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Nutritional values and antioxidant activities of juice extracted from some Tunisian date varieties

I. SOULI*[1,2], M. BAGUES[2], B. LACHEHIB[2], A. FERCHICHI[3]

[1] University of Tunis El Manar, Faculty of Sciences of Tunis, Department of Biology, 2092, El Manar II, Tunis, Tunisia
[2] Aridlands and Oases Cropping Laboratory, Institute of the Arid Areas of Medenine, Tunisia
[3] Rural Laboratory, National Institute of Agronomic of Tunisia, 43, Charles Nicolle, 1082, Tunis, Mahrajene, Tunisia

*Corresponding author: souliikbel86@gmail.com

Abstract - The present study deals with the biotechnological valorization of dates having low market value, the production of the juice of eight cultivars of Tunisian date palm (*Phoenix dactylifera L.*) fruits grown in Gabes region (Oasis of Gabes, Tunisia) have analyzed their juice extracts for their nutritional quality, TPC, TFC, TCT and antioxidant activities using ABTS, DPPH, and FRAP assays. The analysis has shown that fruits of date cultivars contain a high amount of sugar (37.75-67.34 % FW) and the total sugars obtained by HPLC method showed that only DegletNour variety contains sucrose (non reducing sugar). But, a low content of fat (0.142–0.24% FW) and protein (1.19–2.89% FW) was found. For the minerals content, the fruit of dates are considered as very important sources of potassium and several minerals, followed in decreasing order by calcium, magnesium, sodium, iron, zinc and manganese. The obtained results have shown that all samples had the highest TPC, TFC, CTC, and the values of antioxidant of Trolox equivalent were higher in ABTS assay than those observed by DPPH and FRAP methods. A significant correlation was found between TPC, TFC, CTC and antioxidant activities. This syrup, produced by simple technological means, was rich in reducing sugars. These results suggest that this syrup, containing high nutriments value and natural antioxidants, might be more widely used by the food industry as a source of bioactive human health promoter phytochemicals.

Keywords: Date syrup, nutritional value, antioxidant activity

1. Introduction

The date palm (*Phoenix dactylifera* L.) is a widely cultivated plant in the arid and semi-arid areas of North Africa and the Middle East. It is a critical component of oasis ecosystems. It also plays an important socio-economic role for the inhabitants of these regions. In recent years, the production, use and industrialization of dates have experienced a gradual growth. According to FAOSTAT (2010), date production is rising continuously in several producing countries, such as Egypt (1 352 950 tons), Saudi Arabia (1 078 300 tons), Iran (1023130 tons), the United Arab Emirates (775 000 tons) and Algeria (710 000 tons). In 2008, like other producing countries, the Tunisian production exceeded 144 000 tons of which 9600 tons are of "DegletNour" variety (DGPA 2009). Unfortunately, this rise in date production is accompanied by a significant loss of common or secondary dates that constitute approximately 40% of the total production (50 000 tons / year for Tunisia vs. 200,000 tons / year for the whole world). These dates, usually incorporated in animal feed, can be considered as a real economic loss. Qualitatively, the genetic inheritance of the Tunisian phoenicicole is approximately 3400 000 palmtrees, including 94.20% of the total returns to DegletNour variety. By this selective orientation, we are witnessing a gradual disappearance, and therefore a decrease in genetic variability of cultivars of common dates that are of lesser commercial importance. This reflects the trend of the Tunisian phoenici-culture to mono-variety Culture (Rhouma 1994). The valorization of these date palm cultivars requires a better knowledge of the qualities of dates. Thus, the study of the chemical composition of the fruit becomes so important. Indeed, dates are considered as a highly-nutritious fruit. Thus, they present an energy source where the sugar content can reach 88% of the fresh material

in certain varieties (Al-Shahib et al. 2003). Dates are also viewed as a good source of minerals (potassium, calcium and iron) and fiber (Al-Shahib et al. 2002; Chaira et al. 2009). Further, these fruits are rich in vitamins and polyphenols (Allaith. 2008; Wu et al. 2004). The recommended daily intake is 25-30 g for an adult (Labell 1990). Besides, they contain an important amount of phytochemicals, such as phenolic compounds. Recently, several studies have reported such activity of date from Tunisia, Algeria, Oman and the USA. An antioxidant, which can quench reactive free radicals, can prevent the oxidation of other molecules and may, therefore, have health-promoting effects in the prevention of degenerative diseases (Shahid 1997). The interest in antioxidants has been increasing because of their high capacity in scavenging free radicals related to various illnesses (Silva et al. 2007). Several studies on the valorization of low-value dates have been made. The work was carried primarily on biological transformations using the pulp of dates as a carbon source to produce secondary metabolites, such as alcohol, acetic acid, citric acid... (Roukas et al. 1997; Nancib et al. 1997). Other studies have examined the biotechnological transformation of dates to produce pasta, flours, or syrups of dates (Mrabet et al. 2008; Besbes et al. 2009; Smaali et al. 2011). The aim of this work was to evaluate the nutritional qualities: sugar soluble, mineral components, total phenols and antioxidant properties of juices extracts of date palm fruits from Gabes oasis (south of Tunisia).

2. Materials and methods

2.1. Chemical Reagents

All reagents used were of analytical garde, Bradford reagent, Folin-Ciocalteu reagent, Di-ntitro-salicilique acid (DNS), FRAP, ABTS and DPPH reagent, Tripyridyltriazine (TPTZ), Glucose, Fructose and Saccharose Standard. The water used in high-performance liquid chromatography (HPLC) and sampling was prepared with a Millipore Simplicity (Millipore S.A.S, France).

2.2. Date Palm Cultivars

In October 2015, eight varieties of common Tunisians mature dates (*Phoenix dactylifera L.)*were collected from Oases in Gabes « Stage Tamar ». Then, they were stored at 20°C until analysis.

2.3. Syrup production

Syrups from eight date varieties were produced according to the method of Al-Farsi (2003). First, the dates were washed, drained and pitted. Then, the dates were extracted twice with water (1:1) at 60 °C and then filtered through a Whatman N°41 filter paper. Finally, the Centrifugation was to have a clearer juice at 8000 rpm for 20 min (20°C). The juice was poured in conical tubes that will be stored at (4°C) prior to experimentation.

2.4. Statistical analysis

All parameters were determined in triplicate for each sample. Statistical analysis was performed with SPSS (20.0). Besides, the multivariate analysis of variance (ANOVA) was carried out to study the chemical composition of date fruits juice. Duncan's test ($p < 0.05$) was used to determine significant differences between means. Correlation analysis was performed using Pearson's test.

2.5. Physicochemical analysis

2.5.1. Titrable acidity, pH, and °Brix

The titrable acidity was calculated as the percentage of citric acid by titrating 10 ml date juice with a solution of NaOH (0.1 N), a color indicator, phenolphthalein used to locate the equivalence point during the titration. The pH was measured by a pH-meter InoLab (WTW, Weilheim, Germany). The level of sugars was measured as °Brix by a digital refractometer (Model 10430, 0-30°Brix; Cambridg Instruments Inc., Buffalo, N, USA).

2.5.2. Determination of ash and mineral contents

The method of AOAC (1997) was employed to determine the ash and mineral content in the fruits of date varieties. One gram of the pulverized samples was placed in a crucible, ignited in a muffle furnace overnight at 550°C. Then, it is cooled in a desiccator and weighed at room temperature to obtain the weight of the ash. To the resulting ash, 5 mL of the 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. After that, the volume was made up with bi-distilled water. This solution was used for mineral analysis, such as sodium, potassium, calcium, iron, magnesium, zinc, manganese and phosphorus. The sodium and potassium were determined by Atomic absorption spectrophotometer (Sherwood 410; Sherwood Scientific Ltd, Cambridge, UK).

2.5.3. Protein, Lipids and Total sugars content

The protein content of each sample was quantified using the method described by Bradford M.M. (1976). Under heat and with the sulphuric acid, the lipids formed, in the presence of vanillin and orthophosphorique acid, a complex pink. In 100 µl of lipid extracts, 1ml sulphuric acid (96 %) was added. After five-minute cooling, 2.5 ml of sulphosphovanilique reactive were added to 200 µl of this mixture Goldsworthy G.J et al (1972). We determined the total amount of carbohydrates by using the Roy method modified by Duchateau and Flokin (1959). This technique consists in adding 0.5 ml of the sample as well as 4.5 ml of the anthrone reagent, and then heating the mixture at 80°C for 10 min. the Absorbance was read at 620 nm.

2.5.4. Determination of sugars by HPLC

The reducing and non-reducing sugars from pomegranate juice were defined by HPLC (Mrabet et al. 2008). Prior to injection into the HPLC system, juice was filtered over a 0.45 mM membrane filter. Liquid chromatography separation was carried out at room temperature on a Eurospher NH2 column, 100 A pore size, 7 mm particle size and 250 m_4.6 mm I.D from Knauer (Germany). Before use, solvents were filtered over a 0.45 mm membrane filter and sonicated for 15 min in an ultrasonic bath (Ultrasonic Cleaner Model SM 25 E-MT; Branson Ultrasonic Corporation, Danbury, CT, USA). The used mobile phase was acetonitrile_ultrapure water (80%, 20%, v/v). The liquid chromatogram was connected to the RI Detector K-230l Knauer (Berlin, Germany). The flow-rate and the injection volume during the experiment were 1.0 ml/min and 20 ml, respectively. The integrator was calibrated with external standards containing solutions of glucose (2%), fructose (2%) and saccharose (1%). The peak surfaces were determined by the Eurochrome 2000 software (Prolabo, Paris, France).

2.5.5. Total Polyphenols, Flavonoid and Condensed Tannins Contents

Total phenolic compound was quantified in the juice palm according to the method described by Allaith (2008) using the Folin–Ciocalteu Reagent. The absorbance against blank was read at 760 nm. The TPC was expressed as mg of Gallic acid equivalents (GAE) per 100 g of fresh weight (FW). The total amount of the flavonoid juice was obtained by applying the method described by Julkunen-Tiitto (1985). The absorbance against blank was read at 510 nm. The results were expressed as mg catechin equivalents (CE)/100g FW.

Tannins condensed A 50 µl of the juice or standard solution was mixed with 1.5 mL of 4% vanillin. Then, 750 µl of concentrated HClwere added. The well-mixed solution was incubated at ambient temperature in the dark for 20 min. The absorbance against blank was read at 500 nm. The results were expressed as mg (CE)/100g FW.

2.5.6. 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). 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 was read at 734 nm. A standard curve was obtained by using aqueous solution of Trolox. The total antioxidants were expressed as µmol of Trolox equivalent per 100g of date fruit (FW).

2.5.7. FRAP 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 mLtripyridyltriazine (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 the extract. Then, the absorbance was measured at 593 nm against the blank after being put for 10 min at room temperature. The standard curve was constructed using Trolox. The result was expressed as Trolox equivalent in µmol/100 g of fresh weight (FW) date fruit.

2.5.8. DPPH radical scavenging activity

Scavenging radical activity of date fruit against stable DPPH was assessed as described by Brand-Williams (1995). 2 ml of the extract was mixed with 2.2-diphenyl-1 picrylhydrazyl (DPPH). After 60 min, the standing of the mixture absorbance was measured at 517 nm against the blank.

3. Results and discussion

3.1. Physicochemical characteristics of date juices

The moisture of dates juice varies between 12,303 and 26,131% for the varieties of *GarenGhzal* and *Aguiwa*, respectively.

The ash content of the studied varieties is between 1.23 and 1.99 % for the varieties of *Hammouri* and *DegletNour*, respectively. These rates correspond to those found by Chaira (2010) for the varieties of *DegletNour* and *Allig*.

Concerning the lipid content, this value ranges from 0.142 and 0.24 % for *Aguiwa* and *DegletNour* varieties. However, the date flesh from United Arab Emirates varieties has a similar content of lipids range of 0.2 to 0.5% (Al-Hootiet al. 2002).

The proteins content of juice date varieties varies between 1.19 and 2.89% in *Hammouri* and *Aguiwa*, respectively. These values were compared with those found by Razi(1993). They are between 0.38 and 2.5%. Generally, the protein content is lower in the dates. But, several studies (Al-Shahib et al. 2003), have shown that proteins of dates contain 23 amino acids, some of which are not present in other fruits like banana, apple and orange.

The refractive index is a parameter proportional to the amount of soluble material solution, mainly sugars. The results show that values of the refractive index vary between 15.2 and 19.9°Brix in *Rotbi*and *DegletNour* respectively. However, in this study, the juice extracts from the varieties are characterized by a higher soluble content than other Tunisian varieties listed in the bibliography.

The pH of juice prepared from the studied dates varieties is considered slightly acid as shown in **Table 1**. The obtained values vary from 5.04 to 6.17 for *Garn Ghzal* and *Aguiwa*, respectively. They are consistent with those provided by Chaira et al. 2007; Noui 2007).

For the titrable acidity, according to **Table 1**, we notice that the studied dates are characterized by an acidity varying between 0.1237 g / 100 ml to 0.1860 g / 100 ml for *DegletNour* and *Hammouri*, respectively. These values are comparable to those found by Khalil et al. (2002).

Table 1. Physicochemical characteristics of date cultivars

	° Brix	pH	TTA (g/100 ml)	Ash (%)	Dry matter (%)	Proteins (g/100g FW)	Lipids (g/100g FW)
Aguiwa	16,933±0,2309c	6,179±0,0023g	0,149±0,0080b	1,765± 0,015f	3.869± 0.369	2,897±0,1516b	0,142± 0,0138a
BedhHmam	16,533±0,1527b	6,001±0,0015f	0,164±0,0072b	1,550±0,030e	76.236±0.254	2,045±0,1719e	0,220±0,0162a
Bou Hattam	17,266±0,1154c	5,148±0,0005b	0,156±0,0035b	1,395±0,015d	80.147±0.897	2,039±0,1043e	0,230±0,0120a
DegletNour	19,966±0,2516f	5,253±0,0020c	0,186±0,0043c	1,990±0,06b	77.247±0.247	1,676±0,1401a	0,245±0,0096c
Ftimi	16,933±0,1527c	5,386±0,0015e	0,185±0,0130c	1,515±0,005d	84.015±0.178	2,633±0,0003cd	0,177±0,0163d
GarnGhzal	17,966±0,2081c	5,042±0,0020a	0,149±0,0058b	1,840±0,22a	87.697±0.364	1,702±1,4868e	0,235±0,0139b
Hammouri	19,100±0,2645e	5,150±0,0030b	0,123±0,0150a	1,230±0,02c	81.144±0.654	1,198±0,1529d	0,188±0,0146b
Rotbi	15,200±0,1000a	5,270±0,0020d	0,156±0,0094b	1,550±0,03f	80.879±0.897	1,653±0,0162bc	0,161±0,0151e

Data within a column followed by different letter are significantly different ($p \leq 0.05$) according to LSD test?

Concerning the mineral content of the date varieties flesh, the potassium tenor presented the highest amount, followed in decreasing order by calcium, magnesium, sodium, iron, zinc and manganese as shown in **Table 2**. The high intake of dates minerals participates in a balanced diet. According to Booij et al (1992) the compositions of the different varieties of dates in minerals vary significantly depending on the geographical origin of the studied varieties.

Table 2. Mineral content of flesh date cultivars

	Potassium	Calcium	Sodium	Magnesium	Iron	Zinc	Manganese
Aguiwa	648,171±1,8327 bc	92,670±2,5198b	29,337±1,9925 bc	62,060±1,9903 b	1,299±1,1645 a	0,532±3,1099 a	0,113±1,9903 a
BedhHmam	623,138±1,2379 bc	181,110±2,2004 c	31,334±1,8083a b	65,991±1,1725 c	1,327±1,0786 a	0,460±2,0346 a	0,123±1,1725 a
Bou Hattam	655,448±1,0860 bc	222,945±1,3777 de	25,034±2,3950a	72,040±1,6994 c	1,244±1,1473 a	0,721±1,0598 b	0,481±3,6994 c
DegletNour	677,383±1,8357 a	191,376±1,3649 cd	22,493±2,2992a	51,344±1,9347 a	1,899±1,1373 b	0,525±1,041a	0,110±3,9347 a
Ftimi	630,408±1,3508 bc	52,817±1,3324a	29,826±1,2977 bc	60,325±1,6823 b	1,134±1,0613 a	0,880±1,1515 c	0,291±1,6823 b
GarnGhzal	575,332±1,0445 b	238,408±1,4994 ef	29,341±1,6042 bc	62,231±1,4822 b	1,808±1,1870 b	0,695±2,0327 b	0,276±0,4822 b
Hammouri	651,788±1,1920 bc	264,886±1,8534f	34,125±1,5243c d	64,749±2,3515 b	1,155±2,0212 a	0,540±1,0064 a	0,265±1,3515 b
Rotbi	721,027±1,1661 c	171,130±2,8685 c	37,208±1,9107 d	81,053±2,1624 d	1,123±2,1114 a	0,858±0,047c	0,463±0,1624 c

Data within a column followed by different letter are significantly different ($p \leq 0.05$) according to LSD test?

Sugars are the major components of dates. The results of analyzing the sugar composition of different varieties by HPLC are given in **Table 3**. Qualitatively, *DegletNour* is the only variety that contains sucrose (non-reducing sugar). The other varieties showed that the presence of the reducing sugars (glucose and fructose). These results are in agreement with those provided by Ben Salah (1995). They indicated that the majority of the studied varieties are low in sucrose. Even if this non-reducing sugar is present, it constitutes a low tenor so that the action of invertase, the enzyme characteristic of dates, transforms it into reducing sugars. Quantitatively, the total sugar was approximately between 37.75 g /

100g in FW and 67.34 g / 100g FW for *Rotbi* and *DegletNour* respectively. These values are similar to that found by carbohydrate assay. These values are similar to that found by carbohydrate assay.

Table 3. Composition of the reducing and non-reducing sugars of date juices

Varieties	Fructose (g/100g FW)	Glucose (g/100g FW)	Sucrose (g/100g FW)	Total sugar (g/100g FW)
Aguiwa	19,6288819	29,5506234	-	49,1795053
BedhHmam	17,9354384	18,5831802	-	36,5186186
Bou Hattam	27,3596399	33,3123032	-	60,6719431
DegletNour	18,4904127	18,931424	31,9243652	67,3462019
Ftimi	18,819562	20,106387	-	38,9259492
GarnGhzal	27,3026813	28,0751173	-	55,3777986
Hammouri	19,1880803	19,0973183	-	38,2853986
Rotbi	18,9262086	19,8322913	-	37,7584999

3.2. Total phenolics (TPC), Total flavonoids (TFC) and condensed tannins Content

The total phenolic content (TPC) ranged from 21.4 to 42 mg/100 g FW(Figure 1). The highest level of TPC was observed in *Bedhhmam* variety (42.06 mg/100 g FW) followed by *DegletNour* (39.16 mg/100 g FW), *Aguiwa* (37.04 mg/100 g FW), *Bouhattam* 35.29 (mg/100 g FW) *Ftimi*(29.81 mg/100 g FW), *Garn ghzal* (28.34 mg/100 g FW) and *Hammouri* (27.26 mg/100 g FW). However, the lowest concentration was found in Rotbi (21.46 mg/100 g FW). This result corresponds to that found by Al-harthi et al. (2015). It shows that the TPC ranged from 32.24 to 35.84 mg / 100g for Omani varieties. For the varieties of Tunisian dates, the TPC varies from 3.87 to 31.86 mg / 100 mg FW (Chaira et al. 2009). However, the date varieties from Morocco, found that most of TPC ranged from 331,86 to 537,07 mg of GAE / 100 mg of FW (Bouhlali et al. 2015).

Total flavonoids content (TFC) of the studied dates varied from 16.7 to 29.18 mg/100g FW. The maximum value was obtained from *Ftimi*and *Rotbi*varieties. The minimum value was concerning and *BouHattam*. Our results are in agreement with the findings provided by three Saudi Arabia common dates called *Sukkari*, *Nabtat Ali*, and *Rashudia*. Their TFC were 11.30, 14.70, and 17.10 mg QE/100 g of sample, respectively. This variation of TPC and TFC may be explained by various factors: cultivar type, geographic origin, soil types, season, maturity ... (Al-Humaid et al, 2010).

The different concentrations of content tannins are presented in **Figure 1**.The obtained results concerning the CTC show that the maximum phenolic content (34.85 to 33.96 mg CE/100g FW) was found in *Aguiwa* and *Bed Hmam* varieties, while the lowest content (19.9 mg CE/100g FW) was detected in *Rotbi* variety. Our results are different to those reported by El-Arem et al (2012) who demonstrated that the lowest content (41.77 to 111.39 mg CE/100g FW) was detected at the Tamr stage.

3.3. Antioxidant Activity of Date juice

Date fruit contains a wide range of phenolic compounds, which have diverse antioxidant capacities. To better examine their antioxidant capacities, different assays are required. In this study the ferric reducing ability (FRAP), free radical scavenging activity assay DPPH and ABTS were used in this respect.This result showed that all cultivars exhibited a good reducing power which is varied significantly differences ($P < 0.05$) in antioxidant activity (**Figure 2**) values were observed among date varieties. The values of antioxidant of Trolox equivalent were highest in ABTS assay than the

low values observed by DPPH and FRAP methods. These results indicated that the components of the juice of date reacted differently with chemicals involved in different antioxidant analytical protocols. These significant variations among date samples could be due to varietal, extraction techniques used, and instrumental analysis (manual or automated). Unless there is standard method for antioxidant analysis, such variations could exist.

3.4. Antioxidant Capacity by ABTS

In the present study, the total antioxidant activity of the date juice was evaluated by ABTS radical decolorizationassay which was measured spectrophotometrically at 734 nm. The results were expressed as a percentage of inhibition based on absorbance. The maximum total antioxidant activity was shown by *Bed Hamem* and *DegletNour varieties*: 39.4 and 37.8, respectively. Troloxwas used as the standard for the antioxidant activity measurement.

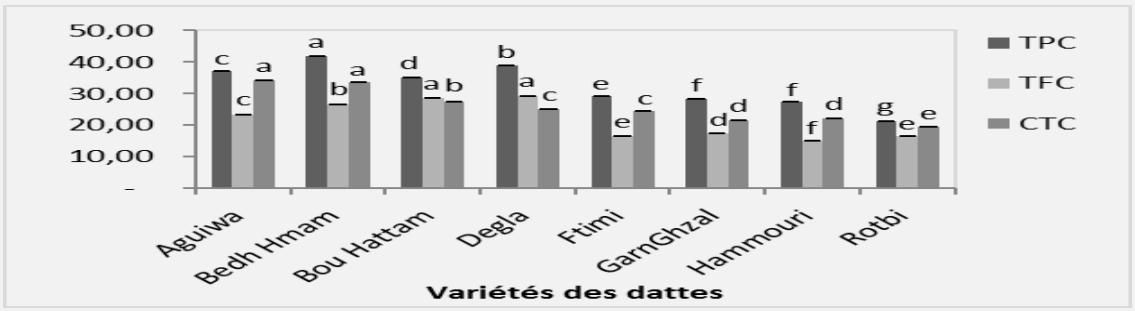

Figure 1. Total phenolics, flavonids and tannins contents of juice of date varieties

3.5. Antioxidant Capacity by DPPH

The averages of free radical scavenging activity of date fruit cultivars using DPPH assay are displayed in **Figure 2**, which showed a significant difference between examined date fruit varieties. The results were expressed as a percentage inhibition based on absorbance. The higher DPPH free radical scavenging activity was shown by *DegletNour* variety from (30.69 and 33.66) respectively.

3.6. Ferric Reducing Antioxidant Power (FRAP)

This method is based on the ability of electron-donating antioxidants to reduce at an acidic medium, a colorless ferric complex (Fe^{3+}–tripyridyltriazine) to blue-colored ferrous complex (Fe^{2+}–tripyridyltriazine) which had a maximum absorbance at 593 nm. The Antioxidant activity assayed by FRAP showed that values varied from 12.36 to 25.02 % by *Rotbi*and *BouHattamm* variety.

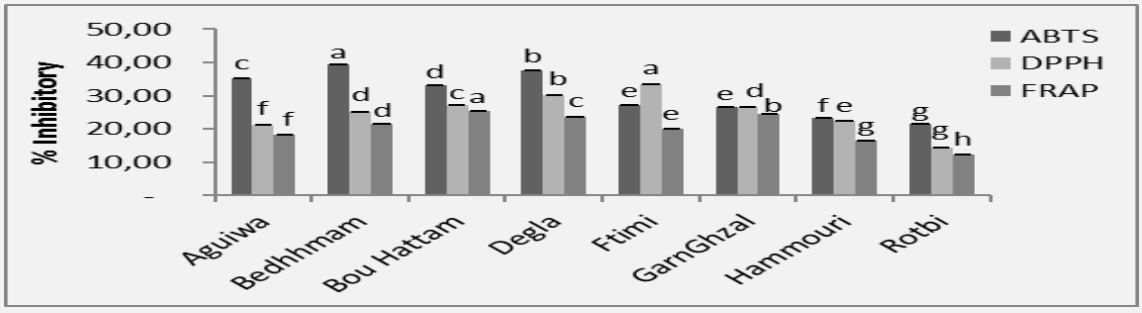

Figure2. Antioxidant activity (% inhibitory of ABTS, DPPH and FRAP) of the different juice of date varieties

3.7. Correlations

The correlation coefficients between the antioxidant capacities as well as the TPC, TFC and TCT of date cultivars were determined in **Table 4**. Significant relationships were obtained between the TPC and the antioxidant capacities assessed by ABTS, DPPH and FRAP methods as it can be revealed from correlation coefficients (0.983, 0.430 and 0.59 respectively). A similar trend of the relationships was observed in the TFC and the antioxidant capacities assessed by ABTS and FRAP methods (0.894 and 0.604, respectively). Furthermore, significant correlation coefficients were noticed between the antioxidant capacity (ABTS) and the TCT (0.827). These results are in agreement with those given by Biglari et al (2008) who reported that the phenolic compounds contribute significant to the antioxidant capacities of date varieties. Our simulation results showed that the correlations observed between the assay by ABTS and the TPC, TFC and TCT were much stronger compared to those of DPPH and FRAP assays.

Table 4. Correlation between Phenolic, Flavonoid and Condensed tannin content and antioxidant capacities of eight juice of date cultivars

	TPC	TFC	TCT	ABTS	DPPH	FRAP
TPC	1					
TFC	0,851**	1				
TCT	0,829**	0,623**	1			
ABTS	0,983**	0,43*	0,59**	1		
DPPH	0,894**	0,291	0,604**	0,4	1	
FRAP	0,827**	0,12	0,263	0,591**	0,734**	1

* Significantcorrelation at P < 0.05.
** Significantcorrelation at P < 0.01.
*** Significantcorrelation at P < 0.001.

4. Conclusion

The results presented here suggest that date by-products, serve as a good source of nutritional properties, total phenolics, and antioxidant activity that could potentially be considered as inexpensive source of natural antioxidants. Therefore, these by-products can be used as a functional food or functional food ingredient. Further studies are needed to isolate, identify and quantify the main composition of phenolic acids, flavonoids and antioxidant activity in date by-products « syrup ».

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