PAPER

PHYTOCHEMICAL CHARACTERISTICS AND ANTIOXIDANT ACTIVITY OF SEVERAL FIG (*FICUS CARICA* L.) ECOTYPES

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ABSTRACT

In this study, phenolics and reducing sugar compositions of fig fruits (27 Tunisian ecotypes) were analyzed. In addition, the antioxidant activity was determined by two methods; the ABTS and the DPPH assays. Phytochemical composition of the 27 fig ecotypes was found to be very diverse, as the total polyphenols varied from 51.50 (*'Bouholi'*) to 100.23 (*'Nasri'*) mg gallic acid equivalent/100 g fresh weight. Total flavonoids also varied from 0.33 (*'Bayoudhi1'*) to 17.59 (*'SoltaniAhmar'*) mg quercetin equivalent/100 g fresh weight, and total anthocyanins extended from 1.61 (*'Besbessi'*) to 11.67 (*'Zidi2'*) mg/100 g fresh weight. Additionally, DPPH % inhibition ranged from 11.37 (*'Besbessi'*) to 64.73 % (*'Bouharrag'*) and ABTS from 38.50 (*'Sawoudi5'*) to 676.13 (*'Nemri'*). The ecotypes 'Zergui' and 'Nasri' had the highest contents of glucose (5.68 and 4.83 g/ 100 g FW, respectively) and fructose (5.43 and 4.69 g/ 100 g FW, respectively). The results also showed that fig fruits are a good and valuable source of natural antioxidants that can be used in food and medical sectors.

Keywords: anthocyanins, antioxidant activity, ecotypes, *Ficus carica*, flavonoids, fruits, polyphenols

1. INTRODUCTION

Fig (*Ficus carica* L.), which belongs to the *Moraceae* family, is considered to be one of the oldest cultivated fruit species and an important crop worldwide for both fresh and dry consumption (DUENAS *et al*., 2008; BACHIR BEY and LOUAILECHE, 2015). The world production of figs is about one million tons, and it is mostly concentrated in the Mediterranean area (VEBERIC *et al*., 2008). Tunisia produces about 29 000 tons, which represents 3 % of total world production (FAOSTAT, 2015).
In Tunisia, figs have been grown traditionally for several centuries (ALJANE *et al*., 2018). Local fig ecotypes are numerous and well adapted to the local agro-ecological conditions (ALJANE and FERCHICHI, 2010). Their denominations relate to the fruit color, the period of fruit maturation or to their geographic origin (ALJANE, 2016). Exchange of plant material was frequent between regions of which synonymy and homonymy may be encountered (CHATTI *et al*., 2004; MARS, 2003; ALJANE and FERCHICHI, 2010). Since several decades, the cultivated areas decreased due to the extinction of many ecotypes, the intensive urbanization as well as the biotic and abiotic stresses (MARS *et al*., 1998; MARS, 2003) despite the installation of many new plantations (MARS *et al*., 2008). Whether fresh or dried, figs constitute an important part of the human diet; they are especially rich in fiber, minerals, proteins, sugars, organic acids and antioxidant compounds (ERCISLI *et al*., 2012). Fig fruit is an important source of minerals, vitamins and polyphenols (DUENAS *et al*., 2008; ALJANE and FERCHICHI, 2009; ADILETTA *et al*., 2019). In addition, SOLOMON *et al*. (2006) recorded high polyphenols contents, especially flavonoids and anthocyanins, the highest being their antioxidant activity. The contents of total polyphenols, anthocyanins as well as total antioxidant activity and other properties such as skin color are strongly influenced by the ecotype (SOLOMON *et al*., 2006; VEBERIC *et al*., 2008; CALISKAN and POLAT, 2011; ERCISLI *et al*., 2012). Similarly, several reports have highlighted the influence of fruit variety, harvest season and growing technology in the fields of phenolic contents (TREUTTER, 2010; VALLEJO *et al*., 2012). Moreover, antioxidant activity and phenolic compounds varied considerably depending on the part of the fruit. Indeed, several authors have reported the great contribution of fruit skin (compared to pulp) to these compounds especially in darker varieties (VEBERIC *et al*., 2008; DUENAS *et al*., 2008). The aim of the present work was to study the phytochemical characteristics and sugar composition of 27 fig ecotypes grown in Tunisia.

2. MATERIALS AND METHODS

2.1. Fruit fig material

Ripe Fig fruits from 27 Tunisian fig ecotypes (different fig-growing traditional geographic regions) were harvested in 2015 from the experimental field for germplasm collection of the Institute of Arid Regions (IRA) of Medenine, Tunisia (Table 1). The experimental orchard of 10 years old, included 3 replicates of 5 x 5 m cultivated understandard cultural practices. Within 2 h after harvest, whole fruits were stored at - 20°C for further analysis. Triplicate of 10 frozen fruits samples from each ecotype were homogenized in a blender and used for phytochemical and nutritional analysis.

Table 1. Ecotype's name, types, localities of origin of the studied 27 Tunisian fig fruits.

Ecotype's name	Types	Localities of Origin (Governorate)
Bither1	San Pedro	Ghadhabna (Mahdia)
Jebali1	Smyrna	Islands of Kerkenah (Sfax)
Mahdoui	Smyrna	Islands of Kerkenah (Sfax)
Bayoudhi1	Common	Beni Kheddache (Médenine)
Bayoudhi2	Common	Toujen (Gabès)
Besbessi	San Pedro	MasjedAissa (Sousse)
Bither2	San Pedro	Islands of Kerkenah (Sfax)
Jemâaoui	Smyrna	Beni Kheddache (Médenine)
Rogabi	Smyrna	Beni Kheddache (Médenine)
Gaa Zir	Smyrna	Gafsa (Gafsa)
Temri	Smyrna	Islands of Kerkenah (Sfax)
Zergui	Smyrna	Djébba (Béja)
Baghali2	Smyrna	Ghadhabna (Mahdia)
Baghali3	Smyrna	Islands of Kerkenah (Sfax)
Chetoui Akhal	Common	Ghadhabna (Mahdia)
Croussi	Smyrna	Beni Kheddache (Médenine)
Kahli2	Smyrna	Islands of Kerkenah (Sfax)
Nemri	Smyrna	Djébba (Béja)
Soltani Ahmer	Smyrna	Djébba (Béja)
Wedlani	Smyrna	Beni Kheddache (Médenine)
Bouharrag	Smyrna	Djébba (Béja)
Bouholi	San Pedro	Djébba (Béja)
Kahli1	Smyrna	Ghadhabna (Mahdia)
Nasri	Smyrna	Toujen (Gabès)
Sawoudi3	Smyrna	Bir Amir (Tataouine)
Sawoudi5	Smyrna	Gafsa (Gafsa)
Zidi2	Smyrna	Djébba (Béja)

2.2. Determination of phenolics composition of fig fruits

2.2.1 Methanolic Extraction

A total of 1 g of fruit samples was homogenized in 25 ml of extraction solution and 80% methanol. It was stirred for 2 h in the dark at room temperature. The obtained mixture was centrifuged two sequential times for 15 min at 3500 rpm, and supernatant was filtered and taken for further analysis.

2.2.2 Total Polyphenols (TP)

Total polyphenols (TP) contents of fig fruits were determined spectrophotometrically using the Folin-Ciocalteu method as previously described by SLINGARD and SINGLETON (1977) with some modifications. The absorbance of each sample was measured at 760 nm using a spectrophotometer (Shimadzu 1600-UV, Japan).

Quantifications were calculated using a calibration curve daily prepared with known concentrations of gallic acid standards, and results are expressed as mg gallic acid equivalents (GAE) on fresh weight (FW) basis (mg GAE/100 g FW).

2.2.3 Total anthocyanins (TA)

Total anthocyanins (TA) contents were quantified in accordance with the pH differential method using two buffer systems as previously described by CHENG and BREEN (1991). In brief, methanolic extract were diluted with two buffer solutions of pH 1 and 4.5. Anthocyanins were estimated using absorbance measurement at 530 and 657 nm in buffers at pH 1.0 and 4.5, respectively; where Absorbance (A) was measured using this formula:

$$A = [(A530 – A657)\ pH\ 1.0 - (A530 – A657)\ pH\ 4.5]$$

with a molar extinction coefficient of cyanidin-3-glucosid of 29.600. Total anthocyanin quantities were expressed as mg of cyanidin-3-glucoside equivalents (CGE) per g fresh weight of fig fruit (mg CGE/100 g FW).

2.2.4 Total flavonoïds (TF)

Total flavonoïds were determined using a colorimetric method previously described by KARADENIZ *et al.* (2005). Methanolic extract (1 ml) was added to 5 ml of distilled water and mixed. Then, 5% sodium nitrite solution (0.3 ml) was added, followed by 10% aluminium chloride solution (0.3 ml), mixed and incubated at room temperature for 5 min. After incubation, 2 ml of 1M sodium hydroxide were added to the mixture and thenthe volume of reaction mixture was made up to 10 ml with distilled water. The mixture was thoroughly vortexed and the absorbance was determined at 510 nm. Flavonoid contents were calculated using a standard calibration curve, prepared from quercetinand expressed as quercetin equivalent in mg per g fresh weight of fruit (mg quercetin/100 g FW).

2.3. Determination of antioxidant properties of fig fruits

The DPPH (1,1 diphenyl 2 pycrilhydrazil (DPPH) radical-scavenging activity of the extract was measured as described by REBAI et al. (2012) and BACHIR BEY et al. (2013). An aliquot (200 μl) of the extract was added to 1 ml of a methanolic DPPH solution (500 μM). The decolorizing process was measured at 517 nm after 30 min of reaction. The scavenging activity percentage of DPPH (%) of the fig extract was calculated using this formula: A = (A blank – A sample)/ (A blank) * 100.
For the standard TEAC (Trolox equivalent antioxidant capacity) assay, ABTS (2, 2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid) was dissolved in methanolic solution (14 mM) and prepared with 10 ml ammonium persulfate (NH_2 $2S_2O_8$) (4.9 mM) as described by OZGEN *et al.* (2009). The mixture was diluted in methanol to an absorbance of 1.00±0.01 at 734 nm for long stability (OZGEN *et al.*, 2009). For the spectrophotometric assay, 30 μl of fig fruit extract and 2.97 ml of ABTS+ solution were mixed and incubated for 1 h in darkness. The absorbance was determined at 734 nm using a spectrophotometer (SPECORD 210 Plus-Analytik Jena, Japan). The TEAC was expressed as mg equivalent vitamin C (Acid ascorbic) per 100 g fresh weight of fig fruit (mg EVC/100 g FW).

2.4. Determination of reducing sugars of fig fruits

Reducing sugars (glucose and fructose) were determined according to the method described by MELGAREJO *et al.* (2003) and GUNDOGDU *et al.* (2011). Briefly, 10 g fruit was centrifuged at 12000 rpm for 2 min at 4°C, thereafter, the supernatant was filtered and transferred into a vial and used for analysis. Analysis of glucose and fructose was performed by HPLC (KNAUER type) with Eurospher 100 NH_2 column and refractive index detector (RI Detectors K-2301) using 80% acetonitrile as a mobile phase. The calculation of concentrations was based on standards solutions of glucose (2%) and fructose (2%). The results were expressed in g/100 g FW and all the samples were analysed in triplicate.

2.5. Statistical analysis

All analyses were performed with R software (R Core Team, 2019). DPPH inhibition %data were arcsine transformed to meet assumptions of analysis of variance (ANOVA) for homogeneity of variance and normality and are reported in tables as untransformed values. Data were analyzed using one-way analysis of variance (ANOVA) considering them as factor ecotypes or ecotype groups, followed by post-hoc Tukey multiple comparison to determine if differences ($P < 0.05$) between fig ecotypes were significant. Additionally, Pearson's correlation coefficients were also performed based on phytochemical compositions and antioxidant activity of the 27 fig ecotypes.

3. RESULTS AND DISCUSSION

3.1. Fruit skin color

The 27 Tunisian local fig ecotypes revealed great morphological variability in their external fruit color (Fig. 1) and consequently were classified into 6 groups which are: (green yellowish, green, red greenish, brown purplish, purple greenish and purple blackish). Among the studied fruit fig ecotypes, fifteen had variably intense purple skin (eight had purple-greenish and seven purple blackish). Additionally, seven ecotypes showed skin color ranging from green to yellow. The remaining ecotypes: 'Jemâaoui' and 'Rogabi' presented red greenish and 'Gaa Zir', 'Temri' and 'Zergui' were brown purplish (Table 2). Color is one of the most important indicators of maturity and quality of fruits, which is influenced by the concentration and distribution of various anthocyanins (GAO and MAZZA, 1995).

3.2. Fruit phenolic compound contents

The level of phenolic compounds of the 27 Tunisian fig ecotypes are given in Table 2, while the mean values obtained for each skin color group are shown in Fig. 2. The one-way ANOVA analysis followed by post-hoc Tukey multiple comparison test of total polyphenols, total anthocyanins and total flavonoids showed highly significant differences ($p < 0.001$) among the 27 fig ecotypes. When we applied ANOVA analysis to the six skin color groups, the total anthocyanins showed highly significant differences ($p<0.001$),

whereas the total flavonoids were only significant ($p<0.05$). Unlike these compounds, the total polyphenols revealed no significant differences among the six groups.

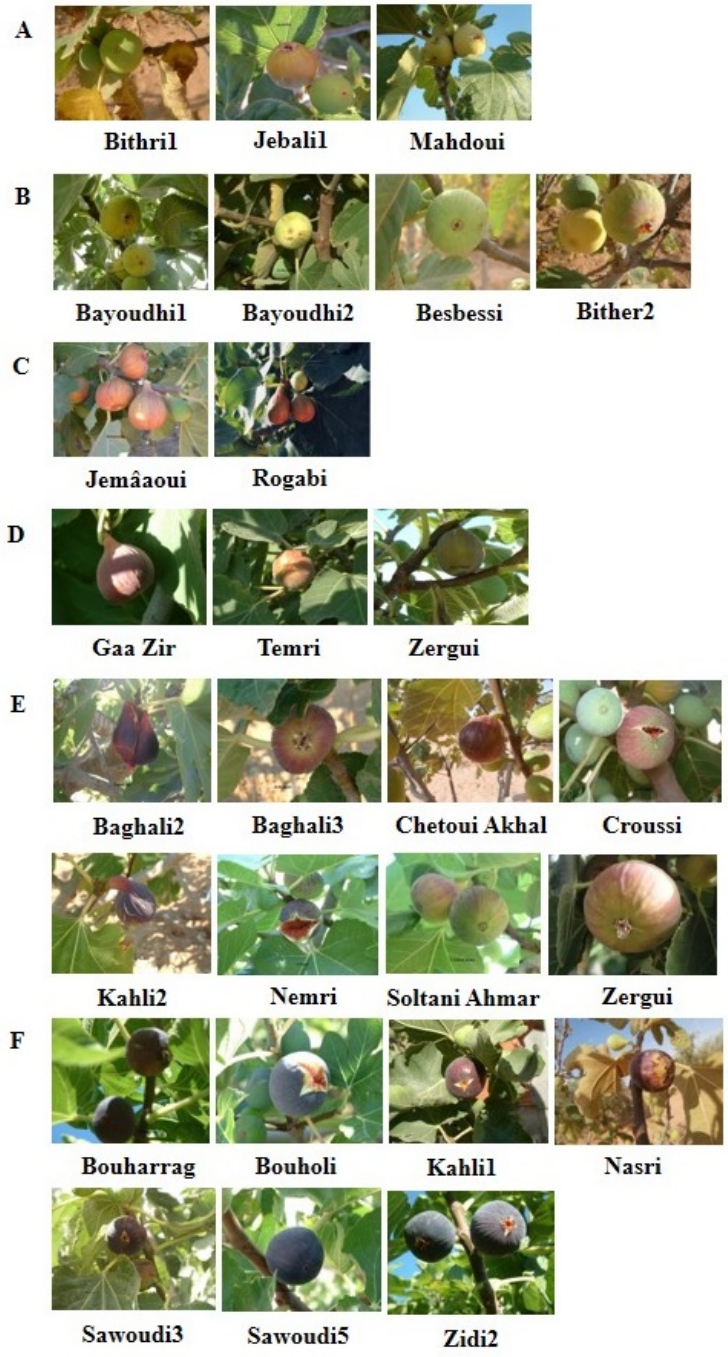


Figure 1. Morphological variability in external fruit color of the 27 studied fig ecotypes (A: Green yellowish, B: Green, C: Red greenish, D: Brown purplish, E: Purple greenish and F: Purple blackish).

3.2.1 Total polyphenols

The total polyphenols (TP) have been reported to be the main phytochemical responsible for the antioxidant activity of figs. The TP contents of fig ecotypes varied from 51.50 ('Bouholi') to 100.22 ('Nasri') mg GAE/ 100 g FW. The highest TP levels were observed, in descending order, in the following ecotypes ('Nasri', 'Bayoudhi2', 'Zidi2', Baghali3', 'Rogabi', Sawoudi5') (Table 2). The results of the total polyphenols contents are higher than those obtained in previous studies conducted by ALJANE and SDIRI (2014). Nevertheless, thesecontents are inferior to those found by VALLEJO et *al.* (2012) and CAPANOGLU (2014), who reported concentrations of 331.93 and 169.4 mg GAE/ 100 g FW in Indian and Turkish figs, respectively, but are comparable to the results of PIGA *et al.* (2008). On the contrary SOLOMON *et al.* (2006), CALISKAN and POLAT (2011) and DEBIB *et al.* (2014) showed that the dark fig fruits contain higher total polyphenols than the light ones. We did not obtain significant differences in total polyphenols based on fruit skin color groups (Fig. 2). This discrepancy might be explained by the fact that total polyphenols contents are greatly influenced by various parameters such as weather conditions, ripening stage, degree of fruit maturation, and postharvest storage conditions (VALLEJO *et al*., 2012; BACHIR BEY and LOUAILECHE, 2015).

3.2.2. Total anthocyanins

The total anthocyanins (TA) are natural pigments belonging to the flavonoid family and are responsible for the red, blue and purple color of many fruits. The total anthocyanins amounts of the studied fig ecotypes varied from 2.57 ('Baghali3') to 11.67 ('Zidi2') mg CGE/100 g FW (Table 2). 'Zidi2' ecotypes had the highest contents (11.67) followed by 'Sawoudi3' (9.7) and then 'Bouholi' (8.17). It is apparent that purple blackish ecotypes contain more anthocyanins, with average value of 7.11 mg CGE/ 100 g FW. The other fruit ecotypes varied within 3.17 in green-yellowish fruit skin color group to 5.08 mg CGE/100 g FW in red greenish (Fig. 2). These levels are similar to those obtained in our previous study on Tunisian fig varieties, where we found TA to be between 0.55 and 9.16 mg CGE/100 g FW (ALJANE and SDIRI, 2014). SOLOMON *et al.* (2006) reported that the dark fig 'Mission' variety has eight times higher total anthocyanins (10.9 mg CGE/100 g FW) than the red-brown Turkey one (1.3 mg CGE/ 100 g FW), while these compounds were not detected in 'Brunswick' and 'Kadota' ecotypes, which have light fruit skin color. The TA content of the majority purple-blackish ecotypes is higher than that found by OUCHEMOUKH *et al.* (2012) in black figs (5.9 mg CGE/ 100 g FW). In addition, the total anthocyanins content of our samples was lower than that of other studies on commercial fig ecotypes (DEL CARO and PIGA, 2007; PIGA *et al*., 2008; DUENAS *et al*., 2008; ERCISLI *et al*., 2012). The results showed that total anthocyanins (TA) contents were strongly influenced by fruit skin color. Indeed, the purple blackish fig ecotypes ('Zidi2', 'Sawoudi3' and 'Bouholi') had the highest contents and might be used as good sources of anthocyanins. Such result is in good agreement with those advanced by SOLOMON *et al.* (2006), who reported a large contribution of fig fruit skin to the total anthocyanins accumulation.

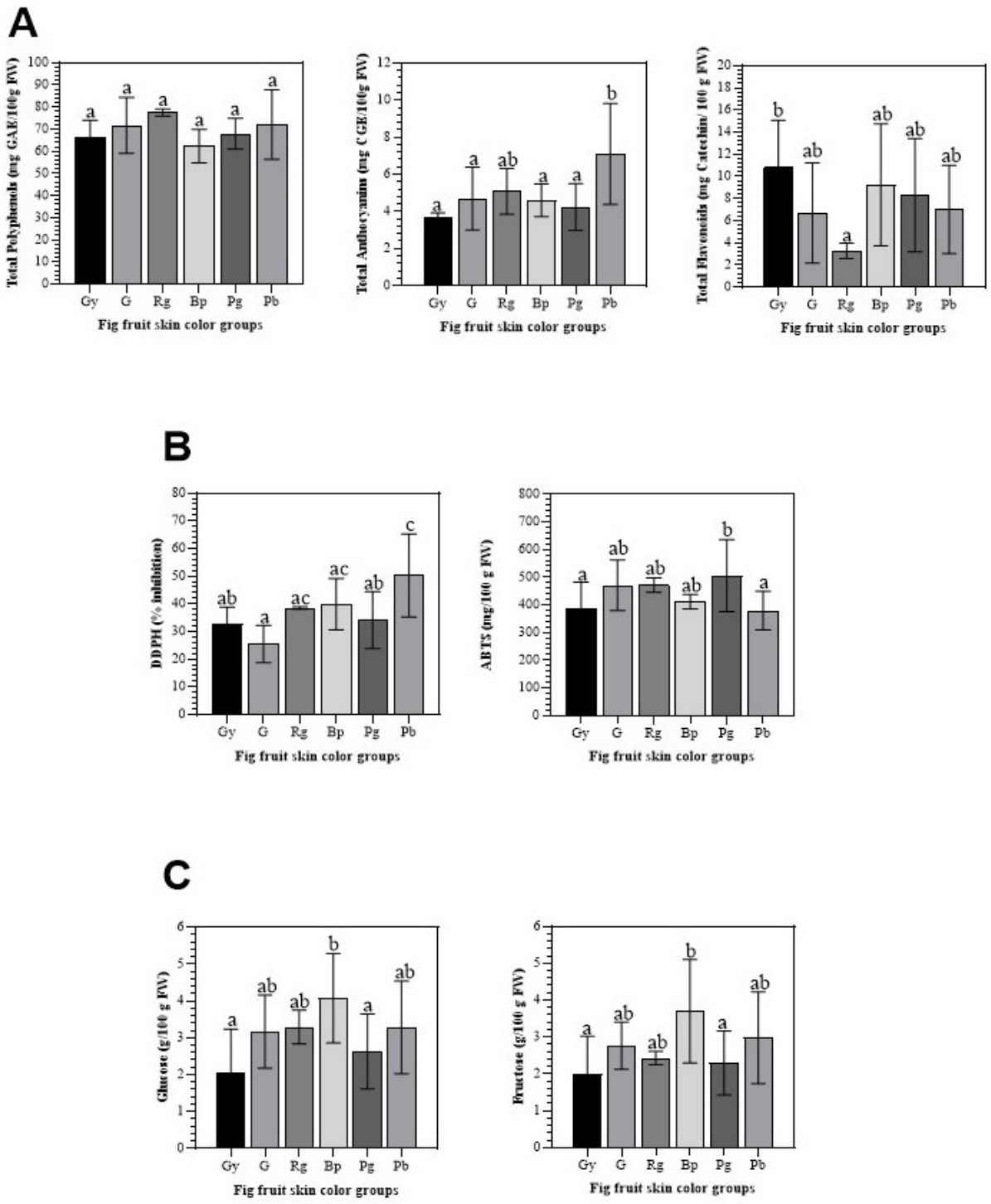
Table 2. Total Polyphenols, total anthocyanins and total flavonoids of 27 Tunisian fig ecotypes.

Ecotype's name	Total polyphenols mg GAE/ 100 g FW	Total anthocyanins mg CGE/ 100 g FW	Total flavonoids mg QE/ 100 g FW	Fruit skin color group
Bither1	60.50±0.74 ef	3.75±0.19 ade	5.68±0.30 ef	
Jebali1	76.47±0.10 lm	3.43±0.40 ad	11.50±0.90 i	Green yellowish
Mahdoui	63.21±0.31 g	3.73±0.12 ade	15.26±0.9 j	
Bayoudhi1	76.62±0.05 lm	3.00±0.1 ab	0.33±0.11a	
Bayoudhi2	88.45±0.47 p	5.61±0.10 ghi	5.68±0.30 ef	Green
Besbessi	56.29±0.76 bc	3.33±0.27 ac	12.16±0.30 i	
Bither2	65.53±1.45 h	6.80±0.82 ij	8.59±0.3 h	
Jemâaoui	76.15±0.24 lm	6.20±0.1 hj	2.77±0.68 bc	Red greenish
Rogabi	79.03±0.15 no	3.96±0.24 bcdf	3.76±0.19 cd	
Gaa Zir	71.75±0.07 ij	4.54±0.38 cdfg	5.42±0.11 def	
Temri	60.61±0.03 ef	3.67±0.47 ade	5.68±0.3 ef	Brown purplish
Zergui	54.60±1.36 b	5.57±0.08 ghi	16.57±0.14 jk	
Baghali2	69.93±0.10 i	3.75±0.08 ade	6.14±0.9 fg	
Baghali3	79.42±0.61 no	2.57±0.04 a	4.36±0.36 ce	
Chetoui Akhal	73.35±0.59 jk	7.03±0.72 jk	12.29±0.19 i	
Croussi	74.57±0.52 kl	4.28±0.24 cdf	5.68±0.41 ef	Purple greenish
Kahli2	62.33±0.09 fg	4.21±0.08 bcdf	12.75±0.30 i	
Nemri	59.34±0.56 de	3.78±0.34 ade	5.76±0.82 eg	
Soltani Ahmer	61.59±0.66 eg	4.67±0.12 dfg	17.59±0.14 k	
Wedlani	63.56±0.3 gh	3.55±0.10 c	1.78±0.19 ab	
Bouharrag	58.20±1.58 cd	5.12±0.24 fh	7.47±0.24 gh	
Bouholi	51.50±1.49 a	8.17±0.90 i	1.78±0.90 ab	
Kahli1	61.29±0.62 eg	6.21±0.06 hj	11.70±0.07i	
Nasri	100.22±0.38 q	3.95±0.94 bcdf	1.85±0.94 ab	Purple blackish
Sawoudi3	75.44±0.41 km	9.70±0.47 l	8.99±0.48 h	
Sawoudi5	77.37±0.44 mn	4.90±0.25 efg	11.70±0.26 i	
Zidi2	81.25±0.99 o	11.67±0.15 m	5.62±0.16 ef	
Total mean	69.58±11.14	4.08±2.11	7.73±4.72	
F value	731.6	85.1	222.1	
P value	***	***	***	

'***' 0.001 '.Values in the same column with different lower- case letters are significantly different at P<0.05 according to post-hoc Tukey multiple comparison, GAE: Gallic acid equivalent, CGE: cyanidin-3-glucoside equivalent, QE: quercetin equivalent, FW: Fresh weight.

3.2.3 Total flavonoids

The purple-greenish ecotype 'Soltani Ahmar' had the highest contents (17.59 mg QE/100 g FW) followed by 'Zergui' from the brown purplish group (16.57 mg QE/100 g FW) and 'Mahdoui' from the green-yellowish with an amount of 15.26 mg QE/100 g FW. Whereas, the lowest contents were observed in the following ecotypes ('Bayoudhi1', 'Bouholi', 'Wedlani', 'Nasri', 'Jemâaoui' and 'Rogabi') (Table 2).



Gy: Green yellowish, G: Green, Rg: Red greenish, Bp: Brown purplish, Pg: Purple greenish, Pb: Purple blackish

Figure 2. Total phenolic content (A): total polyphenols, total anthocyanins, total flavonoids, antioxidant capacity (B): DPPH: 1.1 Diphenyl 2 pycril hydrazil, ABTS: acid 2.2-azino-bis-3 ethylbenzothiazoline-6-sulfonique and sugar compositions (C): Glucose and Fructose of 6 fig fruit skin color groups. Different letters indicate significant differences by post-hoc Tukey multiple comparison at $p < 0.05$.

The obtained values of total flavonoids are lower than those found by BACHIR BEY and LOUAILECHE (2015) who have advanced contents of 87.24 and 126.55 mg/100 g FW for Algerian light and dark varieties, respectively. The green yellowish group, which is light figs, has the highest total flavonoid contents, followed by green, brown purplish, purple greenish and purple blackish groups (Fig. 2). Such result is quite different from those reported by SOLOMON et *al.* (2006) and VALLEJO et *al.* (2012) who found that the total flavonoids contents of dark-purple fig varieties were greater than those of light ones.

3.3. Antioxidant activities

The antioxidant activities of the 27 Tunisian fig ecotypes are summarized in Table 3. The one -way ANOVA analysis of ABTS and DDPH followed by post-hoc Tukey multiple comparison test indicated highly significant differences among the 27 fig ecotypes and also between the six groups.

3.3.1 DPPH radical-scavenging activity

Data of the scavenging activity against DDPH indicated that the best antiradical effect was achieved by the 'Bouharrag' ecotypes (64.73%), whereas, 'Besbessi' had the least activity (14.59%) (Table 3). The results clearly revealed a stronger DPPH scavenging activity in purple blackish ecotypes compared to green ones, with average values of 50.25% and 26.95%, respectively (Fig. 2). These results are in accordance with those obtained by BACHIR BEY and LOUAILECHE (2015), who reported a DDPH radical scavenging activity varying from 28.33% to 45.25% in 'Taghanimt' and 'Bouankik' varieties, respectively. The study of DDPH scavenging activity of Algerian fig varieties clearly showed that dark varieties have stronger DDPH scavenging activities than the light one, with mean values of 41.63 and 31.3%, respectively (BACHIR BEY AND LOUAILECHE, 2015).

3.3.2 ABTS radical cation scavenging activity

The results of the scavenging activity of ABTS radical ranged from 'Mahdoui' (263.7 EVC mg/100 g FW) to 'Nemri' (676.13 EVC mg/100 g FW). It is apparent that antioxidant activity (ABTS) was lower in green yellowish and purple-blackish groups, whereas, the purple greenish showed the highest value (Fig. 2). The current results are comparable to the data obtained by SOLOMON *et al.* (2006), who indicated that dark fig varieties had high ABTS antioxidant capacities.

3.4. Reducing Sugars compositions

The analyses of variance for glucose (GLUC) and fructose (FRUC) revealed significant differences among the 27 studied ecotypes and within the fruit skin color groups. The ecotypes 'Zergui' and 'Nasri' had the highest contents of glucose (5.68 and 4.83 g/100 g FW, respectively) and fructose (5.43 and 4.69 g/100 g FW) values. Nevertheless, GLUC and FRUC were very low for the 'Mahdoui' ecotype (1.12 and 0.86 g/100 g FW, respectively) (Table 3). These results were lower than those obtained by MELGAREJO *et al.* (2003), as the glucose contents of 'Tio Antonio' and 'Calar' variety were 15.89 and 13.41 g/100 g FW, respectively. Similarly, CALISKAN and POLAT (2012) reported that GLUC and FRUC contents obtained in 'Sarilop' variety were 10.7 and 7.8 mg 100/ g FW,

respectively. The sugar composition of figs, especially fructose, can influence perceived fruit sweetness (SETSER, 1993).

Table 3. Effects of genotype on antioxidant activity (DPPH and ABTS) and sugar compositions for 27 Tunisian fig ecotypes.

Ecotype name	DPPH inhibition %	ABTS mg EVC/ 100 g FW	GLUC g/ 100 gFW	FRUC g/ 100 gFW	Fruit skin color group
Bither1	40.74±0.65 l	412.96±6.60 def	1.79±0.29 ab	1.96±0.21 acd	Green yellowish
Jebali1	28.99±0.99 f	480.26±26.04 hi	3.30±0.90 bde	3.16±0.42 cef	
Mahdoui	28.63±0.54 f	263.70±9.31 a	1.12±0.88 a	0.86±0.12 a	
Bayoudhi1	30.38±0.53 g	496.76±5.68 ij	4.66±0.10 ef	3.52±0.09 eg	Green
Bayoudhi2	26.55±0.50 e	376.40±5.55 cd	2.52±0.30 ad	2.47±0.10 bce	
Besbessi	14.59±0.52 b	407.96±3.61 de	3.20±0.31 bde	2.89±0.28 bcef	
Bither2	30.37±0.54 g	601.13±1.02 k	2.30±0.29 ad	2.18±0.81 ae	
Jemâaoui	38.49±0.50 j	448.60±10.28 fgh	3.37±0.67bde	2.45±0.11bce	Red greenish
Rogabi	38.49±0.50 j	493.76±6.26 ij	3.21±0.23 bde	2.41±0.26 bce	
Gaa Zir	45.49±0.50 m	384.06±5.47 cd	3.32±0.11 bde	3.34±0.31 cef	Brown purplish
Temri	27.42±0.51 e	441.56±7.76 eg	3.32±0.30 bef	2.32±0.45 bce	
Zergui	46.61±0.53 n	409.36±10.96 de	5.68±0.16 f	5.43±0.10 h	
Baghali2	29.47±0.50 fg	378.73±1.55 cd	2.00±0.90 abc	1.96±0.10 acd	Purple greenish
Baghali 3	26.48±0.50 e	658.96±10.15 l	2.57±0.90 ad	2.39±0.08 bce	
Chetoui Akhal	15.46±0.50 b	465.16±4.19 gi	2.56±0.30 ad	1.98±0.80 ade	
Croussi	35.54±0.50 i	575.86±3.58 k	2.52±0.40 ad	2.32±0.30 acd	
Kahli2	45.30±0.60 m	275.60±39.57 a	2.26±0.30 ad	2.15±0.10 ae	
Nemri	41.05±1.07 l	676.13±13.85 l	4.33±0.12 ef	3.96±0.35 fg	
Soltani Ahmer	48.07±1.00 o	490.43±10.50 ij	1.73±0.18 ab	1.56±0.11 ab	
Wedlani	31.52±0.50 h	519.70±1.47 j	3.63±0.20 cde	2.90±0.12 bcef	
Bouharrag	39.63±0.65 k	347.16±4.07 bc	3.58±1.05 cde	3.29±0.95 deg	Purple blackish
Bouholi	64.73±0.55 s	264.70±7.59 a	3.19±0.22 bde	3.05±0.95 cef	
Kahli1	19.62±0.54 d	407.80±5.63 de	2.25±0.90 ad	2.19±0.10 ae	
Nasri	56.55±0.51 q	465.16±4.19 gi	4.83±0.12 ef	4.69±0.95 ghe	
Sawoudi3	52.42±0.52 p	462.83±7.00 gi	3.12±0.30 ade	2.52±0.45 bcef	
Sawoudi5	62.45±0.51 r	383.50±15.05 cd	2.24±0.90 ad	1.82±0.25 ac	
Zidi2	56.37±0.54 q	322.20±1.92 b	3.84±0.30 de	3.22±0.17 cef	
Total mean	36.62±13.42	441.13±105.74	3.00±1.15	2.63±1.04	
F value	1454	763.1	10.47	13.47	
P value	***	***	***	***	

0 '***' 0.001. Values in the column with different lower-case letters are significantly different at $p< 0.05$ according to post-hoc Tukey multiple comparison. DPPH: 1.1 Diphényl 2 PycrilHydrazil. ABTS: acide 2.2-azino-bis-3-ethylbenzothiazoline-6-sulfonique, EVC: equivalent vitamin C, GLUC: Glucose, FRUC: Fructose, FW: Fresh weight.

It is more likely that the GLUC and FRUC contents depended on fruit skin color (Fig. 2). Similarly, CALISKAN and POLAT (2012) observed that fig genotypes with green or brown fruit skin color had higher GLUC and FRUC than the genotypes with black skin fruit. ABIDI *et al.* (2011) and CALISKAN and POLAT (2011) have also mentioned that several parameters like: climate variables, cultural practices and harvest time could introduce variability among sugar compositions of fig fruits.

3.5. Correlations between phytochemical and antioxidant activities parameters

Obtained results revealed the existence of a significant positive correlation between GLUC and FRUC (r = 0.889). Similar results between fructose and sucrose contents in fig fruits havealso been reported by CALISKAN and POLAT (2011; 2012). In addition, we detected slightly positive correlations between GLUC and DPPH (r = 0.374) and between TA and DDPH antioxidant activity (r = 0.292). The later correlation was not significant as reported by BACHIR BEY and LOUAILECHE (2015) and SOLOMON *et al*. (2006), who recorded a high correlation (r=0.91).It is also worthy to mention a slightly negative correlation between TP and TF, with value of r=-0.370 (Table 4).

Table 4. Pearson's linear correlation coefficients between total polyphenols (TP), total anthocyanins (TA), total flavonoids (TF), antioxidant capacity (DPPH and ABTS) and sugar composition (GLUC and FRUC) in fig fruits (n =30).

TF	-0.370					
TA	0.053	0.037				
DPPH	0.144	-0.038	0.292			
ABTS	0.187	-0.225	-0.294	-0.213		
GLUC	0.185	-0.171	0.012	0.374	0.104	
FRUC	0.082	-0.236	-0.118	0.284	0.154	0.889*
Parameters	TP	TF	TA	DPPH	ABTS	GLUC

DPPH: 1.1 Diphényl 2 PycrilHydrazil, ABTS: acide 2.2-azino-bis-3-ethylbenzothiazoline-6-sulfonique; *, P<0.05.

4. CONCLUSIONS

Since all fig trees were grown under the same environmental and edaphic conditions and subjected to uniform cultural practices (irrigation, fertilization, pruning), the observed differences in the phytochemical composition, antioxidant activity and sugar contents on fig fruits are largely dependent on the biochemical characteristic of each ecotype and to a lesser extent on the ripening stage and postharvest storage conditions. Our results revealed a considerable variation in the phytochemical, antioxidant activity and sugar compositions were observed in the 27 Tunisian fig ecotypes. The ecotypes with purple-blackish skin 'Bouholi', 'Sawoudi3' and 'Zidi2' had the highest contents of TA. Skin color had a highly significant effect on total anthocyanins and was the major tissue that contributed to anthocyanin compositions in figs fruits. Among all studied ecotypes, 'Nasri' showed the highest amount of TP. In addition, 'Bouholi' ecotype presented the highest antioxidant activity of DDPH and 'Nemri', 'Baghali3' and 'Bither2' ecotypes

showed the highest ABTS radical scavenging activity. Regarding the sugar contents, the ecotypes with higher values of GLUC and FRUC were 'Zergui' and 'Nasri', respectively. Due to high contents of bioactive substances and antioxidant activities, figs (particularly dark varieties) are an interesting alternative for antioxidant additives that could be used in pharmaceutical and food industry.

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