Date Fruit Composition and Nutrition

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Date Fruit Composition and Nutrition

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Introduction

Palm date (*Phoenix dactylifera* L.) is an important fruit in Middle Eastern countries and it is one of the oldest fruit trees in the world (Marzouk and Kassem 2011). Dates are of religious importance for Muslims throughout the world and it is mentioned in many places in the Holy Quran. Dates have been traditionally used to break the fast during the holy month of Ramadan

Dates: Postharvest Science, Processing Technology and Health Benefits, First Edition.
Edited by Muhammad Siddiq, Salah M. Aleid and Adel A. Kader.

Table 11.1 Proximate analysis of fresh and dried dates (from 10 fresh and 16 dried varieties).

	Fresh dates		Dried dates	
	Range	Average	Range	Average
Moisture (g/100g)	37.9–50.4	42.4	7.2–29.5	15.2
Protein (g/100g)	1.1–2.0	1.5	1.5–3.0	2.14
Fat (g/100g)	0.1–0.2	0.14	0.1–0.5	0.38
Ash (g/100g)	1.0–1.4	1.16	1.3–1.9	1.67
Carbohydrates (g/100g)	47.8–58.8	54.9	66.1–88.6	80.6
Total sugars (g/100g)	38.8–50.2	43.4	44.4–79.8	64.1
Fructose (g/100g)	13.6–24.1	19.4	14.1–36.8	29.4
Glucose (g/100g)	17.6–26.1	22.8	17.6–41.4	30.4
Energy (kcal/100g)	185–229	213	258–344	314

Fresh varieties: Naghal, Khunaizy, Khalas, Barhi, Lulu, Fard, Khasab, Bushibal, Gash Gaafar, Gash Habash.
Dried varieties: All of the above plus Deglet Nour, Medjhool, Hallawi, Sayer, Khadrawi, Zahidi.
Source: Adapted from Al-Farsi and Lee (2008a).

(Al-Shahib and Marshall 2003, Al-Farsi and Lee 2008a). The earliest examples of the use of date palm in the Middle East come from two sites (the island of Dalma, United Arab Emirates and Sabiyah in Kuwait) as evidenced by carbonized date seeds and stones (Beech 2003, Tengberg 2012). The fruit is composed of a seed and fleshy pericarp which constitutes between 85% and 90% of date fruit weight (Hussein and Alhadrami 1998).

Dates are rich in sugar, protein, dietary fiber, minerals, and some vitamins. Table 11.1 shows average proximate composition of 10 fresh and 16 dried date varieties. A high percentage of sugar in the dates fruit provide a good source of rapid energy (Al-Shahib and Marshall 2003). Recent studies have indicated that date fruit contains significant amount of flavonoid glycosides including quercetin, apigenin, *p*-coumaric acid, ferulic acid, and sinapic acids (Hong et al. 2006, Abdelhak et al. 2005, Biglari et al. 2008). Flavonoid glycosides are a group of chemical compounds found in many commonly eaten foods. They have beneficial effects on human health include antioxidants, strengthening of the immune system, protection against cancer and cell damage, and a reduction in capillary fragility (Biglari et al. 2008). Overall, the nutritional profile of dates compares very well with other popular dried fruits. Figure 11.1 shows moisture, carbohydrates, fiber and vitamin C content of dates along with some common dried fruits.

Consumers are increasingly looking for foods with health benefits which eventually change the diet patterns. High-fiber diets are in great demand in the market, which are associated with the prevention and treatment of some diseases such as coronary heart-related diseases, diabetes, constipation, diverticular disease, colonic cancer etc. (Brighenti 1999, Cassidy et al. 1994). Furthermore, the most common form of fiber is insoluble fiber (cellulose, lignin, and some hemicelluloses), which reduces constipation and is being studied for its potential to reduce the risk of colon/rectal cancer (Peressini and Sensidoni 2009). Cereal grains, fruits and vegetables are major source of dietary fiber; fibers obtained from different sources have some advantages

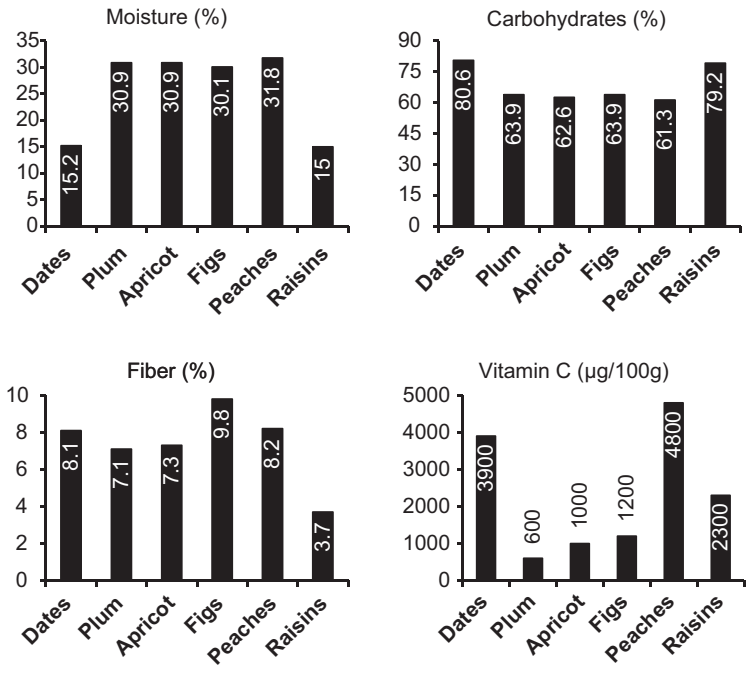

Figure 11.1 Moisture, carbohydrates, fiber, and vitamin-C content of dates and other common dry fruits. *Source:* Adapted from Al-Farsi and Lee (2008a).

over others, and the list of dietary fibers is growing continuously. Date fiber is also an addition to the list since it has also some advantages in functional properties and health benefits.

This chapter provides a review of date fruit composition, with special emphasis on varietal differences and changes at various stages of maturity, phytochemicals profile, antioxidant properties, medicinal uses of dates, and date-based functional foods.

Production, losses, and value-addition

The annual world date production in 2011 was 7.5 million metric tons, with an average yield of 6.5 tons/ ha (FAOSTAT 2012). The Arabian Peninsula produces about 30% of the global date production with an estimated area of 33% of global world acreage occupied by date palm. However, a significant portion of dates is wasted in date-producing countries (loss is about 30% of total production in Tunisia) due to their inferior quality, damage, and undersized fruit of unattractive appearance (Besbes et al. 2009). It is further reported that dates are also wasted during the sorting, the storage and the conditioning (Cheikh-Rouhou et al. 1994). The non-use of this by-product for human food constitutes a real economic loss since it is rich in bioactive compounds and dietary fiber, which can be extracted and used as value-added ingredients (Elleuch et al. 2008). Attempts should be made to process these

unutilized portions into value-added products to increase economic feasibility of date industry and processors. Converting unutilized or lower grade dates into date fiber and biomass production (e.g., yeast) on a commercial basis could be a sustainable solution for solid waste utilization. Researchers 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/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 nutrient-rich date fruit.

Date fruit composition

Carbohydrate and sugar profile

Palm date is a rich source of carbohydrates, most of which is in the form of simple sugars. According to the USDA National Nutrient Database, a 100 g serving of dates provides almost 75 g of carbohydrates, which accounts for 18% of the daily value for carbohydrates. About 85% of total carbohydrate in dates is present in the form of simple sugars. The sugar content of date fruit of a particular variety might vary significantly with cultivar, soil, climatic conditions, and fruit maturity stage. The date sugars contain glucose, fructose, and sucrose, although the presence of sucrose is minimal or negligible for most of the date varieties, and the ratio of glucose to fructose is almost equal.

Considering the importance of the date fruit, several studies have been carried out on the characterization of its chemical composition at different stages of maturation. Dates ripen in four stages: *Kimri* (the immature green), *Khalal* (the mature full-colored, crunchy), *Rutab* (ripe, soft), and *Tamar* (relatively hard and ripe, reduced moisture). Ahmed et al. (1995a) analyzed date fruits from 12 varieties from the United Arab Emirates and observed that glucose and fructose increase gradually with four distinct stages of ripening from *Kimri* through *Khalal* and *Rutab* to *Tamar*.

A change in sugar profile of dates at various stages of maturation is shown in Table 11.2, which clearly indicates that the fruit becomes sugar rich after the *Khalal* stage. Al-Noimi and Al-Amir (1980) reported that in the *Tamar* stage the fruit shows a sharp increase in sucrose content and dramatic drop in moisture content. Also, sucrose content exceeds glucose and fructose content in the first growth stages, and thereafter sucrose starts to convert into monosaccharides until sucrose content is less than 5% in the *Tamar* stage. Figure 11.2 shows the general proportion of sugars during the various stages of date fruit growth and maturity. It is to be noted that the sugars conversion rate depends on temperature and relative humidity of storage environment in addition to the physiological activities of the fruit. Date pulps contain easily digestible sugars (70%), mainly glucose, fructose, and sucrose; dietary fibers and contain less proteins and fats (Al-Farsi and Lee 2008a).

Table 11.2 Sugar content of selected commercial varieties of dates at different stages of ripening (g/100 g fresh weight[a]).

Variety	Ripening stage	Total sugars	Glucose (G)	Fructose (F)	Sucrose	G/F Ratio
Naghal	*Kimri*	5.1	3.2	1.9	0	1.7
	Khalal	30.6	16.1	14.5	0	1.1
	Rutab	44.2	23.4	20.8	0	1.1
	Tamar	44.3	23.2	21.2	0	1.1
Buchibal	*Kimri*	5.1	3.2	2	0	1.6
	Khalal	18.7	8.1	6.3	4.3	1.3
	Rutab	49	25.5	23.3	0.1	1.1
	Tamar	55.1	27.6	27.6	0	1
Khunaizy	*Kimri*	6.4	4	2.4	0	1.7
	Khalal	23.4	12.4	11	0	1.1
	Rutab	46.3	24.7	21.5	0.1	1.2
	Tamar	53.9	28.5	25.4	0	1.1
Khulas	*Kimri*	7	4.5	2.5	0	1.8
	Khalal	31.9	16.9	15	0	1.1
	Rutab	46.1	24.5	21.7	0	1.2
	Tamar	57	30.5	26.5	0	1.1
Gurh Rabei	*Kimri*	5.3	3.4	1.9	0	1.8
	Khalal	24.9	13.2	11.7	0	1.1
	Rutab	48.1	25.5	22.7	0	1.1
	Tamar	49.9	26.1	23.7	0	1.1
Hilali Ahmr	*Kimri*	3.4	2.2	1.1	0	1.9
	Khalal	23	8.5	7.7	6.8	1.1
	Rutab	43.6	23.3	20.6	0	1.1
	Tamar	64.1	32.5	31.5	0	1
Barhi	*Kimri*	7.7	4.9	2.8	0	1.6
	Khalal	31.1	13.1	11.8	6.2	1.1
	Rutab	40.8	21.4	19.4	0	1.1
	Tamar	57.2	29.7	27.6	0	1.1
Lula	*Kimri*	7.6	4.8	2.9	0	1.7
	Khalal	29.7	15.6	14.1	0	1.1
	Rutab	43.9	22	21.9	0	1
	Tamar	57.7	30.5	27.1	0	1.1
Fard	*Kimri*	5.6	3.5	2.1	0	1.6
	Khalal	27.1	14.6	12.6	0	1.1
	Rutab	50.1	26.1	24.1	0	1.1
	Tamar	59.5	29.8	29.8	0	1
Naghal Hilali	*Kimri*	6.8	4.1	2.6	0.1	1.7
	Khalal	31.8	16.5	15.1	0	1.1
	Rutab	44.8	23.7	21.9	0	1.1
	Tamar	52.7	29.1	23.6	0	1.2
Khasab[b]	*Kimri*	7.6	5	2.6	0	1.9
	Khalal	22.9	12.6	10.3	0	1.2
	Rutab	41.7	21.9	19.8	0	1.1
Hilali Pakistan	*Kimri*	6.6	2.2	2.5	0	2.2
	Khalal	23.8	8.5	10.8	0	1.1
	Rutab	44.1	23.3	21	0	1.1
	Tamar	51.4	32.5	23.7	0	1.2

[a]Mean of three replicates of fruits of two consecutive seasons; [b]does not produce *Tamar* stage.
Source: Ahmed et al. (1995). Reproduced with permission from Elsevier.

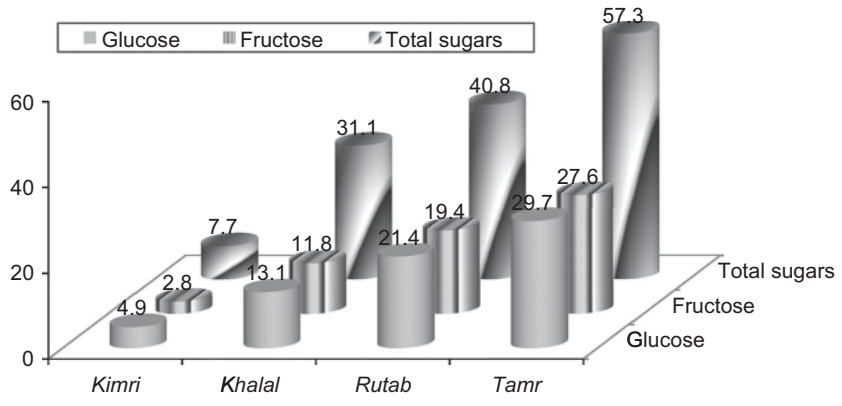

Figure 11.2 Sugar profile (%) of dates at various stages of maturity.

Proteins and amino acids

Dates contain high levels of protein compared to most other fruits. The highest content is observed during *Kimri* phase (5.5–6.4%), which gradually decreases to 2–2.5% during the *Tamar* stage (Al-Hooti et al. 1997). The flesh of date also contains 0.2–0.5% oil, while the seeds contain 7.7–9.7% oil. Table 11.3 shows the protein in dates during the *Khalal, Rutab*, and *Tamar* stages. The nutritional profile of US-grown Medjhool and Deglet Nour dates is presented in Table 11.4.

Ahmed et al. (1995b) isolated proteins from various date cultivars from different countries (Oman, Saudi Arabia, Iran, and USA) by phosphate-buffered saline (PBS) extraction and those proteins were analyzed by sodium dodecyl sulfate–polyacrylamide gel electrophoresis (SDS-PAGE). Dates contained a number of proteins with molecular weights ranging from 12,000 to 72,000 Dalton; however, most date cultivars contained two prominent bands appearing at 30,000 and 72,000 Dalton. Sequential extraction of date pulps showed that most date proteins were water-soluble albumins. At the early stage, green dates contained very little protein which increased rapidly at later stages in maturation. Dates from Saudi Arabia, Oman, and Iran were similar in their protein profiles since they contained similar complex mixtures of proteins in the molecular weight range of 12,000–72,000 Dalton. A date variety from the USA contained very little protein with a simple protein profile containing one major band appearing at 30,000 Dalton.

The amino acid profile of fresh and dried dates are shown in Table 11.5. Amino acid analysis revealed that dates, irrespective of cultivar 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. Within the same stage of maturation, the amino acid content varies significantly. Amino acids content increased in dried varieties mainly due to water reduction (Auda et al. 1976). Glutamic, aspartic, lysine, leucine, and glycine were the predominant amino acids in fresh dates, whereas glutamic,

Table 11.3 Proximate composition of selected commercial varieties of dates at different stages of ripening (g/100 g fresh weight[a]).

Variety	Ripening stage	Moisture	Protein (crude)	Lipid	Ash
Naghal	*Kimri*	80.1	1.1	0.1	0.8
	Khalal	54.5	1.6	0.1	1.0
	Rutab	44.1	2.0	0.2	1.2
	Tamar	9.2	2.7	0.2	1.9
Buchibal	*Kimri*	83.7	1.0	0.1	0.7
	Khalal	76.5	0.9	0.1	0.5
	Rutab	35.9	2.1	0.1	1.1
	Tamar	18.0	2.2	0.2	1.5
Khunaizy	*Kimri*	84.2	1.1	0.1	0.7
	Khalal	66.5	1.1	0.1	0.8
	Rutab	37.9	1.9	0.1	1.2
	Tamar	25.1	3.0	0.1	1.4
Khulas	*Kimri*	83.7	0.8	0.1	0.7
	Khalal	58.9	1.1	0.1	0.9
	Rutab	41.3	1.1	0.1	1.0
	Tamar	22.3	2.1	0.1	1.4
Gurh Rabei	*Kimri*	85.1	0.7	0.1	0.6
	Khalal	64.1	1.0	0.1	1.0
	Rutab	44.7	1.4	0.1	1.1
	Tamar	25.5	2.0	0.2	1.6
Hilali Ahmr	*Kimri*	84.6	0.9	0.1	0.7
	Khalal	74.0	0.9	0.1	0.6
	Rutab	45.8	1.5	0.1	1.0
	Tamar	31.1	2.2	0.1	1.6
Barhi	*Kimri*	83.2	1.1	0.1	0.8
	Khalal	62.6	1.4	0.1	0.9
	Rutab	39.7	1.8	0.2	1.1
	Tamar	29.5	2.3	0.1	1.5
Lula	*Kimri*	81.7	1.3	0.1	0.8
	Khalal	62.2	1.1	0.1	0.7
	Rutab	45.2	1.6	0.2	1.0
	Tamar	21.3	2.4	0.2	1.3
Fard	*Kimri*	82.7	0.9	0.1	0.8
	Khalal	72.1	1.0	0.1	1.0
	Rutab	37.6	1.5	0.2	1.3
	Tamar	27.7	2.1	0.1	1.8
Naghal Hilali	*Kimri*	85.5	0.8	0.1	0.6
	Khalal	57.0	1.3	0.1	1.0
	Rutab	48.9	1.2	0.1	0.8
	Tamar	32.1	1.9	0.1	1.3
Khasab[b]	*Kimri*	84.6	0.8	0.1	0.6
	Khalal	72.6	1.0	0.1	0.8
	Rutab	50.4	1.1	0.1	1.0
Hilali Pakistan	*Kimri*	84.2	1.0	0.1	0.6
	Khalal	70.5	0.9	0.1	0.6
	Rutab	44.2	1.4	0.1	1.1
	Tamar	nr[c]	nr	nr	nr

[a]Mean of three replicates of fruits of two consecutive seasons; [b]does not produce *Tamar* stage; [c]not reported

Source: Ahmed et al. (1995). Reproduced with permission from Elsevier.

Table 11.4 Nutritional profile of US grown Medjhool and Deglet Nour dates.

		Medjhool		Deglet Nour		
Components	Units	Raw/ 100 g	Pitted/ 24 g	Raw/ 100 g	Cup, chopped/ 147 g	Pitted/ 7.1 g
Proximate:						
Water	g	21.32	5.12	20.53	30.18	1.46
Energy	kcal	277	66	282	415	20
Protein	g	1.81	0.43	2.45	3.6	0.17
Total lipid (fat)	g	0.15	0.04	0.39	0.57	0.03
Carbohydrate, by difference	g	74.97	17.99	75.03	110.29	5.33
Fiber, total dietary	g	6.7	1.6	8	11.8	0.6
Sugars, total	g	66.47	15.95	63.35	93.12	4.5
Minerals:						
Calcium	mg	64	15	39	57	3
Iron	mg	0.9	0.22	1.02	1.5	0.07
Magnesium	mg	54	13	43	63	3
Phosphorus	mg	62	15	62	91	4
Potassium	mg	696	167	656	964	47
Sodium	mg	1	0	2	3	0
Zinc	mg	0.44	0.11	0.29	0.43	0.02
Vitamins:						
Vitamin C, total ascorbic acid	mg	0	0	0.4	0.6	0
Thiamin	mg	0.05	0.012	0.052	0.076	0.004
Riboflavin	mg	0.06	0.014	0.066	0.097	0.005
Niacin	mg	1.61	0.386	1.274	1.873	0.09
Vitamin B6	mg	0.249	0.06	0.165	0.243	0.012
Folate, DFE	μg	15	4	19	28	1
Vitamin A	IU	149	36	10	15	1
Vitamin K (phylloquinone)	μg	2.7	0.6	2.7	4	0.2

Source: USDA (2012).

Table 11.5 Range of amino acids in fresh and dried dates.

Amino acid	Content (mg/100g)
Alanine	30–133
Arginine	34–148
Aspartic acid	59–309
Cysteine	13–67
Glutamic acid	100–382
Glycine	42–268
Histidine	0.1–46
Isoleucine	4–55
Leucine	41–242
Lysine	42–154
Methionine	4–62
Phenylalanine	25–67
Proline	36–148
Serine	29–128
Threonine	23–95
Tryptophan	7-92
Tyrosine	15–156

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

aspartic, glycine, proline, and leucine were the predominant amino acids in dried dates (Al-Farsi and Lee 2008a).

Dietary fiber

Fiber or dietary fiber (DF) or crude fiber is the solid insoluble part of date flesh, mainly composed of cellulose, hemicellulose, lignin, and insoluble proteins. In addition to these, it may be associated with other non-carbohydrate components like polyphenols, waxes, saponins, cutin, phytates, and resistant protein. In the early stage of the date fruit, the fiber content is very high. However, during the ripening process, cellulase and pectinase enzymes present in the fruit break down insoluble polymers to smaller soluble molecules (Shafiei et al. 2010). El-Zoghbi (1994) reported that the DF content of dates decreases from 13.7% in the first stage of ripening to 3.6% in the fourth stage, the dried dates. Furthermore, the pectin, hemicellulose, cellulose and lignin contents decrease as the dates ripen.

There are wide variations in the DF content for dried dates reported in the literature, ranging from 4% to 8% (Spiller 1993, Al-Showiman 1998, Lund et al. 1983). The wide difference in DF contents has been attributed partly to analytical techniques adopted. In the *Handbook of Dietary Fiber in Human Nutrition* (Spiller 1993), the DF was reported as being 4.4% (3.2% insoluble bran and 1.2% soluble fiber) whereas Holland et al. (1991) reported the DF content of dried dates as 6.5% by the Southgate method and 3.4% by the Englyst method. Lund et al. (1983) claimed that the fiber content of dates, measured by an enzymatic method, was 6.9% (insoluble) and 2.3% (soluble). These studies clearly indicate that the DF value has to be mentioned along with these method used for its determination. Al-Shahib and Marshall (2002) estimated DF for nine varieties of dried dates from various countries (Saudi Arabia, Egypt, Iraq, Iran) and observed that the overall mean DF content of the dates was 10.2% (w/w). Conversion of these values to an 'as is' basis indicated that the dates contained from 6.4 to 11.4% DF. These results depend not only on the method used for analysis but also on the variety of dates, the stage of ripening and how dry they were.

Elleuch et al. (2008) extracted date fiber concentrate from two second grade (low in commercial value) dates flesh (cv. Deglet Nour and Allig). The initial DF contents were 14.4% and 18.4% for Deglet Nour and Allig, respectively. The elaboration of DF concentrates from date flesh was characterized by an extraction yield of 67%. The chemical composition of these DF concentrates showed high total DF contents (between 88% and 92.4% DM) and low protein and ash contents (8.98–9.12% and 2.0–2.1% DM, respectively). The DF concentrates showed a high water-holding capacity (15.5 g water/g sample) and oil-holding capacity (9.7 g oil/g sample) and pseudoplasticity behavior of their suspensions. Thus, date DF concentrates may not only be an excellent source of DF but also an ingredient for the food industry with good functional properties.

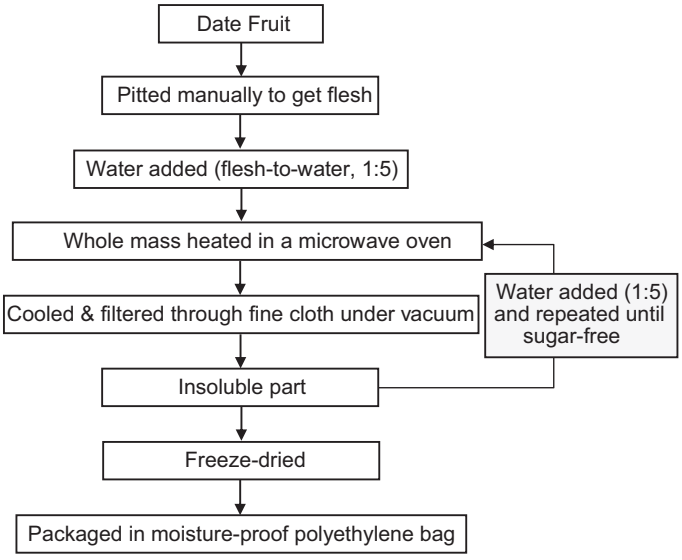

Figure 11.3 Insoluble date fiber extraction flow diagram.

Ahmed et al. (2013) used multistage water extraction of date flesh using microwave (MW) heating followed by freeze-drying, and grinding to obtain insoluble fiber (Figure 11.3). High-performance liquid chromatography (HPLC) analysis was used to confirm the complete removal of sugar. After the sixth extraction, the sample became sugar-free and the fiber yield was about 6% on dry basis. The particle size of the fiber was measured by dynamic light scattering, and the particle diameters ranged between 700 and 1000 nm. Mineral analysis confirmed that date fiber was rich in potassium, calcium, and magnesium (1.5–2.4 g/kg) and low in sodium. Date fiber showed high water and oil holding capacities. Fiber slurry (20% w/w) behaved as a viscoelastic fluid with predominating solid-like property. There were significant differences in tristimulus color values, mineral contents, water- and oil-holding capacities among date cultivars.

Al-Farsi and Lee (2008b) optimized process parameters (temperature, extraction time, solvent type, and solvent-to-sample ratio) for extraction of dietary fiber from date seeds. A two-stage extraction, each stage 1 hour duration at 45 °C with a solvent-to-sample ratio of 60:1, was considered optimum. Acetone (50%) and butanone were the most efficient solvents for extraction and purification, increasing the yield. The total dietary fiber of seeds (57.87 g/100 g) increased after water and acetone extractions to 83.50 and 82.17 g/100 g, respectively.

For the recommended daily intake of 25 g of total dietary fiber (Marlett et al. 2002), dates could be a good source of dietary fiber in the diet, as 100 g of dates provide 32% of the recommended daily intake of dietary fiber. The high content of the insoluble fiber induces satiety, and has a laxative effect

due to increased stool volume. It therefore may reduce the risk of serious conditions such as colon cancer and diverticular disease (Marlett et al. 2002).

Vitamins

Date pulp contains vitamins such as riboflavin, thiamine, biotin, folic acid, and ascorbic acid that are essential for the body. Dates are rich in B-complex vitamins, such as thiamine (B_1), riboflavin (B_2), niacin (B_3), pantothenic acid (B_5), pyridoxine (B_6), and folate (B_9) and vitamin K (Al-Farsi and Lee 2008a). It is worth mentioning that some vitamins (B_3, B_5, B_6, and B_9) are found in higher concentrations in dates than some common fruits like apple, orange, and berries. The niacin content is very high and it varies between 1.27 and 1.61 mg/100 g. Quantitative analysis of water-soluble vitamins (B_1, B_2, B_3, B_5, B_6, B_9, B_{12}) showed a significant variation within the different cultivars and the developing stages of date fruit (Aslam et al. 2011). Vitamins B_1, B_3, B_5, B_6 are highest in mature stages; however, vitamins B_2, B_9, B_{12} have been detected in immature fruit. Vitamin C content is found to be very low in dates, however, it is still higher than plums, apricots, figs, and raisins (Figure 11.1).

Minerals

Mineral profiles of different varieties of dates at various stages of maturation is shown in Table 11.6. Dates contain essential minerals, for example, potassium, which is essential for muscle contractions and helps to control heart rate and blood pressure (Al-Shahib and Marshall 2002). One hundred grams of date contains 696 mg of potassium, 90 mg of iron, 362 μg of copper, and 90 mg of magnesium, which are essential for bone growth. Also, copper is needed for the production of red blood cells. The significantly high potassium and low sodium contents in dates are optimum for people suffering from hypertension (Appel et al. 1997). In comparison with other dried fruits (as per USDA National nutrient database), 100 g dates contain on average of 0.8 μg selenium, 0.3 μg copper, 864 mg potassium, and 43 mg magnesium (USDA 2007). It is noted that the data reported by USDA is for fruit grown in the US, hence variations are expected for fruit grown in other countries. Moreover, often times, variations in data reported are due to varietal and maturity differences. Nonetheless, dates are regarded as a good source of these minerals. A 100-g consumption 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 2008a); 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 2008a, Ali-Mohamed and Khamis 2004). In many date varieties, potassium

Table 11.6 Trace metal content of selected varieties of dates at different stages of ripening (mg/100 g dry weight[a]).

Variety	Ripening Stage	Ca	Fe	Mg	K	Na	Cu	Mn	Zn
Naghal	*Kimri*	70	1.1	114	1,082	87	0.5	1.1	2.7
	Khalal	23	1.5	83	872	95	0.5	0.6	0.2
	Rutab	14	0.7	60	806	302	0.3	0.7	0.3
	Tamar	15	0.5	47	788	287	0.2	0.5	0.2
Buchibal	*Kimri*	47	1.9	149	1,037	28	0.4	0.8	0.7
	Khalal	20	0.8	61	658	183	0.3	1.2	0.6
	Rutab	13	1.2	57	696	130	0.3	0.3	0.3
	Tamar	19	1.2	57	700	153	0.4	0.5	0.2
Khunaizy	*Kimri*	86	1.3	190	986	109	0.9	1.1	0.9
	Khalal	17	1.2	88	926	133	0.3	0.6	0.3
	Rutab	8.2	1.1	78	752	200	0.3	0.5	0.2
	Tamar	15	1.5	59	704	197	0.1	0.4	0.2
Khulas	*Kimri*	101	2.2	151	1,101	52	0.6	0.7	0.5
	Khalal	60	1.6	89	789	83	0.4	0.4	0.3
	Rutab	18	1.4	62	588	212	0.4	0.3	0.3
	Tamar	16	1.7	62	630	82	0.4	0.3	0.3
Gurh Rabie	*Kimri*	86	1.4	112	1,041	28	0.5	0.8	0.8
	Khalal	15	1.0	81	841	65	0.3	1.3	0.8
	Rutab	15	1.4	71	809	140	0.5	0.5	0.5
	Tamar	15	1.2	64	797	104	0.5	0.6	0.3
Hilali Ahmr	*Kimri*	54	1.4	103	1,201	99	0.5	0.6	0.6
	Khalal	15	1.1	58	849	94	0.3	0.6	0.5
	Rutab	13	1.5	47	702	142	0.1	1.1	0.2
	Tamar	10	1.1	50	916	113	0.3	0.3	0.1
Barhi	*Kimri*	88	1.1	209	1,163	29	0.4	1.7	0.8
	Khalal	10	0.9	45	796	204	0.2	1	0.4
	Rutab	12	1.4	89	799	209	0.3	0.3	0.2
	Tamar	12	0.3	82	855	75	0.2	0.5	0.1
Lula	*Kimri*	48	1.8	144	1,070	28	0.6	1.1	—
	Khalal	9.7	1.1	88	498	62	0.6	1.1	0.4
	Rutab	8.3	1.3	78	697	139	0.3	0.3	0.3
	Tamar	9.5	0.6	71	565	64	0.3	0.5	0.1
Fard	*Kimri*	53	1.5	121	1,243	66	0.5	0.7	0.7
	Khalal	18	1.3	97	1,106	64	0.5	1.3	0.6
	Rutab	14	1.2	68	1,414	282	0.3	0.5	0.3
	Tamar	14	1.2	63	914	141	0.4	0.5	0.2
Naghal Hilali	*Kimri*	52	1.6	123	682	46	0.2	0.7	0.8
	Khalal	14	1.0	45	683	41	0.2	1.3	0.4
	Rutab	10	1.1	53	622	147	0.2	0.3	0.2
	Tamar	9.7	1.2	56	704	55	0.3	0.3	0.6
Khasab[b]	*Kimri*	88	1.7	147	1,121	96	0.9	1.7	0.9
	Khalal	19	1.5	90	816	54	0.4	1.3	0.6
	Rutab	17	1.1	62	820	216	0.3	0.5	0.4
Hilali Pakistan	*Kimri*	59	2	119	1,085	43	0.7	2	1
	Khalal	16	1.5	66	890	49	0.4	0.4	0.4
	Rutab	11	1.2	51	804	213	0.2	0.4	0.3
	Tamar	12	1.6	62	770	153	0.2	0.4	0.2

[a]Mean of three replicates of fruits of two consecutive seasons; [b]does not produce *Tamar* stage.
Source: Ahmed et al. (1995). Reproduced with permission from Elsevier.

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. Other minerals and salts that are found in various proportions include boron, calcium, cobalt, manganese, phosphorus, and zinc. Additionally, the seeds also contain aluminum, cadmium, chloride, lead and sulfur in various proportions (Al-Farsi et al. 2005a, Al-Farsi and Lee 2008a, Ali-Mohamed and Khamis 2004). According to Al-Showiman (1998) and El Hadrami and Al-Khayri (2012), the date fruit contains fluorine, which is proven to protect against tooth decay. Also, selenium has many functions in the human body; it can prevent cancer and stimulate the immune system. Dates are a good source of iron and can correct iron deficiencies and anemia.

Table 11.7 shows physicochemical proprieties of date syrups prepared from three date varieties using traditional extraction (TE) and enzymatic extraction (EE). The method of extraction of syrup can have significant effect on composition of date syrup including minerals (Abbès et al. 2011). However, it may be noted that the differences due to extraction methods were not consistent across three varieties studied (Deglet Nour, Allig, and Kentichi).

Table 11.7 Physico-chemical proprieties of date syrups prepared from three date varieties using traditional extraction (TE) and enzymatic extraction (EE).

	Deglet Nour		Allig		Kentichi	
Component	TE[5]	EE[6]	TE	EE	TE	EE
Soluble sugars[1]	70	74.26	69.41	74.68	62.14	72.06
Reducing sugars[1]	27.31	64.41	66.89	70.95	24.4	65.59
Polysaccharide[1]	3.1	2.3	3.1	1.7	3.1	2.1
Pectin[2]	0.43	1.16	0.92	1.29	0.45	1.22
Protein[1]	1.24	1.27	1.31	1.5	0.97	1.03
Ash[1]	2.4	2.42	1.79	1.88	2.05	2.12
Potassium[3]	1004.8	1024.8	674.8	565.4	799.2	749.3
Magnesium[3]	78.2	69.5	38.8	34.4	77.8	60.1
Sodium[3]	165.2	160.8	76.0	75.5	180.2	157.5
Calcium[3]	180.5	150.5	64.8	81.2	270.6	240.5
Phosphorus[3]	100.5	91.2	48.3	57.2	70	90.4
Zinc[3]	0.64	0.93	0.83	1.7	0.64	1.1
Manganese[3]	0.04	0.13	0.07	0.2	0.07	0.14
Iron[3]	0.63	0.06	1.39	1.53	1.07	0.16
Total phenolic[4]	461.21	326.84	356.42	292.34	400.51	304.28
pH	4.87	3.2	4.48	3.12	4.82	3.07
Acidity (as % citric acid)	0.27	1.25	0.18	1.22	0.2	1.29
Water activity (a_w)	0.46	0.48	0.47	0.47	0.47	0.45

[1]g/100g, dry weight; [2]mg galacturonic acid /100 g, fresh weight; [3]mg/100 g, fresh weight; [4]mg gallic acid equiv./100 g, fresh weight.
[5]at 100 °C for 15 min without enzyme addition.
[6]at 50 °C for 120 min with pectinase and cellulose.
Source: Abbes et al. (2011). Reproduced with permission from Elsevier.

Total fat and fatty acids profile

The evolution of the oil content during date fruits ripening shows a continuous decrease, and there are marked differences in the oil content at different stages of ripening. The fruit contains very low fat content (0.24–0.42%). A total of 15 different fatty acids have been identified in the fruit oils (Arem et al. 2011). The oil obtained from the pulp of the fruits is composed of approximately 50% saturated fatty acids (SFA), 40% monounsaturated fatty acids (MUFA), and 10% polyunsaturated fatty acids (PUFA). The major saturated fatty acid (SFA) was palmitic acid ($C_{16:0}$). There is minor presence of myristic ($C_{14:0}$), arachidic ($C_{20:0}$), pentadecanoic ($C_{15:0}$), heneicosanoic ($C_{21:0}$), and tricosanoic ($C_{23:0}$) acids. During maturation of the date fruit, and especially from *Rutab* to *Tamar* stage, PUFA content, especially linoleic acid, increases. These results could be explained by the conversion of oleic acid to linoleic acid by D12-desaturase, a membrane-bound enzyme. Content of oleic acid in seed ranges from 41.1% to 58.8%, which indicates that seeds can be used as a source of oleic acid (Al-Shahib and Marshall, 2003).

Phytochemicals and aroma profile

In addition to being a rich source of carbohydrates, dietary fibers, some essential vitamins, and minerals, dates are also rich in a variety of phytochemicals, for example, phenolics, sterols, carotenoids, anthocyanins, procyanidins, and flavonoids (Baliga et al. 2011). Phenolic content and antioxidant activity of dates and selected common dry fruits is shown in Figure 11.4. Even date pits are an excellent source of phytochemicals besides dietary 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). Phytochemicals in fruits have been shown to possess significant antioxidant capacities that may be associated with lower incidence and lower mortality rates of degenerative diseases in human (Baliga et al. 2011, Vayalil 2012).

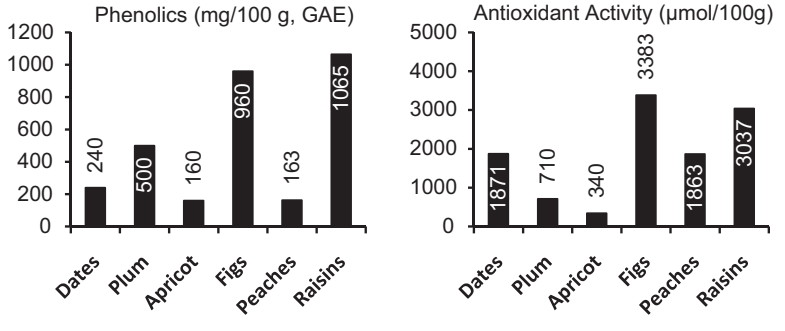

Figure 11.4 Phenolic content and antioxidant activity* of dates and other common dry fruits (*by FRAP assay for plum and apricot and by ORAC for others). *Source:* Adapted from Al-Farsi and Lee (2008a).

Carotenoids

According to USDA National Nutrient Database for Standard Reference, Release 19 (USDA 2007) the total carotenoids in Deglet Nour and Medjhool are 81 μg/100 g (6.0 μg of β-carotene and 25.0 μg of lutein plus zeaxanthin) and 112 μg/100 g (89.0 μg of β-carotene and 23.0 μg of lutein together with zeaxanthin), respectively. The carotenoid composition and the provitamin A value of three Algerian date varieties (Deglet Nour, Hamraya, and Tantebouchte) at three different ripening stages showed that the major carotenoid pigment present in dates was lutein followed by β-carotene (Boudries et al. 2007). Interestingly, the carotenoid content of the fruit decreased significantly during ripening from the *Khalal* to the *Tamar* stage. The β-carotene content was reported to be 6.4, 3.3 and 2.5 μg/100 g for Deglet-Nour, Hamraya and Tantebouchte dates, respectively, while that of the lutein was 156, 28, and 33.6 μg/100 g, respectively (Boudries et al. 2007, Al-Farsi and Lee 2008a). The carotenoid degradation is probably due primarily to the loss of moisture during maturation, and is probably unrelated to the gradual darkening of the ripening fruits (Gross et al. 1983).

Anthocyanins and procyanidins

Anthocyanins have been detected in various fresh date cultivars and their concentration ranged between 0.87 and 1.5 mg/100 g; generally, there was a direct correlation between the levels of anthocyanins and the fruit color. Anthocyanins are detected only in fresh dates, indicating that they may be destroyed in sun-dried fruit (Al-Farsi et al. 2005b). The presence of procyanidins in date fruits has been reported in the literature. Chemical analysis of acetone–water–acetic acid-extracted procyanidins indicated that the procyanidin existed as higher molecular weight polymers, undecamers through heptadecamers, and decamers (Hong et al. 2006).

Phenolic acids

Phenolic compounds are one of the most important bioactive materials and are characterized as potent antioxidants and free radical scavengers which can act as hydrogen donors, reducing agents, metal chelators and singlet oxygen quenchers (Yen et al. 1993). Phenolic acids and their consumption have increased recently due to potential health benefits.

Mansouri et al. (2005) studied the phenolic profile of seven different varieties of Algerian ripe date fruits. These date samples contained *p*-coumaric, ferulic and sinapic acids, some cinnamic acid derivatives, and three different isomers of 5-*o*-caffeoyl shikimic acid. Presence of both free (protocatechuic acid, vanillic acid, syringic acid, and ferulic acid) and bound phenolic acids (gallic acid, protocatechuic acid, *p*-hydroxybenzoic acid, vanillic acid, caffeic acid, syringic acid, *p*-coumaric acid, ferulic acid, and *o*-coumaric acid) have been reported in three varieties of Omani dates (Al-Farsi et al. 2005b). Further, it has been reported that the phenolic content increased significantly

after drying, possibly due to the degradation of tannins and lower activity of degradative enzymes at higher drying temperatures (Al-Farsi et al. 2005b).

Antioxidant properties

Date has been considered as a source of antioxidants. Antioxidants inhibit oxidative mechanisms that lead to do generative diseases such as heart disease, brain dysfunction and arthritis (Prior et al. 1999). Dates are reported to have antitumor activity, antimutagenic properties, and can lower the rate of cancers, especially pancreatic cancer and activate immune system and regulate the role of antibiotics (Ishurd and Kennedy 2005, Mansouri et al. 2005, Vayalil 2002). An aqueous extract of date flesh has potent free radical scavenging activity of reactive oxygen species like superoxide ($O^{\bullet -}$) and hydroxyl ($OH^{\bullet}$) radicals (Vayalil 2002). The same extract also showed a strong inhibitory effect on in vitro macromolecular damages such as lipid peroxidation and protein oxidation. Vinson et al. (2005) have reported that the concentration of extracts required preventing LDL + VLDL oxidation with cupric ions (1/IC50) by dried Deglet Nour and Zahidi dates was about 2.17, which is five times higher than the antioxidant vitamins such as Vitamin C and E.

Studies conducted on antioxidant activity and phenolic content of various fruits of dates demonstrated a linear relationship between antioxidant activity and the total phenolic content of date fruit extract (Alliath and Abdalla 2005). Fruits of different date palm cultivars have different total phenolics content and antioxidant activity (Al-Farsi et al. 2007, Al-Turki et al. 2010). The antioxidant properties of date fruits vary depending on their content of phenolic components and vitamins C and E, carotenoids and flavonoids (Mansouri et al. 2005; Al-Farsi et al. 2007). Sun-dried dates grown in Oman (cv. Fard, Khasab, and Khalas) were found to be a good source of antioxidant constituents including selenium (0.356 to 0.528 mg/100 g), total antioxidants (8,212–12,543 μmol Trolox equiv/g), carotenoids (0.92–2.91 mg/100 g), and phenolics (217–343 mg of ferulic acid equiv/100 g). These results suggest that all date varieties can serve as a good source of natural antioxidants and could potentially be considered as a functional food or functional food ingredient (Al-Farsi et al. 2007).

Aroma and volatile matter

A total of 80 volatile compounds have been detected in date fruits which included 20 esters, 19 alcohols, 10 terpenes, 13 aldehydes, 6 ketones, 12 hydrocarbons, and 1 lactone (Arem et al. 2011). The identified compounds accounted for 90.7–99.6% of the total aroma profile. The number of aromatic compounds differed according to the maturation stage and to the fruit kind. Other compounds (2-propanol, isoamyl alcohol, phenylethyl alcohol, isoamyl

acetate, etc.) have also been identified in Tunisian dates. Each volatile compound was characterized by an odor threshold (varying from a few ppb to several ppm). Alcohols, aldehydes, ketones, and terpenes were responsible for the citrus, floral, and fruity characteristics of date aroma (Richard 1992). Two straight chain aldehydes, nonanal and decanal were suggested to be responsible for the fresh and slightly green notes of dates (Crouzet 1992). Terpene or aliphatic alcohols are characterized by herbaceous, fruity, citrus, floral and fungal odors (Richard 1992).

Medicinal uses of dates

In traditional medicine, the use of date fruit is recommended for treatment of liver diseases and to be consumed by pregnant women before and after delivery (Al-Mamary et al. 2010). Although date fruit is admired for its nutritional and pharmacological properties by the natives of Middle East and northern Africa, it is still hardly recognized in the west due to the lack of sufficient scientific documentation (Vayalil 2012). In vitro study of the aqueous extract of palm date fruits showed antioxidative and antimutagenic properties (Vayalil 2002). On the other hand, in vivo studies (Al-Qarawi et al. 2004, Bastway et al. 2008) have shown that the ethanolic and aqueous date extracts had hepatoprotective effects when they are fed to rats, in which acute hepatotoxicity was induced by carbon tetrachloride and thioacetamide, respectively. A number of other health benefits of dates consumption are reported in the literature: e.g., anticancer activity (Sun et al. 2002), effect on immume response (Pur 2000, Al-Chramawindi 2007), anti-ulcer activity (Al-Qarawi et al. 2005), antimicrobial activity (Sabah et al. 2007), antihyperlipidemic activity (Al-Maiman 2005, Rock et al. 2009), and positive effect on reproductive system (Ali et al. 1999, Bahmanpour et al. 2006). However, date fruit is still poorly studied in relation to their total phenolic and total polyphenolic compounds, and consequently their antioxidant activity. Owing to its high nutritive values and potential health promoting activities, date fruit may be considered as an emerging and potential candidate for the development of health-promoting foods.

Glycemic index of date fruit

Carbohydrate foods when consumed in isoglucidic or isoenergetic amounts have different glycemic potential and insulinemic response (Vayalil 2012). Carbohydrates or carbohydrate foods are classified based on their glycemic responses which are termed as the glycemic index (GI). An extension of the GI concept is the glycemic load (GL). The GL value incorporates the amount of digestible carbohydrates in a serving in order to better gauge the impact of a diet on postprandial glucose response (Wolever et al. 1991). There are various factors that influence the GI value of date fruit. It depends on the type of component sugars (e.g., glucose, fructose, sucrose, or sorbitol), the physical form of the carbohydrate (e.g., particle size), the nature of the food

item (fat, protein, and fiber content), and the modification of the food (e.g., food processing, extent of hydration) (Wolever et al. 1991, Augustin et al. 2002, Jenkins et al. 1981).

Few studies have been carried out to test the GI of date fruits. However, the calculated GI values are inconsistent and sometimes are contradictory (Vayalil 2012). Lock et al. (1988) provided the first report where the GI was 61.1 in pregnancy-related diabetic patients. However, the study did not consider various important factors of date fruit like cultivar, maturity stage and, the percentage available carbohydrate. Miller et al. (2002, 2003) found the GI value ranged between 31 and 50 in normal subjects depending in one variety where the value dropped (ranging from 29 to 47) when the fruit was consumed either alone or as mixed meals (Miller et al. 2003; Denyer and Dickinson, 2005). An international database of GI and GI/GL reported that the GI of Australian dried dates was 103, which was significantly higher than reported for dates from some other countries (Denyer and Dickinson 2005). More recently, the GI of different varieties of dates from Oman was reported to range from 47.6 to 57.7 (Ali et al. 2009).

Date-based functional foods

Inferior quality dates have been used to produce different value-added products to make the palm date as economically viable commodity to producers and producing countries. As mentioned earlier, date fiber concentrate (DFC) is one of the products obtained from lower quality dates. Since DFC has high water-binding capacities (WBC) and oil-binding capacities (OBC) so attempts have made to produce various functional foods based on DFC utilization. The use of DFC in beef burger formulations has improved cooking properties, e.g., increase cooking yield and decrease shrinkage and minimize production cost without negatively affecting their sensory properties (Besbes et al. 2010). The increased fiber content constitutes an additional nutritional benefit for the consumer and permits a reduction of the amount of meat incorporation that passes from $\sim$ 63% in the control to $\sim$ 46% in the product with 1% DFC level.

Second-grade dates (Deglet Nour and Kentichi cultivars with a hard texture) were used to make jam by Besbes et al. (2009). Results showed a significant effect of the date variety on the composition and physical characteristics of date jams. Results from this work revealed essential information about jam quality that could promote the commercialization of date jam.

Date pits

Date seeds (pits) constitute about 10–15% of the fruit, depending on the fruit size (Almana and Mahmoud 1994). Many date-producing countries use date pits as poultry and animal feed. Hamada et al. (2002) examined date pits for extractable high value-added components for adding to functional foods. Date pits are odorless and have light to dark brown color and a bland

taste with slight bitterness. They contained 7.1–10.3% moisture, 5.0–6.3% protein, 9.9–13.5% fat, 46–51% acid detergent fiber, 65–69% neutral detergent fiber, and 1.0–1.8% ash. Pits had a substantial amount of oil that needed to be characterized for constituent components, biological activities and stability. The chemical characteristics of seed oil from six Libyan date cultivars were: iodine number 54.8, saponification value 207, and acid value 1.75 (El-Shurafa et al. 1982). The major fatty acid found in date seed oil was oleic acid (Al-Showiman 1990, Devshony et al. 1992) whereas fair amounts of lauric acid, myristic acid and palmitic acid ranging between 15.4% and 23.8%; 7.42% and 11.8%, 6.96%, and 10.2% were also reported (Al-Showiman 1990).

Properties of oil extracted from date pits revealed that the oil content ranged between 10.19 and 12.67% (Besbes et al. 2004). Gas–liquid chromatography revealed that the major unsaturated fatty acid was oleic acid (41.3–47.7%), while the main saturated fatty acid was lauric acid (17.8%) and palmitic acid. Capric, myristic, myristoleic, palmitoleic, stearic, linoleic, and linolenic acids were also found. Thermal profiles of both date seed oils, determined by their Differential Scanning Calorimetry (DSC) melting curves, revealed simple thermograms. Results showed that date seed oil could be used in cosmetic, pharmaceutical, and food products.

Conclusion

Dates are consumed fresh or in the dried form. Dried dates can be classified as “intermediate moisture” foods. Besides being a rich source of carbohydrates, dietary fibers, some essential vitamins, and minerals, dates are also rich in a variety of phytochemicals, e.g., phenolics, carotenoids, anthocyanins, procyanidins, and flavonoids. They are also high in insoluble fiber, which is important for gastrointestinal health. Even date pits are an excellent source of dietary fiber, minerals, lipids, and protein. In addition to their pharmacological properties, phytochemicals also contribute to nutritional and sensorial properties of dates. 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 reported on the positive contribution of dates to human diet. As compared to other fruits and vegetables, regarded as functional foods (e.g., grapes and carrots), dates are equally as valuable, due to their fiber and antioxidants. Overall, dates may be considered as a nutritious food that can play a major role in human nutrition and health because of their wide range of nutritional and functional properties.

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