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ORIGINAL ARTICLE

Sugar profile, volatile compounds, composition and antioxidant activity of Sukkari date palm fruit

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Abstract The target of this research was to determine sugar profile, volatile compounds, minerals content and antioxidant properties of the Sukkari date flesh as methanolic and ethanolic extracts. Sukkari date showed sugar 78.32% (dry weight), while fibre, crude protein, ash and crude fat were 3.15, 3.01, 2.30 and 0.56, respectively. Glucose (51.80%), fructose (47.50%), while small amount sucrose, fucose and galacturonic acid were also detected. Potassium, calcium and magnesium were observed to be the predominant. Twenty-two components were identified; 5-Hydroxymethylfurfural was present in the highest amount (27.25%), followed by 4H-Pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl (9.45%). Total phenolic and flavonoid content of methanolic extract were 62.50 mg GAE/100 g and 3.20 mg CE/100 g, respectively, against 60.25 mg GAE/100 g and 2.90 mg CE/100 g respectively, for ethanolic extracts. Three assays including DPPH, reducing power and ABTS radical scavenging activities showed a good antioxidant activity of date palm extract. Sukkari date was observed to have good nutritional and antioxidant characteristics and can be utilize as potential nutrition.

Keywords Sukkari · Date palm · Antioxidant activity · Extracts · Physicochemical characteristics

Introduction

Sukkari variety of date palm is a famous type grown in almost places of the Iraq and Kingdom Saudi Arabia due to its good economical returns to farmers and buyers as well as its high quality of fruits (Nasser et al. 2016). The Sukkari date fruits are considered the most famous premium date kind is the Arab countries, it has a very unique colour that easily differentiate it from the other date palm fruit varieties. It is named in the Arabic word (*Sukkar*) which dose it means "sugar", hence the extra sweetness you taste when you taste it (Soliman and Harhash 2012). This variety is commonly spelled as "Sukkari", "Sukkary" or "Succary". Date palm is actually have little content of fat and cholesterol. Therefore, these fruits are desirable for human health, particularly with heart conditions and also a good source of fibre which is good for the digestive system (Al-Abdoulhadi et al. 2011). Date palm (*Phoenix dactylifera* L.) was described as a dioecious fruit tree native to the hot arid countries in the world and grown mainly in North Africa and the Middle East. Date palm production has extended to the United States of America, Southern Africa, Australia, South America and Mexico within germplasm exchange (Jain et al. 2011). Right now, date palm fruits are mainly consumed in a lot of countries and considered as a vital ingredient and a staple food in almost Arab countries (Al-Farsi and Lee 2008). Date fruit is a good source of phenolics, flavonoids and carotenoids, antioxidant,

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antimutagenic, as well as medicinal values (Tang et al. 2013). In previous researches, physicochemical and antioxidant characteristics of different varieties of date palm were studied, sugar content (71.2–81.4%), ash (1.68–3.94%), while contained low concentrations of lipid and protein (0.12–0.72% and 1.72–4.73%, respectively). Potassium, calcium and magnesium were predominant minerals, and the main sugars were fructose and glucose (Assirey 2015; Mohamed et al. 2014; Parvin et al. 2015). Wine can be produced form date palm by fermentation or processing into an alcoholic beverage its only needs the optimum the temperature, yeasts, and production conditions (Chandrasekhar et al. 2012). Almost of dates palm fruits varieties are rich in sugar (glucose and fructose), fibre and minerals (potassium, magnesium and calcium), but have a low content of protein, amino acids (methionine tyrosine and phenylalanine) and lipids (Assirey 2015). Antioxidant activity of volatile, phenolics and flavonoids compounds is due to their redox characteristics, which play an important role in scavenging free-radicals, quenching oxygen and decomposing peroxides (Singh et al. 2016b). Earlier study about variety of date palm from Sudan, antioxidant activities ferric-reducing antioxidant power was 2.82–27.5 mmol/100 g, chelation of Fe^{2+} ion ranged from 54.31 to 94.98%, and scavenging of H_2O_2 ranged from 38.48 to 49.13% (Mohamed et al. 2014). Detailed information on the proximate composition and bioactive compounds of Sukkari date fruit will improve our knowledge for the use of these fruits their use as functional food and ingredients. To the best of our knowledge, limited data are available on the chemical composition of Sukkari date fruit. Therefore, the main purpose of current study was to investigate volatile compounds, sugar profile, minerals content and antioxidant activity of methanolic and ethanolic extracts of Sukkari variety of date palm.

Materials and methods

Materials and chemicals

Sukkari variety of date palm (*P. dactylifera* L.) was grown in Iraq and was brought as fresh fruits from a local market in Guangzhou city, People's Republic of China in September of 2017 and then, was transported to the school of Food Science and Engineering Laboratory of South China University of Technology, Guangzhou, China. Methanol, ethanol and DPPH (2,2-diphenyl-1-picrylhydrazyl) were purchased from Aladdin Industrial Corporation, Shanghai, China. All other chemicals and reagents were of the highest grade commercially available.

Physical analysis

The weight of 20 fresh whole randomly chosen fruits was determined using an analytical balance (Mettler-Toledo, Columbus, OH, USA). The seeds and pulp of the 20 fresh fruits were separated manually, collected in a Petri dish, and then the weight was determined in the same manner. Thickness, width and length of 20 fresh fruits were determined using a Vernier caliper.

Proximate composition analysis

Moisture, fibre, fat and ash contents of Sukkari date palm were determined using the standard AOAC, methods 925.09, 985.29, 932.06 and 923.03, respectively (Chemists 1990). The crude protein content of the sample was determined using a FOSS nitrogen analyser with a conversion factor of 6.25 (DK-3400, Hilleroed, Denmark), while the total carbohydrate content was calculated by difference from the others content in the proximate analysis.

Sugar profile

Carbohydrates content of Sukkari date fruits were determined using an ion chromatography system. Each of the commercial sugars standards: fucose, galactose, glucose, xylose, fructose, sucrose, glucuronic acid and rhamnose were dissolved in 1 mL of distilled water to yield a 0.1 mM solution which was used for calibration process, and then, the system was stabilized automatically by injecting of all standards solutions. Sample injections for each sugar experiments were made with a Thermo Spectra-Physics AS3500 or a Dionex AS50 or auto-sampler equipped with a 50 μL sample injection loop, 500 μL syringe, and injection valve fitted with a Tefzel rotor seal. A DX- 500 equipped with a CarboPac^{TM} PA20 column (3150 mm), working at a flow rate of 0.5 mL/min. PA20 chromatography (0.5 speed and 30 °C, ultra-pure water) was performed at an isocratic concentration of 95% distilled, deionized water (eluent 1) and 5% 200 mM NaOH (eluent 2) for 12 min. A wash step consisting of 100% eluent 2 (200 mM NaOH) is then implemented for 8 min. Finally, the column is re-equilibrated to the initial conditions for 12 min, after which the next injection is made. The elapsed time between sample injections was 32 min (Weitzhandler et al. 2004). The separated sugars were detected using an ED40 or an ED50. The data from a sequence of chromatographic runs were collected and the peaks in every sequence were identified by comparing their retention times (RTs) with those of the auto-calibration chromatograms. All peaks were thus identified, quantified, and organized into spreadsheet

format where the data was further processed using Microsoft Excel program.

Volatile compounds

GC–MS analysis of the Sukkari date extract was measured in an Agilent 7890 A instruments (Shanghai, China) with a computer for control at 70 eV. For this purpose, The Sukkari variety date palm fruits sample was subjected to a Clevenger apparatus for 6 h to steam distillation, and then the aqueous phase was isolated with diethyl ether and finally, the ether phase was dried over anhydrous sodium sulphate and collected in a dark glass bottle at 4 °C until use (Hanbali et al. 2005). A volume of extracted sample (1 µL) was injected into the GC–MS and the scanning process was done for 45 min. The initial time to when elution occurred was referred to as the retention time. The computer was generated a chromatogram from the signal during the instrument is running. The temperature (100 °C) of the oven was maintained and helium gas with flow rate (1 mL/min) was used as a carrier in addition, an eluent. The electron gun of mass detector liberated electrons having energy of about 70 eV. The column employed for the separation of components was Elite 1 (100% dimethyl polysiloxane). The identity of the components in the sample was assigned by comparison of their retention indices and mass spectra fragmentation patterns (Hussein et al. 2016). Volatile compounds identification was carried out also by matching the compounds with the mass spectra of standard compounds found in the wily 130 K and national institute of standards and technology (NIST) 98 library of MS. The experiment was conducted in duplicate.

Mineral analysis

Mineral contents of Sukkari fruit was determined by ashing the sample at 550 °C. The ash was dissolved in 6 M hydrochloric acid and made up to 10 mL. The magnesium (Mg) and calcium (Ca) content were determined according to the method of (Siddeeg et al. 2014), the blue colour that developed was read at 650 nm using UV–visible spectrophotometry (model UV-160A; Shimadzu) and expressed as mg of Mg/100 g meal, while the titrimetric method was used for Ca determination. The iron content was analysed using UV–visible spectrophotometry (model UV-160A; Shimadzu, Shanghai, China) at 480 nm. The other mineral contents were determined using atomic absorption spectroscopy (AA 6701F, Atomic Absorption Flame Emission Spectrophotometer equipped with hollow cathode lamps; Shimadzu).

Extraction process

Methanolic and ethanolic extracts were carried out according to the method of Mohamed et al. (2014) with a slight modification. Briefly, 50 g of the pulp date palm fruit was extracted with 150 mL ethanol–water and methanol–water (4:1) v/v at room temperature (24 °C) for 6 h using a basic orbital shaker. The ethanolic and methanolic extracts were filtered and then centrifuged (JW-3021 HR, high speed refrigerated centrifuge, Anhui Jiaven Equipments Industry Co. Ltd, China) at 5000 rpm for 12 min. The supernatant of the the extraction process was concentrated using a rotary evaporator at 40 °C (RE-2000E, Zhengzhou, Henan, China) to obtain the Sukkari variety of date palm fruits ethanolic and methanolic extract. In the end, the crude extracts were kept in dark bottles and kept at 4 °C until use.

Total phenolic content (TPC)

TPC of date flesh was conducted using the Folin–Ciocalteu method. Briefly, 200 mg of extracts (equivalents/mL) were mixed with 1.0 mL of Folin–Ciocalteu reagent and 4 mL of solvent; the mixture was then shaken for 2 min. 3.0 mL of Na_2CO_3 (15%) was added and the mixture was shaken again. The solution was then brought up to 20 mL with distilled water. The mixture was incubated for 20 min at 50 °C and centrifuged at 3000 rpm for 10 min. The absorbance was reported at 750 nm using spectrophotometer (TU-1810 series of UV–visible, General Analysis of General Instrument Co. Ltd., Beijing, China). Finally, TPC of the sample was calculated using Gallic acid equivalent as a standard (Azhari et al. 2014).

Total flavonoids content (TFC)

TFC of Sukkari variety date extracts were determined as follows: 2 mL of each ethanolic and methanolic extract were added to 600 µL $NaNO_2$ at concentration 5% solution, with also 600 µL $AlCl_3$ (10%). All test tubes were incubated for 5 min at room temperature (24 °C), followed by addition of 4 mL of 1 mol/L NaOH, and then the reaction mixture volumes were immediately made to 20 mL distilled water. The mixture was then carefully vortexed. Finally, the mixture absorbance's were recorded using spectrophotometer (TU-1810 series of UV–visible, General Analysis of General Instrument Co. Ltd., Beijing, China) at 510 nm. TFC of samples were recorded as mg catechin equivalents per 100 g dry weight (Kim et al. 2003).

Reducing power assay

According to Siddeeg et al. (2015), the reducing power assay of date flesh were carried out with a little modification. Different concentrations (200, 400, 600, 800 and 1000 µL) of Sukkari flesh date palm extracts equivalents/mL were mixed with 200 µL, 10 mg/mL potassium ferricyanide and 200 µL, 0.2 M, pH 6.6 sodium phosphate buffer and then were incubated for 30 min at 50 °C, after that, 200 µL, 100 mg/mL of Trichloroacetic acid was added. The mixtures were also incubated again at the same temperature for 5 min to drop the reaction process. A volume of the reaction mixture (680 µL) was mixed with distilled water (680 µL) and 68 µL of ferric chloride (10 mg/mL). Ascorbic acid (0.3 mM) was used as a reference component for comparison. The absorbance's of samples were reported using spectrophotometer (TU-1810 series of UV–visible, General Analysis of General Instrument Co. Ltd., Beijing, China) at 700 nm.

DPPH radical scavenging assay

DPPH radical scavenging activity of Sukkari date palm extracts were measured using the standard method (de Oliveira et al. 2012) with a little modification. Briefly, a various concentration of Sukkari date extract (200, 400, 600, 800 and 1000 µL) equivalents/mL was mixed with 2,2-diphenyl-1-picrylhydrazyl solution (3.5 mL) at 517 nm absorbance. The mixture were incubated at 25 °C for 30 min. The absorbance of sample solutions was recorded using spectrophotometer (TU-1810 series of UV–visible, General Analysis of General Instrument Co. Ltd., Beijing, China) at 517 nm. The DPPH radical scavenging activity was then calculated by the following equation: DPPH scavenging activity % = $(A_C–A_S/A_C) \times 100$, where A_S representative absorbance of extracts, while A_C representative absorbance of control and Gallic acid was used as a reference.

ABTS radical scavenging activity

ABTS radical scavenging assay of Sukkari date palm extracts was measured according to the method reported by Azhari et al. (2014). In brief, an aliquot of sample extracts concentrations (200, 400, 600, 800 and 1000 µL) equivalents/mL were mixed with 100 mM Tris–HCl buffer (900 µL) at pH 7.4, methanol (40 µL) and Tween 20 solution 50 µL of 0.5% (w/w). The ABTS radical was generated by mixing ABTS (7 mM) and potassium persulfate (2.45 mM) through incubation in the dark for 12 h at 24 °C. A volume of sample solution (0.1 mL) was mixed with a diluted ABTS radical solution (2.6 mL). After the incubation at 24 °C for 6 min, a spectrophotometer (TU-1810 series of UV–visible, General Analysis of General Instrument Co. Ltd., Beijing, China) was used to measure the absorbance of the solution at 734 nm. ABTS radical scavenging activity was calculated using the following equation: ABTS scavenging activity % = $(A_B–A_S/A_B)- \times 100$, where A_B representative the absorption of blank sample, while A_S representative the absorption of the sample. Ascorbic acid was used as a reference component for comparison.

Statistical analysis

All the experiments were carried out at least in duplicate, and statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) software, version 16.0 for Windows (SPSS Inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) was used to determine significant differences between means and Tukey's test was used to carry out multiple comparisons between means. The significance level was defined as $p < 0.05$. Origin version 8 and Microsoft Excel were used to help in the analysis of the data.

Results and discussion

Physical analysis

Whole fruit, pulp and seed showed weight of 9.19, 8.26, and 0.88 g, respectively. The percentage of flesh was (89.88%) higher than seed (10.12%), indicated that this variety has pertained for processing such as the transformative industries. Whole fruit showed the width, thickness and length of 1.99, 1.52 and 3.29 cm, respectively.

Proximate composition analysis

The proximate composition of the fruit pulp is shown in Table 1. Total carbohydrates content was the highest (78.32%), followed by fibre (3.15) and protein (3.00). Ash content was 2.30%, while fat was the lowest (0.56%). The proximate analysis results of Sukkari date palm were in general similar earlier studies on other varieties of date palm with some differences may be due to environmental conditions (Ahmed et al. 1995; Assirey 2015; Mohamed et al. 2014). Total soluble solids content, pH and energy value were 86.86%, 6.20 and 342 k/cal, respectively (Table 1). Sukkari fruit was observed to be a good source of energy and fibre. Results of proximate composition suggested that Sukkari dates are nutritious and can play a major role in human nutrition and health and an important nutritional source of minerals.

Table 1 Proximate composition (g/100 g), nutritional value and minerals content (mg/100 g dry weight) of Sukkari date flesh fruits

Parameters	Content (g/100 g)
Moisture	12.57 ± 0.32
Dry matter	87.43 ± 0.33
Ash	2.30 ± 0.20
Crude fiber	3.15 ± 0.80
Crude protein	3.00 ± 0.18
Crude oil and fat	0.65 ± 0.09
Total carbohydrates	78.32 ± 0.98
Energy (K/cal)	342 ± 2.26
Total soluble solids (%)	86.86 ± 0.26
pH	6.20 ± 0.10
Minerals content (mg/100 g dry weight)	
Calcium	186.55 ± 0.22
Phosphorus	26.50 ± 0.13
Sodium	4.75 ± 0.10
Magnesium	148.10 ± 0.09
Iron	6.50 ± 0.17
Copper	1.20 ± 0.15
Potassium	620.00 ± 0.27

All determinations were carried out in triplicates and mean value ± standard deviation

Minerals content

Minerals content of Sukkari flesh is shown in Table 1. Potassium content was the highest (620 mg/100 g dry); followed by calcium (186 mg/100 g dry) and magnesium (148 mg/100 g dry weight). The highest potassium content in flesh of this variety indicates that this can be used as a natural source of potassium supplementary for lactating women and pregnant, as well as for elderly and the children (Siddeeg et al. 2014). Earlier similar results were observed for other dates varieties for magnesium, calcium and potassium (Al-Farsi et al. 2005; Mohamed et al. 2014). Phosphorus, iron, sodium and copper were lowest content 26.50, 6.50, 4.75 and 1.20 mg/100 g, respectively (Table 1). The results of the present study were slightly different with the previous studies due to variation in dates cultivation, ripening stage, and genotypes. The low sodium and high potassium in date flesh was considered suitable for a human who have hypertension (Ralston et al. 2012). Minerals content of Sukkari date flesh was found higher than some fruit pulps such as pomegranate, kinnow, mango and banana (Singh et al. 2016a). Generally, minerals results were in close agreement with those of many other studies, which showed that Sukkari dates contained suitable concentrations of microelements such as calcium and phosphorus, which were important for metabolism in human cells.

Sugar profile

The major sugars found in the date flesh were monosaccharide's (glucose and fructose) followed by disaccharide (sucrose). Glucose, fructose and sucrose content were 51.80, 47.50 and 3.20 g/100 g dry weight, respectively. These results were found similar to those obtained by Mohamed et al. (2014) for the same variety of date palm grown in Saudi Arabia. Galacturonic acid and fucose were 2.23 and 2.51, respectively, while the other sugars were not detected. Reducing sugar and non-reducing sugar percentages of date flesh were 74.80 and 25.20%, respectively (Table 2). The high content of reducing sugar suggests the existence of pronounced invertase activity that may have reduced its sucrose content (Besbes et al. 2009). Glucose, fructose and fucose content of Sukkari were higher when compared them with other varieties such as Deglet-Nour and Allig date flesh from Tunisia (Elleuch et al. 2008).

Volatile compounds

Twenty-two components of volatile compounds were identified in the extract of Sukkari flesh using GC–MS (Table 3). 5-Hydroxymethylfurfural, 4H-Pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl, 4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy were present in highest amount (27.26, 9.45 and 7.85%, respectively), followed by 1,3,5-Triazine-2,4,6-triamine (5.14%), Morpholine, 4-methyl-, 4-oxide (4.40%), Butanoic acid, 2-methyl- and

Table 2 Sugar profile of Sukkari date flesh fruits (g/100 g dry weight)

Parameters	Value
Glucose	51.80 ± 0.10
Fucose	2.51 ± 0.18
Fructose	47.50 ± 0.31
Arabinose	ND
Xylose	ND
Sucrose	3.20 ± 0.30
Galacturonic acid	2.23 ± 0.26
Rhamnose	ND
Glucose/fructose	1.09 ± 0.30
Reducing sugar	74.80 ± 0.31
Non-reducing sugar	25.20 ± 0.30

All determinations were carried out in triplicates and mean value ± standard deviation

ND Not detected

Table 3 Volatile compounds of Sukkari date flesh fruits

Peak	RT	Percentage	Constituent
1	4.391	1.60	Urea, N-butyl-N-nitroso-
2	4.709	4.40	Morpholine, 4-methyl-, 4-oxide
3	7.683	5.14	1,3,5-Triazine-2,4,6-triamine
4	8.781	9.45	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-
5	9.083	1.65	2(3H)-Furanone, dihydro-4-hydroxy-
6	9.362	3.90	Dimethylamine, N-(neopentyloxy)-
7	9.551	5.38	Isosorbide Dinitrate
8	10.08	27.26	5-Hydroxymethylfurfural
9	10.332	5.41	1,2,3-Propanetriol, 1-acetate
10	10.521	1.26	2-Methyl-1-isopropyl(dimethyl)silyloxypropane
11	11.054	7.85	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy
12	11.328	1.92	2-Methyl-3,4,5,6-tetrahydropyrazine
13	11.832	3.16	3-Methyl-3-buten-1-ol, TMS derivative
14	12.418	3.57	Glycoluril
15	12.972	2.11	Propanamide, N,N-dimethyl-
16	13.557	4.07	Butanoic acid, 2-methyl-, 2-methylpropyl ester
17	13.811	2.20	1-Nitro-2-acetamido-1,2-dideoxy-d-glucitol
18	15.328	1.01	β-D-Glucopyranose, 4-O-β-D-galactopyranosyl-
19	15.692	3.44	3-Deoxy-d-mannoic lactone
20	15.992	2.68	3-Deoxy-d-mannoic lactone
21	18.729	1.06	n-Hexadecanoic acid
22	20.378	1.50	9,12-Octadecadienoic acid (Z,Z)-

RT Retention time

2-methylpropyl ester (4.07%). 5-Hydroxymethylfurfural has been identified preferred reaction conditions to produce it. Furfural can be produced by dehydration of monosaccharides like xylose in the presence of acidic catalysts (Chheda et al. 2007). Depending on the functional groups, the volatile compounds of Sukkari flesh extract contained different groups such as ester, hydroxyl, methyl and acid. There were some volatile compounds which were identified in the flesh extract belonging to unsaturated fatty acids and their derivatives such as 9,12-Octadecadienoic acid (Z,Z)- and n-Hexadecanoic acid (Table 3). Similar compounds were also reported (Albishri et al. 2013). However the bioactive have not been examined, but date flesh extract contained n-Hexadecanoic acid and 5-Hydroxymethylfurfural; these compound's derivatives were suggested as possible bioactive compounds due to their antioxidant, antibacterial and anti-inflammatory activity (Abubakar and Majinda 2016; Zhao et al. 2013).

TPC and TFC of methanolic and ethanolic extracts

TPC and TFC content of ethanolic extract were 62.50 mg GAE/100 g and 3.20 mg CE/100 g, respectively, against 60.25 mg GAE/100 g and 2.90 mg CE/100 g respectively, for methanolic extracts. Our results were agreement with Biglari et al. (2008); Mohamed et al. (2014) these studies reported between 1.62 and 81.79 mg catechin equivalents/100 g dry weight. The results of TPC were different compared with previous studies may be due to differences in varieties (Baliga et al. 2011; Benmeddour et al. 2013). The higher values of TFC and TPC observed in the ethanolic extracts ($p < 0.05$) compared with the methanolic extracts may be due to the polarity index of methanol and water (Usman et al. 2013). Though it is apparent that the flavonoids were an important phenolic compound contributing to the antioxidant activity of date flesh, it is also possible that other phenolic compounds can also contribute to the antioxidant characteristics of this kind of dates (Biglari et al. 2008). Phenolics and flavonoids were the largest groups among the plant phenolics which have been reported to have health benefits owing to their antioxidant characteristics (Singh et al. 2016b).

DPPH radical scavenging activity

DPPH radical scavenging activity of Sukkari flesh extracts and the radical scavenging potential of ascorbic acid as a reference compound is shown in Fig. 1. DPPH radical scavenging capacity of the ethanolic and methanolic flesh extracts in the range between 43–76 and 40–72%,

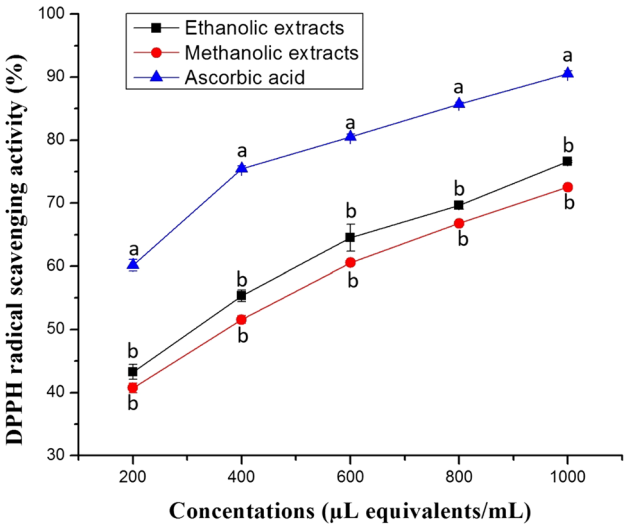

Fig. 1 DPPH radical scavenging activity of methanolic and ethanolic extracts of Sukkari date flesh. All determinations were carried out in triplicates and mean value ± standard deviation. Mean values with different letters are significantly different ($p < 0.05$) by Tukey's multiple range test

respectively, with IC_{50}; of 309.75 and 389.23 µL equivalent/mL, respectively. These had lower activity than the reference (ascorbic acid) used under similar concentrations. These results indicated the Sukkari flesh extracts free radical scavenging abilities. These results were in agreement with earlier studies done for different varieties of date palm fruits (Benmeddour et al. 2013; Hasan et al. 2010). Ethanolic extracts showed higher ($p < 0.05$) antioxidant activity, however, the differences were non-significant. DPPH is a stable free radical scavenged from purple to yellow after accepting an electron or proton radical to become a stable diamagnetic molecule when antioxidants are encountered (Singh et al. 2016b). DPPH results indicated that Sukkari date palm fruit had a diverse range of bioactive components, and thus may provide significant protection against the oxidation of essential biological macromolecules.

Reducing power assay

The reducing power of the compounds is used to assess their ability to donate an electrons and also may serve as an important indicator of their potential antioxidant capacity (Meir et al. 1995). The reducing powers of Sukkari extracts and Gallic acid as a reference compound are reported in Fig. 2. As can be seen, the absorbance's of the ethanolic and methanolic extracts ranged between 0.08–0.63 and 0.04–0.56, respectively which were lower than the absorbance recorded for the reference (0.93) at the concentration of 0.3 mM. These results were found in agreement of general trend reported before which can be seen; the reducing power increased with an increase in the concentration of the Sukkari flesh date palm. A similar trend was observed for DPPH results was found also in reducing power. The reducing power results for ethanolic > methanolic indicated that Sukkari date flesh extracts were able of converting the free radicals to donating electrons for steady products thus, due to these free radicals can readily terminate the reactions initiated (Anwar and Przybylski 2012). Thus, a strong correlation existed between antioxidant activity and the presence of volatile components, TPC and TFC of these dates.

ABTS radical scavenging activity

Generally, ABTS radical assay is used to determine the in vitro antioxidant activity of different bioactive compounds and the other substances. ABTS radical scavenging activity of Sukkari flesh extracts is shown in Fig. 3. The IC_{50} values of the ethanolic and methanolic extracts were 440.76 and 522.0 µL equivalent/mL, respectively, compared to 240.0 µL equivalent/mL. As reported by Neffati et al. (2009), decolorization of ABTS reflects the antioxidant activity of species to donate hydrogen, atoms or electrons to stop the activation of this radical action. However, the ethanolic extract was higher activity than methanolic extract; however, differences were not significant. Earlier ABTS radical scavenging activity has been used as a method to assess the total antioxidant activity of various varieties of date palm (Biglari et al. 2008; Mansouri et al. 2005). Presence of volatile, phenolics and flavonoids compounds showed moderate to good antioxidant activities in ABTS assay; this finding was in accordance with the bioactive components and chemical compositions (Biglari et al. 2008).

Conclusion

The physicochemical properties (proximate composition, minerals content, volatile compounds and sugars profile) and antioxidant activity (TPC, TFC, reducing power and DPPH and ABTS radical activities) of ethanolic and methanolic extracts of the date flesh. The results indicated that Sukkari date flesh had high content of sugar (glucose and fructose), minerals (K, Ca and Mg) and volatile compounds. Ethanolic extract gave better extraction efficiency than methanolic extract. Sukkari date variety has high levels of TPC, TFC and volatile compounds, suggesting potential protection capabilities against the action of oxidation which was confirmed by reducing power, DPPH and ABTS radical scavenging activities.

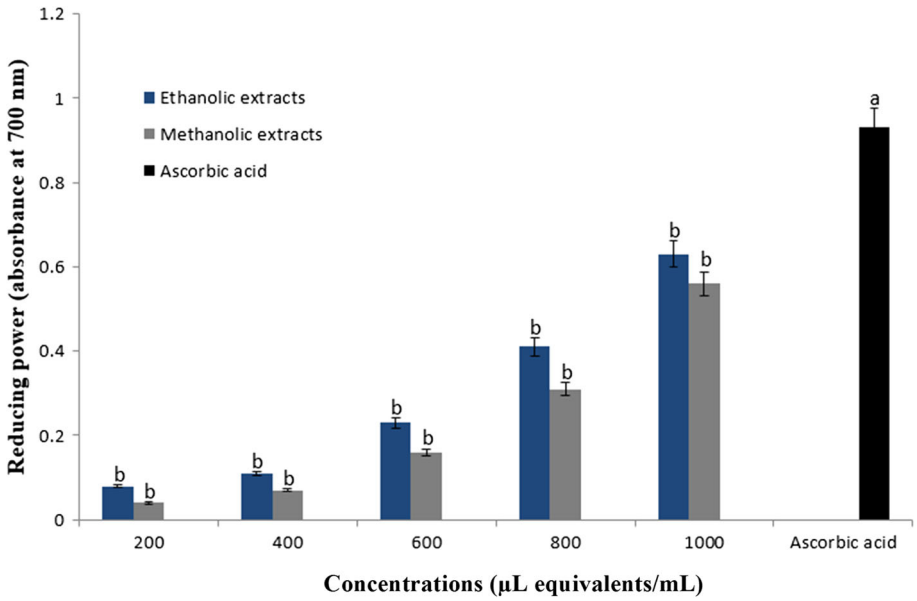

Fig. 2 Reducing power assay of methanolic and ethanolic extracts of Sukkari date flesh. All determinations were carried out in triplicates and mean value ± standard deviation. Mean values with different letters are significantly different ($p < 0.05$) by Tukey's multiple range test

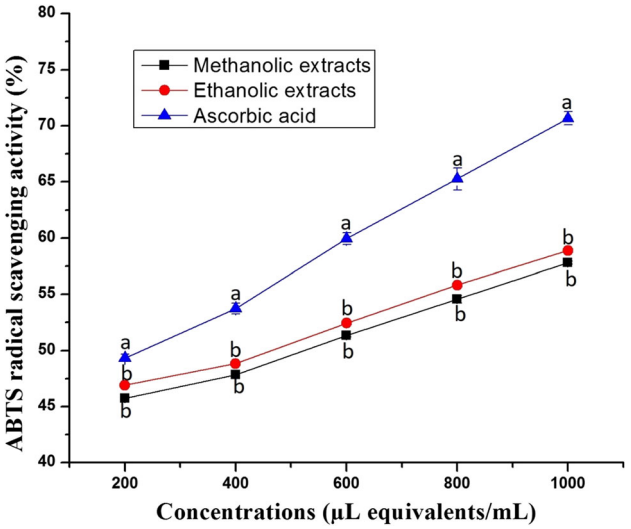

Fig. 3 ABTS radical scavenging activity of methanolic and ethanolic extracts of Sukkari date flesh. All determinations were carried out in triplicates and mean value ± standard deviation. Mean values with different letters are significantly different ($p < 0.05$) by Tukey's multiple range test

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