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Compositional and functional characteristics of dates, syrups, and their by-products

Mohamed Al-Farsi [a,*], Cesarettin Alasalvar [b], Mohammed Al-Abid [a], Khalid Al-Shoaily [a], Mansorah Al-Amry [a], Fawziah Al-Rawahy [a]

[a] *Plant Research Centre, Ministry of Agriculture and Fisheries, P.O. Box 292, P.C. 132, Al-Khoud, Muscat, Oman*
[b] *TÜBİTAK Marmara Research Centre, Food Institute, P.O. Box 21, 41470 Gebze/Kocaeli, Turkey*

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Abstract

Three native sun-dried date varieties from Oman (namely Mabseeli, Um-sellah, and Shahal), as well as their syrups and by-products (press cake and seed) were examined for their proximate composition, dietary fibre, total phenolics, and total antioxidant activity. Carbohydrate was the predominant component in all date varieties, syrups, and their by-products, followed by moisture, along with small amounts of protein, fat, and ash. Press cakes had the highest protein content, ranging in concentration from 3.62 g/100 g in Shahal to 5.23 g/100 g in Mabseeli, whereas fat was the highest in seeds and ranged from 5.02 g/100 g in Mabseeli to 5.90 g/100 g in Um-sellah. Seeds and press cakes were found to be good sources of dietary fibre, varied between 77.75 and 80.15 g/100 g fresh weight and between 25.39 and 33.81 g/100 g fresh weight, respectively. Among dates, syrups, and their by-products, seeds had the highest contents of total phenolics (3102–4430 mg of gallic acid equivalents/100 g fresh weight) and antioxidant activity (580–929 μmol of Trolox equivalents/g fresh weight). The results obtained suggest that date by-products (particularly seeds) serve as a good source of natural antioxidants and could potentially be considered as a functional food or functional food ingredient.

Keywords: Date; Syrup; Press cake; Seed; Dietary fibre; Total phenolics; Total antioxidant activity

1. Introduction

Oman produced 240 000 metric tons of dates in 2005, contributing around 3.5% to the total global production (MAF, 2006). According to the Omani Ministry of Agriculture and Fisheries (MAF, 2005), date palm cultivation accounted for 49% of the total cultivated land and date production, representing 81% of the total fruit production. In 2004, surplus from dates were 52 000 metric tons, 32% of which were from low quality dates such as Mabseeli, Um-sellah, and Shahal (MAF, 2005). Therefore, utilisation of such surplus is very important to maintain dates cultivation and to increase the income of that sector. 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 (Al-Farsi, Alasalvar, Morris, Baron, & Shahidi, 2005a; Myhara, Karkalas, & Taylor, 1999).

Epidemiological studies have consistently shown that high fruit and vegetable consumption is associated with a reduced risk of several chronic diseases such as coronary heart disease (CHD), cardiovascular disease (CVD), cancers, aging, atherosclerosis, neurodegenerative diseases (such as Parkinson and Ahlzeimer), and inflammation, among others (Dillard & German, 2000; Fuhrman, Lavy, & Aviram, 1995; Joseph et al., 1999; Prior & Cao, 2000; Wargovich, 2000). This is attributed to the fact that these foods may provide an optimal mixture of phytochemicals

* Corresponding author. Tel.: +968 26893917; fax: +968 26893097.
E-mail address: malfarsi61@hotmail.com (M. Al-Farsi).

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such as dietary fibre, phenolics, natural antioxidants, and other bioactive compounds.

To best of our knowledge, limited data is available regarding the compositional and functional characteristics of date by-products grown in Oman. Detailed information on nutritional composition and health-promoting components of dates and their by-products will enhance our knowledge and appreciation for the use of dates, syrups, and their products in a variety of food and specialty products, including their use as functional foods and ingredients in nutraceuticals, pharmaceuticals, and medicine. The objectives of this research were to compare the existing differences in compositional and functional characteristics of three low quality of date varieties, as well as their syrups and by-products (press cakes and seeds) grown in Oman.

2. Materials and methods

2.1. Materials

Three native sun dried date varieties, namely Mabseeli, Um-sellah, and Shahal, were procured from Batinah region, Oman, at the beginning of the 2005 harvest season. Mature fruits of uniform size, free of physical damage and injury from insects and fungal infection, were selected and used for all experiments.

2.2. Chemicals

All chemicals and solvents were obtained from Sigma–Aldrich Co. Ltd. (Dorset, UK), unless otherwise specified.

2.3. Syrup production

Syrups from three date varieties were produced according to the method of Al-Farsi (2003). Briefly, dates were extracted twice with water (1:1) at 60 °C and then filtered through a Whatman no. 41 filter paper. Clear juice was concentrated to 72 °Brix using rotary evaporator at 70 °C. Finally, syrup, press cake (date flesh), and seeds were obtained.

2.4. Proximate analysis

Percentages of moisture by vacuum oven (method 934.06), protein by Kjeldahl nitrogen (method 920.152), and ash by direct analysis (method 940.26) were determined according to the Association of Official Analytical Chemists' methods (AOAC, 1995). The percentage of crude protein was estimated by multiplying the total nitrogen content by a factor of 6.25 (AOAC, 1995). The Bligh and Dyer method (Hanson & Olley, 1963) was used to determine the lipid content. Total carbohydrates were calculated by subtracting the total percent values of other measurements from 100. Proximate analyses were expressed as grams per 100 g of fresh weight.

2.5. Dietary fibre analysis

Determination of dietary fibbers was carried out using the AOAC enzymatic-gravimetric official method (991.43) (AOAC, 1995). The sample was de-sugared by three extractions, each with 85% ethanol (10 ml/g), and then dried overnight at 40 °C. Otherwise, the total dietary fibre content would have been overestimated. The flow diagram outlined by the AOAC procedure was followed. Contents of crude protein (percentage total nitrogen X 6.25) and ash determined by using the methods described above were used to correct the fibre content. Dietary fibre was expressed as grams per 100 g of fresh weight.

2.6. Measurement of total phenolics

Total phenolics were determined colorimetrically using Folin-Ciocalteau reagent as described by Al-Farsi, Alasalvar, Morris, Baron, and Shahidi (2005b), using a UV-1601 spectrophotometer (Shimadzu, Kyoto, Japan). The concentrations are expressed as milligrams of gallic acid equivalents (GA) per 100 g of fresh weight.

2.7. Measurement of total antioxidants

An improved oxygen radical absorbance capacity (ORAC) method of Ou, Hampsch-Woodill, and Prior (2001), using fluorescein (FL) as the fluorescent probe, was used with slight modifications. The $ORAC_{FL}$ assay measures the ability of antioxidative compounds in test materials to inhibit the decline in fluorescence induced by peroxyl radical 2,2′-azobis (2-amidinopropane) dihydrochloride (AAPH). The $ORAC_{FL}$ values were calculated according to the method of Wang, Cao, and Prior (1996) and Al-Farsi et al. (2005b) and $ORAC_{FL}$ values are expressed as micromoles of Trolox equivalents (TE) per gram of fresh weight.

2.8. Statistical analysis

Results were expressed as mean ± standard deviation (SD) ($n = 3$) on an extract. Statistical significance (t-test: two-sample equal variance, using two-tailed distribution) was determined using Microsoft Excel statistical software (Microsoft Corporation, Microsoft Office Excel 2003, Redmond, WA). Differences at $P < 0.05$ were considered to be significant.

3. Results and discussion

3.1. Weight and proximate analysis

Syrups had the highest weight (52–63.7 g/100 g), followed by press cakes (17.4–28.0 g/100 g), and seeds (7.8–14.8 g/100 g) (Table 1). Low temperature (60–70 °C) of extraction and concentration was used in order to minimise the effect of heat on syrup quality. No significant differ-

Table 1
Weight, proximate composition, dietary fibre, total phenolics and antioxidant activity of dates, syrup and their by-products[1]

	Date fruit	Date flesh	Syrup	By-products	
				Press cake	Seed
Weight[2]					
Mabseeli	11.19 ± 0.79^a	10.30 ± 0.79^a	61.0^a	24.0^a	7.8^a
Um-sellah	4.53 ± 0.39^b	3.85 ± 0.42^b	63.7^a	17.4^b	14.8^b
Shahal	5.71 ± 0.82^c	4.97 ± 0.81^c	52.0^b	28.0^c	12.9^c
Proximate composition[3]					
Mabseeli					
Protein		1.15 ± 0.08	0.95 ± 0.03	5.23 ± 0.23	3.92 ± 0.32
Fat		3.25 ± 0.18	2.84 ± 0.19	1.40 ± 0.13	5.02 ± 0.32
Moisture		14.58 ± 0.26	20.56 ± 0.28	9.80 ± 0.20	3.14 ± 0.09
Ash		1.41 ± 0.04	1.41 ± 0.08	1.71 ± 0.04	1.03 ± 0.07
Carbohydrates		79.61 ± 0.56	74.24 ± 0.58	81.86 ± 0.60	86.89 ± 0.80
Um-sellah					
Protein		1.79 ± 0.17	0.95 ± 0.04	4.33 ± 0.09	5.40 ± 0.17
Fat		2.04 ± 0.15	2.43 ± 0.14	1.58 ± 0.09	5.90 ± 0.47
Moisture		9.73 ± 0.07	21.21 ± 0.52	8.30 ± 0.20	4.40 ± 0.05
Ash		1.99 ± 0.01	1.76 ± 0.02	2.46 ± 0.21	1.16 ± 0.04
Carbohydrates		84.45 ± 0.40	73.65 ± 0.72	83.33 ± 0.59	83.14 ± 0.73
Shahal					
Protein		1.10 ± 0.07	1.09 ± 0.03	3.62 ± 0.19	2.29 ± 0.21
Fat		2.20 ± 0.17	0.62 ± 0.05	2.20 ± 0.11	5.09 ± 0.31
Moisture		17.52 ± 0.12	34.33 ± 0.28	10.59 ± 0.02	5.19 ± 0.06
Ash		1.84 ± 0.15	1.23 ± 0.12	1.68 ± 0.12	0.89 ± 0.02
Carbohydrates		77.34 ± 0.51	62.73 ± 0.48	81.91 ± 0.44	86.54 ± 0.51
Dietary fibre[4]					
Mabseeli		5.94 ± 0.07^a	0.18 ± 0.02^a	26.53 ± 0.75^a	79.84 ± 1.85^a
Um-sellah		8.72 ± 0.09^b	0.29 ± 0.03^b	33.81 ± 3.37^b	80.15 ± 3.19^b
Shahal		8.46 ± 0.52^b	0.01 ± 0.01^c	25.39 ± 2.27^a	77.75 ± 1.97^a
Total phenolics[5]					
Mabseeli		246 ± 8.3^a	162 ± 10.4^a	435 ± 11.6^a	4430 ± 297^a
Um-sellah		186 ± 13.3^b	141 ± 9.3^b	229 ± 18.5^b	4293 ± 180^a
Shahal		172 ± 6.6^c	96 ± 2.3^c	165 ± 8.1^c	3102 ± 58^b
Antioxidant activity[6]					
Mabseeli		150 ± 3.4^a	84 ± 0.9^a	357 ± 20^a	580 ± 29^a
Um-sellah		146 ± 5.6^a	174 ± 6.6^b	158 ± 2.8^b	903 ± 46^b
Shahal		162 ± 5.9^b	106 ± 0.2^c	134 ± 11^c	929 ± 24^b

1 Means ± SD followed by the same letter, within a column, are not significantly different ($P > 0.05$).
2 Fruit and flesh weight are expressed in grams ±SD ($n = 10$), whereas syrup, press cake, and seed are expressed as g/100 g of fruit.
3 Data are expressed as g/100 g ± SD ($n = 3$).
4 Data are expressed as g/100 g ± SD ($n = 3$) on a fresh weight basis.
5 Data are expressed as milligrams of gallic acid equivalents (GA) per 100 g ±SD ($n = 3$) on a fresh weight basis.
6 Data are expressed as micromoles of Trolox equivalents (TE) per gram ±SD ($n = 3$) on a fresh weight basis.

ences ($P > 0.05$) existed between Mabseeli and Um-sellah syrups, whereas significant differences ($P > 0.05$) were found between these two syrups and syrup from Shahal. This was due low concentration of juice extracted from Shahal (20 °Brix) in comparison with Mabseeli (24 °Brix) and Um-sellah (24 °Brix).

Carbohydrate was the predominant component in all date varieties, syrups, and their by-products, followed by moisture, along with small amounts of protein, fat, and ash (Table 1). Moisture contents of date fleshes varied between 9.73 and 17.52 g/100 g, being lowest in Um-sellah and highest in Shahal. These differences were due to uncontrolled condition of sun-drying. Moisture contents of syrups from Mabseeli and Um-sellah varieties were the same as they were concentrated to 72 °Brix, whereas syrup from Shahal had higher moisture content than others as it was concentrated to 63 °Brix due to its increased viscosity. Press cakes had the highest protein content, ranging in concentration from 3.62 g/100 g in Shahal to 5.23 g/100 g in Mabseeli, whereas fat was the highest in seeds and ranged from 5.02 g/100 g in Mabseeli to 5.90 g/100 g in Um-sellah. Values for date fleshes were within the range of results previously published results in the literature (Al-Farsi et al., 2005a; Barreveld, 1993).

3.2. Dietary fibre

Total dietary fibre contents in Mabseeli, Um-sellah, and Shahal were 5.94, 8.72, and 8.46 g/100 g fresh weight, respectively (Table 1). Seeds and press cakes were found to be good sources of dietary fibre, varied between 77.75 and 80.15 g/100 g fresh weight and between 25.39 and 33.81 g/100 g fresh weight, respectively. In contrast, syrup contained trace amounts of total dietary fibre.

Al-Shahib and Marshall (2002), who surveyed the total dietary fibre contents of 13 date varieties from various countries, found that the percentage of total dietary fibre was in the range of 6.4–11.5%, depending on variety and degree of ripeness. Recently, we analysed dietary fibre content of three sun-dried date varieties (Fard, Khasab, and Khalas) and found that total dietary fibre contents ranged from 6.26 to 8.44 g/100 fresh weight (Al-Farsi et al., 2005a). The current results are within the range of our previous findings. There is no data available on dietary fibre of date by-products. Barreveld (1993) reported the crude fibre contents of pit (seed) and press cake of other date varieties, which ranged from 10 to 20 g/100 g and from 9 to 22 g/100 g, respectively. These values are much lower than those found in this study due to the differences between crude and dietary fibre analysis. Crude fibre is the residue of plant cells after extraction by acid and alkaline hydrolysis. The acid hydrolysis removes free sugars and starch, and alkaline hydrolysis removes protein and some carbohydrates. This process also removes some hemicellulose and lignin; therefore, only partial recovery of fibre components is achieved. Whereas dietary fibre measured the remnants of plant cells resistant to the alimentary enzymes of humans.

The dietary fibre contents of a number of fresh fruits, namely apples, apricots, berries, grapes, oranges, peaches, and plums, were reported by Marlett et al. (1994). The values obtained ranged from 1.0 g/100 g for grapes to 4.4 g/100 g for raspberries. In addition, the contents of dietary fibre in dried apricots, prunes, figs, and raisins were 7.7, 8.0, 12.2, and 5.1 g/100 g, respectively (Camire & Dougherty, 2003; Marlett et al., 1994; Vinson, 1999). Thus, dates and their by-products serve as good sources of fibre compared with syrups and other fresh and most dried fruits. Although no recommended dietary allowances (RDA) has been set, most health/nutrition professionals agree on the benefits of increased consumption of dietary fibre to 25–35 g/day (Dreher, 1987; NACNE, 1983).

3.3. Total phenolics

Of the varieties studied, significant differences ($P < 0.05$) in total phenolic contents were observed (Table 1). Among dates, syrups, and their by-products, seeds contained the highest contents of total phenolics (3102–4430 mg of GAE/100 g fresh weight). Mabseeli flesh had the highest amount of total phenolics (246 mg of GAE/100 g), followed by Um-sellah (186 mg of GAE/100 g), and Shahal (172 mg of GAE/100 g). Press cakes and syrups were also found to be good sources of total phenolics.

No data is available in the literature regarding total phenolic contents of date by-products. In our previous study (Al-Farsi et al., 2005b), we found that the mean total content of phenolics ranged from 134 to 280 mg of ferulic acid equivalents (FAE)/100 g and 217–343 mg of FAE/100 g in fresh and sun-dried date varieties (Fard, Khasab, and Khalas), respectively. Our previous results are comparable with those found in the present study despite being used different phenolic acid standards for quantification. Mansouri, Embarek, Kokkalou, and Kefalas (2005) studied the phenolic profiles of seven different varieties of ripe date fruits grown in Algeria. They found that total phenolic content ranged from 2.49 to 8.36 mg of GAE/100 g fresh weight. Recently, Wu et al. (2004) reported much higher contents of total phenolics in two date varieties than those of Mansouri et al. (2005), which were 661 and 572 mg of GAE/100 g fresh weight in Deglet Noor and Medjol varieties, respectively. Various factors such as variety, growing condition, maturity, season, geographic origin, fertilizer, soil type, storage conditions, and amount of sunlight received, among others, might be responsible for the observed differences.

In comparison with fresh fruits (Ancos, Gonzalez, & Cano, 2000; Gil, Tomás-Barberán, Hess-Pierce, & Kader, 2002; Imeh & Khokhar, 2002; Moyer, Hummer, Finn, Frei, & Wrolstad, 2002; Prior et al., 1998) and dried fruits (Wu et al., 2004), dates and their by-products (particularly seeds) may be considered as rich sources of total phenolics.

3.4. $ORAC_{FL}$

Significant differences ($P < 0.05$) in $ORAC_{FL}$ values were observed among date varieties, with some exceptions (Table 1). Among the flesh samples, Shahal flesh had the highest antioxidant activity (162 μmol of TE/g fresh weight), followed by Mabseeli (150 μmol of TE/g fresh weight), and Um-sellah (146 μmol of TE/g fresh weight). Wu et al. (2004) measured total antioxidant activity (lipophilic and hydrophilic $ORAC_{FL}$) of two date varieties and values were lower than those reported in this study. These significant variations among date samples could be due to varietal, extraction techniques used, ORAC version, and instrumental analysis (manual or automated). Unless there is standard method for antioxidant analysis, such variations could exist.

The high antioxidant of dates is supported by Vayalil (2002) and Guo et al. (2003). Although these researchers used different methods and extraction solvents, which make any quantitative difficult, Vayalil (2002) stated that potent antioxidant and antimutagenic activities of dates implicate free radical scavenging activity. In addition, Guo et al. (2003) reported that dates had the second highest antioxidant value of 28 fruits commonly consumed in China. The antioxidant activity of figs, prunes, and raisins when determined by the $ORAC_{FL}$ assay were found to be 34, 86, and 30 μmol of TE/g fresh weight, respectively (Wu et al., 2004). Thus in comparison with these fruits, dates are good sources of antioxidants. With regard to by-products, seeds had the highest antioxidant activity in all varieties ranging from 580 to 929 μmol of TE/g fresh weight. The highest $ORAC_{FL}$ values in seeds are due to their highest phenolic contents.

4. Conclusions

The results presented here suggest that date by-products, in particular seeds, serve as a good source of dietary fibre, total phenolics, and antioxidant activity that could potentially be considered as inexpensive source of natural antioxidants. Therefore, these by-products can be used as a functional food or functional food ingredient. Further research is needed to identify and quantify the composition of phenolic acids and flavonoids in date by-products.

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