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Biochemical and physicochemical properties of some date palm (*Phoenix dactylifera*) fruit cultivars

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ABSTRACT

Purpose: The main aim of the present research was to determine the qualitative and quantitative properties of some commercial cultivars of date palm (*Phoenix dactylifera*) fruit from Iran. **Research method:** Mature fruits of uniform size, without of physical damage or injury from insects and fungal infection were used for all biochemical and physicochemical properties. The total phenolic and flavonoid contents were determined using the modified Folin–Ciocalteu colorimetric and aluminum chloride colorimetric methods, respectively. The antioxidant activity was determined by DPPH scavenging assay method. **Findings:** Among the evaluated cultivars, 'Kabkab' had the highest fruit length and diameter, seed length, flesh weight, flesh to seed ratio, total weight and moisture percentage. The mount of antioxidant activity (AA) was in the range 57.29 ± 2.91 to 70.04 ± 0.91 in the 'Hamrawi' and 'Barhee' cultivars, respectively. 'Khadrawi-Ahwaz' and 'Deiry' showed the highest (1103.76 ± 100.89 mg gallic acid/100 g fresh weight) and the lowest (261.86 ± 44.48 mg/100 g FW) content of total phenolic compounds (TPC), respectively. Besides, the highest soluble solid content (SSC) and titratable acidity (TA) were observed in 'Berim' (82.5%) and 'Hamrawi' (0.086%), respectively. **Research limitations:** No limitations were founded. **Originality/Value:** Selected date cultivars in this study had relatively high levels of TPC, TFC and AA. The highest content of AA, TPC and TFC were observed in 'Barhee', 'Khadrawi-Ahwaz', and 'Hamrawi' cultivars, respectively.

INTRODUCTION

The Date palm (*Phoenix dactylifera* L.) belongs to the Arecaceae family. Dates are one of the main horticultural products of Iran (Hassanzadeh Khankahdani & Bagheri, 2019). Iran is the third largest producer of dates in the world (FAO, 2019). Date palm fruits contain a high percentage of carbohydrate, protein, vitamins, dietary fiber, phenolic compounds, and flavonoids that are believed to be potential sources of antioxidant offering health benefits (Mia et al., 2020). These compounds reduce the damages of reactive oxygen species (ROS). Damage mediated by ROS results in the disruption of membrane fluidity, protein denaturation, lipid peroxidation, oxidative DNA and alteration of platelet functions (Fridovich, 1978; Hussah Al-Shwyeh, 2019; Kinsella et al., 1993), which have generally been considered to be linked with many chronic health problems such as cancers, inflammation, aging and atherosclerosis. Antioxidants, destroys free radicals and reactive oxygen. However, due to a defect in the production of antioxidants in the body or due to environmental factors pathophysiological situations in which they are product in the wrong place and time, dietary antioxidants are required to prevent oxidative damage (Chaudiere & Ferrari-Iliou, 1999; Halliwell, 1997). In addition, the presence of variable antioxidant including phenolic and flavonoid compounds in date palm is useful in the treatment of diabetes (Al-Zuhair et al., 2010; Mia et al., 2020). There are many commercials date cultivars in the world that regarding the moisture contents of fruits at mature Tamr stage divided in three groups including dry dates, semi-dry dates and soft dates. The dry and soft date fruits have high a proportion of cane sugar (sucrose) invert sugars respectively (Hussah Al-Shwyeh, 2019). Regarding of nutritional quality and rich source of polyphenols of date fruits, there have been efforts to develop functional food from it (Selim et al., 2012). Al-Fars et al. (2005) reported the soluble phenolic compounds of sun-dried Oman date cultivars are higher than other date cultivars (217-243 217–343 mg of ferulic acid equivalents/100 g). Although, some studies have reported antioxidant properties of date fruits (Al-Turky et al., 2010; Al-Farsi et al., 2005; Hong et al., 2006; Mansouri et al., 2005; Saafi et al., 2009; Saleh et al., 2011), but due to differences among cultivars from the physical and biochemical point of view researches in this topic are important not only for health and phytochemical aspects, but also for breeding works. The number of date varieties grown worldwide exceeds 2000 but less than 10% of these are explained regarding their quantitative and qualitative characteristics (Ghnimi et al., 2017). Therefore, due to high diversity in date palm cultivars and importance of individual cultivars in different countries research that describing quantity and quality of various date fruit cultivars is of paramount importance. The main objective of the present research was to determine the quantitative and qualitative properties of some commercial cultivars of date palm (*Phoenix dactylifera*) fruit from Iran.

MATERIALS AND METHODS

Plant materials

This study was conducted at the University of Gulian. The ripe fruits of nine important and commercial date cultivars namely ‘Khadrawi’ (from the Shoshtar and Ahawas region), ‘Gantar’ (from the Shoshtar and Shadegan region), ‘Barhee’, ‘Kabkab’, ‘Estamaran’, ‘Breim’, ‘Deiry’, ‘Zahedi’, and ‘Hamrawi’ cultivars growing in Khuzestan province were studied. Mature fruits of uniform size, without of physical damage or injury from insects and fungal infection were harvested at Tamar stage in October and used for all experiments. Since various date fruits cultivars including soft, semi-dry and dry were harvested, the specimens were stored at -18 ºC prior to analyses.

Physical properties

The length and diameter of the fruit and seed were measured using a micrometer caliper and expressed as cm. In addition, the total weight and flesh were measured using a digital scale and expressed as g. All measurements were performed in triplicate (20 date fruits from each replication).

Moisture and ash percentage

Moisture contents were estimated in accordance with the methods of the AOAC (1990). Ash Percentage of the fruit samples with a precise distribution of 3 g of the dry samples, and burning them in the electronical furnace were determined in the 550 centigrade (Egna et al., 1981). Results are expressed as percent of moisture and ash.

Chemical composition

Titratable acidity (TA)

For measuring titratable acidity, 5 g of the fruit samples was mixed with 50 ml of distilled water; then, it was titrated by 0.1 normal Sodium Hydroxide (NaOH) and with pH-meter up to 8.4-8.6 pH. The sample's acidity amount was measured by the following formula (1) (Hosseini, 2005).

$$z = \frac{V \times N \times Meq \times 100}{w} \qquad (1)$$

V= the amount of Sodium Hydroxide volume (ml), N= normalized consumed NaOH, Meq = milli equivalent malic acid (0.067), W= weight of the sample (g).

Soluble solid content

Soluble solid content (SSC) percentages were determined using a hand refractometer. Practically, 1 g of each sample was mixed with 10 ml of distilled water and then a drop of soluble phase was used for SSC evaluation. Results are expressed as percent of soluble solid content. Observed digit was used for quantification after being multiplied by 2 (Hosseini, 2005).

Extraction for measuring total phenolics and flavonoids and antioxidant activityα-Amylase activity assay

For the biochemical analyses, 10 g of fruits from each treatment were homogenized in a blender at room temperature. 1g aliquots of each homogenate were transferred to polypropylene tubes and extracted with 3 mL of extraction buffer containing methanol and acetic acid (85:15, v/v) for 24 h at room temperature. The upper solution was centrifuged at 10,000 rpm, and the supernatant fluid was decanted (Bakhshi & Arakawa, 2006). The extracts were used for measuring phenolics and flavonoids and antioxidant activity (AA).

Total phenolic content

Total phenolic contents (TPC) were determined using the modified Folin– Ciocalteu colorimetric method (Singleton et al., 1999). Values of total phenolics were estimated by comparing the absorbance of each sample with a standard response curve generated using gallic acid. TPC are expressed in terms of mg gallic acid equivalents (GAE) per 100 g fresh weight (FW) of sample through the calibration curve of gallic acid.

Determining total flavonoid

The total flavonoid contents (TFC) were measured using aluminum chloride colorimetric method (Du et al., 2009). The TFC were determined using (+) -catechin as standard and evaluated as mean of milligrams of (+) -catechin equivalent (CE) per 100 g of fresh weight.

Antioxidant capacity determined by DPPH

DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging capacity was determined based on the method of Du et al. (2009) with some modifications. Briefly, an aliquot (50 µL) of each extract was mixed with the 950 µL of methanolic DPPH solution (0.01 mM). A control sample containing the same volume of solvent in place of extract was used to measure the maximum DPPH absorbance. The reaction was allowed to take place in the dark at for 30 min. After 30 min, the absorbance of these solutions was recorded at 517 nm. The inhibition percentage of the absorbance was calculated using the following formula (2):

$$\% \text{ DPPHsc} = [(\text{Acont} - \text{Asamp}) / \text{Acont}] \times 100 \qquad (2)$$

Where Acont is the absorbance of the control, and Asamp is the absorbance of the sample. Results are expressed as the percentage of scavenged DPPH (%DPPHSC).

Statistical analysis

The research was conducted in a completely randomized design with three replications. Twenty date fruits for each replication were used. Data were analyzed using SAS software (version 9.1 English). Duncan's test was used to determine the significant differences ($p < 0.05$) among the means.

RESULTS AND DISCUSSION

According to the obtained results a significant difference ($p \leq 0.05$) was observed among the cultivars, regarding the studied characteristics (Table 1, 2, and 3). 'Kabkab' had the highest fruit length and diameter, seed length, flesh weight, flesh to seed ratio, total weight, and moisture percentage (Table 1 and 2). The dimensions, volume and weight parameters are important in fruit classification. Knowledge about physical characteristics of horticultural crops and their relations is important for the design of handling, sorting, packaging and processing systems. The mean values of length, width, thickness, geometric mean diameter, thousand fruit- seed weight, and volume of Tunisian date palm fruit (Kentichi) were 30.2, 13.1, 16.1, 18.4 5.833, and 2194.4 mm, respectively (Herchi et al., 2014). Geddeda and Abdassalam (2010) reported that significant differences were between Libyan date palm fruits regarding physical characteristics. They indicated that 'Adhwi'' had the heaviest fruit (14.5 g), while 'Sotrah' fruits were the lightest (7.6 g). Moisture content is an important factor for classification of date crop has dropped into three classes, namely dry, semi-dry and soft fruits (Osman, 2008). However, besides moisture, fiber values are considered also to have a role in determining whether a date fruit is dry, semi-dry or soft (Biglari et al., 2008). Al-Farsi et al. (2007) in their research on different dates reported the moisture contents of fruits varied between 9.73 to 17.52 g/100 g. In this research, 'Deiry' and 'Zahedi' which are categorized under dry dates, their moisture percentage is between the range of 15.96% to 17.05%; the semi dry dates, including 'Khadrawi-Shoshtar', 'Khadrawi-Ahwaz', 'Estamaran', and 'Breim' their moisture fluctuates between 17.92% to 18.25% and the soft dates, including 'Kabkab', 'Gantar-Shadgan', 'Barhee', 'Gantar-Shoshtar', and 'Hamrawi' had the moisture of 19.30%

to 22.14% (Table 2). The ash percent fluctuated between 1.43 to 2.53%, and among the studied cultivars 'Khadrawi Shoshtar', a semi-dry variety, had the highest and 'Gantar-Shadgan' had the lowest ash weight (Table 2). Moosavi and Hojjati (2009) reported that 'Deiry', a dry variety, and 'Estamaran', a semi-dry one had highest and lowest ash percentage, respectively.

According to the results here, there was a significant variation among the cultivars regarding TA. Most of the horticultural products contain organic acids, which affect the quality of products, especially in the case of fruits (Walker & Famiani, 2018; Wills et al, 1998). The 'Hamrawi' and 'Gantar-Shoshtar' showed the highest (0.086 %) and the lowest (0.024) content of TA, respectively. Accorded to Barreveld (1993) the TA content of date fruit was low and fluctuates between 0.023 to 0.086. It has been shown that the production and accumulation of acids is under control of genes, and the amount of these ingredients is different, not only between the cultivars, but also between the different species (Saradhuldhat & Paull, 2007). 'Breim' and 'Khadrawi-Shoshtar' showed the highest and the lowest content of SSC, respectively (Table 2). The highest percent of the SSC is in the ripe stage and at this stage the fruit of date palm has the best conditions for being stored (Farahnaky & Afshari-Jouybari, 2011).

Results revealed that the amount of TPC and TFC varied between 1103.76 ± 100.89 to 261.86 ± 44.48 mg gallic acid equivalent (GAE) per 100 g fresh fruits; and 167.08 ± 19.57 to 58.08 ± 3.0 of (+) -catechin equivalent (CE) per 100 g fresh weight, respectively. The highest content of TPC and TFC were observed in Khadrawi-Ahwaz and Hamrawi cultivar and its lowest content was detected in Deiry and Kabkab cultivars, respectively (Table 3). Myhara et al. (2000) during their investigation on sensory and textural changes in maturing Omani date fruits reported that phenolic substances (referred to generically as tannins) were high in the Kimri stage of dates and reduced continuously at Tamr stage. Zihad et al. (2021) indicated that 'Ajwah', 'Safawy', and 'Sukkari' date fruits contain considerable amount of phenolic and flavonoid contents that positively correlated with the antioxidant capacity. They reported that that 'Safawy' cultivar contains the highest amount of phenolic and flavonoid (101.66 mg GAE/g and 78.6 mg QE/g, respectively) while 'Sukkari' cultivar has the lowest values (39.01 mg GAE/g and 61.0 mg QE/g, respectively) among the three date cultivars. Our results showed that the evaluated date cultivars contain considerable amount of phenolic and flavonoid contents. Also, Najm et al. (2021) found that date of Ajwa cultivar is a rich source of phytochemicals and Polyphenols were the main phytochemicals identified in the fruits. Mansouri et al. (2005) found that TPC ranged from 2.49 to 8.36 mg of GAE/100 g fresh weight. Besides, phenolic content of plant foods depends on a number of intrinsic (genus, species, cultivars) and extrinsic (agronomic, environmental, handling and storage) factors (Balasundram et al., 2006). Like other fruits, total phenolic compounds and their composition existing in the fruit of the date palm differ among different cultivars (Al-Farsi et al., 2007). In this research, significant differences were found in total phenolic and flavonoid content (Table 3). The difference among the phytochemical values of different date cultivars throughout the world could be due to the cultivar, soil conditions, extraction procedure, methods of calculation and analysis (Zihad et al., 2021).

It is noteworthy to mention that phenolic compounds could have a considerable effect in the prevention of cancer and heart diseases.

The DPPH radical has been extensively used to estimate the free radicals scavenging capacity of different natural products (Shahdadi et al., 2015). According to the results, the mount of AA was between 57.29 ± 2.91 to 70.04 ± 0.91. The highest and the lowest content of the AA were observed in 'Barhee' and 'Hamrawi' (Table 3). The antioxidant activity of date fruits could be associated with its polyphenolic contents. Biglari et al. (2008) reported

that phenolic substances were the dominant compounds in the date palm fruits. The antioxidant capacity of date fruits could be due generally to the presence of water-soluble substances with strong free radical-scavenging effects including phenolic and flavonoids compounds (Mansouri et al., 2005; Vayalil, 2002). Different factors such as genotype (cultivar), growth condition, maturity stage, geographical origin, fertilizing, soil type, storage condition, and other factors may cause diversity in antioxidant capacity (Al-Farsi et al., 2007).

Table 1. Physical properties in the fruits of selected date palm cultivars

Treatment (cultivar)	Fruit width (mm)	Fruit length (mm)	Seed width (mm)	Seed length (mm)	Flesh weight (g)	Total weight (g)	Flesh to seed ratio
'Gantar-Shoshtar'	21.40±0.38cb	34.43±0.95c	7.63±0.15d	21.05±0.36cb	7.68±0.35c	8.32±0.30c	9.21±0.71b
'Khadrawi-Shoshtar'	21.01±0.38cbd	32.15±0.64dc	7.79±0.06dc	20.74±0.13cb	5.98±0.01e	6.87±0.06fe	7.09±0.23dc
'Barhee'	21.74±0.23b	30.29±0.61de	7.91±0.07dc	15.99±0.25e	7.50±0.16dc	8.14±0.13dc	12.47±0.85a
'Kabkab'	24.03±0.52a	41.94±1.25a	7.86±0.06dc	25.20±0.29a	12.89± 0.12a	13.86±0.12a	13.65±0.19a
'Estamaran'	20.08±0.14ed	34.33±0.62c	7.05±0.05e	21.72±0.14b	6.75±0.27d	7.52±0.24de	9.36±0.20b
'Breim'	21.44±0.1cb	34.48±0.49c	8.09±0.17bc	20.59±0.25c	8.83±0.18b	9.72±0.06b	10.12±0.41b
'Gantar-Shadgan'	19.76±0.43fe	29.57±0.81e	8.35±0.19ba	18.53±0.34d	5.70±0.23e	6.52±0.25f	6.84±0.37dc
'Deiry'	20.00±0.14fed	37.49±1.37b	8.65±0.16a	24.80±0.40a	7.29±0.29dc	8.46±0.25c	6.11±0.38d
'Zahedi'	20.60±0.43ced	33.01±0.99c	7.92±0.02dc	21.11±0.47cb	6.80±0.51d	7.73±0.52dc	7.61±0.34c
''Khadrawi-Ahwaz'	18.91±0.46f	29.04±0.16e	7.89±0.11dc	18.65±0.10d	4.72±0.07f	5.41±0.04g	6.37±0.33dc
'Hamrawi'	19.84±0.21fe	32.49±0.33dc	7.19±0.14e	20.89±0.40cb	4.85±0.21f	5.60±0.23g	6.46±0.14dc

Means with different letters in each column are significantly different ($p < 0.05$) according to Duncan's multiple range test. Data represents as means ± SE.

Table 2. Soluble solid content (SSC), titratable acidity, moisture and ash percent in the date palm fruits

Treatment	Soluble solid Content (%)	Titratable acidity (%)	Moisture (%)	Ash (%)
'Gantar-Shoshtar'	67.3 ± 2.52ed	0.024 ± 0.001g	19.56 ± 0.61b	2.35 ± 0.02a
'Khadrawi-Shoshtar'	64.8 ± 0.60e	0.028 ± 0.0ef	18.25 ± 0.39cb	2.54 ± 0.09a
'Barhee'	71.6 ± 1.99ecd	0.039 ± 0.0c	21.34 ± 0.18a	1.93 ± 0.06cb
'Kabkab'	71.8 ± 1.99ecd	0.028 ± 0.0ef	22.14 ± 0.81 a	1.56 ± 0.05ed
'Estamaran'	73.4 ± 1.23bcd	0.031 ± 0.001ed	18.0 ± 0.12cb	1.59 ± 0.02ed
'Breim'	82.5 ± 0.52a	0.027 ± 0.0ef	17.92 ± 0.11cb	1.74 ± 0.07cd
'Gantar-Shadgan'	75.4 ± 2.90bc	0.025 ± 0.01gf	21.34 ± 0.29a	1.45 ± 0.06e
'Deiry'	74 ± 4.45bcd	0.032 ± 0.0d	17.05 ± 0.14cd	2.0 ± 0.06b
'Zahedi'	79.9 ± 0.36ba	0.031 ± 0.001ed	15.96 ± 1.33d	1.84 ± 0.15cb
'Khadrawi-Ahwaz'	65.8 ± 2.88e	0.061 ± 0.01b	18.15 ± 0.14cb	2.42 ± 0.08a
'Hamrawi'	68.4 ± 1.71ecd	0.086 ± 0.003a	19.30 ± 0.25b	2.05 ± 0.02b

Means with different letters in each column are significantly different ($p < 0.05$) according to Duncan's multiple range test. Data represents as means ± SE

Table 3. Biochemical characteristics of different date palm fruit cultivars

Treatment	Antioxidant capacity (DPPH %)	Total phenolic (mg GAE/100 g FW)	Total flavonoid (mg CE/100 g FW)
'Gantar-Shoshtar'	53.02 ± 2.58c	403.29 ± 45.23cebd	65.24 ± 2.74c
'Khadrawi-Shoshtar'	56.66 ± 1.69bac	469 ± 13.88cbd	76.58 ± 2.14c
'Barhee'	70.04 ± 0.91a	531.38 ± 36.37b	73.41 ±2.03c
'Kabkab'	55.37 ± 0.33bac	309.41 ± 9.80ed	58.08 ± 3.0c
'Estamaran'	56.17 ± 0.42bac	513.29 ± 57.29cb	77.91 ± 6.06c
'Breim'	56.07 ± 2.06bac	374.71 ± 34.32cebd	61.91 ± 1.96c
'Gantar-Shadgan'	53.02 ± 1.74c	343.29 ± 15.67ced	68.83 ± 3.04c
'Deiry'	59.54 ± 2.02ba	261.86 ± 44.48e	72.91 ± 5.89c
'Zahedi'	54.91 ± 1.09bac	351.86 ± 33.78ced	64.49 ± 6.04c
'Khadrawi-Ahwaz'	53.65 ± 2.42bc	1103.76 ± 100.89a	125.41 ± 10.34b
'Hamrawi'	57.29 ±2.91d	1086.67 ± 93.77a	167.08 ± 19.57a

Means with different letters in each column are significantly different ($p < 0.05$) according to Duncan's multiple range test. Data represents as means ± SE.

CONCLUSION

Present study confirmed that Iranian date cultivars have potential antioxidant activities. The fruits of different date palm cultivars have different biochemical and physicochemical properties. The superiority of 'Kabkab' cultivar regarding the quantitative traits compared to other cultivars was evident. Selected date cultivars in this study had relatively high levels of TPC, TFC and AA and could serve as a good source of natural antioxidant. Overall, the present study shows that the evaluated date fruits with high amounts of antioxidants and different physical characteristics can be considered for use as functional food ingredients and for breeding researches in the future. Further studies are required to characterize the main phenolic and flavonoid compounds of local cultivars.

Conflict of interest

The authors have no conflict of interest to report.

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