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## Overview of Date Fruit Production, Postharvest handling, Processing, and Nutrition

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### Introduction

Date palm (*Phoenix dactylifera* L.) belongs to the family Arecaceae (syn. Palmaceae) that includes 200 genera; genus *Phoenix* contains 12 of the 1500 species that belong to the date palm family. *Phoenix* palms are dioecious and are characterized by pinnate leaves and by duplicate leaflets with acute

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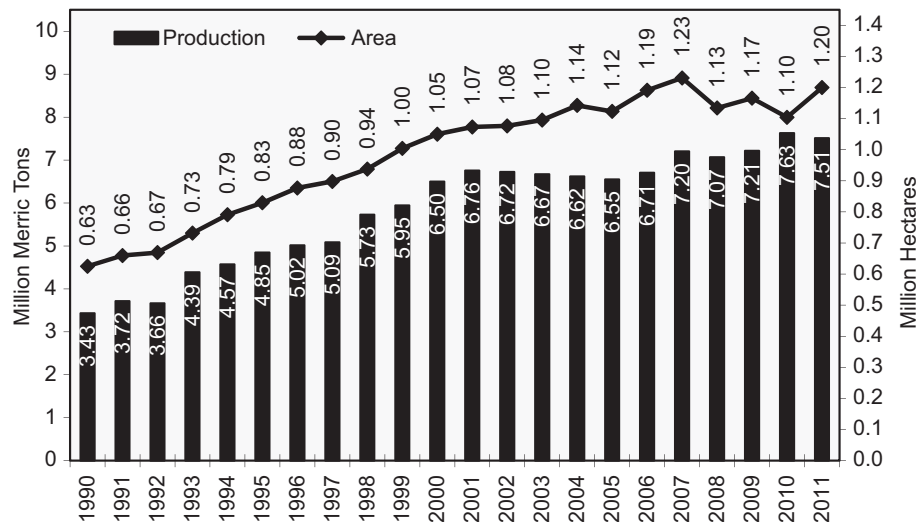
and sharp tips (Sanderson 2001, Uhl and Dransfield 1987). Besides date palm, the other two most highly valued *Phoenix* palms are Canary Island Palm (*P. canariensis* Chabeaud), an ornamental palm and the sugar palm (*P. sylvestris* Roxb), which is common in the Indian subcontinent for its sugar syrup (Zaid and de Wet 2002). Date palms grow in hot, arid regions of the world and are marketed worldwide as a high-value sweet fruit crop. It is considered as an important subsistence crop in most of the world's desert areas (Al-Shahib and Marshall 2003). The date palm has traveled remarkably well as civilization moved out of the Middle East and reached places such as Spain and the United States, with the Coachella Valley (California) later becoming the primary commercial region of date production in the US (Sauer 1993). Beyond the arid climates, date palm can also be grown in many other countries for food or as an ornamental plant including the continents of Americas, southern Europe, Asia, Africa, and Australia. The majority of date palm-growing areas are located in developing or underdeveloped countries where date fruit is considered the primary food crop, thus playing a major role in the nutritional status of these communities (Pruessner 1920, Sanderson 2001).

The earliest evidence of date palm cultivation goes back to 4000 BCE in Ur, lower Mesopotamia (now Iraq), where the date palm trunks were used for the construction of the temples; while in the Nile Valley, date palm cultivation goes back to 3000 BCE (Erskine et al. 2011). The date palm tree was praised and cherished, as is evident from the drawings and sculptures of ancient civilizations of the Sumerians, Assyrians, Babylonians, and Egyptians, and later by the Greeks and the Romans (Pruessner 1920). Throughout time, dates have been held in very high esteem in all three major regions of the world. In Islam, the date palm is mentioned multiple times in the Holy Quran and 300 times in the sayings or *Hadith* of the Prophet Muhammad. Likewise, the date palm is praised in Christianity and Judaism and has been linked to numerous religious ceremonies such as Passover and Palm Sunday (Jalbani 2002, Musselman 2007). The date fruit is relished for its sweet, succulent, and exotic flavor. Besides fresh consumption, this fruit is processed into a wide variety of value-added products: such as dry dates, date paste, date syrup, date juice concentrate, date jam, date butter, date bars, date chutney, date relish, and date pickles. Date oil and date coffee are some of the by-products produced from date seeds (Huntrods 2011, Vijayanand and Kulkarni 2012).

This chapter provides an overview of date production, trade, and consumption, fruit biology and postharvest physiology, packaging and storage, processing and processed products, food safety and quality, and nutritional and medicinal significance.

## World production and trade

The area under date palm cultivation almost doubled from 1990 to 2007 (0.63 to 1.23 million hectares), however, there has been some decrease in years



**Figure 1.1** World date production and area under cultivation (1990–2011). *Source:* Adapted from FAO (2012).

2008 to 2010 (Figure 1.1). The 2011 area figures stood at 1.20 million hectares (FAO 2012), which represented an increase of 90.5% as compared to 1990's. It is noted the increases in area under date cultivation were more rapid from 1990 to 2001 – about 70% increase to 1.07 million hectares – whereas only 11% increase was observed from 2001 to 2011. The total world production of dates was 7.51 million metric tons (MMT) in 2011, which represented an almost 120% increase as compared to the 1990 production of 3.43 MMT (Figure 1.1). World date production increased consistently between years 1990 and 2001, for a total of 97% increase to 6.76 MMT. The production from 2001 to 2011 showed mixed trends, with about 11% increase. The peak area under cultivation and production were 1.23 million hectare and 7.63 MMT, reported in 2007 and 2010, respectively (FAO 2012). Overall, it is noteworthy to mention that date cultivation and production have shown positive growth trends.

Table 1.1 presents data on the area under date cultivation and production for leading countries. Egypt was the top-most producer of dates with 1.37 MMT or 18.30% of total world production; followed by Saudi Arabia (1.12 MMT), Iran (1.02 MMT), United Arab Emirates (UAE) (0.90 MMT), and Algeria (0.69 MMT). Combined, these top five countries contributed a 68% share of total world production. Other countries, not shown in Table 1.1, with noticeable production (in thousand metric tons) were: Israel (37.0), Kuwait (33.6), USA (30.0), and Turkey (28.3). As per FAO's 2011 data, dates are produced in 37 countries (FAO 2012), however, it is noted that countries listed in Table 1.1 accounted for 95.4% of the total production while the remaining 25 countries contributed less than 5%. A regional

**Table 1.1** Leading date-producing countries in the world in 2011 (with over 50,000 metric tons).

Country	Area (hectares)	Production (metric tons)	Share of world production (%)
Egypt	41,652	1,373,570	18.30
Saudi Arabia	172,297	1,122,820	14.96
Iran	154,274	1,016,610	13.55
United Arab Emirates	200,000	900,000	11.99
Algeria	172,500	690,000	9.19
Pakistan	93,088	557,279	7.43
Oman	31,348	268,011	3.57
Tunisia	51,000	180,000	2.40
Libya	30,056	165,948	2.21
China	10,500	150,000	2.00
Morocco	43,982	119,473	1.59
Yemen	14,983	59,627	0.79
<i>World total</i> <sup>1</sup>	<i>1,200,006</i>	<i>7,504,984</i>	–

<sup>1</sup>Including all other countries not listed.

Source: Adapted from FAO (2012).

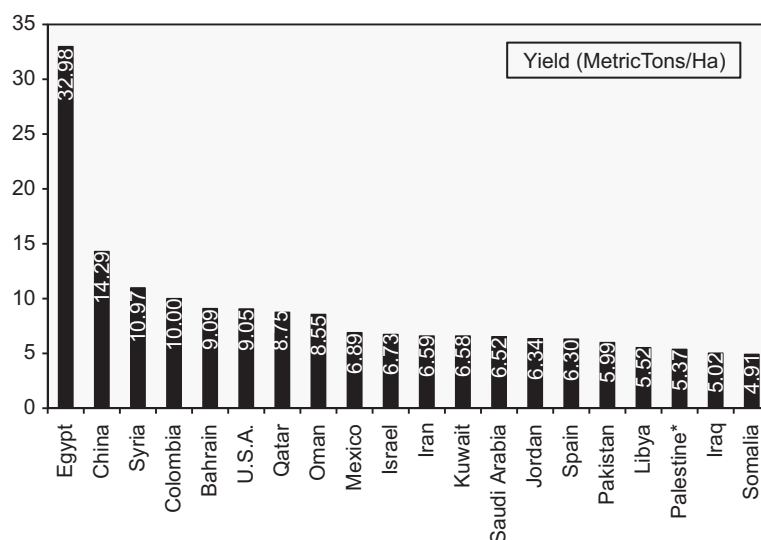
distribution of date-producing countries is give below (\*countries producing less than 10,000 metric tons):

- *Asia (16)*: Saudi Arabia, Iran, UAE, Iraq, Pakistan, Oman, China, Yemen, Israel, Kuwait, Turkey, Qatar, Bahrain, Jordan, Occupied Palestinian Territory\*, and Syria\*
- *Africa (15)*: Egypt, Algeria, Tunisia, Libya, Morocco, Mauritania, Chad, Niger, Somalia, Benin\*, Kenya\*, Cameroon\*, Namibia\*, Swaziland\*, and Djibouti\*
- *Americas (4)*: USA, Mexico\*, Peru\*, and Colombia\*
- *Europe (2)*: Albania\* and Spain\*.

Egypt had significantly less area under date palm cultivation (41,652 hectares) as compared to next five countries on the list, with a range of 123,230 hectares to 200,000 hectares (Table 1.1). The highest production of dates in Egypt is attributed to significantly higher tree density per hectare as compared to Saudi Arabia, Iran, UAE, Algeria, and Iraq. The disparity between the area under cultivation and production in individual countries can be further explained by date fruit yield per hectare in 20 countries (Figure 1.2). Owing to the high density of trees per unit area, Egypt had the highest date yield of almost 33 metric tons/hectare. China, the next country on the list, had a yield of 14.29 tons/hectare (or about 43.5% of that in Egypt). On the yield basis (4.5 tons/hectare), UAE, the fourth-largest producer of dates in the world, was not in the list of countries shown in Figure 1.2. It is

## WORLD PRODUCTION AND TRADE

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**Figure 1.2** Country-specific average yield of dates in 2011 (\*Occupied Palestinian Territory).  
*Source:* Adapted from FAO (2012).

further noted that, in addition to higher tree density, higher yield could be contributed partially to better production and management practices in some countries.

Major date exporting and importing countries, by quantity and value, are listed in Table 1.2. UAE led the list of both exporting and importing countries by quantity, with 237,898 and 227,726 metric tons, respectively. Based on the value of dates exported, Tunisia was the leader with over US \$200,000 for 84,282 metric tons of dates exported. The wide variations based on quantity and value are due to a well-established grading and packaging industry

**Table 1.2** Major date exporting and importing countries in 2010.

Exporters			Importers		
Country	Quantity (metric tons)	Value (1000 US\$)	Country	Quantity (metric tons)	Value (1000 US\$)
United Arab Emirates	237,898	22,306	United Arab Emirates	227,726	25,613
Pakistan	121,681	48,690	India	193,467	95,042
Iraq	120,123	35,913	Morocco	51,449	77,894
Iran	106,760	134,001	France	28,171	72,011
Tunisia	84,282	200,091	Yemen	23,935	11,167
Saudi Arabia	73,362	78,126	Russian Federation	20,814	29,166
Egypt	19,562	18,529	Malaysia	17,980	36,120
Israel	12,676	63,381	Syria	17,343	7,947
France	11,514	32,112	Indonesia	16,986	18,097
Algeria	10,393	16,930	Turkey	13,158	13,127

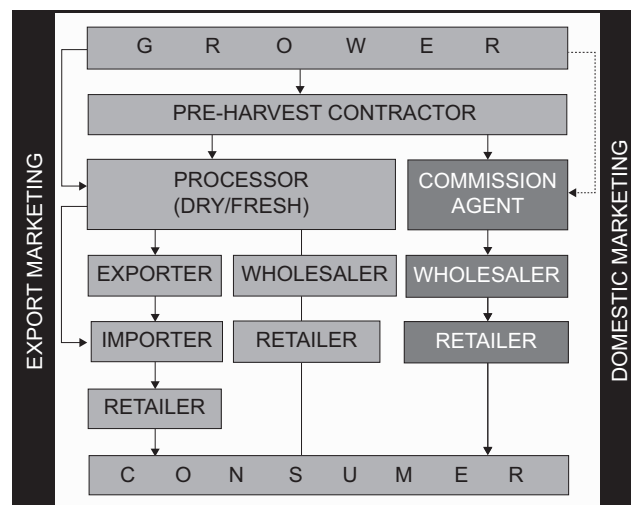
*Source:* Adapted from FAO (2012).

in Tunisia as compared to UAE, Pakistan, and Iraq. For example, Pakistan ranked second in dates exported by quantity but earned only US \$48,282 in value. UAE, which exported about twice the amount, earned even less than one-half as compared to Pakistan. Based on the value, India was the leading importer of dates, followed by Morocco and France.

## Marketing and consumption trends

Marketing of dates involves various operations through the value-chain, for example, harvesting, cleaning, grading, packaging, processing, and transportation/shipment to local or export markets. Among date-producing countries, the state of marketing channels varies widely. It is not uncommon to see growers selling their harvest roadside or in small village/town markets, which represents an unsophisticated manner of marketing with low returns. Where proper marketing channels exist, they range from basic to well established and developed. For example, Pakistan has a typical and unsophisticated network of up to six or seven intermediaries between the primary source (growers) and the end user (Figure 1.3). Because of the presence of so many layers and the lack of adequate marketing infrastructure and storage facilities, 30 to 40% of the perishable produce gets spoiled before reaching the ultimate consumer (PHDEB 2008).

Per capita consumption of dates varies widely from country to country. According to 2003 data, per capita consumption is the highest in Saudi Arabia, with 34 kg/year. Other countries with high per capita consumption of dates are: UAE (17 kg), Libya (15 kg), Algeria (14 kg), and Egypt (13 kg). In some Middle-Eastern countries (Jordan, Lebanon, Palestinian Territory) the



**Figure 1.3** Domestic and export marketing channels for dates in Pakistan. *Source:* Adapted from PHDEB (2008).

per capita date consumption is very low— around 1 kg (Ashraf and Hamidi-Esfahani 2011). Al-Marshudi (2002) noted that the date palm has retained its value for the desert population owing to its good adaptation to the environment and the wide range of benefits it provides. To many desert inhabitants, date fruit represent an important source of nutrition as its products can be used the year round (fresh mature dates are used during the June and October period). In addition, dates can be processed and stored for the remaining months of the year simply by using traditional ways of packing in jars or bags (Al-Marshudi 2002). Dried dates are one of the few food sources that are self preserving (due to the high sugar content), are light to carry, especially in view of the small quantity needed for daily consumption, and are pleasant to eat (Sanderson 2001).

## Date palm growth and fruit production

Date trees grow readily from seed but the quality of the resultant plant is not reliable, therefore, the most common method of reproduction is the planting of suckers. There have been further refinements in propagation methods including, in the last 30 years or so, production of “tissue culture” dates in laboratories and then transplantation into the field (Sanderson 2001). Among *Phoenix* species, date palm is the tallest one, which can grow to 30 meter in some regions. The trunk of this tree is surrounded from the ground upwards in a spiral pattern of leaf bases. The leaves are large, measuring 4–5 meter, alternate, sheathing in a dense terminal rosette (Erskine et al. 2011). For optimum growth and fruit bearing, date palms must have full sun because they cannot grow in the shade. The fruit must be produced commercially at a temperature of 32 °C (90 °F) with no or low (<12 mm, 0.5 inch) rain during the ripening period. In the desert conditions, date palms can tolerate long periods of drought (Huntrods 2011).

Date palms are dioecious – i.e., the male and female parts are on separate plants. Dates are naturally wind or insect pollinated, and natural pollination can be practiced in seedling orchards with mixed cultivation of male and female trees. In most commercial orchards, only one male tree is typically sufficient for pollinating up to 50 females (Huntrods 2011, Sanderson 2001). Pollination is accomplished artificially and the traditional method involves cutting several pollen clusters from the male tree and inverting them among clusters of female flowers. Today, besides the traditional method, pollination can be done using machines, which has made the process quicker, easier, and efficient (Huntrods 2011). Fruit thinning is practiced at pollination time, or occasionally 6–8 weeks post-pollination. Thinning can be done by bunch thinning, where some strands or portions are removed, by complete bunch removal or both. Dates are planted about 25–35 feet apart, yielding about 50 plants per acre on average, but some varieties such as Khadrawi can be planted at higher densities. It is also recommended to prune off persistent leaves and old fruit stalks (Huntrods 2011, Sanderson 2001). The tree density

varies from country to country, for example, low density in Saudi Arabia to very high density in Egypt.

The date palms begin producing fruit when they are about 7 years old and generally produce fruit for 75 years. The date palm fruit is a berry type, also known as a “drupe” having a single hard seed. Only female date palms bear fruit, so for commercial purposes female trees are planted predominantly. However, it must be noted that male trees that produce plentiful pollen are very valuable as well, because the pollen quality significantly affects the size of the fruit and its ripening rate. Fruit is born on clusters called bunches and it is the largest among all other species, with a few varieties reaching up to 100 × 40 mm in size. After pollination, it takes the fruit 150–200 days to reach the fully ripened or *Tamar* (*Tamr*) stage. Generally, a fully productive palm can support 5–10 fruit bunches that can weigh from 60 to 100 kg. Depending on the cultivar, the fruit is 25–75 mm (1–3 inches) long with a thick skin and very sweet flesh and a large seed (Erskine et al. 2011, Huntrods 2011).

## Cultivars

A wide variety of date palm cultivars are grown in different countries; however, according to Anon. (2002), the following date varieties are the common types: Barhi (fresh consumption at *Khalal* or early stage, sweet and juicy, yellow color, available seasonally during harvest months); Hayani (fresh consumption, black and shiny color, long fruit, not very sweet); Medjhoor (dried date, large fruit, soft and sweet, light brown to dark-brown color); Amari (dried date, soft, sweet, medium sized date); Deglet Nour (dried date, semi-soft, famous flavor, light to dark-brown color, harvested semi-dry); Hadrawi (dried date, sweet and fleshy date, dark brown color); Zahidi (dried date, round, medium sized and not too sweet date, golden color). The date cultivars that dominate the market, based on consumption, are Medjhoor, Deglet Nour, and Barhi.

The date cultivars grown in various countries, as described by Ashraf and Hamidi-Esfahani (2011) are:

- *Algeria*: Iteema, Deglet Nour, Thoory
- *Egypt*: Hayani, Zoghloul, Siwi, Samany, Amhat
- *India*: Kajur, Bericcha Pazham
- *Iran*: Estamaran, Shahani, Kabkab, Mazafati, Rabbi, Zahidi, Barhi, Gentar, Alemehtari, Kazrawi, Khasui, Shakkar, Mordarsang, Pyarom, Halawi, Dayri, Sowaidani
- *Iraq*: Dayri, Barhi, Halawy, Khadrawi, Maktoom, Amir Hajj, Zahidi, Sayer, Khastawi

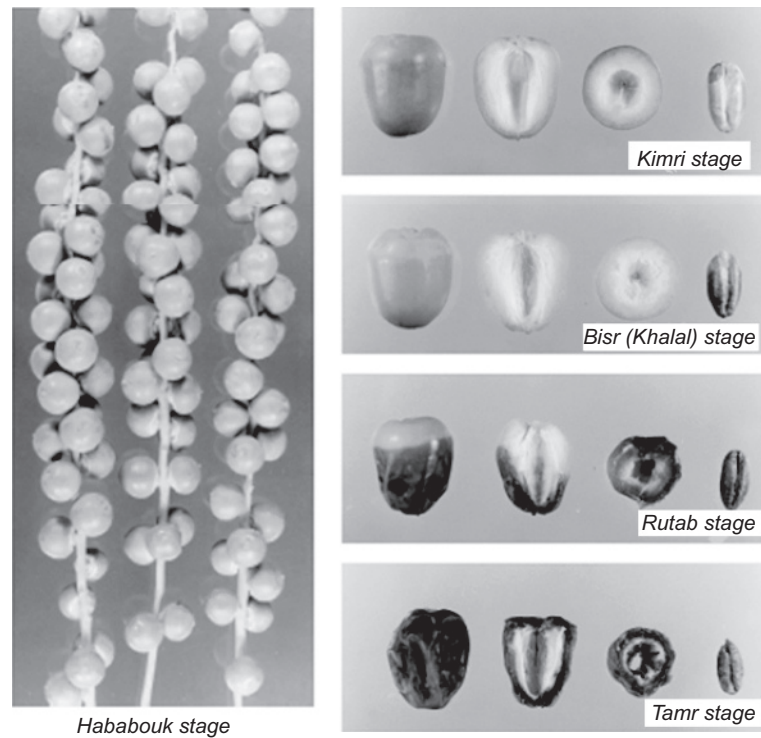


- *Israel*: Medjhood, Hadrawi
- *Jordan*: Medjhood
- *Libya*: Saidy, Haleema, Aabel, Mgmaget Ayoub, Tagyat, Tamej, Umeljwary
- *Morocco*: Medjhood
- *Pakistan*: Zaidi, Mobini, Shakri, Obaidullah, Hsaini, Basra, Khadrawi, Gulistan, Sabzo, Mozafati, Dhakki, Kajur
- *Saudi Arabia*: Miskani, Nabbut Ghrain, Hulwa, Thamani, Sokkary, Rothanat, Al-Qaseem, Sebakat Al-Riazh, Helwet El-Goof, Zaghloul, Ajwah, Khalasah, Nabtat Seyf, Mishriq, Sag'ai, Sellaj, Umelkhashab, Al-Barakah, Berhi, Gur, Hiladi, Khasab, Majnaz, Ruzeiz, Sahal, Shashi, Tanjeeb, Tayyar, Um Rahim, Zamil
- *Sudan*: Mishriq, Abid Rahim, Barakawi, Birier, Kulma Suda, Mishriq Wad, Khatieb, Mishriq Wad Lagi, Medina, Bentamoda, Gondaila, Jawa, Zughloul
- *Tunisia*: Deglet Nour, Ftimi (Alligue), Rouchdi, Mermella, Lemsi, Kenta, Korkobbi, Garn ghazel, Eguiwa, Mattata, Bouhattam, Ksebba, Amari, Angou, Arichti, Bejjou, Bisr Helou, gounda, gousbi, Brance de dates, Hamraya, Hissa, Kentichi, lagou, Touzerzayet
- *UAE*: Lolo, Khalas, Berhi, Fard, Bomaan
- *USA*: Medjhood, Deglet Nour, Empress, Zahidi, Khadrawy, Halawy
- *Yemen*: Migraf

## Maturity stages

Date fruit development progresses through five maturity stages that take about 6–8 months; fruit: (1) grow rapidly, (2) turn their characteristic color, (3) lose water, (4) accumulate sugars, and (5) ripen completely (Huntrods 2011). These stages are shown in Figure 1.4; Ashraf and Hamidi-Esfahani (2011) described these stages as:

- *Hababouk* – The first stage that appears after pollination and continues for 4–5 weeks. The fruit has round shape, whitish-cream color with green stripes.



**Figure 1.4** Different growth and maturity stages of date fruit. Reproduced with permission of Saleh M. Aleid. (For a color version of this figure, please see the color plate section).

- *Kimri* – This stage appears in the first 17 weeks after pollination. The fruit is young, elongated, greenish in color, hard in texture and with about 85% moisture. Fruit weight increases significantly and the tannin concentration is high. Although the fruit is inedible for direct consumption at this stage, it can be used for making chutney (sauce) or pickles.
- *Khalal* – During the next 6 weeks, date fruit gains maximum size and weight, color gradually becomes a typical yellow, purplish-pink, or red depending on the cultivar, with hard texture. At this stage, sugar increases slowly and becomes mainly sucrose. This is the stage at which dates are mainly consumed raw as fresh fruit or they can be used for jam, butter, or date-in-syrup.
- *Rutab* – In the next 4 weeks, the dates lose water with half of the fruit becoming soft, sweeter and darker in color (light brown), and less astringent. Sucrose converts to reducing sugars and protein, fat and ash percentages decrease. This stage is the start of ripening. Dates at *Rutab* stage from many cultivars are eaten fresh or processed into jam, butter, date bars, and date paste.

- *Tamr* or *Tamar/Tamer* – During this final stage, that typically lasts 2 weeks, the fruit gains maximum total solids, highest sweetness, lowest astringency, dark brown color, soft texture, and a typical wrinkled shape. There is a high concentration of reducing sugars, especially glucose and fructose, with no or very low sucrose. The percentages of protein, fat and ash are less compared to *Rutab* stage. Owing to low moisture and high sugar content, dates of this stage have good storage stability (about one year at room temperature if they are packed tightly. For dry cultivars, *Tamr* dates become light colored with a dry hard skin, whereas for soft cultivars the flesh remains intact and soft and intact with a dark color.

## Harvesting and fruit quality/grades

### Harvesting

Dates are harvested and marketed generally at three stages of development: mature firm (*Bisir* or *Khalal*), full ripe (*Rutab*) and dry (*Tamar* or *Tamr*). The decision for harvesting at one or other stage depends on cultivar characteristics; especially, soluble tannins levels, climatic conditions, and market demand (Glasner et al. 2002). Time of harvest is based on the date fruit's appearance and texture (related to moisture and sugar content). Proper timing of harvest reduces incidence and severity of cracking or splitting of dates, excessive dehydration, insect infestation, and attack by microorganisms (Kader and Hussein 2009). Date moisture should be 20–26% (when fresh), with equilibrium relative humidity (ERH) of not more than 65%. Consequently, dates of <65% RH ensure resistance to microbiological factors such as mold, yeast, and bacteria that attack the fruit. Therefore, harvesting should take place while the fruit has a relatively high water content in order to prevent the fruit from losing water and becoming hard in texture (Navarro 2006). *Rutab* and *Tamar* dates are harvested as whole bunches (when the majority of dates are ripe) by lowering close to the ground level and shaking into a bin to remove the ripe dates; alternatively, individual ripe dates are picked from the bunches and on average three pickings are required over several days. Pickers use different types of containers and harvesting aids to lower the dates to the ground level (Kader and Hussein 2009).

Although dates are historically a labor-intensive crop, modern high-tech processing allows producers to handle the large volume (Huntrods 2011). Kader and Hussein (2009) reported that for harvesting from very tall trees, ladders may be mounted on the palm tree or various types of lifts, such as a tree squirrel and self-propelled elevating platform, are used to elevate the harvesting laborers to facilitate harvesting.

After harvesting, dates should be cooled to 0°C and transported under refrigeration (0–2°C and 90–95% RH) to maintain their quality. Hydro-cooling can be used to cool *Khalal* dates to near 0°C in 10–20 minutes, depending on initial temperature, this requires effective disinfection of the water and removal of excess surface moisture from the cooled dates before

packing in the shipping containers; thus, forced air cooling may be a better choice than hydrocooling (Kader and Hussein 2009). At a typical processing plant, dates are inspected for quality and weighed prior to entry in the plant. Then dates are fumigated in completely sealed chambers. For further processing, dates are transferred to feeding line elevator and automatically dumped over a shaker for preliminary washing; hot air blast is applied to remove excess water (PHDEB 2008).

Proper food safety measures should be taken during date harvesting and handling. Cleaning and sanitizing food contact surfaces, such as harvest aides, harvest containers, and packing lines, involves following four steps (Bihn and Reiners 2011):

*Step 1 – Pre-Rinse:* Pre-rinse surfaces to remove soil that may have accumulated, paying particular attention to cracks, crevices, and hard-to-reach areas. Pre-rinsing may require scraping and brushing to remove the soil.

*Step 2 – Wash:* This step requires thorough washing (cleaning) of the surface to disperse the soil in the detergent solution. All detergent (cleaner) should be mixed according to label directions and applied to the surface to break down the soil and all its components including fats, carbohydrates, and proteins. The chemical action of the detergent and the physical action of scrubbing helps remove the soil.

*Step 3 – Rinse:* In this step, the detergent solution containing the soil is rinsed away to ensure that the surface is visibly free of soil and detergent solution.

*Step 4 – Sanitize:* Finally, a sanitizer is applied to the surface as per the label's directions. All sanitizers should be tested with a simple test kit specific to the sanitizer being used to determine that the appropriate concentration (strength) is achieved and maintained. Sanitizers reduce the level of spoilage and pathogenic microorganisms on the surface to safe levels. Steps 1–3 must be done properly because if the surface is not clean, then the sanitizer quickly loses its effectiveness (Bihn and Reiner 2011).

### **Fruit quality and grades**

Yahia (2004) reported that the skin of dates should be smooth, with little or no shriveling, golden-brown, amber, green or dark-brown color depending on the variety; whereas, the texture may be soft and syrupy, or firm or dry texture depending on the cultivar. Other criteria for a high quality for fresh dates include: adequate size and color, thick flesh, free from dirt, sand and leaf particles, birds, insect and rodent damages, fungi and mold infestation, sugar crystal formation or 'sugaring' (Dowson 1982). Date fruit quality grades are based on uniformity of color/size and absence of defects or damages by

discoloration of the flesh, rupture of the skin, deformity of the fruit, puffiness of the skin, scars, sunburn, insect damage, decay, black scald, fermentation, improper ripening, mechanical damage, dirt or any other foreign material. Codex and US Grades *A, B, C, standard* and *substandard* applied for whole, pitted or dry dates use these criteria for grading (Yahia 2004).

Generally, the sugar contents for different grades are usually the same when expressed as a percentage of dry weight, but the higher grades usually contain higher amount of sugar per date. Medjool dates in the USA are classified into three size categories: *Jumbo* for <10 dates per lb (0.45 kg), *Mixed* for 10–15 dates per lb and *Conventional* for 15 dates per lb (Yahia 2004). Jalbani (2002) reported that dates in Pakistan are usually classified according to the following grades: *Extra Class, Select-A, Select-B, Good Average Quality, Fair Average Quality, and Industrial Grade*.

Sorting and grading of dates in all countries is essentially done manually. In postharvest operations, the date grading and sorting process can be a source of delay in packaging and marketing of fruit. The reason being that it is a repetitive, labor intensive and time consuming process and it is carried out by humans manually through visual inspection (Al Ohali 2011). Jalbani (2002) indicated that the job of date grading is quite technical in nature and that a batch of workers under the supervision of a highly experienced quality controller, who gives instructions to his team for preparing the desired grades. To speed up the date grading process and maintain the consistency/uniformity, Al Ohali (2011) designed and tested a prototype computer vision based date grading/sorting system by a defined set of fruit external quality features; the test results showed that the system can sort 80% dates accurately. Further refinement of prototype systems and development of commercial machine-vision grading systems can improve the grading operation efficiency significantly.

## Postharvest handling and storage

The respiration rate of dates is very low: <5 mg CO<sub>2</sub> kg/hr at 20 °C (68 °F) at the *Khalal* stage, and <2 mg/kg/hr at the *Rutab* and *Tamar* stages. Ethylene production of dates is also very low: <0.1 μl/kg/hr at *Khalal* stage and none at *Rutab* and *Tamar* stages (Yahia 2004). Dates beyond *Kimri* and *Khalal* stages are not sensitive to chilling injury. Yahia (2004) reported that dates may require postharvest ripening if picked early. Soft and semi-dry cultivars need to be dehydrated to eliminate excess moisture if they will not be consumed immediately. Hydration is used to soften the texture of hard-type cultivars. Kader and Hussein (2009) suggested that dates should not be mixed with onions, garlic, potatoes, apples, or other commodities with strong odors that can be adsorbed by the dates.

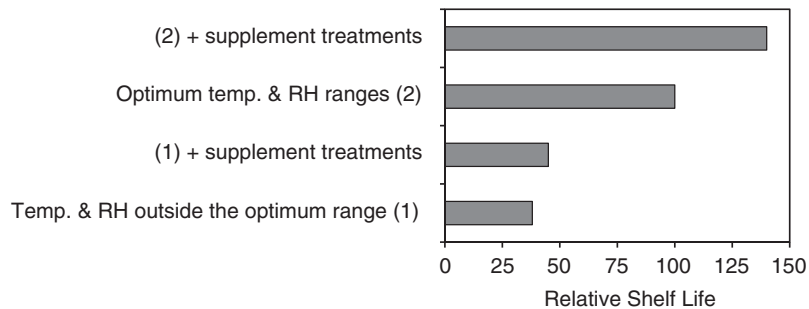
Date fruit quality loss resulting from pathological and physiological deterioration increases with increasing moisture content and storage temperature (Yahia 2004). Storing dates at low temperatures is the most important way

of maintaining quality: because it minimizes loss of color, flavor, and textural quality; delays development of sugar spotting, incidence of molds and yeasts, and insect infestation; and prevents development of syrupiness (due to conversion of sucrose into reducing sugars) and souring of excessively moist dates. *Khalal* dates should be stored at 0 °C and 85–95% RH to reduce water loss, delay ripening to the *Rutab* stage, and maintain their textural and flavor quality (Kader and Hussein 2009). In order to reduce moisture loss and improve shelf life, packaging in moisture-barrier plastic bags or use of plastic liner in the box is helpful. Optimal temperature for *Tamar* dates is 0 °C for 6–12 months, depending on cultivar (semi-soft dates, like Deglet Nour and Halawy, have longer storage-life than soft dates, like Medjool and Barhee). For extended storage, the use of temperatures below the highest freezing temperature of –15.7 °C is recommended. Dates with 20% or lower moisture can be kept at –18 °C for more than one year, at 0 °C for one year, at 4 °C for 8 months, or at 20 °C for one month; RH should be kept at 65–75% for all cases (Kader and Hussein 2009).

There is a continuing trend toward increased precision in temperature and RH management to provide the optimum environment for fresh produce during cooling, storage, and transport; precision temperature control and management tools, including time–temperature monitors, are becoming more common in cooling/storage facilities and during transportation and shipping (Kader 2003). Storage at optimum temperature and RH along with supplementary postharvest treatments (edible coating, modified atmosphere packaging) can significantly increase the shelf life of fruits, including dates (Figure 1.5).

Kader (2003) recommended maintaining a cold chain for perishables throughout the marketing channels. These recommendations can be applied to dates handling for maintaining their quality and safety at various steps:

- *Harvest*: Protect the product from the sun, transport quickly to the packinghouse.



**Figure 1.5** Relative postharvest shelf life of perishable commodities under different conditions. *Source:* Adapted from (Kader 2003).

- *Cooling*: Minimize delays before cooling, cool the product thoroughly as soon as possible.
- *Temporary storage*: Store the product at its optimum temperature, practice ‘first in first out’ rotation, ship to market without any delays.
- *Transport to market*: Use refrigerated loading area, cool truck before loading, load pellets towards the center of the truck, put insulating plastic strips inside door or reefer if truck makes multiple stops, avoid delays during transport, monitor product temperature during transport.
- *Handling at destination*: Use a refrigerated unloading area, measure product temperature, move product quickly to the proper storage area, transport to retail markets or foodservice, operations in refrigerated trucks, display at proper temperature range.
- *Handling at foodservice outlet or home*: Monitor product temperature during transport, store product at proper temperature, use the product as soon as possible.

After all the necessary steps have been taken by the producer, processor, and marketer to ensure food safety aspects, it is consumer’s responsibility, too, to handle and store a food product in a safe manner to avoid any food safety issues.

## Postharvest quality evaluation

Aleid (2012) reported that quality profile of dates in the marketplace involves evaluating four aspects: (a) color, shape, size, taste, texture, pit/flesh ratio, and uniformity in color and size of the fruit; (b) moisture, sugar, and fiber content; (c) defects of the fruits, which may include discoloration, broken skin, sunburn, blemishes, shrivel deformity, etc.; and (d) insect infestation, foreign matter, pesticide residues, mold, and decay. Such evaluation forms the basis of “chemical,” “physical,” and “sensory” quality attributes.

*Chemical quality attributes*: Date varieties can vary significantly in their chemical composition, especially the amounts of reducing, non-reducing sugars, and the amount and composition of dietary fiber. The variations in composition have a significant effect on their structural, sensory and textural properties (Rahman and Al-Farsi 2005).

*Physical quality attributes*: Texture is the most important physical quality attribute of dates, which is determined by instrumental analysis. The texture profile analysis (TPA) includes measuring hardness, cohesiveness, adhesiveness, springiness, resilience, and chewiness. Hardness, chewiness, and resilience usually increase exponentially with the decrease of moisture content, whereas adhesiveness, cohesiveness, and springiness increase

**Table 1.3** Quality definitions of attributes based on consumer preferences.

Attribute	Quality definition
Color	Good quality dates tend to be light brown in color
Appearance	Most preferable dates tend to be uniform in shape and long
Sweetness	Preferred dates tend to be moderately sweet
Fruit size	A good quality date fruit tends to be moderately large
Chewiness	A date of good quality ranges from slightly to moderately chewy
Flesh thickness	The flesh thickness of a good quality date fruit ranges from moderately thick to thick
Solubility	A good quality date tends to be moderately soluble to very soluble when consumed
Elasticity	Dates of good preference tend to range between slightly elastic and moderately elastic
Texture and mouth feel	A good quality date tends to have a smooth texture and mouth feel
Mouth shear	A slight force is needed to shear or tear a good quality date fruit
Pit size	The pit of a good quality date tends to be medium in size, i.e., neither big nor small

Source: Ismail et al. (2001). Reproduced with permission from Elsevier.

exponentially with the decrease of moisture content (Rahman and Al-Farsi 2005).

*Sensory quality attributes:* With respect to consumers, important quality criteria of a produce are appearance (including color, size, and shape, condition and absence of defects), mouth feel or texture, flavor and nutritional value (Wills et al. 1998). A well-defined, standardized scoring system for evaluating the total quality of a date (*Tamar*) based on consumer preferences was developed and tested for validity by Ismail et al. (2001), as shown in Table 1.3. Eleven defined quality attributes of the *Tamar* dates using a five-point scale (very poor, poor, satisfactory, good, and excellent), that later was transformed to quantitative scores, were evaluated. For most of the attributes (color, appearance, sweetness, fruit size, mouth feel, mouth shear, and pit size) there was a single preferred category by a majority of date consumers.

## Date processing and by-products

Date fruit has not been processed into value-added products on a scale similar to some other tropical fruits, especially on a commercial scale. Nonetheless, beside direct consumption of the whole dates, this fruit is used traditionally to prepare a wide range of different products, for example, date juice concentrates (spread, syrup, and liquid sugar), fermented date products (alcohol, vinegar, organic acids), and date pastes for uses in the bakery and confectionary industry (Aleid 2012, Anon. 2002). A separate



chapter “Date Fruit Processing and Processed Products” (Chapter 8) covers date processing/products in detail; here, a brief description of selected products is provided:

*Date syrup:* Generally, the low quality (cull) dates are used to produce date syrup and date syrup concentrate, since the fruit is a good source of glucose and fructose. Sucrose is present in significant amounts, as well. Sugars are responsible for much of the physical nature of syrups as well as its hygroscopy (Tavakolipour et al. 2007). Date syrup can potentially replace sugar in food formulations where slight coloring it imparts is not critical in the quality of such prepared products.

*Date paste:* Processing of date fruits into date paste is a way to preserve the fruit and offer flavorful choices for adding it to different foods, especially in baked goods and confectionery. Date paste is produced from clean-pitted dates by mixing/mincing with simultaneous addition of pre-determined amounts of water or steam. Date paste contains high levels (78%) of invert sugar and dietary fiber (7%) and it is a good source of minerals and trace elements. Ascorbic acid or a combination of ascorbic and citric acid are effective in keeping the changes in the pH of the date paste stored at 25 °C to a minimum (Yousif et al. 1991).

*Date jam/jelly:* The use of second-grade Tunisian dates (with a hard texture) as raw materials for jam production was explored by Besbes et al. (2009). The resulting jams were characterized in terms of chemical composition, physical properties (texture and water retention capacities), and sensory properties. The date variety had a significant effect on the composition and physical characteristics of the date jams, which had high overall acceptability. Masmoudi et al. (2011) prepared four jelly formulations using date juice enriched with pectin and lemon flavoring.

*Date vinegar:* Date fruit ferments readily, making dark, rich vinegar that has a fruity flavor. It can be used like balsamic vinegar; date vinegar was made 5,000 years ago in Babylonia (now Iraq) (Huntrods 2011).

*Fructose production:* Date syrups are composed of large amounts of reducing sugars and possess more fructose than glucose. Separation of sugars from dates is one of the best methods to produce value-added products, and fructose, in particular, yields high quality products. Fructose has been known the sweetest of all natural sugars and considered as the ideal dietary sugar (Aleid 2006).

*Single-cell protein (SCP):* SCP is produced from bacteria, yeasts, fungi, and algae using different substrates as sources of carbon and energy. Dates are a good potential substrate for SCP production. Their carbohydrate content amount to 65–87% dry matter and includes sucrose, glucose, and

fructose, which are readily metabolized by most microorganisms. SCP can be used in animal feed for cattle, sheep, fish, and poultry (Aleid 2006, Kwangnam 2003).

*Baker's yeast production:* Though molasses is the conventional substrate for the production of baker's yeast worldwide, dates can be a good potential substrate for this purpose since date syrup compares very well to molasses with respect to its nutritional content. Date syrup contains more sugars, biotin, and pantothenic acid than molasses, approximately similar amounts of nitrogen, phosphorus, and magnesium, and about half the content of potassium; this is sufficient for baker's yeast production (Aleid et al. 2009).

*Canned products:* Aljasass and Siddiq (2013) studied the feasibility of preparing a canned chickpea–date product. Date bits were added to chickpeas at 10%, 20%, and 30% replacement levels. Chickpeas with added dates had significantly higher amount total phenolics and antioxidant activity. Adding dates to canned chickpeas had significant effect on chickpea color, which became light-brown to dark-brown with increasing level of dates. The canned chickpeas–dates were also evaluated for sensory attributes of aroma, texture, appearance, color, and the overall acceptability as compared to the control. Canned chickpeas with 20% date bits had the highest mean scores for aroma, texture, appearance, color, and overall acceptability. The control without dates had the lowest scores for all sensory attributes.

*By-products:* Date pits (seeds) and press cake are the two major by-products of date fruit. Presently, date pits are used mainly for animal feeds for the cattle, sheep, camel and poultry industries. However, given their excellent nutritional profile, especially, high fiber content, value-added utilization of date seed powder has a potential for use in food applications as well (Amany et al. 2012). Cull dates are dehydrated, ground, and mixed with grain to form a very nutritious stock-feed and are fed to camels and horses in desert regions. The terminal buds of the date palm tree or hearts of palm make tasty additions to salads; whereas in some European countries, date palm groves are maintained exclusively for the supply of young leaves for religious use (Huntrods 2011).

## Food safety considerations

Dates are prone to contamination both in the preharvest and postharvest stages (Box 1.1). Therefore, safety of dates, just like other fruits and fruit products, begins with appropriate practices followed at farm level through processing. The conditions and environment at the farms and specifically the use of production inputs such as insecticides, pesticides, fertilizers, (chemical risk factors), sanitation, quality of water and workers' health (biological risk

**Box 1.1 Potential sources of fruit contamination****Preharvest**

- Soil
- Irrigation water
- Animal manure
- Inadequately composted manure
- Wild and domestic animals
- Inadequate field worker hygiene
- Harvesting equipment

**Postharvest**

- Transport containers (field to packing facility)
- Wash and rinse water
- Unsanitary handling during sorting and packaging
- Equipment used to soak, pack, or cut produce
- Ice, for cooling produce
- Cooling units (hydrocoolers)
- Transport vehicles
- Improper storage temperature
- Improper packaging
- Cross contamination in storage, display, and preparation

*Source:* Anon. (2013), Rangarajan et al. (2000).

factors), postharvest handling (precooling, use of sanitizers), storage (refrigeration and freezing facilities), and shipment practices, as these relate to good agricultural practices (GAPs; Table 1.4), are critical to ensure food safety. Similarly, at fruit processing plants safe and sanitary manufacturing and handling of food for human consumption require adherence to current good manufacturing practices (cGMPs) and good hygienic practices (GHPs), which are important foundations and prerequisites for process-specific, food safety control programs, such as hazard analysis and critical control points (HACCP).

Processed fruit products, an important food category in many countries, are globally traded and certain branded processed fruit products are considered premium because of their good quality and safety records. The manufactures of these products have adopted strong current cGMPs, prevention, quality control, certification and audit measures to ensure safe food quality. Table 1.5 lists the important aspects of cGMPs, as per USDA (2002). Adherence to GMP practices also minimizes the risk of adulteration and misbranding.

**Table 1.4** Important parameters for good agricultural practices (GAPs) to minimize microbial food safety hazards.

Parameters	Key consideration
1. Water quality	<ul style="list-style-type: none"> <li>• As water can be a potential carrier of microorganisms and pathogens, identify source and distribution of water to be used.</li> <li>• Regularly test and maintain a record of water quality.</li> <li>• The quality of water in direct contact with edible portion of produce should be of potable quality.</li> <li>• GAPs include protecting surface waters, wells, and pump areas from uncontrolled livestock or wildlife access to prevent fecal contamination, which can be sources of pathogens.</li> <li>• Use of polluted water should not be permitted.</li> </ul>
2. Worker health and hygiene	<ul style="list-style-type: none"> <li>• Infected and sick workers can contaminate fresh produce, water supply, and other workers and transmit foodborne illness.</li> <li>• Workers and other food handling employees should be trained in aspects of good hygienic practices, importance of sanitation, and proper hand washing technique.</li> </ul>
3. Sanitary facilities	<ul style="list-style-type: none"> <li>• It is important to maintain a clean and sanitary work place.</li> <li>• The toilet and wash room facilities, production, and other areas, should be provided with facilities such as tissue paper, soaps, etc., and be properly cleaned on a regular basis.</li> <li>• The sewage and waste should be properly disposed of.</li> </ul>
4. Field and packing house sanitation	<ul style="list-style-type: none"> <li>• Maintain sanitary clean facility including buildings, fixtures, other physical facilities, and equipment.</li> <li>• Prevent and control pest infestations.</li> </ul>
5. Manure and municipal biosolids	<ul style="list-style-type: none"> <li>• Manure and animal waste can be a potential source of contamination and should be disposed of carefully.</li> </ul>
6. Transportation	<ul style="list-style-type: none"> <li>• Microbial cross-contamination from other foods and nonfood sources and contaminated surfaces may occur during loading, unloading, storage, and transportation operations.</li> <li>• Keep transportation vehicle clean.</li> <li>• Maintain proper temperature.</li> </ul>
7. Traceback	<ul style="list-style-type: none"> <li>• Maintain records of dates of production, area of production, packing, etc. to be able to trace back each step in the supply chain.</li> </ul>

Source: Anon. (2013), Rangarajan et al. (2000).

## Nutritional and health considerations

### Nutritional profile

The proximate composition of fresh and dried dates is shown in Table 1.6. Date fruit is a rich source of carbohydrates, most of which are in the form of simple sugars. Sugar contents range from about 40% (fresh dates) to 80% (dried dates) and are mostly of inverted form (glucose and fructose). The ratio of glucose to fructose is almost equal. Depending on the variety, water content is between 7% and 79% for dry and fresh dates, respectively (Erskine

**Table 1.5** Important aspects for current good manufacturing practices (cGMPs).

Parameters	Key considerations
1. Building, water supply and sewage disposal	<ul style="list-style-type: none"> <li>• Building should be of adequate size, construction, and design.</li> <li>• Floors, walls, and ceilings are properly maintained for safe operation.</li> <li>• Lighting, ventilation, ducts and pipes are maintained and routinely replaced to minimize safety violations.</li> <li>• Water supply system, washing and toilet facilities, drainage and sewage disposal systems are well maintained to support quality.</li> </ul>
2. Equipment	<ul style="list-style-type: none"> <li>• Equipment used in processing should be of sanitary design and quality.</li> <li>• A proper record of plant clean-up procedure and its frequency should be maintained.</li> </ul>
3. Personnel	<ul style="list-style-type: none"> <li>• The employees should have proper training in jobs to be performed and follow safe handling of food protocols, wear appropriate clothing, hairnet, etc., and maintain good personal hygiene so as avoid any potential contamination of products.</li> </ul>
4. Incoming ingredients	<ul style="list-style-type: none"> <li>• Raw materials and ingredients used in the processing should be obtained from certified and approved vendors.</li> <li>• Raw materials should be maintained at proper storage conditions under sanitary conditions.</li> <li>• Raw materials not meeting quality standards should not be used.</li> </ul>
5. Production	<ul style="list-style-type: none"> <li>• Production should follow HACCP principles and standard operating procedures to minimize risk of contamination and quality defects.</li> </ul>
6. Quality control (QC)	<ul style="list-style-type: none"> <li>• Proper quality control (QC) testing set-up should be followed for incoming material and finished product to be able to issue a certificate of analysis (COA).</li> <li>• The QC should maintain proper records of quality procedures and data including certification, audits and compliance to customer complaints.</li> <li>• The QC should have proper protocols on recalls.</li> <li>• The QC should have retain samples and maintain a traceability program.</li> </ul>
7. Labeling	<ul style="list-style-type: none"> <li>• The products should have proper labels indicating date of manufacture, ingredients, nutritional information, storage requirements, etc.</li> </ul>

Source: Adapted from USDA (2002).

et al. 2011, USDA 2012). The sugar content of date fruit might vary significantly with respect to cultivar, soil, climatic conditions, field practices, and fruit maturity stage.

Dates are a rich source of dietary fiber (DF), however, there are wide variations in the DF content for dried dates reported in the literature (Lund et al. 1983, Spiller 1993). The wide difference in DF contents has been attributed partly to measurement techniques adopted. Al-Shahib and Marshall (2003)

**Table 1.6** Proximate analysis of fresh and dried date varieties (in %, energy in kcal/100 g).

	Average (Range) Values	
	Fresh dates	Dried dates
Moisture	42.4 (37.9–50.4)	15.2 (7.2–29.5)
Protein	1.5 (1.1–2.0)	2.14 (1.5–3.0)
Fat	0.14 (0.1–0.2)	0.38 (0.1–0.5)
Ash	1.16 (1.0–1.4)	1.67 (1.3–1.9)
Carbohydrates	54.9 (47.8–58.8)	80.6 (66.1–88.6)
Total sugars	43.4 (38.8–50.2)	64.1 (44.4–79.8)
Fructose	19.4 (13.6–24.1)	29.4 (14.1–36.8)
Glucose	22.8 (17.6–26.1)	30.4 (17.6–41.4)
Energy	213 (185–229)	314 (258–344)

Fresh varieties (10): Naghal, Khunaizy, Khalas, Barhi, Lulu, Fard, Khasab, Bushibal, Gash Gaafar, Gash Habash.

Dried varieties (16): All of the above plus Deglet Nour, Medjool, Hallawi, Sayer, Khadrawi, Zahidi.

Source: Adapted from Al-Farsi and Lee (2008).

estimated DF for nine varieties of dried dates from Saudi Arabia, Egypt, Iraq, and Iran and observed that the overall mean DF content of the dates was 10.2%. Elleuch et al. (2008) extracted date fiber concentrate (DFC) from the flesh of two low-grade dates (Deglet Nour and Allig); the initial DF contents were 14.4% and 18.4%, respectively, from these two date cultivars. The DF concentrates showed high water-holding capacity (15.5 g water/g sample) and oil-holding capacity (9.7 g oil/g sample). Date fiber can be an excellent source of DF that can be used as an ingredient for the food industry with good functional properties.

Dates contain high levels of protein compared to most other fruits. The highest content is observed during *Kimri* stage (5.5–6.4%), which gradually decreases to 2–2.5% during the *Tamar* stage (Al-Hooti et al. 1997). Amino acid analysis revealed that dates, irrespective of their cultivars, contained all the essential amino acids. Date proteins were found to be rich in acidic amino acids and poor in sulfur-containing amino acids such as methionine and cysteine. Glutamic, aspartic, lysine, leucine, and glycine were the predominant amino acids in fresh dates, whereas glutamic, aspartic, glycine, proline, and leucine were the predominant amino acids in dried dates (Al-Farsi and Lee 2008).

Dates contain a number of essential minerals in variable concentrations. A consumption of 100 g of dates provides over 15% of the daily Recommended Dietary Allowance (RDA) to Adequate Intakes (AI) of selenium, copper, potassium, and magnesium (Al-Farsi and Lee 2008). Moderate concentrations of manganese, iron, phosphorus, and calcium, per 100 g of dates, provide over 7% of the daily RDA/AI. The pulps are rich in iron, calcium, cobalt, copper, fluorine, magnesium, manganese, potassium, phosphorus,

sodium, copper, sulfur, boron, selenium, and zinc (Al-Farsi and Lee 2008; Ali-Mohamed and Khamis 2004). Dates have 2.5-times more potassium than bananas (Anon. 2002); in many date varieties, potassium can be found at a concentration as high as 0.9% in the flesh while it is as high as 0.5% in some pits/seeds.

In general, dates are low in vitamin content, however, they are rich in vitamin B complex, such as thiamine (B<sub>1</sub>), riboflavin (B<sub>2</sub>), niacin (B<sub>3</sub>), pantothenic acid (B<sub>5</sub>), pyridoxine (B<sub>6</sub>), and folate (B<sub>9</sub>), and vitamin K (Al-Farsi and Lee 2008). It is worth mentioning that some vitamins (B<sub>3</sub>, B<sub>5</sub>, B<sub>6</sub>, and B<sub>9</sub>) are found in higher concentration in date than other conventional fruits like apples, oranges, and berries. Vitamin C content is found to be very low in dates, however, it is still higher than in plums, apricots, figs, and raisins.

For expanding the use of nutrients rich date fruit and its products (syrup, paste), research in the field of date industry (production, processing, marketing) should focus on innovative products such as antioxidants, dried date bits that can be used in breakfast cereals, baked products, salads, or nutritionally fortified foods and supplements. In addition to developing value-added products from dates, research should focus on packaging and shelf life studies to fully realize the economic potential of this nutrient-rich fruit.

## Bioactive compounds and health significance

Besides being a rich source of carbohydrates, dietary fibers, some essential vitamins, and minerals, dates are also rich in a variety of phytochemicals, such as phenolics, sterols, carotenoids, anthocyanins, procyanidins, and flavonoids (Baliga et al. 2011). Even date pits are an excellent source of fiber, minerals, lipids, and protein. In addition to their pharmacological properties, phytochemicals also contribute to nutritional and sensorial properties of dates (Baliga et al. 2011). In date-producing countries, this fruit has been used for centuries to treat a variety of ailments in the various traditional systems of medicine. In recent years, research to assess the health benefits of dates has interfiled and a number of studies have reviewed and reported on the positive contribution dates to human diet (Al-Farsi and Lee 2008, Baliga et al. 2011, Vayalil 2002, Vayalil 2012).

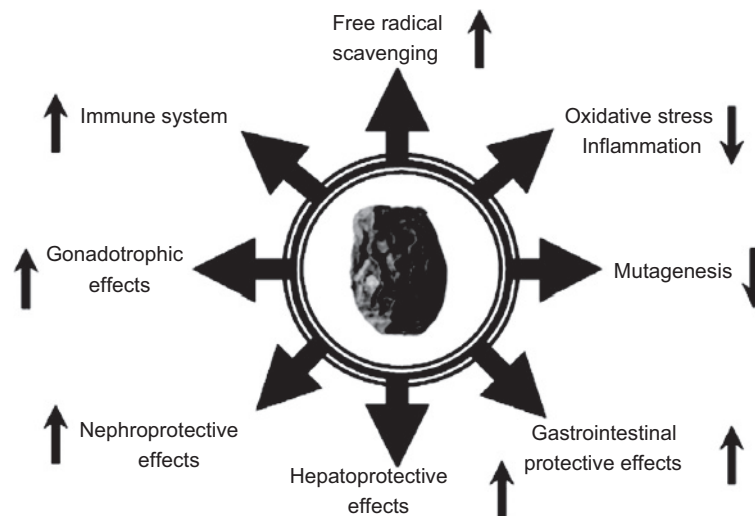
Ali et al. (2012) reported that consuming dates is believed to have many medicinal properties and relief against a number of ailments and pains including fever, stomach disorders, memory disturbances, nervous disorders, as well as being an aphrodisiac and boosting immunity. They are also considered to potentially protect against many chronic diseases including cancer and heart diseases. Dates, due to their high potassium and low sodium contents, can also help minimize potassium deficiency and maintain optimum sodium–potassium balance in the body. Further, dates may help in treating the cardiac disorder especially after diarrhea, vomiting or after the use of diuretic medications (Ali et al. 2012).

Baliga et al. (2011), in a review of date fruit properties, listed the following pharmacological properties based on *in vitro* studies:

- *Antioxidant activity* – scavenges free radical, inhibit iron-induced lipid peroxidation and protein oxidation
- *Antimutagenic activity* – inhibits benzo(a)pyrene-induced mutagenicity in the Ames test
- *Antihemolytic activity* – inhibits hemolytic activity of streptolysin-O
- *Antiviral activity* – prevents lytic activity of *Pseudomonas* phage ATCC 14209-B1 on *Pseudomonas aeruginosa*
- *Antifungal activity* – activity against *Candida albicans* and *C. krusei*.

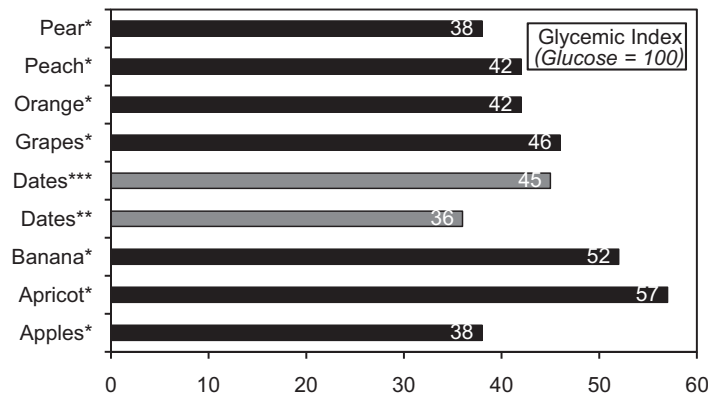
Figure 1.6 shows a complete list of date fruit's pharmacological activities.

Wu et al. (2004) analyzed common foods consumed in the US for antioxidant capacity, measured as trolox equivalent (TE) oxygen radical absorbance capacity or ORAC. Medjool and Deglet Nour dates were shown to have 23.87 and 38.95  $\mu\text{mol TE/g}$  total antioxidant capacity (TAC). The TAC reported for some other fruits were ( $\mu\text{mol TE/g}$ ): apples (22.21–42.2), blackberries (53.48), blueberries (62.2–92.6), grapes (11.2–12.6), and Navel oranges (18.14). Generally, dates are not known as a high antioxidant food (e.g., blueberries) but compared reasonably well with some other fruits.



**Figure 1.6** Pharmacological activities of date fruit (arrow up = increase, arrow down = decrease). Source: Baliga et al. (2011). Reproduced with permission from Elsevier.





**Figure 1.7** Glycemic index (GI) of dates compared to some common fruits on typical per serving basis (\*raw, mean value; \*\*Khalas, sun-dried, vacuum-packed; \*\*\*Khalas, traditionally-dried). Source: Denyer and Dickenson (2005), Foster-Powell et al. (2002), Krinsky (1993), Vayalil (2012).

Although dates are high in sugars, their glycemic index (GI), on per serving basis, is lower than some commonly consumed fruits (Figure 1.7). Dates have about 41 g available carbohydrates per serving as compared to an average of 9 to 19 g in other fruits listed in Figure 1.7, ranging from lower amounts in apricots to higher amounts in bananas. The GI measures the extent to which foods increase blood glucose over a period of 2 hours after consumption compared to eating an equivalent amount of carbohydrate, usually from glucose (Jenkins et al. 2002).

## Summary

Dates are an important fruit, especially in many African, Middle-Eastern, and Asian countries. In recent years, this fruit has gained significant importance in global commerce. During the last two decades, world production of dates saw an increase of 120%, to 7.51 million metric tons in 2011. This trend is expected to continue as per FAO projections. The majority of date palm-growing areas are located in developing or underdeveloped countries where date fruit is considered the primary food crop, thus playing a major role in the nutritional status of these communities. Marketing of dates involves various operations through the value-chain: e.g., harvesting, cleaning, grading, packaging, processing, and transportation/shipment to local or export markets. Among date-producing countries, the state of marketing channels varies widely. The quality profile of dates in the marketplace is done by evaluating four sets of attributes: (a) color, shape, size, taste, texture, pit/flesh ratio, and uniformity in color and size of the fruit; (b) moisture, sugar, and fiber content; (c) defects of the fruits, which may include discoloration, broken skin, sunburn, blemishes, shrivel deformity, etc.; and (d) insect infestation, foreign matter, pesticide residues, mold, and decay. Collectively, these evaluations form the basis of chemical, physical, and sensory quality. Some of the major

challenges confronting date fruit production and commerce are issues related to postharvest handling technologies, use of appropriate processing and packaging technologies, food safety aspects and quality assurance. This chapter provided an overview of production, harvesting and GAPs, GMPs, postharvest handling and storage, processing, processed products/by-products, nutritional profile and health benefits, and bioactive and phytochemical compounds in dates.

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