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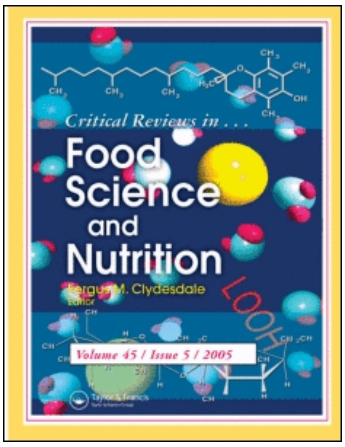

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Nutritional and Functional Properties of Dates: A Review

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*This review article provides information on the nutritional and functional constituents of dates (*Phoenix dactylifera L.*) and their seeds from over 80 references. Date flesh is found to be low in fat and protein but rich in sugars, mainly fructose and glucose. It is a high source of energy, as 100 g of flesh can provide an average of 314 kcal. Ten minerals were reported, the major being selenium, copper, potassium, and magnesium. The consumption of 100 g of dates can provide over 15% of the recommended daily allowance from these minerals. Vitamins B-complex and C are the major vitamins in dates. High in dietary fiber (8.0 g/100 g), insoluble dietary fiber was the major fraction of dietary fiber in dates. Dates are a good source of antioxidants, mainly carotenoids and phenolics. Date seeds contain higher protein (5.1 g/100 g) and fat (9.0 g/100 g) as compared to the flesh. It is also high in dietary fiber (73.1 g/100 g), phenolics (3942 mg/100 g) and antioxidants (80400 μmol/100 g). This detailed information on nutritional and health promoting components of dates and their seeds will enhance our knowledge and appreciation for the use of dates in our daily diet and their seeds as a functional food ingredient.*

Keywords sugars, mineral, vitamins, fiber, phenolics, antioxidants

INTRODUCTION

Dates are produced largely in the hot desert regions of Southwest Asia and North Africa, and are marketed worldwide as a high-value fruit crop. With the present uncertainty in the world food supply and an expected increase in demand, the date palm is likely to continue to provide a good source of low cost food. The world production of dates has increased from about 4.60 million tons in 1994 to 6.9 million tons in 2004 (FAO, 2007). Egypt, Saudi Arabia, Iran, and Iraq are the main producing countries (Table 1). Table 1 shows that Tunisia is leading the exporting countries in terms of gross exports (84.4 million US $), followed by Iran (36.4 million US $), Saudi Arabia (24.1 million US $), and Pakistan (22.5 million US $). However, the United States achieved the highest export price (3,339 US $/ton) among these countries, followed by Tunisia and Algeria, due to their strategy of growing top quality date varieties and targeting the high-value European markets (Zaid and Arias-Jimenez, 2002).

Dates pass through four stages of development known by their Arabic names; Kimri, Khalaal, Rutab, and Tamer. Many studies had discussed the physical and chemical development of dates as they pass through these stages (Sawaya et al., 1982; 1983; Mustafa et al., 1986; Siddiqui and Gupta, 1994; El-Zoghbi, 1994; Ahmed and Ahmed, 1995; Al-Hooti et al., 1997; Myhara et al., 1999; Al-Shahib and Marshall, 2003). At the Kimri stages there is a rapid increase in size, weight, and sugar content. The moisture content at this stage is up to 85%. At the end of this stage the fruit starts to turn yellow or red depending on the variety. In the Khalaal stage weight gain is slow, the sucrose starts to be converted to glucose and fructose, the moisture content goes down, and tannins will start to precipitate and lose their astringency. In some varieties this latter process occurs rapidly, which makes the fruit palatable at the Khalaal stage. Normally the tips of the fruit start ripening by turning brown as they enter the Rutab stage which is characterized by a decrease in weight due to moisture loss, the conversion of sucrose into invert sugar (the degree depending on the variety) and a browning of the skin and softening of the tissues. The moisture content decreases to about 35% and the dates at this stage are sold as fresh fruit. Only when the dates are left to ripen further on the palm or sun dried will they develop into the Tamer (dried) stage. Therefore, dates distinguished from most other fruits in that they have a botanical maturity at least 3 commercial maturation levels, the sweet Khalaal, the Rutab, and the Tamer stage (Barreveld, 1993). There are over 2000 different date varieties (Amer, 1994). According to variety and growth conditions, date fruits (Tamer) vary in shape, size, and weight. Usually they are oblong in shape although

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Table 1 Cultivation area, production, export, and export value of dates for 2004.

Countries	Area 1000 Hectares	Production 1000 tons	Export 1000 tons	Commercial value US $/ton	Export value 1000 US $
Algeria	135	470	8	1,820	14,563
Egypt	35	1,166	3	457	1,370
Iran	185	880	95	383	36,430
Iraq	102	875	24	183	4,392
Oman	34	238	5	436	2,180
Pakistan	81	622	65	346	22,473
Saudi Arabia	145	901	44	548	24,090
Tunisia	45	122	40	2,110	84,382
UAE	186	760	60	219	13,127
USA	2	15	4	3,339	13,357
World	1,129	6,908	377	786	296,248

Source: (FAOSTAT). (FAO 2007).

certain varieties may be almost round. Length and width may vary from 18–110 mm to 8–32 mm, respectively and the average weight per fruit is about 2 to 60 grams (Zaid and Arias-Jimenez, 2002).

Sun drying is the common method of drying dates; taking around 7 to 10 days depending on the daytime temperature which varies from 30 to 50°C and the humidity (60–85%) (Al-Farsi et al., 2005). Several factors affect date quality during sun drying. These include insect infestation, microbial infestation, and browning by enzymatic and non-enzymatic reactions (Barreveld, 1993). The drying of dates can also be achieved by artificial heat treatment in circumstances where early rains threaten to damage the crop. The process requires rooms in which temperature, humidity, and air ventilation can be controlled. Drying rate is a function of temperature, relative humidity, and velocity of the air. For drying soft dates, 65°C is recommended, which ensures a reasonable drying rate with minimal effect on the basic qualities. Relative humidity should be maintained at over 40%, but should not exceed 60% to avoid case-hardening and also for fuel economy (Barreveld, 1993).

Dates consumption is seasonal; it reaches its peak in the Ramadan month (Muslims fasting month) where dates are needed to break the fasting, and the consumption drops after that month. Dates are mainly consumed dried, the average daily consumption per capita of dates was estimated in Oman and United Arab Emirates at 164 and 114 grams respectively (MAF, 2005; Ismail et al., 2006). Socio-economic changes have reduced date consumption due to improvement in living standards, changes in eating habits, continued urban drift, and the tendency toward a smaller size family. The wide availability of alternative competitive confectioneries and other fruits all year round have aggravated the problem.

Dates consist of 70% carbohydrates, most of which is in the form of sugars. In most varieties, the sugar content is almost entirely invert sugar, which is rapidly absorbed by the human body (Ahmed and Ahmed, 1995; Al-Hooti et al., 1997; Myhara et al., 1999). Dates also contain large amounts of dietary fiber, and are thought to be a good source of some minerals, e.g., iron, potassium, and calcium. However, relatively few detailed analyses of their composition have been published. In some instances, the variety analyzed has not been identified and, in addition, conflicting results for some constituents have been published.

There is a particular lack of information on functional constituents of dates and their potential value as functional foods. Functional foods are defined as those foods that provide health benefits beyond basic nutrition (IFICF, 1998). Epidemiological studies have consistently shown that there are clear significant positive associations between intake of fruits and vegetables and reduced rate of heart diseases mortality, common cancers, and other degenerative diseases as well as ageing (Joseph et al., 1999; Dillard and German, 2000; Prior and Cao, 2000; Wargovich, 2000). This is attributed to the fact that these foods may provide an optimal mix of dietary fiber, natural antioxidants, and other biotic compounds.

The functional constituents of dates include dietary fiber, which is important for the health of the digestive tract. Dietary fiber consists of the edible plant material which is not hydrolyzed by the human digestive tract. Many studies recommend the public to consume adequate amounts of dietary fiber from a variety of plant foods (NIM, 2001; Marlett et al., 2002; Mai et al., 2003).

0It is possible that dates may also contain useful quantities of antioxidants. Antioxidants are thought to play an essential role in the prevention of cardiovascular disease (Renaud and De Lorgeril, 1992; Fuhrman et al., 1995), cancers (Wargovich, 2000; Dragsted et al., 1993), neurodegenerative diseases, such as Parkinson's and Ahlzeimer's diseases (Joseph et al., 1999; Okuda et al., 1992; Clarke, 1999), as well as inflammation (Joseph et al., 1999; Lietty et al., 1976) and continuous ageing (Prior and Cao, 2000; Ames et al., 1993; Gaulejac et al., 1999). A dietary antioxidant is defined as a substance in foods that significantly decreases the adverse effects of reactive species, such as reactive oxygen and nitrogen, on normal physiological function in humans (NIM, 2000). Antioxidants markedly delay or prevent oxidation of the substrate when they are present in foods or in the body at low concentrations (Halliwell, 1999; Shahidi, 2000). Natural antioxidants consist primarily of plant-phenolics, vitamin C, carotenoids, and selenium (NIM, 2000; Shahidi and Naczk, 2004). Examples of common plant phenolic antioxidants include flavonoid compounds (anthocyanins), cinnamic acid derivatives, coumarins, and tocopherols (vitamin E) (Shahidi and Naczk, 2004).

This review examines the major constituents of dates and date seeds and discusses their nutritional and functional properties. In order to compare the composition of fresh (Rutab) and dried (Tamer) dates with other dried fruits, all presented data from cited references has been recalculated on wet weight bases.

PROXIMATE COMPOSITION

The moisture content, protein, fat, ash, carbohydrates, and energy of fresh and dried dates are shown in Table 2. The average moisture content of 10 fresh date varieties is 42.4 g/100 g

Table 2 Proximate composition of fresh and dried dates[a].

Varieties	Moisture g/100 g	Protein g/100 g	Fat g/100 g	Ash g/100 g	Carbohydrates[b] g/100 g	Energy[c] kcal/100 g	References
Fresh dates							
Naghal	44.1	2.0	0.2	1.2	52.6	207	(Ahmed and Ahmed, 1995)
Khunaizy	37.9	1.9	0.1	1.2	58.8	229	(Ahmed and Ahmed, 1995)
Khalas	41.3	1.1	0.1	1.0	56.8	218	(Ahmed and Ahmed, 1995)
Barhi	39.7	1.8	0.2	1.1	56.9	222	(Ahmed and Ahmed, 1995)
Lulu	45.2	1.6	0.2	1.0	52.2	204	(Ahmed and Ahmed, 1995)
Fard	37.6	1.5	0.2	1.3	59.4	229	(Ahmed and Ahmed, 1995)
Khasab	50.4	1.1	0.1	1.0	47.8	185	(Ahmed and Ahmed, 1995)
Bushibal	43.2	1.4	0.1	1.1	54.2	210	(Al-Hooti et al., 1997)
Gash Gaafar	40.0	1.5	0.1	1.4	57.0	221	(Al-Hooti et al., 1997)
Gash Habash	44.2	1.3	0.1	1.3	53.1	205	(Al-Hooti et al., 1997)
Average	42.4	1.5	0.14	1.16	54.9	213	
Dried dates							
Naghal	9.2	2.7	0.2	1.9	86.2	336	(Ahmed and Ahmed, 1995)
Khunaizy	25.1	3.0	0.1	1.4	70.5	277	(Ahmed and Ahmed, 1995)
Khalas	12.6	1.7	0.5	1.8	83.4	324	(Al-Farsi et al., 2005)
Barhi	29.5	2.3	0.1	1.5	66.1	258	(Ahmed and Ahmed, 1995)
Lulu	21.3	2.4	0.2	1.3	75.1	293	(Ahmed and Ahmed, 1995)
Fard	18.5	1.5	1.4	1.5	77.1	308	(Al-Farsi et al., 2005)
Khasab	16.5	1.6	1.0	1.6	79.3	313	(Al-Farsi et al., 2005)
Bushibal	16.3	1.9	0.1	1.8	79.9	308	(Al-Hooti et al., 1997)
Gash Gaafar	7.2	2.2	0.1	1.9	88.6	342	(Al-Hooti et al., 1997)
Gash Habash	12.8	1.7	0.1	1.6	83.8	322	(Al-Hooti et al., 1997)
Deglet Noor	20.5	2.5	0.4	1.6	75.0	293	(USDA, 2007)
Medjool	21.3	1.8	0.2	1.7	75.0	290	(USDA, 2007)
Hallawi	7.3	2.1	0.5	1.8	88.3	344	(Yousif et al., 1982)
Sayer	7.5	2.6	0.3	1.7	87.9	343	(Yousif et al., 1982)
Khadrawi	9.5	2.2	0.4	1.9	86.0	335	(Yousif et al., 1982)
Zahdi	8.3	2.0	0.4	1.7	87.6	340	(Yousif et al., 1982)
Average	15.2	2.14	0.38	1.67	80.6	314	

[a] All data are expressed on wet weight basis. [b] Carbohydrates were calculated by subtracting total percent values of moisture, protein, fat and ash from 100. [c] Energy value was calculated by multiplying carbohydrates by 3.75, protein by 4 and fat by 9.

where the average moisture of 16 dried varieties is 15.2 g/100 g. The significant reduction in the moisture content of dried dates is mainly due to sun drying. Sun drying is the traditional way of preserving dates. Since sun drying depends on uncontrolled factors such as daytime temperature and humidity, the production of uniform and high quality products is not expected (Barreveld, 1993; Arthey and Ashurst, 1996).

Protein and fat occur in small amounts in dates. The average protein content of fresh and dried dates is 1.50 and 2.14 g/100 g respectively. The fat content is 0.14 g/100 g for fresh dates and 0.38 g/100 g for dried dates. The increased protein and fat after drying are mainly due to moisture loss. However, these values, differing between varieties, would be expected due to differences in cultivation, drying conditions, and determination methods.

Carbohydrate composition was calculated by subtracting the sum of the contents of moisture, protein, lipid, and ash from 100. As shown in Table 2, the average carbohydrates in fresh and dried dates are 54.9 and 80.6 g/100 g, respectively. The carbohydrate content would be expected to be high and consists of mainly sugars and fiber.

The energy provided by the protein, fat, and carbohydrates in dates was calculated according to MAFF (1995) and shown in Table 2. This method of calculation of energy assumes that all carbohydrate present is energy providing. However, a proportion of the carbohydrate in dates would be expected to be dietary fiber, which would not contribute to the energy provided when they are consumed by humans.

Dates are a good source of energy mainly due to their high sugar content. The average energy of fresh and dried dates is 213 and 314 kcal/100 g respectively. The energy requirements of adult men range from 2300 to 2900 kcal/day and 1900 to 2200 kcal/day for adult women (NIM, 2001). Hence, a portion of 100 g of dates supplies approximately 12 to 15% of the total energy requirement per day per adult. Table 10 shows comparison data of different dried fruits including dates. Although dates have the lowest content of protein and fat compared to other dried fruits, it can still provide high carbohydrates and energy to our diet. Thus dates make a significant contribution to the diet and, therefore, their nutrient contribution is important.

Table 3 Sugar content of fresh and dried dates[a].

Varieties	Fructose g/100 g	Glucose g/100 g	Sucrose g/100 g	Total g/100 g	References
Fresh dates					
Naghal	20.8	23.4	Nd	44.2	(Ahmed and Ahmed, 1995)
Khunaizy	21.5	24.7	Nd	46.2	(Ahmed and Ahmed, 1995)
Khalas	21.7	24.5	Nd	46.2	(Ahmed and Ahmed, 1995)
Lulu	21.9	22.0	Nd	43.9	(Ahmed and Ahmed, 1995)
Fard	24.1	26.1	Nd	50.2	(Ahmed and Ahmed, 1995)
Khasab	19.8	21.9	Nd	41.7	(Ahmed and Ahmed, 1995)
Barhi	19.4	21.4	Nd	40.8	(Ahmed and Ahmed, 1995)
Bushibal	13.6	21.9	3.3	38.8	(Al-Hooti et al., 1997)
Gash Gaafar	15.0	24.6	0.7	40.3	(Al-Hooti et al., 1997)
Gash Habash	16.2	17.6	8.1	41.9	(Al-Hooti et al., 1997)
Average	19.4	22.8	4.03	43.4	
Dried dates					
Naghal	21.2	23.2	Nd	44.4	(Ahmed and Ahmed, 1995)
Khunaizy	25.4	28.5	Nd	53.9	(Ahmed and Ahmed, 1995)
Khalas	31.9	30.3	Nd	62.2	(Al-Farsi et al., 2005)
Lulu	27.1	30.5	Nd	57.6	(Ahmed and Ahmed, 1995)
Fard	28.2	28.5	Nd	56.7	(Al-Farsi et al., 2005)
Khasab	27.4	28.7	Nd	56.1	(Al-Farsi et al., 2005)
Barhi	27.6	29.7	Nd	57.3	(Ahmed and Ahmed, 1995)
Boumaan	29.5	26.8	Nd	56.3	(Ismail et al., 2006)
Bushibal	33.4	33.0	Nd	66.4	(Al-Hooti et al., 1997)
Gash Gaafar	36.8	36.8	Nd	73.6	(Al-Hooti et al., 1997)
Gash Habash	34.4	33.5	Nd	67.9	(Al-Hooti et al., 1997)
Ruzeiz	29.4	24.6	Nd	54.0	(Ismail et al., 2006)
Dalady	14.1	17.6	33.9	65.6	(Salem and Hegazi, 1971)
Deglet noor	19.6	19.9	23.8	63.3	(USDA, 2007)
Medjool	32.0	33.7	0.5	66.2	(USDA, 2007)
Hallawi	34.5	40.5	4.4	79.4	(Yousif et al., 1982)
Sayer	35.2	41.4	3.2	79.8	(Yousif et al., 1982)
Khadrawi	34.8	40.5	4.1	79.4	(Yousif et al., 1982)
Zahdi	35.9	30.1	11.6	77.6	(Yousif et al., 1982)
Average	29.4	30.4	11.6	64.1	

[a] All data are expressed on wet weight basis. nd: not detected.

SUGARS

Fructose, glucose, and sucrose were the only sugars detected in fresh and dried dates. The sugar contents of fresh and dried dates are shown in Table 3. The average content of fructose, glucose, and sucrose in fresh dates are 19.4, 22.8, and 4.03 g/100 g respectively, with an average total of 43.4 g/100 g. Sugars increased in dried dates to 29.4, 30.4, and 11.6 g/100 g for fructose, glucose, and sucrose respectively, with a total content of 64.1 g/100 g. Fructose and glucose were the major sugars in most date varieties and are found almost in equal amounts. The sugar differences between fresh and dried dates could be related to the stage of maturation and to the cultivation area with moisture reduction (Barreveld, 1993).

Sugars in dates are the most important constituents as they provide a rich source of energy to humans. Reducing sugars, such as glucose, are readily absorbed during digestion and lead to rapid elevation of blood sugars (Liu et al., 2000). As fructose is twice as sweet as glucose, it induces a feeling of satiety and may also reduce the total calorie intake compared to fat-rich foods (ACBCI-EU, 2007). However, sticky foods such as dried fruits may contribute to tooth decay (Whitney and Rolfes, 2002).

MINERALS

Table 4 shows the mineral content of fresh and dried dates and their Recommended Dietary Allowance (RDA) or Adequate Intakes (AI). Dates were found to be rich sources of selenium, copper, potassium, and magnesium in the diet, as the consumption of 100 g of dates provides over 15% of the daily RDA/AI of these minerals. Moderate concentrations of manganese, iron, phosphorus, and calcium, per 100 g of dates, provide over 7% of the daily RDA/AI. The high potassium and low sodium contents in dates are desirable for people suffering from hypertension (Appel et al., 1997). In comparison with other dried fruits (plums, apricot, figs, raisins, and peaches), USDA National nutrient database reported, that 100 g of these fruits contain on average of 0.8 μg Se, 0.3 mg Cu, 864 mg K, and 43 mg Mg (USDA, 2007). Thus, dates are regarded as a good source of these minerals.

Selenium is a coenzyme for the antioxidant enzyme glutathione peroxidase, and therefore, has a role in the protection of body tissues against oxidative stress, maintenance of defenses against infection, and the modulation of growth and development (NIM, 2000). The high levels of selenium in dates could

Table 4 Mineral content of fresh and dried dates (mg/100 g)[a].

Varieties	Mg	Na	Ca	P	K	Mn	Fe	Zn	Cu	Se	References
Fresh dates											
Naghal	34	169	7.8	—	451	0.4	0.3	0.2	0.2	—	(Ahmed and Ahmed, 1995)
Khunaizy	48	124	5.1	—	467	0.3	0.7	0.1	0.2	—	(Ahmed and Ahmed, 1995)
Khalas	36	124	11	—	345	0.2	0.8	0.2	0.2	—	(Ahmed and Ahmed, 1995)
Barhi	54	126	7.0	—	482	0.2	0.8	0.1	0.2	0.24	(Ahmed and Ahmed, 1995, Al-Showiman et al., 1994)
Lulu	43	76	5.0	—	382	0.2	0.7	0.2	0.2	—	(Ahmed and Ahmed, 1995)
Fard	42	176	8.7	—	882	0.3	0.8	0.2	0.2	—	(Ahmed and Ahmed, 1995)
Khasab	31	107	8.4	—	407	0.3	0.6	0.2	0.2	—	(Ahmed and Ahmed, 1995)
Bushibal	54	1.8	48	39	423	0.4	0.4	0.4	0.2	—	(Al-Hooti et al., 1997)
Gash Gaafar	53	3.2	57	49	537	0.4	0.8	0.5	0.3	—	(Al-Hooti et al., 1997)
Gash Habash	38	1.8	44	35	487	0.2	0.5	0.3	0.2	—	(Al-Hooti et al., 1997)
Average	43.3	90.9	20.2	41.0	486	0.29	0.64	0.24	0.21	0.24	
Dried dates											
Naghal	43	261	14	—	716	0.5	1.1	0.2	0.2	—	(Ahmed and Ahmed, 1995)
Khunaizy	44	148	11	—	527	0.3	1.1	0.2	0.1	—	(Ahmed and Ahmed, 1995)
Khalas	76	3.6	85	74	742	0.3	0.6	0.5	0.6	0.28	(Al-Farsi et al., 2005)
Barhi	58	53	9	—	603	0.4	0.2	0.1	0.1	—	(Ahmed and Ahmed, 1995)
Lulu	56	50	8	—	445	0.4	0.5	0.1	0.2	—	(Ahmed and Ahmed, 1995)
Fard	61	3.5	82	59	624	0.3	0.6	0.5	0.8	0.4	(Al-Farsi et al., 2005)
Khasab	67	2.4	55	63	603	0.2	1.1	0.6	0.6	0.4	(Al-Farsi et al., 2005)
Bushibal	41	4.3	41	41	468	0.4	1.5	0.39	0.2	—	(Al-Hooti et al., 1997)
Gash Gaafar	45	2.9	52	56	550	0.3	1.4	0.5	0.3	—	(Al-Hooti et al., 1997)
Gash Habash	44	1.3	44	48	500	0.3	1.4	0.6	0.3	—	(Al-Hooti et al., 1997)
Hardrami	91	1.0	94	—	787	0.01	0.3	0.02	0.01	—	(Mohamed, 2000)
Succari	140	14	206	—	1093	0.03	0.2	0.1	0.03	0.25	(Al-Showiman et al., 1994, Mohamed, 2000)
Mabroom	86	4.5	136	—	1062	0.03	–	0.02	0.01	—	(Mohamed, 2000)
Safawi	150	1.4	132	—	1287	–	0.1	0.02	0.03	—	(Mohamed, 2000)
Beed	55	6.8	129	—	524	0.02	–	0.02	0.02	—	(Mohamed, 2000)
Boumaan	25	9.1	—	—	1248	0.3	0.7	0.2	—	—	(Ismail et al., 2006)
Ruzeiz	41	55	—	—	413	0.4	1.4	0.38	—	0.24	(Ismail et al., 2006, Al-Showiman et al., 1994)
Medjool	54	1.0	64	62	696	0.3	0.9	0.4	0.4	—	(USDA, 2007)
Deglet noor	43	2.0	39	62	656	0.3	1.0	0.3	0.2	—	(USDA, 2007)
Average	64.2	32.9	70.7	58.1	713	0.27	0.83	0.27	0.24	0.31	
RDA/AI mg/day	420	—	1000	700	3500	2.3	8.0	11	0.9	0.055	(Whitney and Rolfes, 2002)

[a] All data are expressed on wet weight basis. RDA/AI is Recommended Dietary Allowance/Adequate Intakes per adult per day.

be used to promote and market this crop in the producing countries as well as in other countries. However, the high level of selenium is also a cause of concern as the concentration present in dates (0.31 mg/100 g) is close to the toxic level (0.85 mg) (NIM, 2000). Although each mineral has its own health benefits, minerals are generally important as constituents of bones, teeth, soft tissues, hemoglobin, muscle, and nerve cells (O'Dell and Sunde, 1997; Sardesai, 1998).

VITAMINS

Table 5 shows the vitamin content of dried dates with their daily RDA/AI. Dried dates are generally a moderate source of vitamin B_6, B_9, B_2, and B_3 as 100 g of dates provide over 9% of the daily RDA/AI for adults. Vitamins B_1, C, and A are found in relatively low concentrations in dried dates, as 100 g of dates provide less than 7% of the daily RDA/AI. Dried fruits of plums, apricot, figs, raisins, and peaches contain, on average, 52 μg B_1, 136 μg B_2, 2046 μg B_3 and 1980 μg vitamin C per 100 g respectively (USDA, 2007). Therefore, compared to these dried fruits, dates are regarded as a reasonable source of vitamins, particularly vitamin C (3900 μg/100 g).

Vitamins are essential nutrients found in foods; the daily requirements are small but they perform specific and vital functions essential for maintaining health. Dates contain mainly water soluble vitamins (B-complex and C). They dissolve in water and are not stored in the body; they are eliminated in urine and therefore we need a continuous supply of them in our diets. By contrast fat-soluble vitamins (A, D, E, and K) dissolve in fat before they are absorbed in the blood stream to carry out their functions. Excesses of these vitamins are stored in the liver. B and C vitamins serve as coenzymes that facilitate the work of every cell in our body. They are active in carbohydrates, fat, protein metabolism, and in the making of DNA of new cells. Vitamin C, acts as well as an antioxidant, protects tissues from

Table 5 Vitamin content of dried date (μg/100 g)[a].

Varieties	A Retinol	B_1 Thiamin	B_2 Riboflavin	B_3 Niacin	B_6 Pyridoxal	B_9 Folate	C Ascorbic	References
Medjool	44.7	50	60	1610	249	—	—	(USDA, 2007)
Deglet noor	3.0	52	66	1274	165	—	400	(USDA, 2007)
Hallawi	—	92	160	—	—	53	3300	(Yousif et al., 1982)
Sayer	—	120	125	—	—	65	16000	(Yousif et al., 1982)
Khadrawi	—	85	135	—	—	39	2900	(Yousif et al., 1982)
Zahdi	—	73	153	—	—	58	2200	(Yousif et al., 1982)
Khudari	—	—	—	—	—	—	1000	(Sawaya et al., 1982)
Sullaj	—	—	—	—	—	—	1500	(Sawaya et al., 1982)
Average	23.85	78.67	116.5	1442	207	53.75	3900	
RDA/AI μg/day	900	1200	1300	16000	1300	400	90000	(Whitney and Rolfes, 2002)

[a] All data are expressed on wet weight basis. RDA/AI is Recommended Dietary Allowance/Adequate Intakes per adult male per day.

oxidative stress, and thus may play an important role in preventing diseases (Whitney and Rolfes, 2002).

AMINO ACIDS

Table 6 shows the amino acid content of fresh and dried dates. Within the same stage of maturation, the amino acid content varies significantly. Most of the studies cited used an amino acid analyzer for determination with the exception of Salem and Hegazi (1971) (colorimetric method). Amino acids content increased in dried varieties mainly due to water reduction, as Auda et al. (1976) and Ishurd et al. (2004) reported the reduction of the amino acid content through maturation stages.

Although the amounts of protein are too small to be considered an important nutritional source, dates contain essential amino acids which the body cannot make and must be provided in the diet. Glutamic, aspartic, lysine, leucine, and glycine are the predominant amino acids in fresh dates, whereas glutamic, aspartic, glycine, prolin, and leucine are the predominant amino acids in dried dates.

DIETARY FIBER

Table 7 shows the content of soluble, insoluble, and total dietary fiber of fresh and dried dates. The references selected used the same principle for determining dietary fiber, mainly cellulose, hemicelluloses, pectin, and lignin. Insoluble dietary fiber was the major fraction of dietary fiber in dates. The total fiber content in fresh dates increased from 7.5 g/100 g to 8.0 g/100 g in dried dates due to moisture reduction and to the ripening process in which enzymes gradually break down these substances to the more soluble compounds which softens the fruit (Fennema, 1996).

From the total dietary fiber content in dates and the recommended daily intake of total dietary fiber (25 g/day) (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 weight. It therefore may reduce the risk of serious conditions such as bowel cancer, and diverticular disease (Marlett et al.,

Table 6 Amino acid content of fresh and dried dates (mg/100 g)[a].

Varieties	Ala	Arg	Asp	Cys	Glu	Gly	His	Iso	Leu	Lys	Met	Phe	Pro	Ser	Thr	Try	Tyr	Ref.
Fresh dates																		
Khastawi	68	76	183	48	217	86	34	4	94	136	13	51	73	70	57	—	34	(Auda et al., 1976)
Khadhrawi	52	46	100	21	125	53	23	37	69	70	4	35	53	47	38	—	29	(Auda et al., 1976)
Zahdi	30	34	72	13	100	42	14	23	41	53	6	25	36	29	23	—	16	(Auda et al., 1976)
Average	50.0	52.0	118	27.3	147	60.3	23.7	21.3	68.0	86.3	7.7	37.0	54.0	48.7	39.3	—	26.3	
Dried dates																		
Khastawi	83	72	143	53	202	107	33	55	102	75	14	55	113	60	56	—	33	(Auda et al., 1976)
Khadhrawi	104	56	144	36	232	102	0.1	55	100	60	21	56	97	62	50	—	40	(Auda et al., 1976)
Zahdi	133	67	117	53	231	106	24	43	76	85	11	49	69	58	41	—	25	(Auda et al., 1976)
Hallawi	105	39	129	32	158	98	21	43	84	51	18	53	110	64	51	46	15	(Al-Rawi et al., 1967)
Sayir	79	45	119	35	183	92	19	41	78	51	12	43	100	58	45	46	15	(Al-Rawi et al., 1967)
Balady	110	148	309	—	382	268	—	—	242	154	—	—	—	128	95	92	156	(Salem and Hegazi, 1971)
Zahdi	63	81	67	—	200	45	46	37	61	42	24	45	94	65	55	—	37	(Al-Aswad, 1971)
Hillawi	70	91	59	—	225	64	44	44	72	46	28	66	81	53	44	—	49	(Al-Aswad, 1971)
Sayer	117	95	148	—	248	105	29	50	105	52	62	67	148	74	57	—	52	(Al-Aswad, 1971)
Medjool	78	60	220	46	265	90	29	45	82	54	17	48	111	62	42	7	16	(USDA, 2007)
Deglet noor	83	136	213	67	359	101	32	49	84	66	22	50	130	57	43	12	15	(USDA, 2007)
Average	93.2	80.9	152	46.0	244	107	27.7	46.2	98.7	66.9	22.9	53.2	105	67.4	52.6	40.6	41.2	

[a] All data are expressed on wet weight basis.

Table 7 Dietary fiber of fresh and dried dates[a].

Varieties	Soluble g/100 g	Insoluble g/100 g	Total g/100 g	References
Fresh dates				
Khalas	—	—	7.1	(Myhara et al., 1999)
Fard	—	—	8.6	(Myhara et al., 1999)
Hayani	0.96	5.89	6.85	(El-Zoghbi, 1994)
Average	0.96	5.89	7.5	
Dried dates				
Fard	1.3	6.7	8.0	(Al-Farsi et al., 2005)
Khasab	1.1	7.4	8.4	(Al-Farsi et al., 2005)
Khalas	0.4	5.9	6.3	(Al-Farsi et al., 2005)
Deglet Noor	—	—	8.0	(USDA, 2007)
Medjool	—	—	6.7	(USDA, 2007)
Rabeaah	—	—	9.7	(Al-Shahib and Marshall, 2002)
Shalaby	—	—	10.3	(Al-Shahib and Marshall, 2002)
Mabroom	—	—	8.5	(Al-Shahib and Marshall, 2002)
Sukkary	—	—	8.2	(Al-Shahib and Marshall, 2002)
Sofry	—	—	7.8	(Al-Shahib and Marshall, 2002)
Shorcy	—	—	7.1	(Al-Shahib and Marshall, 2002)
Bamy	—	—	6.4	(Al-Shahib and Marshall, 2002)
Hayani	0.54	3.03	3.57	(El-Zoghbi, 1994)
Khalas	—	—	10.9	(Myhara et al., 1999)
Fard	—	—	10.1	(Myhara et al., 1999)
Average	0.84	5.76	8.00	

[a] All data are expressed on wet weight basis.

2002; Cummings et al., 1992). In comparison with other dried fruits in Table 10, dates are a rich source of dietary fiber.

CAROTENOIDS

Table 8 shows the carotenoids composition and the total carotenoids in fresh and dried dates. The average total carotenoids content of fresh and dried dates are 913 and 973 μg/100 g respectively. With lutein, β-carotene, and neoxanthin are the major carotenoids. Carotenoid values varied probably due to the differences between variety, maturation, drying, and analysis conditions. The total carotenoid content in dates varied between the yellow and red colored varieties. The high content of carotenoids in Khalas was expected, as this variety has a yellow color. Fruits that are red usually contain hydrocarbon carotenoids such as lycopene, neurosporene, gamma-carotene, delta-carotene, alpha-carotene, beta-carotene, phytofluene, and phytoene. The yellow colored fruits contain, in addition to the carotenoids above listed, a complex mixture of carotenol fatty acid esters (Fennema, 1996).

Drying processes can result in degradation or formation of cis isomers of carotenoids (Chen et al., 1995; Sa'nchez-Moreno et al., 2003). Al-Farsi et al. (2005) reported destruction ranged between 4–30% of dates carotenoids after sun drying. This destruction was attributed to the drying temperature (30 to 50 °C) and the duration of the process (7 to 10 days) (Al-Farsi et al., 2005).

Typical carotenoid concentrations in other dried fruits range from 0.032 mg/100 g for figs to 2.2 mg/100 g in apricot (Table 10). Therefore, dates (0.97 mg/100 g) can be considered a moderate source of carotenoids compared to other dried fruits. Although not all carotenoids act as provitamin A, dates are likely to contribute to the human requirement for vitamin A.

ANTHOCYANINS, PHENOLICS, AND ANTIOXIDANTS

Table 9 shows the total content of anthocyanins, phenolics, and antioxidants (ORAC, FRAP, and DPPH) of fresh and dried

Table 8 Carotenoid content of fresh and dried dates (μg/100 g)[a].

Varieties	α-Caro.	β-Caro.	Zeax.	β-Zea.	Lute.	Neox.	Total	References
Fresh dates								
Date (unknown)	3.0	18	33	9.0	—	—	63	(Ben-Amotz and Fishler, 1998)
Deglet Noor	—	6.4	—	—	156	—	167	(Boudries et al., 2007)
Tantebouchte	—	3.3	—	—	28	—	32.6	(Boudries et al., 2007)
Hamraya	—	2.5	—	—	33.6	—	37.3	(Boudries et al., 2007)
Hayany	—	116	—	—	541	381	1270	(Gross et al., 1983)
Deglet Noor	—	60	—	—	461	230	920	(Gross et al., 1983)
Fard	—	—	—	—	—	—	1390	(Al-Farsi et al., 2005)
Khasab	—	—	—	—	—	—	1310	(Al-Farsi et al., 2005)
Khalas	—	—	—	—	—	—	3030	(Al-Farsi et al., 2005)
Average	3.0	34.4	33.0	9.0	244	306	913	
Dried dates								
Deglet Noor	—	3.0	—	—	60	—	64.3	(Boudries et al., 2007)
Tantebouchte	—	9.5	—	—	129	—	145	(Boudries et al., 2007)
Hamraya	—	3.0	—	—	45.7	—	51.3	(Boudries et al., 2007)
Hayany	—	146	—	—	520	365	1260	(Gross et al., 1983)
Deglet Noor	—	54	—	—	485	206	920	(Gross et al., 1983)
Barhee	—	143	—	—	491	184	1320	(Gross et al., 1983)
Fard	—	—	—	—	—	—	1200	(Al-Farsi et al., 2005)
Khasab	—	—	—	—	—	—	900	(Al-Farsi et al., 2005)
Khalas	—	—	—	—	—	—	2900	(Al-Farsi et al., 2005)
Average		59.8			289	252	973	

[a] All data are expressed on wet weight basis. α-Caro: α-Carotene; β-caro: β-carotene; Zeax: Zeaxanthin; β-Zea: β-Zeaxanthin; Lute: Lutein; Neox: Neoxanthin.

Table 9 Phenolics and antioxidants of fresh and dried dates[a].

Varieties	Anthocyanins mg/100 g	Phenolics mg/100 g	ORAC μmol trolox/100 g	FRAP μmol/100 g	DPPH %	References
Fresh dates						
Fard	0.9	280	1738	—	—	(Al-Farsi et al., 2005)
Khasab	1.5	167	1169	—	—	(Al-Farsi et al., 2005)
Khalas	0.2	134	2060	—	—	(Al-Farsi et al., 2005)
Average	0.87	193.7	1656			
Dried dates						
Fard	nd	343	999	—	—	(Al-Farsi et al., 2005)
Khasab	nd	217	821	—	—	(Al-Farsi et al., 2005)
Khalas	nd	339	1254	—	—	(Al-Farsi et al., 2005)
Deglet-Noor	—	661	3895	—	—	(Wu et al., 2004)
Medjool	—	572	2387	—	—	(Wu et al., 2004)
Tazerzait	—	3.91	—	—	0.1	(Mansouri et al., 2005)
Tafiziouine	—	4.59	—	—	0.12	(Mansouri et al., 2005)
Deglet noor	—	6.73	—	—	0.17	(Mansouri et al., 2005)
Tantbouchte	—	8.36	—	—	0.22	(Mansouri et al., 2005)
Date (unknown)				6980		(Guo et al., 2003)
Average		239.5	1871	6980	0.15	

[a] All data are expressed on wet weight basis. nd: not detected.

dates. Anthocyanins, found only in fresh date varieties especially the red color varieties, averages 0.87 mg/100 g. The absence of anthocyanins from dried dates is probably due to their destruction during drying process (Al-Farsi et al., 2005; Markakis, 1982; Shahidi and Naczk, 1995). Al-Farsi et al. (2005) reported 100% destruction of dates anthocyanins after drying. In addition, many other factors such as genetics, light, agronomic factors, and storage are also responsible for the degradation of anthocyanins (Shahidi and Naczk, 2004; Mazza and Miniati, 1993). In comparison, Cantos et al. (2002) reported anthocyanins present in red grapes ranged from 7.0 to 15.0 mg/100 g. Also, according to Tomas-Barberan et al. (2001), anthocyanins in peaches ranged from 5.4 to 14.3 mg/100 g for white varieties and from 8.6 to 27.4 mg/100 g for the yellow varieties.

The average contents of phenolics ranged from 193.7 mg/100 g for fresh dates to 239.5 mg/100 g for dried dates. The total phenolics of dates varied among dried varieties; although they used the same methodology (Folin Ciocalteu), the use of different phenolic acid standards, such as ferulic acid and gallic acid, make the quantitative comparison invalid. In general, drying is regarded as unfavorable due to the possibility of inducing oxidative decomposition either enzymatically by polyphenol oxidase and glycosidase or by thermal degradation of phenolic compounds (Shahidi and Naczk, 2004). However, phenolics increased after drying of some varieties. This could be explained by the degradation of tannins by heat and maturation enzymes during the drying process, which leads to the release of phenolic compounds (Maillard and Berset, 1995). According to Maillard and Berset (1995), the linkages between *p*-coumaric acid and lignin and between ferulic acid and arabinoxylans could be broken at high temperature. In comparison with other dried fruits in Table 10, dates can be considered to be a good source of total phenolics.

The total antioxidant content of fresh and dried dates were reported by three different methods, Oxygen Radical Absorbance Capacity (ORAC), Ferric Reducing Ability of Plasma (FRAP),

Table 10 Composition of common dried fruits[a].

Fruits	Moisture g/100 g	Protein g/100 g	Fat g/100 g	Ash g/100 g	Sugars g/100 g	Carbohydrates g/100 g	Energy kcal/100 g	Fiber g/100 g	Vitamin C μg/100 g	Carotenoids mg/100 g	Phenolics mg/100 g	Antioxidants[b] μmol/100 g	Ref.
Dates	15.2	2.1	0.4	1.7	64.1	80.6	314	8.0	3900	0.97	240	1871	
Plum	30.9	2.2	0.38	2.64	38.1	63.9	240	7.1	600	0.69	500	710	(USDA, 2007; Guo et al., 2003; Vizzotto et al., 2006)
Apricot	30.9	3.4	0.51	2.57	53.4	62.6	241	7.3	1000	2.2	160	340	(USDA, 2007; Guo et al., 2003; Ruiz et al., 2006)
Figs	30.1	3.3	0.93	1.86	47.9	63.9	249	9.8	1200	0.032	960	3383	(USDA, 2007; Wu et al., 2004)
Peaches	31.8	3.6	0.76	2.5	41.7	61.3	239	8.2	4800	2.08	163	1863	(USDA, 2007; Wu et al., 2004)
Raisins	15.0	3.1	0.46	1.85	59.2	79.2	299	3.7	2300	—	1065	3037	(USDA, 2007; Wu et al., 2004)

[a] All data are expressed on wet weight basis. [b] Antioxidants was measured by FRAP method for plum and apricot and by ORAC method for the rest.

Table 11 Date seed composition[a].

Varieties	Moisture g/100 g	Protein g/100 g	Fat g/100 g	Ash g/100 g	Carbohydrates g/100 g	Energy kcal/100 g	Fiber g/100 g	Phenolics mg/100 g	Antioxidants μmol/100 g	References
Mabseeli	3.14	3.92	5.02	1.03	86.89	387	79.84	4430	58000	(Al-Farsi et al., 2007)
Um-sellah	4.40	5.40	5.9	1.16	83.14	386	80.15	4293	90300	(Al-Farsi et al., 2007)
Shahal	5.19	2.29	5.09	0.89	86.54	379	77.75	3102	92900	(Al-Farsi et al., 2007)
Fard	10.3	5.7	9.9	1.4	72.7	385	67.8	—	—	(Hamada et al., 2002)
Khalas	7.1	6.0	13.2	1.8	71.9	412	64.5	—	—	(Hamada et al., 2002)
Lulu	9.9	5.2	10.5	1.0	73.4	391	68.8	—	—	(Hamada et al., 2002)
Deglet noor	9.4	5.04	9.23	1.0	75.3	386	—	—	—	(Besbes et al., 2004)
Allig	8.6	4.73	11.58	1.02	74.07	401	—	—	—	(Besbes et al., 2004)
Ruzeiz	5.4	6.43	9.65	1.04	77.48	403	—	—	—	(Sawaya et al., 1984)
Sifri	4.5	5.92	10.03	1.05	78.5	408	—	—	—	(Sawaya et al., 1984)
Average	6.8	5.1	9.0	1.1	78.0	394	73.1	3942	80400	

[a] Data are expressed on wet weight basis.

and DiPhenyl-l-PicrylHydrazyl (DPPH). Most data available for antioxidants in dates is reported by the ORAC method. ORAC values of fresh dates (Fard, Khasab, and Khalas) averaged 1656 μmol trolox/100 g and reduced after drying to average 1025 μmol trolox/100 g (Al-Farsi et al., 2005). The reduction in antioxidants on drying has been reported by Al-Farsi et al. (2005). They found antioxidant loss ranged from 29.7 to 42.5% after sun drying of three date varieties. This loss could be due to the decomposition of natural antioxidants in dates after drying.

The antioxidant content of other dried fruits ranged between 340 μmol/100 g for apricot to 3383 μmol/100 g for figs (Table 10). Thus, in comparison with these fruits, dates are a good source of antioxidants. This finding is supported by other studies published on date antioxidants; Vayalil (2002) and Guo et al. (2003). Although these researchers used different assays methods, which make the quantitative comparison invalid, Vayalil (2002) stated that the antioxidant and the antimutagenic activity in dates is potent and implicates the presence of compounds with potent free radical scavenging activity. Guo et al. (2003) reported that dates had the second highest antioxidant value of 28 fruits commonly consumed in China, and Hawthorn fruit had the highest amount of antioxidants. The variation between samples could be due to varietal, extraction techniques, and instrumental analysis. Unless there is a standard method for antioxidants analysis, such variation could exist.

SEED COMPOSITION

Date seed constitutes between 10% to 15% of date fruit weight (Almana and Mahmoud, 1994; Hussein et al., 1998). At present, date seeds are used mainly for animal feed, whereas most is regarded as waste. Utilization of such waste is very important to date cultivation and to increase the income to this sector. Table 11 shows the composition of different date seed varieties. Date seeds contain relatively high amounts of protein (5.1 g/100 g) and fat (9.0 g/100 g) compared to date flesh. They are a very rich source of dietary fiber (73.1 g/100 g), phenolics (3942 mg/100 g) and antioxidants (80400 μmol/100 g). Date seeds could potentially be considered as an inexpensive source of dietary fiber and natural antioxidants. Therefore, seeds can be used as a functional food ingredient.

CONCLUSION

The data presented in this review show that dates may be considered as a nutritious food and can play a major role in human nutrition and health because of their wide range of nutritional functional components as well as serving as an important healthy food in the human diet. Also, date seeds are rich sources of dietary fiber and natural antioxidative compounds that could potentially be used as a supplement of fiber and antioxidants in nutraceutical, pharmaceutical, and medicine industries.

Based on the International Food Information Council Foundation's definition of functional food (IFICF, 1998), dates and their seeds may be regarded as good examples. They are rich in antioxidant nutrients including selenium, phenolics, and carotenoids. They are also high in insoluble fiber which is important for gastrointestinal health. In comparison with other fruits and vegetables, regarded as functional foods, e.g. grapes and carrots (ADA, 1999), dates are equally as valuable, due to their fiber and antioxidants constituents. For this reason date consumption and utilization of its seed should be recommended.

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