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Evaluation of biochemical parameters, phenolic compounds and antioxidant capacity of some varieties of *Phoenix dactylifera* L. (Date fruits) to determine the nutritional impact values

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Abstract.
BACKGROUND: The date palms being an important plantation crop in Saudi Arabia have wide varieties with varying nutritional regime. The fruit called date is considered as an important staple food, when such nutritional composition is explored it helps for the community to choose the varieties according to their needs.
OBJECTICVE: An *in vitro* study was undertaken to evaluate various nutritional values of seven different varieties of date fruits collected from the Kingdom of Saudi Arabia.
METHODS: Experiments were conducted to analyse the biometric parameters, biochemical and mineral constituents, defense and antioxidant activities of date fruits extract.
RESULTS: The biometric results revealed that among seven different varieties of date fruits, the highest length of date fruit (52.1 ± 0.08 mm) was recorded in Date variety. In contrast, the highest breadth (32.0 ± 0.18 mm) was recorded in Sukkari. Analysis of biochemical constituents on date fruits showed that the selected varieties contained significantly different amounts of moisture, protein, carbohydrates, lipids, ash, crude fiber and total solid. It showed the presence of vitamins and minerals in substantial amount at varying level. In addition, the date fruit varieties contained appreciable number of total polyphenols and flavonoids which ranged from 21.61 ± 2.36 and 1.25 ± 0.53 to 47.01 ± 2.55 and 2.57 ± 0.63 mg/100 g of DW (Dry Weight) respectively. The antioxidant activities of date fruit varieties exhibited were expressed in percentage inhibition of radical scavenging activity for different methods as follows: DPPH (2, 2-Diphenyl-1-picrylhudrazyl) ranged from 26.78 ± 2.53 to $62.17 \pm 3.37\%$, ferric-reducing antioxidant power (FRAP) was within the range of 22.33 ± 3.33 to $56.55 \pm 3.40\%$, and scavenging of hydrogen peroxide ranged from 17.41 ± 0.78 to $42.11 \pm 2.72\%$ of inhibition.
CONCLUSIONS: The above studies showed the impact of nutritive value of date fruit varieties in the following order: Rothan > Dawee > Ekhlass Alhasa > Abu Minifee > Sukkai > Ekhlass Almajmaah > Sukkari.

Keywords: Saudi Arabian dates, fruit size, vitamins, minerals, phenolics, antioxidant

1. Introduction

The date palm (*Phoenix dactylifera*) belongs to the family Arecaceae, referred as "Candy grown on trees" which is an important plantation crop in the arid regions of most of the Arabian Peninsula, North African, Middle East and Egypt countries. In these countries, Dates fruit act as staple food and play an important role in economy and society especially in Saudi Arabia [1]. There are 15 million palm trees with the production range from 0.941 million tons (2004) to 0.986 million tons (2008) which has a value of 2.12 billion dollars according to 2006 base price [2]. A study on dates fruit confirmed that 11–18% of dates weight is its seed which is composed of carbohydrates, fat, protein, dietary fibers and ash [3]. The geographic that encompasses the cultivation of date palm covers 10° N and 39° N in the Northern hemisphere and 5° S and 33° 51′ S in the southern hemisphere. Date fruit is the edible part of date palm and Muslim people has considered it as most sacred food in their life and it is being used as breakfast by them during the holy month of Ramadan [4]. Seventy percent of these trees are grown in Arab countries and are responsible for 67% of the global date fruit production [5].

Date fruits are rich in certain nutrients and provide a good source of rapid energy, due to their high carbohydrate content (70–80%) as per the report of Mohamed et al. [6]. The antioxidant present in the fruit was the measure of certain biochemical markers like Vitamin C, Vitamin D and phytochemicals [7]. Polyphenols are classified into various groups depending on the phenol rings and structural elements bound to it [8]. This fruit is also a good source of important phytochemicals, including carotenoids, phenolics and flavonoids. It exhibits not only antioxidant, antimutagenic, and immunomodulatory benefits to health but also has diverse medicinal values, including antihyperlipidemic, anticancer, gastroprotective, hepatoprotective, and nephroprotective properties [9].

The date seeds are rich in high amount of proteins and lipids whereas the date flesh contains high amount of sugars. The developmental stage of the date fruit comprises four stages namely Kimri (unripe), Khalal (full size-crunchy), Rutab (ripe soft) and Tamer (ripe sun dried). Date fruits are classified according to their fleshiness. This is an arbitrary classification, but is convenient *viz*., soft date (Barhee, Halawy, Khadrawy, Medjool), semidry date (Dayri, Deglet Noor, Zahidi) and dry date (Thoory). There are some variations in the composition of the date fruits with the changing stages of growth [10].

The nutritive value of the date fruits varies with its type and varieties. Saudi Arabia is the leading producer of date fruits at present. Beyond the consumption of the date fruit, other parts of the date palm like seeds and leaves are also widely used for various purposes towards commercial exploitation [11]. The health benefits of the date fruits include increased bone health and strength, relief from intestinal disorders, treatment for anemia and so on. Benefits of date fruits also include weight gain, healthy heart and improved nervous health system. The biomedical applications of date fruits were studied by many researchers in several areas covering antioxidant property, anti-inflammatory & anti-diarrheal property, neuroprotective effect on diabetic induced neuropathy, reproductive disorders and other related issues [1]. The current study was undertaken to focus on the impact of seven varieties of Saudi Arabian date fruits on the potential of nutritional values for human consumption.

2. Methods

2.1. Collection of selected date fruit varieties

The varieties of date fruits such as Sukkai, Sukkari, Ekhlass Almajmaah, Abu Minifee, Ekhlass Alhasa, Rothan and Dawee were collected from local market in the Kingdom of Saudi Arabia for the present study.

2.2. Morphological and biometric characterization of Saudi Arabian date fruits

Length and width of each date fruits at each stage were measured using a caliper micrometer. Weight of the fruits before and after pitting (de-stoning) was measured using analytical balance. In addition,

the shape of fruits was noted visually. Photos were taken using Canon EOS 700 D to report the appearance.

2.3. Preparation of date fruit pulp extract and fractionation

Standard solvent extraction procedures were followed to extract biochemical constituents from date fruits using soxhlet apparatus based on polarity. The methanol crude extract was fractionated by hexane pure until the hexane becomes colourless. Further, ethyl acetate was used as a solvent to yield fractions. All the collected fractions were dried and subjected for further uses.

2.4. Estimation of minerals and vitamins in date fruits

Mineral nutrient accumulation in different cultivars of date fruits were estimated to assess the nutrient potential of date fruits. The micro and macro elements were quantified using Atomic absorption spectrophotometric [12] and Flame photometric methods [13]. In addition, standard spectrophotometric methods of AOAC (1990) was followed for determination of selected vitamins A, K, B1, B2, B3 and B9 content of the fruits.

2.5. Determination of total polyphenols and total flavonoids content in date fruits

Total polyphenols were determined as described by Al-Farsi et al. [10] using a UV-Visible spectrophotometric (UV Analyst- CT 8200) and Folin Ciocalteau reagent. The calibration curve of standard reference gallic acid was constructed using concentration in the range of 10–100 μg/mL. The TPC was calculated using linear regression equation obtained from the standard plot of gallic acid and results were expressed as milligram gallic acid equivalents per 100 g of dry weight (mg GAE/100 g DW). Similarly, total flavonoids content (TFC) of the date fruit extracts were measured according to the colorimetric assay of Kim et al. [14]. One milliliter of the methanolic extract was added to 300 μl sodium nitrite solution (5%) followed by 300 μl aluminum chloride (10%). Test tubes were incubated at room temperature for 5 min, and then 2 mL of 1 mL of sodium hydroxide was added. Immediately, the volume of reaction mixture was made to 10 mL with distilled water and the mixture was thoroughly vortexed. The absorbance of the mixture was determined at 510 nm. Total flavonoid content was reported as milligrams of catechin equivalents per 100 g (mg CE/100 g DW) with the concentration range of 20–100 μg/mL.

2.6. Detection of phenolics and flavonoid compounds in date fruits by HPLC

The selected date fruit varieties approximately 100 g DW of samples were taken without seeds. It was mashed and sliced into small pieces using knife and subjected to blend for 5 min. Acetone extraction of date fruits was done and then extracted with acetone-water (250 mL, 4 : 1 v/v) mixture at room temperature for 24 h using an orbital shaker. The extracts were then filtered and centrifuged at 4000 g for 10 min and the supernatant was concentrated under reduced pressure at 40°C for 3 h using a rotary evaporator to obtain the DPF hydoxyacetone crude extract. The phenolic related compounds were identified and measured by following the method of Hamad et al. [15]. The residues were dissolved in HPLC (High Performance Liquid Chromatography) grade MeOH to give 1000 mg/L concentration. Briefly methanol-dissolved sample (20 μl) was injected into a Shimadzu HPLC system (SCL-10 A vp, Shimadzu Corporation, Kyoto, Japan). The HPLC system consisted of a diode-array detector and a Lichrosorb Si-60, 7 μm, 3 × 150 mm column. The mobile phase consisted of water/formic acid, 90 : 10, v/v; and acetonitrile/water/formic acid, 85 : 10 : 5, v/v/v. Phenolic acids and flavonoids were quantified with a calibration curve obtained with the corresponding standards and the results were expressed as mg/100 g DW.

Table 1
Biometric analysis of different cultivars of Saudi Arabian date fruits

Dates fruit cultivars	Shape	Fruit Size (mm)			Fruit weight (g)			Seed/fruit Ratio (%)
		Length	Breadth	Length/width	Fruit	Pulp	Seed	
Sukkari	Oblate	36.0 ± 0.22^{c}	32.0 ± 0.18^{a}	1.12 ± 0.20^{e}	12.44 ± 0.23^{d}	10.51 ± 0.02^{c}	1.87 ± 0.19^{b}	15.03 ± 0.09^{b}
Rothan	Ovate	28.0 ± 0.17^{d}	20.0 ± 0.14^{c}	1.40 ± 0.19^{c}	14.56 ± 0.79^{b}	12.36 ± 0.11^{b}	2.10 ± 0.06^{a}	14.42 ± 0.52^{b}
Sukkai	Ovate	39.0 ± 0.16^{bc}	19.0 ± 0.18^{c}	2.05 ± 0.00^{b}	13.38 ± 0.14^{c}	11.74 ± 0.04^{bc}	1.43 ± 0.21^{d}	10.68 ± 0.02^{d}
Abu Minifee	Oblate	36.0 ± 0.23^{c}	28.0 ± 0.22^{bc}	1.28 ± 0.11^{d}	16.50 ± 0.92^{a}	14.31 ± 0.31^{a}	2.09 ± 0.56^{a}	12.67 ± 0.14^{c}
Dawee	Ovate	52.1 ± 0.08^{a}	16.5 ± 0.17^{d}	3.15 ± 0.40^{a}	13.78 ± 0.37^{bc}	12.07 ± 0.74^{b}	1.71 ± 0.32^{c}	12.40 ± 0.71^{c}
Ekhlass Alhasa	Oblate	42.0 ± 0.13^{b}	28.0 ± 0.12^{bc}	1.50 ± 0.21^{c}	12.15 ± 0.41^{d}	10.07 ± 0.27^{c}	2.08 ± 0.93^{a}	17.11 ± 0.83^{a}
Ekhlass Almajmaah	Oblate	37.0 ± 0.24^{c}	29.0 ± 0.13^{b}	1.27 ± 0.07^{d}	13.07 ± 0.85^{c}	11.55 ± 0.07^{c}	1.42 ± 0.30^{d}	10.86 ± 0.65^{d}

Values indicated in the table are mean ± SD for triplicates; similar alphabet in a column denotes they are not significant and vice versa; a lower alphabet denotes they are highly significant and vice versa.

2.7. Antioxidant activities of date fruits

The extracts of date fruits were subjected to various assays of DPPH [13], H_2O_2 [14], Hydroxyl radical assay [16], CUPRAC (cupric reducing antioxidant power) [17], FRAP [18] and Ammonium molybdate [19] scavenging properties. The concentration of 100μg/mL extracts was used for respective assays to perform the antioxidant properties.

2.8. Statistical analysis

The experiments were conducted in triplicates and results were analyzed statistically using Graphpad prism 5.0 Version [20]. Duncan's Multiple Range test was performed to analyze the significance of the obtained results based on SPSS software.

3. Results

3.1. Morphological and biometric characteristics of different cultivars of Saudi Arabian date fruits

In harvested ripened stage, seven different cultivars of date fruits were selected and subjected to study the physiological characters including appearance, fruit shape, size and weight. Morphological features and variations of different cultivars were clearly presented in the (Fig. 1). Ovate shaped dates were observed in the varieties of Rothan, Sukkai and Dawee whereas oblate shaped dates were noted in other four varieties. According to the Table 1, the maximum length of the fruit was observed in Dawee with 52.1 ± 0.08 mm. In contrast, the maximum breadth was noticed in Sukkari with 32.0 ± 0.18 mm. However, the length/width ratio was found to be highest in Dawee with 3.15 ± 0.40 mm. The weight of the fruit ranged from 12.15 ± 0.41 to 16.50 ± 0.92 g. The highest pulp weight (14.31 ± 0.31 g) was measured in Abu Minifee variety. This was followed by Rothan and Dawee varieties, while lowest weight 10.07 ± 0.27 g was identified in Ekhlass Alhasa. In general, shape and size of the fruits were significantly different in the all the varieties of date fruits of the same region.

3.2. Estimation of biochemical constituents in different date fruits

The fruits were different in colour and tastes due to changes in the biochemical constituents present in the (Fig. 1). The biochemical constituents were determined for the crude methanolic extract of seven varieties of

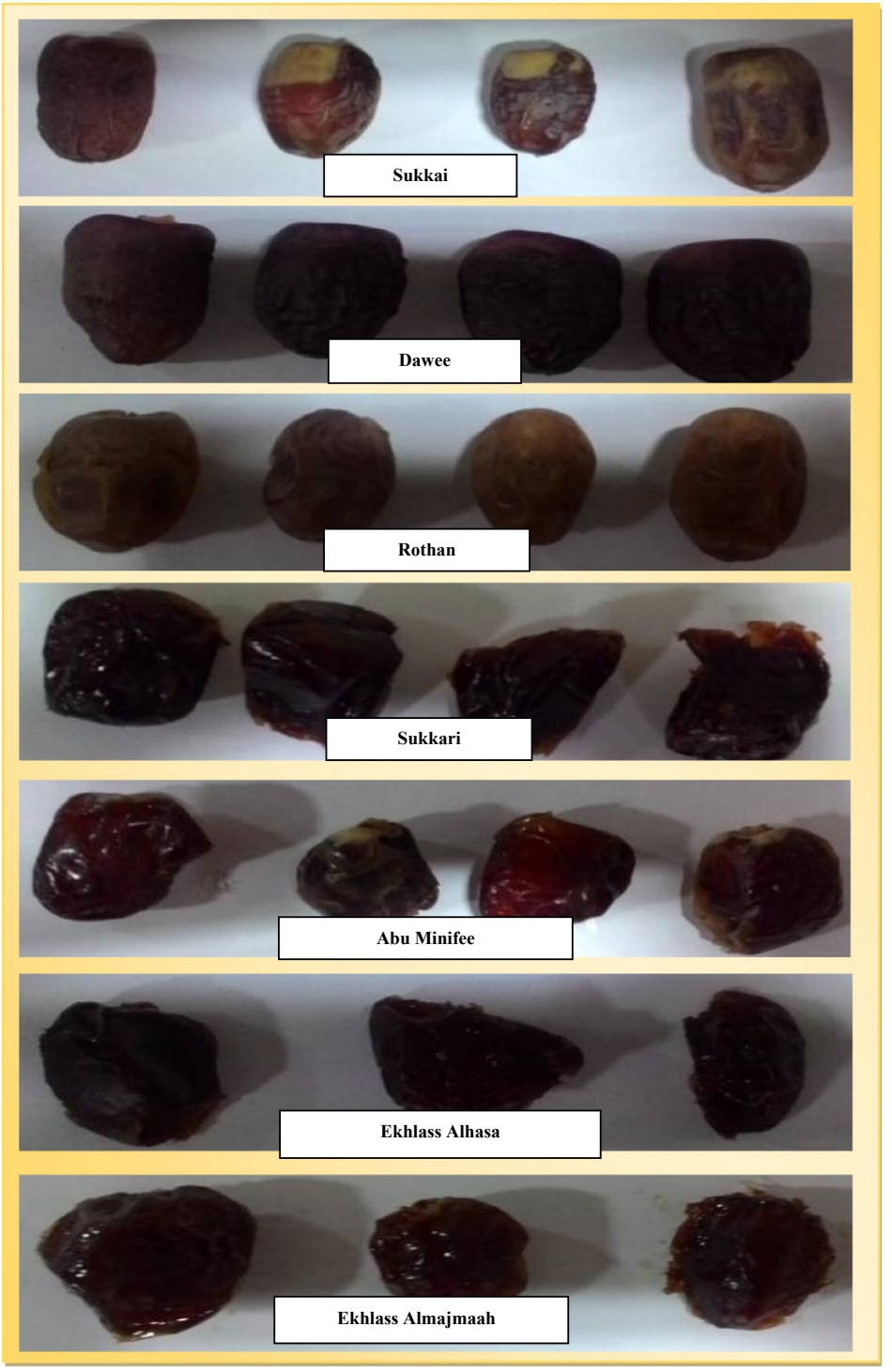

Fig. 1. Morphological appearance of different cultivars of Saudi Arabian date fruits.

Table 2
Biochemical constituents of different cultivars of date fruits fresh

Date fruit varieties	Biochemical constituents (%)						
	Moisture	Protein	Carbohydrates	Lipids	Ash	Crude fiber	Total solid
Sukkari	21.23 ± 0.22^{b}	2.69 ± 0.08^{ef}	69.79 ± 0.59^{e}	1.83 ± 0.004^{d}	2.20 ± 0.02^{ab}	2.41 ± 0.18^{e}	72.93 ± 0.27^{d}
Rothan	11.15 ± 0.07^{e}	3.84 ± 0.03^{a}	85.12 ± 0.22^{a}	2.45 ± 0.015^{b}	1.73 ± 0.02^{cd}	4.06 ± 0.03^{b}	83.74 ± 0.43^{ab}
Sukkai	21.23 ± 0.12^{b}	2.76 ± 0.04^{e}	77.00 ± 0.50^{c}	1.45 ± 0.003^{e}	2.12 ± 0.03^{b}	3.68 ± 0.14^{c}	78.85 ± 0.39^{bc}
Abu Minifee	17.14 ± 0.05^{c}	3.02 ± 0.03^{d}	74.31 ± 0.63^{d}	2.24 ± 0.004^{c}	2.11 ± 0.01^{b}	2.94 ± 0.07^{d}	75.48 ± 0.48^{c}
Dawee	13.23 ± 0.08^{d}	3.73 ± 0.04^{ab}	82.12 ± 0.22^{ab}	2.70 ± 0.006^{a}	1.80 ± 0.02^{c}	4.23 ± 0.11^{a}	85.26 ± 0.55^{a}
Ekhlass Alhasa	14.67 ± 0.15^{d}	3.32 ± 0.04^{c}	81.49 ± 0.59^{ab}	2.06 ± 0.005^{c}	1.85 ± 0.02^{c}	3.74 ± 0.20^{c}	80.13 ± 0.36^{b}
Ekhlass Almajmaah	23.67 ± 0.20^{a}	2.78 ± 0.03^{e}	70.28 ± 0.59^{e}	1.51 ± 0.003^{e}	2.28 ± 0.04^{a}	2.47 ± 0.04^{e}	73.92 ± 0.24^{d}

Values indicated in the table are mean ± SD for triplicates; similar alphabet in a column denotes they are not significant and vice versa; a lower alphabet denotes they are highly significant and vice versa.

date fruits. According to the Table 2, the moisture content of the given date varieties was found to vary from 23.67 ± 0.20 to $11.15 \pm 0.07\%$. The highest protein (3.84 ± 0.03) and carbohydrate (85.12 ± 0.22 g/100 g of dry weight) contents was recorded in Rothan variety. This was followed by Dawee and least amount of these contents (2.69 ± 0.08 and $69.79 \pm 0.59\%$) was noticed in Sukkari variety. In contrast the maximum lipid content (2.70 ± 0.006) was observed in Dawee variety. The ash content of all the selected seven varieties ranged from 1.73 ± 0.02 to $2.28 \pm 0.04\%$. The amount of crude fiber and total solids was superior in Dawee variety registered with 4.23 ± 0.11 and $85.26 \pm 0.55\%$; respectively. The above content in Rothan was slightly inferior to Dawee variety in terms of percentage.

3.3. Analysis of mineral composition status in selected variety of Saudi Arabian date fruit cultivars

The selected date fruit cultivars were subjected to analysis of macro and microelements Table 3. It has been noted that date fruits contained significant amounts of minerals which added nutritional value for diet. Among different macro elements, a significant amount of phosphorus and potassium contents with the values of 121.11 ± 3.23 and 767.86 ± 3.11 mg/100 g of DW was recorded in Rothan variety. This was followed by Dawee variety (94.37 ± 4.12 and 659.39 ± 3.34 mg/100 g of DW). On contrary, sodium content was noted highly in Ekhlass Alhasa variety with 15.64 ± 0.63 mg/100 g of DW. The calcium content was recorded in least amount when compared to sodium content which ranged from 0.52 ± 0.08 to 0.82 ± 0.02 mg/100 g of DW. In case of microelements, iron (1.75 ± 0.36), copper (2.94 ± 0.03) and selenium (0.71 ± 0.01 mg/100 g of DW) contents was superior in Rothan variety, when compared with other date varieties. Sukkai variety was recorded with maximum zinc content with 1.17 ± 0.01 mg/100 g of DW. Based on the above studies, most of the analyzed minerals showed significant differences among the different Saudi Arabian date fruit cultivars.

3.4. Assessment of vitamin profile in selected date fruit varieties of Saudi Arabian cultivars

The selected varieties of dates fruits were tested for nutrient values of different vitamins. From the Table 4, vitamin A, vitamin K, vitamin B1, vitamin B2, vitamin B3 and vitamin B9 were found to be dominant in almost all varieties of date fruits. Among the six different vitamins analyzed, vitamin A and vitamin B1 level was chiefly found in Rothan variety with 0.07%. In contrast, Dawee and Ekhlass Alhasa varieties displayed similar level of vitamin K (0.0025% and 0.0024%). The level of vitamin B2 and B9 ranged from 0.01% to 0.06% respectively. However, there was a significant amount of vitamin B3 registered in all the seven varieties. Among them, Dawee was recorded with the highest amount of 1.74% and Ekhlass Almajmaah was registered with least amount of 1.48%.

Table 3
Mineral composition of different varieties of Saudi Arabian date fruits

Date fruit varieties	Macro elements (mg/100 g of DW)				
	P	K	Na	Ca	Mg
Sukkari	57.32 ± 5.02^{e}	178.54 ± 2.03^{g}	5.96 ± 0.28^{e}	0.44 ± 0.09^{e}	53.80 ± 5.26^{d}
Rothan	121.11 ± 3.23^{a}	767.86 ± 3.11^{a}	12.48 ± 0.72^{b}	0.82 ± 0.02^{a}	70.42 ± 6.19^{c}
Sukkai	78.34 ± 2.34^{d}	344.71 ± 2.23^{e}	9.30 ± 0.44^{c}	0.60 ± 0.04^{c}	57.78 ± 7.11^{cd}
Abu Minifee	74.28 ± 6.06^{d}	426.92 ± 4.07^{d}	10.85 ± 1.07^{bc}	0.58 ± 0.06^{cd}	91.23 ± 4.75^{a}
Dawee	94.37 ± 4.12^{b}	659.39 ± 3.34^{b}	7.81 ± 0.91^{d}	0.79 ± 0.03^{ab}	68.31 ± 2.94^{c}
Ekhlass Alhasa	82.09 ± 2.05^{c}	532.64 ± 4.06^{c}	15.64 ± 0.63^{a}	0.72 ± 0.01^{b}	78.29 ± 3.53^{b}
Ekhlass Akmajmaah	63.21 ± 5.14^{e}	230.48 ± 3.01^{f}	6.77 ± 1.13^{d}	0.52 ± 0.08^{d}	52.88 ± 1.07^{d}
	Microelements (mg/100 g of DW)				
	Fe	Cu	Zn	Se	Mn
Sukkari	0.61 ± 0.04^{d}	1.38 ± 0.04^{cd}	0.45 ± 0.03^{d}	0.58 ± 0.04^{c}	0.28 ± 0.01^{c}
Rothan	1.75 ± 0.36^{a}	2.94 ± 0.03^{a}	0.67 ± 0.02^{c}	0.71 ± 0.01^{a}	0.32 ± 0.02^{b}
Sukkai	0.45 ± 0.14^{e}	0.93 ± 0.01^{d}	1.17 ± 0.01^{a}	0.64 ± 0.02^{b}	0.41 ± 0.01^{ab}
Abu Minifee	1.20 ± 0.09^{c}	0.37 ± 0.02^{f}	0.88 ± 0.05^{b}	0.27 ± 0.04^{f}	0.22 ± 0.03^{d}
Dawee	1.43 ± 0.21^{b}	2.61 ± 0.05^{b}	1.11 ± 0.07^{a}	0.44 ± 0.07^{d}	0.39 ± 0.01^{ab}
Ekhlass Alhasa	1.26 ± 0.07^{c}	0.52 ± 0.01^{e}	1.04 ± 0.06^{ab}	0.35 ± 0.03^{e}	0.47 ± 0.02^{a}
Ekhlass Almajmaah	0.79 ± 0.03^{d}	1.66 ± 0.03^{c}	0.97 ± 0.04^{ab}	0.29 ± 0.02^{f}	0.30 ± 0.04^{b}

Values indicated in the table are mean ± SD for triplicates; similar alphabet in a column denotes they are not significant and vice versa; a lower alphabet denotes they are highly significant and vice versa.

Table 4
Vitamin profile of different varieties of Saudi Arabian date fruits

Date fruit varieties	Fat and water soluble vitamins in date fruits (mg/100 g of DW)					
	Vitamin A	Vitamin K	Vitamin B1	Vitamin B2	Vitamin B3	Vitamin B9
Sukkari	0.05^{b}	0.0014^{d}	0.04^{cd}	0.02^{e}	1.51^{e}	0.01^{d}
Rothan	0.07^{a}	0.0021^{b}	0.07^{a}	0.05^{b}	1.67^{bc}	0.03^{b}
Sukkai	0.03^{cd}	0.0019^{bc}	0.03^{de}	0.03^{d}	1.65^{c}	0.04^{a}
Abu Minifee	0.02^{d}	0.0014^{d}	0.06^{ab}	0.04^{c}	1.70^{ab}	0.02^{c}
Dawee	0.04^{bc}	0.0025^{a}	0.05^{bc}	0.06^{a}	1.74^{a}	0.03^{b}
Ekhlass Alhasa	0.05^{b}	0.0024^{a}	0.03^{de}	0.05^{b}	1.59^{d}	0.04^{a}
Ekhlass Almajmaah	0.03^{cd}	0.0017^{c}	0.04^{cd}	0.03^{d}	1.48^{e}	0.01^{d}

Similar alphabet in a column denotes they are not significant and vice versa; a lower alphabet denotes they are highly significant and vice versa.

3.5. Phenolic and flavonoid compounds detected in Saudi Arabian date fruit varieties

In this study, we estimated the total amount of phenolic and flavonoid compounds present in the seven different cultivars of Saudi Arabian date fruits Tables 5 and 6. Among different phenolic compounds, higher amount of phenolic content was recorded in ferulic acid and gallic acid. The highest amount of ferulic acid of 12.71 ± 0.82 mg/100 g DW was recorded in Dawee variety and the least amount of 4.59 ± 0.25 mg/100 g DW was recorded in Sukkai variety. The gallic acid was found to be in the range from 9 ± 0.94 to 21 ± 0.87 mg/100 g DW. In general, p-coumaric acid, vanillic acid and caffeic acid were found to contain similar amount of phenolic

Table 5
Different types of phenolic compounds present in seven varieties of Saudi date fruit cultivars

Date fruit varieties	Phenolic compounds (mg/100 g of DW)						
	Ferulic acid	Gallic acid	*p*-Coumaric acid	Syringic acid	Vanillic acid	Caffeic acid	Total amount of phenolics
Sukkari	4.65 ± 0.39^{e}	9 ± 0.94^{c}	4.1 ± 0.15^{d}	0.71 ± 0.09^{b}	1.78 ± 0.53^{d}	1.37 ± 0.26^{e}	21.61 ± 2.36^{d}
Rothan	11.64 ± 0.77^{ab}	21 ± 0.87^{a}	7.2 ± 0.59^{a}	0.77 ± 0.06^{a}	4.16 ± 0.09^{ab}	2.24 ± 0.17^{c}	47.01 ± 2.55^{a}
Sukkai	4.59 ± 0.25^{e}	13 ± 0.65^{bc}	3.5 ± 0.24^{e}	0.52 ± 0.07^{d}	2.89 ± 0.38^{c}	0.78 ± 0.45^{f}	25.28 ± 2.04^{c}
Abu Minifee	7.97 ± 0.44^{c}	19 ± 0.54^{a}	1.7 ± 0.47^{f}	0.58 ± 0.04^{cd}	3.63 ± 0.22^{b}	1.84 ± 0.36^{d}	34.72 ± 2.07^{b}
Dawee	12.71 ± 0.82^{a}	17 ± 0.76^{ab}	6.5 ± 0.63^{b}	0.63 ± 0.05^{cd}	4.74 ± 0.46^{a}	2.75 ± 0.20^{b}	44.33 ± 2.92^{ab}
Ekhlass Alhasa	9.52 ± 0.68^{b}	14 ± 0.48^{bc}	5.5 ± 0.36^{c}	0.46 ± 0.03^{d}	3.59 ± 0.18^{b}	3.36 ± 0.07^{a}	36.34 ± 1.59^{b}
Ekhlass Almajmaah	5.78 ± 0.56^{d}	12 ± 0.28^{bc}	4.4 ± 0.09^{d}	0.69 ± 0.08^{b}	1.96 ± 0.27^{d}	2.32 ± 0.51^{c}	27.15 ± 1.79^{c}

Values indicated in the table are mean ± SD for triplicates; similar alphabet in a column denotes they are not significant and vice versa; a lower alphabet denotes they are highly significant and vice versa.

Table 6
Different types of flavonoid compounds present in seven varieties of Saudi Arabian date fruit cultivars

Date fruit varieties	Flavonoid compounds (mg/100 g of DW)					
	Rutin	Isoquercetrin	Quercetin	Luteolin	Apigenin	Total Flavonoids
Sukkari	0.66 ± 0.06^{c}	0.70 ± 0.09^{a}	0.54 ± 0.48^{d}	0.01 ± 0.00^{c}	0.16 ± 0.02^{c}	2.07 ± 0.65^{d}
Rothan	0.87 ± 0.11^{a}	0.36 ± 0.06^{d}	0.97 ± 0.36^{a}	0.05 ± 0.01^{ab}	0.32 ± 0.09^{a}	2.57 ± 0.63^{a}
Sukkai	0.75 ± 0.24^{b}	0.54 ± 0.07^{b}	0.72 ± 0.40^{bc}	0.03 ± 0.00^{bc}	0.15 ± 0.02^{c}	2.19 ± 0.73^{c}
Abu Minifee	0.48 ± 0.17^{e}	0.08 ± 0.05^{f}	0.58 ± 0.31^{d}	0.02 ± 0.00^{c}	0.09 ± 0.00^{d}	1.25 ± 0.53^{f}
Dawee	0.79 ± 0.09^{b}	0.46 ± 0.04^{c}	0.79 ± 0.27^{b}	0.07 ± 0.01^{a}	0.27 ± 0.05^{ab}	2.38 ± 0.46^{b}
Ekhlass Alhasa	0.54 ± 0.21^{d}	0.12 ± 0.02^{f}	0.83 ± 0.62^{b}	0.04 ± 0.00^{b}	0.21 ± 0.04^{b}	1.74 ± 0.89^{e}
Ekhlass Almajmaah	0.58 ± 0.03^{d}	0.25 ± 0.01^{e}	0.64 ± 0.11^{c}	0.03 ± 0.00^{b}	0.16 ± 0.01^{c}	1.66 ± 0.16^{e}

Values indicated in the table are mean ± SD for triplicates; similar alphabet in a column denotes they are not significant and vice versa; a lower alphabet denotes they are highly significant and vice versa.

substances. However, these derivatives were present in moderate level. Hence the total phenolics ranged between 21.61 ± 2.36 and 47.01 ± 2.55 mg/100 g. In addition, five different classes of flavonoids compounds were analysed among them, rutin, isoquercetrin, quercetin were detected in higher amounts when compared to luteolin and apigenin compounds. The highest amount of compound rutin (0.87 ± 0.11) and quercetin (0.97 ± 0.36 mg/100 g of DW) was registered in Rothan variety. Luteolin was noticed with least values of all varieties. Among them, total flavonoid content was identified in the range of 1.25 ± 0.53 and 2.57 ± 0.63 mg/100 g DW. Conversely, the amount of total flavonoid content was found to be inferior when compared to total phenolic content.

3.6. In vitro antioxidant activities of different date fruits

The antioxidant activity of the date fruits was determined using different assays including DPPH, FRAP, CUPRAC, H_2O_2, scavenging, ammonium molybdate and hydroxyl radical scavenging assays Table 7. Among different assays performed, the Rothan sample was found to possess highest antioxidant activity in DPPH FRAP and CUPRAC reducing assay (62.17 ± 3.37, 56.55 ± 3.40 and $78.12 \pm 4.32\%$) as it contained higher amount of phenolic and flavonoid compounds in this variety is the major reason for this biological activity, because flavonoids, especially those having hydroxyl groups, which are potent hydrogen donors could consequently can

Table 7
In vitro antioxidant activities of various date fruits of Saudi Arabia

Date fruit varieties per 100 μg of Extract	Antioxidant activities (%) inhibition					
	DPPH Assay	FRAP Assay	CUPRAC Reducing Assay	H_2O_2 Scavenging Assay	Ammonium Molybdate Assay	Hydroxyl Radical Scavenging Assay
Sukkari	51.36 ± 1.73^{bc}	35.62 ± 5.34^{d}	67.23 ± 3.44^{b}	23.12 ± 0.87^{c}	23.88 ± 0.09^{d}	11.16 ± 0.56^{d}
Rothan	62.17 ± 3.37^{a}	56.55 ± 3.40^{a}	78.12 ± 4.32^{a}	31.73 ± 1.29^{b}	46.13 ± 1.91^{a}	17.54 ± 0.37^{c}
Sukkai	53.18 ± 2.92^{bc}	25.21 ± 2.42^{e}	67.12 ± 1.53^{b}	18.97 ± 1.61^{cd}	28.94 ± 0.42^{cd}	22.83 ± 0.12^{b}
Abu Minifee	47.61 ± 2.39^{cd}	45.76 ± 1.45^{bc}	72.49 ± 2.85^{ab}	42.11 ± 2.72^{a}	35.78 ± 0.43^{bc}	17.34 ± 0.34^{c}
Dawee	26.78 ± 2.53^{d}	22.33 ± 3.33^{e}	75.28 ± 3.98^{a}	20.05 ± 3.12^{c}	32.76 ± 2.54^{bc}	28.94 ± 0.67^{a}
Ekhlass Alhasaa	58.15 ± 1.68^{ab}	42.12 ± 1.78^{c}	61.22 ± 2.49^{c}	17.41 ± 0.78^{d}	40.43 ± 0.32^{ab}	12.32 ± 0.52^{d}
Ekhlass Almajmaah	45.12 ± 2.09^{cd}	51.25 ± 3.12^{b}	71.11 ± 2.21^{ab}	30.55 ± 1.33^{b}	22.19 ± 1.24^{d}	15.36 ± 0.82^{c}

Values indicated in the table are mean ± SD for triplicates; similar alphabet in a column denotes they are not significant and vice versa; a lower alphabet denotes they are highly significant and vice versa.

neutralize free radical easily. The maximum H_2O_2 scavenging activity was observed in Abu Minifee variety with $42.11 \pm 2.72\%$. Ammonium molybdate and hydroxyl radical scavenging assays occurred in between 11.16 ± 0.56 and $46.13 \pm 1.91\%$. However, on the bases of used methods, the antioxidant efficiency of syrups can be arranged as follows: Rothan > Dawee > Ekhlass Alhasa > Abu Minifee > Sukkai > Ekhlass Almajmaah > Sukkari. This arrangement could be attributed to their significant differences in the contents of total phenolic and total flavonoids.

4. Discussion

In the present study, a total of seven varieties of Saudi Arabian date fruits were undertaken to evaluate the impact of nutritional value by analyzing various morphological, biochemical and antioxidant activities. At the ripened stage, morphological variations of shape, size and weight of the selected date fruit cultivars were measured. Most predominantly, ovate and oblate shaped date fruits were observed in the selected varieties. According to Hussein et al. [21] ripened date fruits have different shapes and sizes which are oval-cylindrical in shape, with 3–7 cm long, 2–3 cm diameter due to nature of date fruits and climatic conditions. The above studies demonstrated that the drastically differences exist in size of various date fruits cultivars. One of the criterions of quality of matured date fruits is their seed/fruit ratio. In relation to that Dawee hold commercial value when compared to other date fruit varieties and good quality date fruit varieties have high flesh % and fruit/pit ratio [10].

Analysis of biochemical parameters such as carbohydrates, protein, lipids, ash, crude fiber and total solids revealed a considerable difference between date fruit varieties. Our findings were similar to that of Tang et al. [9]. On the other hand, the findings were unparallel to different amounts of these chemical components in date fruits from various native growing regions. This may be due to various edaphic environmental factors and harvest/postharvest practices [22]. Hence, Rothan and Dawee varieties possess appreciable biochemical components with important nutrient value which can be recommended for daily consumption.

Similar to biochemical constituents, there was a substantial quantity of mineral composition existing in seven varieties of selected date fruit cultivars. Earlier studies of Assirey [23], who reported the presence of significant amount of minerals, which were more than threefold increase contained in date fruits. In addition, date fruits contained large amount of potassium with small amount of sodium contents ideally required for hypertension people. Moreover, the presence of appreciable amount of iron, magnesium and calcium levels is vital for healthy bone development and defeating anemia. The above findings confirmed that dates have high nutritional value. Likewise, the selected date fruit varieties contained different types of fat and water-soluble vitamins. Among

fat soluble vitamins, vitamin A and K are dominantly existed in these varieties at varying level. On contrary, water soluble vitamins B1, B2, B3 and B9 were found to be present at diversified level. Of them niacin (vitamin B3) was found to be in predominant among the group. According to El-Sohaimy and Hafez [24], confirmed the presence of B-complex vitamins B1, B2, nicotinic acid and vitamin A in Egyptian date palm fruits. From these findings, the presence of these vitamins has important role in fat and carbohydrate metabolism, maintain physical body, and retains blood glucose levels and hemoglobin production. Early efforts focused on identifying protective nutrients, for example vitamin E, vitamin C, and β-carotene, have proven to be disappointing when tested in clinical trials. This is almost certainly owing to the complexity of fruit or vegetables and the large number of bioactive compounds present, and also because of other dietary sources containing these bioactive compounds [25].

It has been reported that date fruits exhibit large antioxidant activities due to the presence of large amount of polyphenolic compounds [22]. Similarly, Bilgari et al. [26] detected the presence of flavonoid compounds in date fruits. The amount of total phenolic and flavonoid contents detected in the tested date fruit cultivars was nearly parallel according to the result of Hamad et al. [15] who reported that the total phenolic content ranged between 27.20 and 38.50 mg/100 g FW and total flavonoid content for the methanolic date fruit extracts and between 22.80 and 42.60 mg/100 g FW for the corresponding ethyl acetate extracts. Conversely, Al-Farsi et al. [22] reported total phenolics content values between 217.0 and 343.0 mg/100 g fresh weight for some Omani date fruits. In our study, we totally detected six phenolic (Ferulic acid, gallic acid, p-Coumaric acid, syringic acid, vanillic acid and caffeic acid) and five flavonoid (Rutin, isoquercetrin, quercetin, luteolin and apigenin) contents as well. Earlier, influence and existence of correlations of antioxidants, total polyphenols and flavonoids on minerals suggested the influence of antioxidant compounds on mineral was identified by Mohamed et al. [6]. The varying levels of these compounds in the date fruit varieties may be correlated with edaphic and environmental factors that prevail in the native growing region. These findings revealed that difference in date fruit varieties of same region may be factor for distribution of variation in the content of bioactive compounds and its activities.

The presence of considerable amount of phenolic compounds in date fruits are directly attributed to high antioxidant property. Previously, the above findings were confirmed the potential of the DPF as a source of natural antioxidants or nutraceuticals with possible applications to reduce oxidative stress and provide health benefits [27, 28]. The uses of novel dietary compounds that directly affect the mitochondrial functionality have the potential to emerge as a key platform technology for the next generation of functional foods, nutraceuticals and drugs [28]. The present study reports that palm dates can be a good source of natural antioxidants as they act by several mechanisms such as removal of free radicals, scavengers of – NO, – OH, and H_2O_2, chelation of Fe^{2+} ion, the ability to reduce transition metals (i.e., Fe3+ fi Fe2+) and the ability to prevent lipid peroxidation.

5. Conclusions

Our study showed that the selected date fruits varieties showed different morphological characters that were selected at ripened stage. These varieties grown in the same region however exhibited diverse biochemical composition including phenolic constituents and antioxidant activities. This study provides quantitative and qualitative data of the chemical composition of date fruits collected from the Kingdom of Saudi Arabia that holds applications in the field of nutraceuticals, biopharmaceutical industries and global economy. These results suggest that all date fruit varieties serve as a good source of natural antioxidants among them Rothan variety was found with superior quality and could potentially be considered as a nutritional food ingredient.

Conflict of interest

None to report.

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