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FULL LENGTH ARTICLE

Functional composition and antioxidant activities of eight Moroccan date fruit varieties (*Phoenix dactylifera* L.)

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Abstract The aim of this study was to determine the functional composition and antioxidant activities of eight major date fruit varieties grown in Morocco. The analysis shows that date fruit contains a high amount of sugar (66.03–83.05% DW) but a low content of fat (0.218–0.363% DW) and protein (2.2–3.45% DW). Among the eight studied minerals potassium, calcium and magnesium were the predominant. Moreover, the niacin is the major B vitamin of all analyzed varieties. The total phenolic content was found between 331.86 and 537.07 mg GAE/100 g DW, the flavonoid between 68.88 and 208.53 mg of RE/100 g DW and condensed tannins between 57.56 and 92.141 mg CE/100 g DW, the antioxidant activity ranged between 383.90 and 846.94 μmol TE/100 g DW for ABTS, 6.255 and 2.046 g of date/l for $DPPH_{IC50}$ and 406.614 and 860.89 μmol TE/100 g DW for FRAP assays. The results suggest that date fruit, which is good source of vital nutrients and antioxidant, is an extensive and varied field.

1. Introduction

Date palm is the most important arboricultural crop of the arid regions in Morocco. It has been cultivated for its edible sweet fruit, energy boosters, hunger pacifiers, and its many medicinal properties such as antimutagenic, gastroprotective, hepatoprotective, nephroprotective, immunostimulant and gonadotropic activities (Baliga et al., 2011).

The date fruit contains a wide range of nutritional functional components. It is rich in easily digestible sugars such as glucose and fructose. It represents a good source of fibers

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and traces elements such as potassium, phosphorus, magnesium, calcium, selenium and iron and vitamins such as ascorbic acid, niacin, and pyridoxine. It contains also bioactive components such as anthocyanins, phenolics, carotenoids, procyanidins, and flavonoids which offer protection against oxidative stress (Abdul and Allaith, 2008; Al-Farsi et al., 2005).

Morocco produces yearly more than 113 thousand tones and ranks the thirteenth largest producer in the world (FAOSTAT, 2012). This production is characterized by the predominance of clones from spontaneous natural seedlings named locally "*khalts*" which represent 55.6%. The rest of this production is made up of 223 varieties, each with its own taste and texture (Toutain et al., 1971).

The aim of this study was to enhance the knowledge regarding the compositional and nutritional characteristics of date varieties grown in Morocco, which are the less studied in the date producing countries. This study will shed light on the composition of eight date fruit varieties, considered to be premium quality and the most consumed in Morocco, in terms of the quantity of minerals, vitamins, sugar, protein, fat, phenolic, flavonoid and condensed tannins contents. It will also evaluate their antioxidant activity using three different in vitro assays: DPPH, ABTS and FRAP.

2. Materials and methods

2.1. Plant materials

Eight Moroccan date varieties locally known as *Boufgous*, *Bouskri*, *Bousrdon*, *Bousthammi*, *Bouzgagh*, *Jihl*, *Majhoul* and *Najda* were obtained at Tamr stage from Errachidia National Institute for Agricultural Research. The samples were rinsed, pitted and stored at −20 °C until extraction and analysis.

2.2. Composition analysis

The total nitrogen was determined by the Kjeldahl method (AOAC, 1997) then the Protein amount was calculated using a factor of 6.25. The Lipid was determined from dried date macerated using Soxhlet extraction (AOAC, 1997). The moisture was determined by oven-drying at 105 °C to constant weight (AOAC, 1997).

2.3. Sugar determination by HPLC

The sugar contents (sucrose, glucose and fructose) were determined by liquid chromatography, using the method of Alasalvar et al. (2003) with slight modifications. One gram of each date fruit cultivar was weighed in volumetric flask, and then 100 mL of distilled water was added. The homogenate was then kept in a water bath at 45 °C for 15 min (stirring frequently to aid dissolving sugars). The mixture was filtered through Whatman No. 541 filter paper then filtered again on 0.45 μm membrane filter (Millipore). The equipment consisted of a LC-10AT Shimadzu pump, (HP 1047A) detector, Shimadzu SIL 10ADVP auto sampler, and Shimadzu C-R8A Integrator. The column temperature was set at 30 °C. The mobile phase was acetonitrile/water (75/25, v/v) and the elution was performed at a flow-rate of 1 mL/min. The injection volume was 20 μL. The column was Supelcosil LC-NH 2 (25 × 4.6 mm, 5 μm, Sigma, USA). Identified sugars were quantified based on peak areas compared with a calibration curve obtained with the corresponding standards.

2.4. Determination of energy value

The energy value of the date fruit varieties was calculated based on their content of crude protein, fat and carbohydrate using formula described by Crisan and Sands (1978) as follows:

$$\text{Energy value (kcal/100 g)} = (2.62 \times \%\,\text{protein}) + (8.37 \times \%\,\text{fat}) + (4.2 \times \%\,\text{carbohydrate})$$

2.5. Determination of vitamins content

Niacin (B_3), pyridoxine (B_6) and riboflavin (B_2) were measured according to the HPLC (Moroccan standard 08.1.264). Briefly, 10 g of each date variety was weighed in volumetric flask then 50 mL of Sulfuric acid 0.1 N was added and homogenized for 15 min in room temperature. The mixture was filtered through Whatman No. 541 filter paper then filtered again on 0.45 μm membrane filter (Millipore), and stored at 4 °C until use. The analysis was carried out using a Shimadzu-UFLC Prominence equipped with an auto sampler (Model-SIL 20AC HT), UV–Visible detector (Model-SPD 20A) and Fluorescence Detector (model RF-20A). The HPLC column used was a reversed-phase Hypersil HyPurity C18 (250 × 4.6 mm, 5 μm). The data were recorded using LC solutions software. The mobile phase composition used was 97% octan sulfonic acid buffer (7 mmol/l pH = 3) and 3% acetonitrile (HPLC grade). The analysis was carried out in isocratic mode at a flow rate of 1 ml/min. 20 μL of each samples/standard was injected and monitored at UV 261 for B3 and fluorescence detector for B2 and B6 (λ excitation = 375 nm, 300 nm and λ emission = 400, 525 nm respectively). The standard stock solutions were prepared by dissolving (nicotinamide, pyridoxine hydrochloride and riboflavin) each one alone in hydrochloride acid 0.1 N.

2.6. Determination of ash and mineral contents

The method of AOAC (1997) was employed for the determination of ash and mineral content. Two grams of the pulverized samples was placed in a crucible, ignited in a muffle furnace overnight at 550 °C, Then cooled in a desiccator and weighed at room temperature to get the weight of the ash. To the resulting ash 5 mL of concentrated chloride acid was added, and evaporated on a hot plate; some drops of H_2O_2 and 5 ml of bidistilled water were added and filtered in 100 ml volumetric flasks, then the volume was made up with bidistilled water.

This solution was used for the determination of mineral content. Atomic absorption spectrophotometer (AAS) was used to determine Mg, Fe, Mn, Cu, Ca, K, Na and Zn.

2.7. Preparation of rich polyphenol extracts

The rich phenolic compounds extract was prepared according to the method of Biglari et al. (2008) with slight modifications. Briefly, 30 g of pitted and crushed date fruit was extracted with 150 ml methanol–water (4:1, v/v), at 35 °C for 12 h using an

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orbital shaker-incubator. The mixture was then filtered and the filtrate was concentrated under reduced pressure at 40 °C until the total evaporation of solvent, using a rotary evaporator. The results of methanolic crude extract were kept at −20 °C in dark glass bottles until use. The extract was redissolved in the water in known dilution to determine phenolic, flavonoids and condensed tannins content and their antioxidant capacity was evaluated using the same dilution.

2.8. Measurement of total phenolics compounds

The total phenolic contents in date seeds were determined according to the method described by the International Organization for Standardization (ISO 14502-1). Briefly, 100 µL of the extract was added to 500 µL of a 1/10 dilution of Folin–Ciocalteu reagent in water, then 400 µL sodium carbonate solution (7.5% w/v) was added. The mixture was left for 60 min at room temperature and the absorbance was measured at 765 nm. The calibration curve was prepared using gallic acid. The total phenolic compounds were expressed as gallic acid equivalent in mg/100 g dry weight (DW) date fruit.

2.9. Measurement of flavonoid content

The total flavonoid content of date was determined by the method of Kim et al. (2003). One mL of date fruit extract was mixed with 4 ml of distilled water. Then 0.3 ml sodium nitrite solution (5%) was added, followed by 0.3 ml aluminum chloride solution (10%). Test tubes were incubated for 5 min at ambient temperature, and then 2 ml of 1 M sodium hydroxide (1 M) was added to the mixture and then the final volume was made up to 10 ml with distilled water. The mixture was thoroughly vortexed and the absorbance was determined at 510 nm. Measurements were calibrated to a standard curve of prepared Rutin solution and the results were expressed as mg Rutin equivalents (RE)/100 of dry weight (DW).

2.10. Measurement of total condensed tannins

The total condensed tannins were determined using the method modified by Heimler et al. (2006). 400 µL of the date fruit extract was mixed with 3 mL of methanolic solution of vanillin (4%) and 1.5 mL of concentrated hydrochloric acid. The mixture was incubated at room temperature for 15 min and the absorbance was determined at 500 nm. A calibration curve of catechin was prepared, and the results were expressed as mg CE (catechin equivalents)/100 g of dry weight (DW) date fruit.

2.11. ABTS radical scavenging assay

The ABTS radical scavenging was measured using the method of Re et al. (1999). The ABTS radical cations (ABTS+) were produced by reacting aqueous solution of ABTS (7 mM) with aqueous solution of potassium persulfate (2.45 mM). The mixture was allowed to stand in the dark at room temperature for 12–16 h before use, then diluted with distilled water to obtain an absorbance of 0.700 ± 0.005 at 734 nm. 30 µL of the sample added to 3 mL of the ABTS radical solution was left at room temperature for 6 min and the absorbance at 734 nm was recorded immediately. A standard curve was obtained by using aqueous solution of Trolox. The total antioxidants were expressed as µmol of Trolox equivalents per 100 g of dry weight (DW) date fruit.

2.12. Ferric reducing antioxidant power assay

The ferric reducing activity of date fruits extract was estimated based on the method of Benzie and Strain (1999). The FRAP reagent was prepared by mixing 50 mL of acetate buffer (0.3 M) at pH 3.6, 5 mL tripyridyltriazine (TPTZ) solution 10 mM prepared in HCl (40 mM) and 5 mL of Ferric chloride solution ($FeCl_3$) (20 mM). 2 mL of the freshly prepared FRAP reagent was added to the 10 µL of extract. Then the absorbance was measured at 593 nm against the blank after 10 min at room temperature. The standard curve was constructed using Trolox. The result was expressed as Trolox equivalent in µmol/100 g of dry weight (DW) date fruit.

2.13. DPPH radical scavenging activity

Scavenging radical activity of date fruit syrups against stable DPPH was assessed as described by Blois (1958) method with slight modifications. The reaction mixture contained 100 µL of date fruits at different concentration and 1, 9 mL of methanolic DPPH (0.3 mM). The mixture was incubated at room temperature for 20 min and the absorbance was determined at 517 nm. The IC_{50} (concentration providing 50% inhibition) values were calculated from the plotted graph of scavenging activity against the concentrations of the samples.

2.14. Statistical analysis

Statistical analysis was performed using StatView 5.0 software. The experimental results were reported as the average of five repetitions for all the experiments ± SE (standard error). Analysis of variance (ANOVA) and post hoc Bonferroni ($p < 0.0018$) tests were used to compare the experimental groups. Pearson's correlation coefficient (r) was used to measure the association between two variables. Differences at $p < 0.05$ were considered significant.

3. Results and discussion

3.1. Protein content

The average nitrogen content of the studied date fruit cultivars measured with the Kjeldahl method is given in Table 1. Significant variations were found between cultivars. The highest amount of protein was observed in *Majhoul* (3.45 g/100 g DW) and the lowest one is detected in *Bousthammi* (2.2 g/100 g DW). The protein content of Moroccan date cultivars and Tunisian Cultivars (Hasnaoui et al., 2010; Elleuch et al., 2008) is respectively quite close to the protein content in the present determination.

3.2. Lipid content

The lipid content of date fruit concentrated generally in the skin was low and varied significantly from 0.36 g/100 g DW observed in *Bouzgagh* cultivar to 0.22 g/100 g DW revealed

Table 1 Proximate composition (g/100 g dry weight) and Energetic value (kcal/100 g DW) of date fruit.

Varieties	Protein	Ash	Lipid	Moisture	Total sugar	Energetic value
Boufgous	3.34 ± 0.11^{ab}	2.47 ± 0.10^{a}	0.282 ± 0.003^{a}	28.20 ± 0.12	72.92 ± 0.058^{a}	317.37
Bouskri	2.60 ± 0.09^{cd}	2.64 ± 0.03	0.317 ± 0.004^{bc}	19.65 ± 0.39^{ab}	83.05 ± 0.097	358.32
Bousrdon	3.05 ± 0.01^{e}	2.28 ± 0.03^{bcd}	0.279 ± 0.006^{ad}	20.28 ± 0.96^{ac}	68.85 ± 0.044	299.45
Bousthammi	2.20 ± 0.09	2.99 ± 0.06^{e}	0.218 ± 0.020	21.17 ± 0.83^{bcd}	77.52 ± 0.433	333.13
Bouzgagh	2.76 ± 0.04^{c}	2.14 ± 0.03^{b}	0.363 ± 0.010^{e}	22.86 ± 0.53^{de}	66.34 ± 0.740^{bc}	288.89
Jihl	2.47 ± 0.07^{d}	2.37 ± 0.04^{acf}	0.249 ± 0.007^{d}	23.61 ± 1.28^{e}	66.73 ± 0.238^{db}	288.82
Majhoul	3.45 ± 0.08^{a}	2.30 ± 0.03^{df}	0.318 ± 0.020^{bf}	30.82 ± 1.30	71.76 ± 0.330^{a}	313.05
Najda	3.15 ± 0.05^{be}	2.90 ± 0.02^{e}	0.333 ± 0.010^{cef}	34.22 ± 0.47	66.03 ± 0.246^{cd}	288.37

Values in average (n = 6) ± SE ṡ averages, in the same column, with different letters are significantly different using post hoc Bonferroni tests ($p < 0.0018$).

Table 2 Sugar composition on glucose, fructose and sucrose of analyzed date varieties (g/100 g dry weight).

Varieties	Glucose	Fructose	Sucrose	Fructose/glucose
Boufgous	34.02 ± 0.69^{ab}	38.90 ± 0.59^{ab}	ND	1.14
Bouskri	5.95 ± 0.256	6.48 ± 0.12	70.63 ± 0.29	1.09
Bousrdon	31.11 ± 0.47^{ac}	37.73 ± 0.39^{cd}	ND	1.21
Bousthammi	35.31 ± 0.64	42.20 ± 1.39	ND	1.19
Bouzgagh	29.66 ± 0.46^{d}	36.68 ± 0.81^{ace}	ND	1.27
Jihl	31.71 ± 0.55^{bc}	35.02 ± 0.96^{bdef}	ND	1.10
Majhoul	33.96 ± 0.30^{d}	37.79 ± 0.87^{f}	ND	1.11
Najda	31.12 ± 0.72	34.91 ± 0.3	ND	1.12

Values in average (n = 3) ± SD ṡ averages, in the same column, with different letters are significantly different using post hoc Bonferroni tests ($p < 0.0018$). ND: not determined.

in *Bousthammi*. These results are similar to those of Hasnaoui et al., (2010), but very lower than those reported in Omani date varieties 0.52–1.41 g/100 g DW (Al-Farsi et al., 2005).

3.3. Sugar content

The major sugars in analyzed date fruit are glucose, fructose and sucrose. The reducing sugars (glucose and fructose) were the predominant in all analyzed cultivars with the exception of Bouskri, which contains a large amount of sucrose. This difference in sugar composition suggests the presence of relatively important invertase activity in all analyzed varieties that showed a high amount of reducing sugar, which would considerably reduce its content in sucrose (Fayadh and Al-showiman, 1990). Table 2 shows that *Bousthammi* has the highest level of glucose (35.31 g/100 g DW) and fructose (42.2 g/100 g DW). *Bouskri* exhibited the lowest amount of glucose (6.479 g/100 g DW) and fructose (5.95 g/100 g DW). However, it contains the highest amount of sucrose (70.627 g/100 DW). The fructose-glucose ratio ranged between 1.1 and 1.24. The present results confirm previous finding of Hasnaoui et al. (2010) and Al-Farsi et al., (2005) who found that the total sugar content varied from 54.79 to 75.56 g/100 g DW in 14 different Moroccan date varieties and between 56.1 and 62.2 g/100 g FW in three Omani date varieties, respectively.

Table 3 Vitamin content of date fruit varieties (µg/100 g dry weight) and recommended dietary allowances (RDA).[A]

Varieties	Riboflavin	Pyridoxine	Niacin
Boufgous	19.01 ± 0.289	52.44 ± 0.61	1531.39 ± 16.89^{abc}
Bouskri	11.59 ± 0.353	136.25 ± 0.45	1969.03 ± 19.10^{adef}
Bousrdon	14.97 ± 0.298	118.74 ± 1,14	2061.72 ± 20.85^{bei}
Bousthammi	13.72 ± 0.471	50.72 ± 0.73	1739.63 ± 37.86^{cfg}
Bouzgagh	10.293 ± 0.284	105.44 ± 0.48	1810.75 ± 46.93^{dg}
Jihl	8.26 ± 0.266	33.47 ± 0,26	1988.40 ± 50.14^{h}
Majhoul	26.50 ± 0.13	82.63 ± 0.47	2318.94 ± 81.56^{h}
Najda	19.39 ± 0.42	94.73 ± 0.55	1831.23 ± 79^{i}
Intake on RDA µg/day	0.63–2.04%	1.97–10.48%	9.57–16.56%

Values in average (n = 3) ± SD ṡ averages, in the same column, with different letters are significantly different using post hoc Bonferroni tests ($p < 0.0018$).

[A] 100 g date fruit dry intake on vitamins recommended dietary allowances (RDA) for adults (Whitney and Rolfes, 2007).

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3.4. The energy values

The energy values of analyzed date fruit are high due to abundance of sugar. It ranged from 288 kcal/100 g in *Najda*, *Jihl* and *Bouzgagh* to 358 kcal/100 g in *Bouskri*. The consumption of 100 g of date provides more than 9.94% and can reach 18.86% of energy requirement for adult per day. The energy values reported in this study are similar to those reported by Al-Farsi et al., (2005).

3.5. Vitamins

Among analyzed vitamins, Niacin (B3) was found higher in all date varieties. It ranged between 1.53 mg/100 g DW observed in *Boufgous* and 1.65 mg/100 g DW in *Bousrdon,* followed by pyridoxine (B6) which had a higher content in *Bouskri* (109.48 μg/100 g DW) and lower content in *Jihl* cultivar (25.57 μg/100 g DW) which also contains the lowest amount of Riboflavin (6.31 μg/100 g DW). The highest amount of the last vitamin B2 was featured in *Majhoul* (17.85 μg/100 g DW). The Niacin (B3) values are compatible with the results reported by other researchers (Al-Farsi and Lee, 2008; El-Sohaimy and Hafez, 2010). However, pyridoxine and riboflavin were lower. The consumption of 100 g of dates provides over 9% of Niacin, 1.9% of pyridoxine and 0.6% of riboflavin of the daily RDA/AI for adults. Though they occur in trace amounts, they have very important biochemical roles to play in the body. They are active in carbohydrates, fat, protein metabolism, and in the making of DNA of new cells (Whitney and Rolfes, 2007) (see Table 3).

3.6. Mineral composition

The mineral content of date fruit varieties is shown in Table 4. Potassium was the major mineral element found in all samples (649.86–1154.63 mg/100 g) followed by calcium (54.2–114.2 mg/100 g), magnesium (53.74–102.10 mg/100 g) and sodium (11.21–15.63 mg/100 g). Date contains a low but a good source of iron (1.14–7.57 mg/100 g), copper (0.34–1.02 mg/100 g), manganese (0.32–0.72 mg/100 g) and zinc (0.21–0.57 mg/100 g). Our results are in close agreement with those of many other studies (Kchaou et al., 2013; Juhaimi et al., 2014). Among analyzed cultivars, *Bousthammi* contains the highest amount of magnesium and manganese and has iron seven times more than *jihl* cultivars, which contains a high amount of calcium and copper. The highest amount of zinc was found in *Najda* while the highest amount of potassium was detected in *Bouskri*. The observed variations in mineral content of dates could be explained by various factors such as variety, soil type, amount of fertilizer and agro-climatic changes (Yousif et al., 1982). The high amount of potassium coupled with low sodium serves as a strategy to prevent or control hypertension and decrease cardiovascular morbidity and mortality, kidney disease, stroke, and cardiovascular disease (Aaron and Sanders, 2013). The average ratio of Ca/Mg is 1.1:1 which is very close to the optimal ratio (1.3:1–1.5:1) for bone health which provides an appropriate balance of these important nutrients for maintaining proper growth and bone turnover and vascular function (Bland, 1999). Copper, iron, manganese, and zinc are integral to many metabolic pathways and processes. Aside from magnesium,

Table 4 Mineral content of analyzed date varieties (mg/100 g dry weight) and recommended dietary allowances (RDA).[A]

Varieties	Potassium	Calcium	Magnesium	Sodium	Iron	Copper	Zinc	Manganese
Boufgous	649.85 ± 9.98	64.67 ± 1.24^{a}	74.84 ± 1.07	15.42 ± 0.27^{ab}	2.115 ± 0.013	0.486 ± 0.007	0.328 ± 0.002^{a}	0.458 ± 0.004
Bouskri	1154.63 ± 12.95^{a}	82.42 ± 0.45^{b}	63.7 ± 1.82^{ab}	15.63 ± 0.28^{bc}	1.263 ± 0.04^{ab}	0.624 ± 0.007	0.327 ± 0.003^{a}	0.41 ± 0.007^{a}
Bousrdon	822.2 ± 9.84^{b}	76.02 ± 1.87	65.60 ± 2.22^{ac}	12.95 ± 0.24^{de}	1.794 ± 0.02^{c}	0.666 ± 0.003	0.270 ± 0.009	0.344 ± 0.003^{b}
Bousthammi	1148.83 ± 13.52^{a}	85.00 ± 2.19^{b}	102.1 ± 0.415	11.78 ± 0.35^{fjh}	7.571 ± 0.13	0.941 ± 0.007	0.477 ± 0.006	0.725 ± 0.014
Bouzgagh	919.2 ± 2.07^{c}	67.1 ± 1.811^{a}	53.74 ± 1.98	12.59 ± 0.48^{dfi}	1.61 ± 0.05	0.42 ± 0.008	0.208 ± 0.058^{b}	0.329 ± 0.001^{bc}
Jihl	960.57 ± 11.77^{d}	114.2 ± 0.37	93.82 ± 0.43^{d}	15.36 ± 0.27^{ac}	1.194 ± 0.01^{ad}	1.027 ± 0.006	0.210 ± 0.002^{b}	0.399 ± 0.005^{a}
Majhoul	849.58 ± 17.03^{b}	54.2 ± 1.77	67.78 ± 2.1^{bc}	11.21 ± 0.31^{j}	1.14 ± 0.02^{bd}	0.344 ± 0.005	0.370 ± 0.003	0.32 ± 0.005^{c}
Najda	943.85 ± 14.97^{cd}	105.71 ± 1.16	89.5 ± 2.61^{d}	12.38 ± 0.33^{ehi}	1.902 ± 0.03^{c}	0.733 ± 0.006	0.570 ± 0.0103	0.513 ± 0.004
Intake on RDA mg/day	13.83–24.57%	4.17–10.57%	12.80–32.93%	0.75–1.30%	6.33–94.62%	38.22–115.4%	1.89–7.12%	13.91–31.52%

Values in average ($n = 3$) ± SD ś averages, in the same column, with different letters are significantly different using post hoc Bonferroni tests ($p < 0.0018$).
[A] 100 g date fruit dry intake on minerals recommended dietary allowances (RDA) for adults (Whitney and Rolfes, 2007)

Table 5 Antioxidant activity, total phenolic content, total flavonoid and condensed tannins content of different date varieties from Morocco.

	Total phenolic content mg GA/ 100 g DW	Total flavonoid content mg RE/ 100 gDW	Condensed Tannins content mg CE/ 100gDW	FRAP μmolTE/ 100g DW	ABTS μmolTE/ 100gDW	DPPH g of date/l
Boufgous	506.77 ± 23.95^{abcd}	84.35 ± 2.95^{a}	81.34 ± 2.64	627.99 ± 27.59^{a}	564.65 ± 15.45^{abc}	3.42 ± 0.08^{ab}
Bouskri	331.86 ± 13.24	68.87 ± 2.14	57.56 ± 3.86	406.614 ± 14.31	383.90 ± 31.84	6.25 ± 0.13^{c}
Bousrdon	537.074 ± 19.25^{ae}	188.58 ± 4.45	92.14 ± 4.68	818.86 ± 21.91^{b}	521.24 ± 8.43^{ad}	3.11 ± 0.08^{def}
Bousthammi	441.851 ± 29.79	85.07 ± 100^{a}	69.90 ± 3.97	530.23 ± 15.90	619.50 ± 26.10^{be}	4.79 ± 0.12^{agh}
Bouzgagh	493.04 ± 21.30^{bfg}	136.95 ± 2.29^{b}	83.79 ± 3.86^{a}	600.30 ± 17.91^{a}	659.47 ± 30.70^{e}	3.78 ± 0.01^{bdgi}
Jihl	495.269 ± 20.50^{cfh}	208.53 ± 4.51	87.07 ± 5.29^{a}	860.89 ± 17.08	822.78 ± 31.38^{f}	2.05 ± 0.03^{ej}
Majhoul	398.228 ± 21.58	77.73 ± 3.65	64.29 ± 5.7^{b}	469.03 ± 17.99	553.84 ± 27.29^{cd}	5.25 ± 0.19^{ch}
Najda	525.957 ± 17^{dgeh}	142.89 ± 2.34^{b}	65.94 ± 4.82^{b}	813.76 ± 30.33^{b}	846.94 ± 56.26^{f}	2.87 ± 0.25^{fij}

Values in average (n = 6) ± SE ṡ averages, in the same column, with different letters are significantly different using post hoc Bonferroni tests (p < 0.0018).

which is thought to bind to enzymes only transiently, zinc, iron, and manganese are the three most highly utilized metals by enzymes, and copper is the seventh most utilized (Andreini et al., 2008). As Table 4 below shows, the consumption of 100 g of dates can provide over 12% of the recommended daily allowance of potassium, magnesium, copper and manganese. Eating 100 g of *Bousthammi* covers more than 90% recommended daily allowance of iron.

3.7. Phenolic content

The total polyphenols content of date fruit varieties examined showed significant differences as shown in Table 5. The highest value of total polyphenols was determined in Bousrdon (537.07 mg GAE/100 g DW) followed by *Najda*, *Boufgous*, *Jihl*, *Bouzgagh*, *Bousthammi*, *Majhoul* and the lowest level in *Bouskri* (331.86 mg GAE/100 g DW). The polyphenols content in this study was higher compared to the study of Hasnaoui et al. (2012)) for the Moroccan varieties using a similar measuring technique. They found that the total phenolic content ranged between 171.4 and 353.92 mg GAE/100 g DW. Our results confirm previous results reported by Kchaou et al. (2013) and Benmeddour et al. (2013) who found that the total phenol contents ranged from 199.43 to 576.48 mg GAE/100 g FW in six Tunisian cultivars and 226 to 955 mg GAE/100 g DW in ten analyzed Algerian date varieties respectively. These variations in the total phenolic contents may be due to variety, growing conditions, maturity, seasons, geographic origin, fertilizer, soil type and storage conditions. The amount of sunlight received may also be critical in this respect (Al-Farsi et al., 2007; Besbes et al., 2009). The examined date fruit cultivars are richer in phenolic content than the raisins (194 mg CE/100 g DW), apricots (333 mg CE/100 g DW), and figs (256 mg CE/100 g DW) but poorer than plums (551 mg CE/100 g DW) (Vinson et al. (2005)).

3.8. Flavonoids content

Significant differences in the total flavonoid content were observed between the studied date varieties Table 5. Jihl contained the highest total flavonoid content (208.53 mg of RE/100 g) followed by *Bousrdon*, *Najda*, *Bouzgagh*, *Bousthammi*, *Boufgous*, *Majhoul* and the lowest total flavonoid content was observed in *Bouskri* (68.88 mg of RE/100 g DW). Hasnaoui et al. (2012) and Biglari et al. (2008) reported that the total flavonoid content varied from 43.28 to 84.95 mg QE/100 g and from 1.62 to 81.79 mg CE/100 g DW in the Moroccan date cultivars and the Iranian date cultivars, respectively. However, our results agree, with those reported by Benmeddour et al. (2013) who found that the total flavonoid content ranged from 15.22 to 299.74 mg QE/100 g DW and by Kchaou et al. (2014) who found that the total flavonoid content ranged from 58.92 to 213.76 CE/100 g extract. The results showed that all cultivars except *Majhoul* and *Bouskri* have a high flavonoid content compared to other fruits such as raisins (30.9 mg QE/100 g DW), apricots (31.9 mg QE/100 g DW), prune (46.6 mg QE/100 g DW) and figs (79.9 mg QE/100 g DW) (Ouchemoukh et al., 2012).

3.9. Condensed tannins content

For all the date varieties, significant difference in condensed tannins content was observed. Bousrdon cultivar showed the highest level of condensed tannins (92.141 mg CE/100 g DW) while the lowest level was observed in *Bouskri* cultivar (57.564 mg CE/100 g DW). The order of condensed tannin content of analyzed date fruit cultivars was *Bousrdon* > *Jihl* > *Bouzgagh* > *Boufgous* > *Bousthammi* > *Najda* > *Majhoul* > *Bouskri*. Our results are lower than those reported by Benmeddour et al. (2013) who found condensed tannins content varied between 82.81 and 525.06 mg CE/100 g DW.

3.10. Antioxidant activities

Date fruit contains different types of phenolic compounds, which have different antioxidant capacities. To better examine their antioxidant capacities, date fruit extracts were analyzed using ferric reducing ability (FRAP) and two free radical scavenging activity assays: DPPH and ABTS.

The FRAP assay is widely used in the evaluation of the antioxidant component in the dietary polyphenols. It measures the ferric reducing ability of antioxidant. The result shows that all cultivars exhibited a good reducing power which varied significantly (P < 0.05) from 406.61 to 860 μmol TE/100 g DW for Jihl and *Bouskri*, respectively. As shown in this study, there is a strong positive correlation between antioxidant activity

measured by FRAP assay and total polyphenol contents ($r = 0.83$) as well as flavonoids content ($r = 0.90$). However, a moderate correlation was observed between condensed tannins and FRAP ($r = 0.652$).

The averages of free radical scavenging activity of date fruit cultivars based on ABTS assay and DPPH assay are given in Table 5. As scavenging activity results show, there are significant differences between examined date fruit varieties. *Najda* date showed the highest level of antioxidant activity based on ABTS assay (846.94 μmol TE/100 g DW) while *Jihl* (2.046 of date/l) exhibited the highest level of scavenging activity based on DPPH assay with a low IC50. *Bouskri* cultivar possessed the lowest level of AA based on ABTS assay (383.90 μmol TE/100 g DW) and DPPH assay with a high IC50 (6.255 g of date/l).

The analysis of correlation between scavenging activity and phenolic content as well as flavonoid content indicted a strong negative correlation between DPPH and phenolic content ($r = -0.869$) and between DPPH and flavonoid content ($r = -0.826$). However, moderate correlations were observed between DPPH and condensed tannins ($r = -0.665$), ABTS and Phenolic content ($r = 0.562$) and ABTS and Flavonoid content ($r = 0.573$). No correlation was detected between ABTS and condensed tannins ($r = 0.243$).

The scavenging of the DPPH radical by the methanolic extract of date fruit was found to be higher than that of ABTS radical. This could be attributed to the stereo selectivity of the radicals as reported by Yu et al. (2002).

4. Conclusion

The analysis of the date fruit proves that the total sugar, protein and fat results are similar; hence, the homogeneity of their energetics and nutritional value. However, significant differences between varieties are found on their composition of vitamins, minerals, polyphenol, flavonoids, condensed tannins, antioxidant activities and ratio of sucrose/reducing sugar, which revealed that date fruit is an extensive domain where each variety requires a deep study of their dietetic characteristics.

Conflict of interest

The authors declare that there is no conflict of interest.

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