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Physicochemical properties and mineral contents of seven different date fruit (*Phoenix dactylifera* L.) varieties growing from Saudi Arabia

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Abstract The date (*Phoenix dactylifera* L.) fruits (Soukari, Soulag, Barhi, Khulas, Rozaiz, Soughi and Monaif) were evaluated with respect to some physical and chemical properties. While crude protein contents of fruits change between 1.51 % (Soulag) to 2.41 % (Soughi), crude fibre contents ranged between 1.91 % (Soukari) to 3.90 % (Barhi). Vitamin C contents of date samples changed between 971.82 mg/kg (Soughi) to 1,453.15 mg/kg (Barhi). Antioxidant activity of date fruits ranged from 80.07 IC_{50} (Soukari) to 81.21 IC_{50} (Soulag). The highest phenolic content was found in Khulas with a mean value of 198 mg GAE/100 g. Energy values of date fruits ranged from 3,725 kcal/kg (Soulag) to 3,870 kcal/kg (Soukari). Sucrose contents of date fruits changed between 1.02 % (Soulag) to 55.71 % (Soukari). Mineral contents of several date fruits were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES). Date samples contain potassium at a range between 7,468 mg/kg (Khulas) to 9,619 mg/kg (Soulag). Phosphorus contents of fruits were found between 1,848 mg/kg (Soulag) to 3,066 mg/kg (Rozaiz) and followed by magnesium and calcium. The highest Zn (9.33 mg/kg), Cu (4.27 mg/kg) and Mn (3.26 mg/kg) were found in Rozaiz, Soukari and Barhi samples, respectively.

Keywords Date fruits · Compositions · Antioxidant · Phenol · Minerals

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Introduction

The date palm (*Phoenix dactylifera* L.) is one of mankind's oldest cultivated plants. It has been used as food for centuries (Amer 1994; Al-Shahib and Marshall 2003). The date has been an important crop in the desert regions of Arabian countries and has formed the basis of survival for many ancient nomads, and this continues to be true today (Mohammed et al. 1983). On the other hand, fruit exploitation of date palm trees represents an important economical support for indigenous populations (Reynes et al. 1994). Dates are rich in certain nutrients and provide a good source of rapid energy due to their high carbohydrate content (70–80 %). Most of the carbohydrates in dates are in the form of fructose and glucose, which are easily absorbed by the human body (Myhar et al. 1999; Mrabet et al. 2008; Al-Farsi et al. 2005a). Increase in date fruit production will, therefore, play an extremely significant role in worldwide improvement of the nutritional status of people, with special reference to calories and important minerals (Ahmed et al. 1995; Mrabet et al. 2008).

The aim of this study was to establish some physico-chemical properties, sugar composition, total phenol, antioxidant activity and mineral contents of different date fruits growing in Saudi Arabia.

Material and method

Material

Date palm fruits (Soukari, Soulage, Barhi, Khulas, Rozaiz, Soughi and Monaif) were purchased from local markets. The different date varieties were combined together with the same amount of each variety. About 100 g of sample was taken and stoned, and the average pulp and seed weights were determined. The flesh part was crushed until obtaining a homogeneous paste. This paste was preserved t −18 °C until analyses. The seeds were washed to free them from any adhering date flesh and then air dried. A portion of the seed mixture was grounded by a hammer mill, and the moisture content was established. The remainder part was dried at about 50 °C and kept until use.

Physical properties of date fruits

In the date fruit samples of 25 fruits per each palm, 12 fruits were taken randomly from each mass to determine fruit weight and fruit dimensions (length and diameter).

Chemical analyses of date pulp

The moisture content of pulp and pits were established separately by drying a sample (about 5 g) in a drying oven at 100+5 °C during 24 h. Crude fat, crude fibre, crude protein, crude ash and vitamin C values of samples were determined according to the Association of Official Analytical Chemists (AOAC 2000). Energy value was measured by an IKA C2000 calorimeter. Protein content was determined by the Dumas Nitrogen Analyzer (DNA) (Velp NDA 701, Italy). Protein was calculated using the general factor (6.25).

The following are the working conditions of DNA:

O_2 flow rate, 400 mL/min
He flow rate, 195 mL/min
Combustion reactor, 1,030 °C
Reduction reactor, 650
Pressure (millibar), 881.0

Total phenol

Total phenolic compound were estimated using Folin–Ciocalteu (FC) reagent as described by Yoo et al. (2004) with some modifications. About a 0.5-mL aliquot of the aqueous date extract was mixed with 2.5 mL of 1:10 Folin–Ciocalteu reagent and 1.5 mL of 20 % Na_2CO_3. Absorbance was measured at 517 nm after 30 min standing at room temperature. Gallic acid was used as a standard, and the total phenolics were expressed as milligrams per gram of gallic acid equivalents (GAE).

Radical scavenging assay

The free radical scavenging activity of the extracts was determined by using 1,1-diphenyl-2-picrylhydrazyl or DPPH (Lee et al. 1998).

Sugar analyses

Sugars were extracted from 1 g of broyat by a 100-mL water solution. The supernatant was filtered by a 0.45-μm filter and was analysed by HPLC, using a chromatograph of the type Agilent 1100. The mobile phase was distilled water. The separation was carried out on a Bio-Rad HPLC Carbohydrate Analysis Column Aminex HPX-87C Carbohydrate Column (300 mm× 7.8 mm). The flow rate is 0.60 mL/day. The name of the program is HP Chem/Core/HP Core.Exe. Sugar quantifications were made by comparison to the standards glucose, fructose and sucrose (Merck).

Determination of mineral contents

Collected date samples were dried at 70 °C in a drying cabinet with air circulation until they reached constant weight. Later, about 0.5 g of dried and ground sample was digested by using 5 mL of 65 % HNO_3 and 2 mL of 35 % H_2O_2 in a closed microwave system (Cem-MARS Xpress) at 200 °C. The volumes of the digested samples were completed to 20 mL with ultra-deionized water, and mineral concentrations were determined by inductively coupled plasma-optical emission spectroscopy (ICP-AES) (Varian-Vista, Australia). Distilled deionized water and ultrahigh-purity commercial acids were used to prepare all reagents, standards and samples. After digestion treatment, samples were filtrated through Whatman no. 42. The filtrates were collected in 50-mL flasks and analysed by ICP-AES. The mineral contents

Table 1 Some physical and chemical properties of different date fruits

Date varieties	Moisture (%)	Fruit weight (g)	Ash (%)	Crude oil (%)	Crude protein (%)	Crude fibre (%)
Soukari	4.82±0.13[a]	8.033	2.13±0.12	0.14±0.02	2.32±0.06	1.91±0.09
Soulage	2.11±0.07	5.467	2.22±0.17	0.17±0.01	1.51±0.03	2.89±0.17
Barhi	2.13±0.06	6.391	2.00±0.18	0.13±0.03	2.34±0.17	3.90±0.26
Khulas	1.92±0.03	6.030	1.68±0.08	0.20±0.02	2.10±0.13	3.22±0.32
Rozaiz	2.42±0.03	4.944	1.71±0.07	0.21±0.05	1.67±0.09	3.01±0.27
Soughi	2.06±0.06	7.995	2.15±0.09	0.18±0.01	2.41±0.21	3.00±0.36
Monaif	1.97±0.09	7.673	1.84±0.05	0.14±0.01	2.18±0.16	2.84±0.18

[a]Mean ± standard deviation, $n=3$

of the date samples were quantified against standard solutions of known concentrations which were analysed concurrently (Skujins 1998).

The following are the working conditions of ICP-AES:

Instrument: ICP-AES (Varian-Vista)
RF power, 0.7–1.5 kW (1.2–1.3 kW for axial)
Plasma gas flow rate (Ar), 10.5–15 L/min (radial) 15″ (axial)
Auxilary gas flow rate (Ar), 1.5″
Viewing height, 5–12 mm
Copy and reading time, 1–5 s (max 60 s)
Copy time, 3 s (max 100 s)

Statistical analyses

Results of the research were analysed for statistical significance by analysis of variance (Püskülcü and İkiz 1989).

Results and discussion

The weight of fruit was found between 4.944 g (Rozaiz) to 7.995 g (Soughi). The total oil contents of riped date fruits were established between 0.13 % (Barhi) to 0.21 % (Rozaiz). As seen, oil contents of fruits were found at the very low levels (Table 1). While crude protein contents of fruits change between 1.51 % (Soulag) to 2.41 % (Soughi), crude fibre contents ranged from 1.91 % (Soukari) to 3.90 % (Barhi). Also, ash contents of samples were determined between 1.68 % (Khulas) to 2.22 % (Soulag) (Table 1). The overall composition of physical and chemical properties of date fruits markedly varied among various cultivars. The fruits (dates) of the date palm contain a high percentage of carbohydrate (total sugars, 44–88 %), fat (0.2–0.5 %) and protein (2.3–5.6 %) (Al-Shahib and Marshall 2003). Jamil et al. (2010) determined 0.84–9.8 % moisture, 1.82–2.87 % ash and 352.329–425.147 kcal/100 g energy.

Vitamin C had been established at the high levels in all date fruits. Vitamin C contents of samples changed between 971.82 mg/kg (Soughi) to 1,453.15 mg/kg (Barhi) (Table 2). Results showed that vitamin C content had ranged according to varieties. This content was found 971.82 for Soughi variety and was only 1,453.15 for Barhi. Previously, Mrabet et al. (2008) reported that Tunisian date varieties were rich in vitamin C for Littorial (24 to 46 mg/100 g) and Deglet Nour (1.12 mg/100 g). Sawaya et al. (1982) studied on a large number of date cultivars and reported that ascorbic acid

Table 2 Biochemical properties of different date fruits

Varieties	Vitamin C (mg/kg)	Antioxidant activity (DPPH, IC_{50})	Total phenol (mg GAE/100 g)
Soukari	1,087.84±2.18[a]	80.07±1.17	1.19±0.06
Soulag	1,164.32±3.21	81.21±0.78	1.13±0.07
Barhi	1,453.15±3.67	81.17±0.76	0.94±0.04
Khulas	1,029.90±2.78	81.13±1.02	1.98±0.08
Rozaiz	1,064.62±1.69	80.69±0.98	1.28±0.03
Soughi	971.82±3.21	80.84±0.69	1.63±0.06
Monaif	1,152.56±2.57	80.54±1.13	1.48±0.07

[a]Mean ± standard deviation, $n=3$

Table 3 Energy and sugar values of different date fruits

Varieties	Energy (kcal/kg)	Sucrose (%)	Glucose (%)	Fructose (%)
Soukari	3,870	55.71	22.50	21.79
Soulage	3,725	1.02	51.78	47.20
Barhi	3,945	1.50	18.25	16. 5
Khulas	3,840	1.70	50.44	47.86
Rozaiz	3,755	1.24	51.70	47.06
Soughi	3,830	2.15	49.79	48.06
Monaif	3,760	1.19	49.87	48.94

content varied greatly between cultivars and cultivation regions and between biser (Khalal) and tamer dates and ranged from 1.8 to 11.4 and 1.1 to 6.1 mg per 100 g, respectively. Youssef et al. (1982) showed in Iraqi dates a weak rate in vitamin C, varying from 2.41 to 17.51 mg/100 g. Rates of 2 mg/100 g were determined by Cance and Widdowson (1993). Vitamin C levels were determined in date fruits as shown in Table 2. Significant variation in vitamin C concentration did not exist within the different cultivars. In a previous study, the cultivar Murzaban showed the lowest ascorbic acid content in both stages biser and rutab, with 2.5 and 1.3 mg per 100 g FW, respectively (Alaith 2008).

Based on dates' availability, seven cultivars were analysed for antioxidant activity at the ripe stage. The mean antioxidant activity values for the varieties examined in this study are shown in Table 2. Cultivars at the present stage possessed the highest antioxidant activity. These values ranged between 80.07 IC_{50} (Soukari) to 81.21 IC_{50} (Soulag). Generally, antioxidant activities of samples were found similar. No significant difference was found between date fruit varieties. The highest total antioxidant activity was found at biser (unripe) stage, with a mean ferric reducing antioxidant power (FRAP) value of 5.71±4.31 mmol/100 g fresh weight (FW), followed by rutab (soft and ripped) with FRAP values of 1.2 mmol per 100 g FW and tamer (dried fruit) 0.94±0.21 mmol per 100 g FW (Alaith 2008). Date presented in this study demonstrated that certain date fruits at ripened stages are rich in the level of antioxidants. Such high antioxidant activity was partly reported by other studies that were only confined to riped and dried date fruits (Alaith 2008).

Seven of the date varieties were evaluated for total phenolics (Table 2). Non-large variation in the level of phenolics was found between cultivars. The highest phenolic content was found in Khulas with a mean value of 198 mg GAE/100 g. The overall average total phenolics of biser, rutab and data were 196.8, 116.7 and 159.9 mg GAE 100 g fresh weight, respectively (Alaith 2008).

Date fruits undergo many physical and chemical changes during maturation. Some of these changes, such as the decrease in the concentration of tannins, ascorbic acid and β-carotene directly affect their antioxidant capacity (Alaith 2008). The total phenolic content reported by Al-Farsi et al. (2005b) for several Omani tamer varieties ranged between 217 and 343 mg per 100 g. Provided more information about the concentration and the state of phenolics in date fruits. They reported that the average of soluble free phenolics was 257 and 400 mg of catechin equivalent (CE) per 100 g FW, whereas the insoluble acid extractable total phenolics were 2,546 and 1,959 mg CE per 100 g FW in fresh and dried dates, respectively. Phenolic compounds which have been identified in date fruits and that may

Table 4 Mineral contents of different date fruits (milligram per kilogram)

Dates	Minerals										
	Ca	Mg	K	P	Fe	Zn	Cu	Mn	B	Cr	Ni
Soukari	550±11[a]	734±10	9,309±97	2,190±33	29.8±1.1	5.63±0.18	4.27±0.03	2.35±0.04	16.4±0.1	1.74±0.05	0.3±0.1
Soulage	545±18	551±26	9,619±300	1,848±150	39.8±2.4	4.39±0.23	2.40±0.31	2.09±0.13	12.5±1.0	1.63±0.16	1.3±0.2
Barhi	621±7	762±5	9,289±60	2,024±92	24.4±0.3	6.15±0.16	3.92±0.08	3.26±0.08	16.4±0.3	1.64±0.26	0.4±0.1
Khulas	448±13	615±21	7,468±242	2,005±131	25.4±2.0	3.28±0.16	2.29±0.08	1.85±0.13	10.8±0.5	1.67±0.20	1.1±0.2
Rozaiz	357±25	496±4	7,855±100	3,066±39	29.5±1.9	9.33±0.72	3.75±0.25	0.99±0.11	13.5±0.4	2.07±0.17	1.4±0.4
Soughi	516±2	638±17	9,112±174	1,919±118	28.5±0.1	4.72±0.20	2.53±0.16	2.44±0.11	10.8±0.9	1.13±0.19	0.6±0.1
Monaif	533±7	553±13	8,464±176	2,273±225	30.8±1.1	5.22±0.43	2.48±0.26	1.54±0.09	10.5±0.4	2.18±0.34	2.7±0.5

[a] Mean ± standard deviation, $n=3$

contribute to the antioxidant activities include proto chatechuic, *p*-hydroxybenzoic, syringic, vanillic, caffeic, *p*-coumaric and ferulic (Regnalut-Roger et al. 1987; Mansouri et al. 2005).

Sugar compositions of date fruits are given in Table 3. Several reports were interested in the sugar date compositions. Myhar et al. (1999) considered the percentage of reducing sugar as criteria for date qualities. Sucrose contents of date fruits changed between 1.02 % (Soulag) to 55.71 % (Soukari). Energy values of date fruits ranged between 3,725 kcal/kg (Soulag) to 3,870 kcal/kg (Soukari) (Table 3). The concentration of total sugars in the Kimri stages varies from 3.4 to 7.7 %, and the concentration of total sugars in the Khalal stage varies from 18.8 to 31.9 % (Ahmed et al. 1995). In other varieties of date, the concentration of total sugars is as high as 88 % (Shinwari 1993). The percentage of glucose and fructose in the flesh of Barhi dates increases from the Kimri stage (4.9 and 2.8 %, respectively) to the Khalal stage (13.1 and 11.8 %, respectively) through the Rutab stage (21.4 and 19.4 %, respectively) to the Tamer stage (29.7 and 27.6 %, respectively) (Al-Shahib and Marshall 2003). While glucose contents of several date fruits change between 18.25 % (Barhi) to 51.78 % (Soulag), fructose contents ranged between 21.79 (Soukari) to 48.94 % (Monaif). Depending on date varieties, there were established differences in glucose and fructose contents of fruits. In a previous study, the rapid buildup fructose and glucose at Rutab and Tamar stages is an excellent source of carbohydrate (El-Sharawy et al. 1989; Al-Jasser 2009). Al-Jasser (2009) reported that fructose and glucose contents of date fruits at different stages of ripening in in vitro culture and off shoot date fruit (grams per 100 g wet weight) were found between 2.50 to 33.24 and 5.56 to 28.53, respectively.

Mineral contents of different date fruits are given in Table 4. Among the minerals of date fruits, potassium concentrations were found at the high levels compared with those of others. Potassium contents ranged between 7,468 mg/kg (Khulas) to 9,619 mg/kg (Soulag). Phosphorus contents of fruits were found between 1,848 mg/kg (Soulag) and 3,066 mg/kg (Rozaiz) and followed by magnesium and calcium. Iron contents ranged from 24.4 to 39.8. The Cu, Mn and Zn contents of date fruits were determined between 0.99 and 9.33 mg/Kg. The highest Zn (9.33 mg/kg), Cu (4.27 mg/kg) and Mn (3.26 mg/kg) were found in Rozaiz, Soukari and Barhi samples, respectively. The amount of Ca, Mg, K and P were calculated higher at Barhi, Soulag and Rozaiz, respectively. The other elements in descending order were sodium, iron, zinc and copper. The variations could be due to agro-climatic changes. Al-Shahib and Marshall (2003) reported that lulu date cultivar contained 38.7 mg/100 g Ca, 0.4 mg/100 g Cu, 4.2 mg/100 g Fe, 132.7 mg/100 g Mg, 152.2 mg/100 g P, 633.2 mg/100 g K, 9.7 mg/100 g Na, and 1.6 mg/100 g Zn.

Booij et al. (1992) classified dates on three groups thanks to their composition in potassium (K), calcium (Ca), magnesium (Mg) and phosphorus (P) with percentages of 0.6, 0.05, 0.04 and 0.045 %, respectively. The mineral analysis showed that the littoral dates were relatively rich in potassium (283 to 73 mg/100 g) and presented a weak content in sodium (0.06 to 0.09 mg/100 g). According to the mineral composition of the different date varieties vary according with their geographical origin. The current results seems to confirm those mentioned by Youssef et al. (1982) which showed that the mineral variations in fruits can, in general, show considerable variations not only between the species and the varieties but also within the same varieties cultivated under different agro-climatic conditions.

As a result, obtained values provide an important data to explain the proximate changes at seven different date varieties. More studies on the effect of processing conditions on date composition and technological properties should be carried out.

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