in the UAE. Several date factories with different production capacities have been established in the UAE and are involved in the packaging, local marketing, and exportation of dates (Beyut, 2021). These factories include date packaging lines and the production of date paste and pitted datelines. The date-derived industry includes the production of date syrup, which is used for preparing traditional Emirati sweets (Kakea and Zayed, 2019). One of the companies with high productivity is ALfoah, with two factories: the Emirates dates factory, which is equipped with data processing and packaging lines, and the Marfa factory, for canning vegetables and packaging dates, with a production capacity of 50 thousand tons. The annual production of these two factories is 113 thousand tons, with an investment capacity of 160 million Emirati Dirhams. Their products include date paste, dates stuffed and coated with chocolate, date syrup, date jam, sweets, vinegar, and date seed powder. Approximately 90% of the factory production is exported to 45 countries, including India, Oman, Bangladesh, Morocco, Indonesia, Jordan, Syria, and Somalia, in addition to the markets of the UAE (AlFoah, 2021).

Animal feed, date syrup, date paste, and date seeds powder are produced in Al-Ain Dates Factory. Liwa Dates Factory produces 35 different products with an annual production

capacity of 5000 tons, ranging from traditional date products such as packed dates and dates covered and stuffed with chocolate to date-derived products such as date pollen powder, pollen water, Rutab ice cream, pickled vinegar, Rutab juice, and vinegar. Their products are distributed in many global markets, including China, the European Union, North America, and East Asian countries. In addition to the several dates and date-derived factories with different production capacities, many date products have been developed with the introduction of dates as a healthy ingredient, such as spreadable dates, vinegar, ketchup sweetened with date syrup, and peanut cream at the Concept Food Industries (Kakea and Zayed, 2019).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

In some countries of the Middle East and North Africa, including Algeria, Iraq, Iran, Egypt, Tunisia, Saudi Arabia, and the UAE, are considered the most suitable geographical areas for date palm cultivation. These countries are also found at the top of the list of global production of dates. Dates are a rich source of many nutrients and one of the foods commonly consumed among people in these countries. Recently, there has been a surge in the establishment of modern factories to take advantage of second-class and low-quality dates to manufacture date-derived products, such as date syrup, high-fructose liquid date sugar, citric acid, alcohol, and vinegar. Recently updated data on the number of factories and the production capacity of date-derived industries in the mentioned countries are scarce due to the lack of complete information or information not being published in reliable scientific sources. The FAO has implemented many projects to develop date production and processing in the Middle Eastern and North African countries and has proposed the establishment and activation of the Date Palm Global Network to exchange experiences and information regarding the production and processing of dates in these countries (Arias et al., 2016). Some governmental bodies in the Arab countries, such as the Khalifa International Award for Date Palm and Agricultural Innovation, play a crucial role in encouraging the production and innovation of new date products in the Arab world and globally (Al-Shukair, 2019).

The date-derived industry in Iran includes liquid date sugar, high-fructose liquid date sugar, date syrup, alcohol, and vinegar. A source stated that Iran's production of liquid sugar reached 3600 tons on average during the last ten years.

Egypt is the highest producer of dates globally, with approximately 21% of the annual global production. Many

industrial facilities in Egypt favor the use of low-quality dates to produce date-derived products that have an added value, such as liquid sugar, date powder, jam, citric acid, vinegar, and animal feed. Dates are included in numerous date-derived products in Iraq, such as liquid sugar, yeast, alcohol, and vinegar, reaching 30,000 tons, 4500 tons, 2400 tons, and 5 million liters yearly, respectively. Date palm cultivation is the main source of income for the population in the oases of the Algerian desert. The manufacturing of date-derived products in Algeria has not reached the full industrial level. The production of date juice, vinegar, and sweets has partially started, and the first unit for the production of liquid sugar from dates began in Biskra, Algeria, in 2018. From an economic point of view, Tunisia is the world's first exporter of dates. Most of the date factories in Tunisia are working on date packing. Efforts have been directed towards conducting research in date-derived products and extending the findings to manufacture these products on a commercial scale. The Kingdom of Saudi Arabia is one of the leading countries in cultivating and producing dates. Most date factories in Saudi Arabia focus on non-derived dates such as fresh, pressed, and packed dates under vacuum. Few of these factories have begun manufacturing derived products of dates, where date paste and date syrup are mostly produced. The local production from date-derived industries reached 63.3 thousand tons in 2016. The quantity of imported derived products was 84.8 thousand tons in the same year.

At present, the date-derived industries in the Middle East and North Africa are impacted by many difficulties, including the scarcity of applied research in this field and the lack of production lines in the existing factories for the production of date-derived products. There are promising opportunities to increase the export of date-derived products in these countries, especially due to their surplus dates production and the attractive global prices for date-derived products.

Recommendations

The following are recommendations to enhance the date-derived industry in the Middle East and North Africa:

- (1) Supporting scientific research and economic feasibility studies in manufacturing date-derived products and innovating new products characterized by competition in global markets.
- (2) Cooperation with expert houses specialized in the production and maintenance of date-derived industries to establish high-standard factories in the Middle Eastern and North African countries to attract the interest of investors to establish similar factories.
- (3) Government support for establishing factories for date-derived products with soft loans and laws to protect local production.

- (4) Improving the quality levels of date-derived products by applying international quality systems such as ISO.
- (5) Establishing local and international exhibitions for date-derived products to introduce these products to market them locally and internationally.
- (6) Adopting a strategy to export date-derived products, for example, by establishing free industrial zones for export.
- (7) Providing accurate statistics on the number of factories, production quantity, and prices of date-derived products in each country and exchanging this information between different countries, benefiting from the Date Palm Global Network in this field.

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Authors' Contributions

Nora Abdullah AlFaris: Conceptualization, Resources, Writing - review & editing, Project administration, Funding acquisition, Supervision. Jozaa Zaidan AlTamimi: Conceptualization, Validation, Data curation. Fatima Ali AlGhamdi: Validation Formal analysis, Software. Najla Abdullah Albaridi:, Visualization.: Methodology, Investigation. Software. Lujain Abdulaziz AlMousa: Software, Writing - review & editing: Validation.

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