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A comparative study of phytochemical profile and in vitro antioxidant activities of dark and light dried fig (*Ficus carica* L.) varieties

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Abstract

To study bioactive compounds of the dried fig, nine varieties (3 dark and 6 light varieties) were analyzed for their phytochemical profile and antioxidant activities. The antioxidant activity was evaluated using four methods, including 2,2-diphenyl-1-picryl-hydrazyl radical, hydrogen peroxide, superoxide scavenging effects and phosphomolybdenum assay. The results showed that the fig varieties with a dark skin contain higher amounts of total phenolics, total flavonoïds, anthocyanins, flavonols and proanthocyanidins than the lighter varieties. Our results also revealed that the antioxidant activities of the dark varieties were markedly better than those of the light ones. High correlations were found between phytochemical contents and antioxidant activities. Principal component analysis (PCA) manifests 86.91 of cumulative variance which indicates that the fig varieties were well distinguished by their bioactive phytochemical contents and antioxidant activities. PCA plot confirms a net separation between the dark and light dried fig varieties.

Keywords: Dried fig, Light fig, Dark fig, Phytochemical, Antioxidant activity, PCA.

Introduction

There is growing scientific evidence that dietary antioxidants may be a critical mediator of the beneficial effects of the Mediterranean diet. A major benefit of the Mediterranean diet is its high level of natural antioxidants, derived from vegetables and fruits, such as vitamins E and C, carotenoïds and phenolic compounds.[1] Due to their antioxidant activity, plant phenolics play a major role in the prevention of various pathologies such as cancer and cardiovascular diseases associated with oxidative stress.[2]

Common fig, *Ficus carica* L., a deciduous tree belonging to the Moraceae family, is one of the oldest cultivated fruit trees and an important crop worldwide for both fresh and dry consumption. The most of the world's fig production is provided by Mediterranean countries.[3] In 2011, one million tons was produced worldwide, where Turkey ensures 25% of the global production. Algeria is the third producer of fig with 150,000 tons for the same year.[4]

The fig is a highly perishable fruit and thus a large world production is preserved in the dried form. The dried figs are among the most widely produced fruits in the world and their consumption had positive effects on human health. Besides its energetic role, the dried figs have good nutrient levels and represent an important source of fiber, minerals and polyphénoles.[5]

The dried fig contains phenolic substances which contribute to its quality. The phenolic compounds of dried figs can produce a significant increase of the antioxidant capacity of human plasma and can protect plasma lipoproteins from oxidation.[5] The skin color of fig fruit varies from yellow to black; hence, figs can be divided depending on their skin color into two groups: the light skin fig varieties with a yellow, yellow-green or green color and dark ones with a red, purple, black or brown skin color.

While the majority of antioxidant studies concerning the fig are performed on fresh fruit, there are only a few investigations on the antioxidant activity of dried fig. Moreover, to our knowledge, there are no works on the antioxidant activity of the Algerian fig. Therefore, the purpose of our study is to compare the phytochemical bioactive compound contents and *in vitro* antioxidant activities of some light and dark skin dried fig varieties cultivated in Algeria.

Materials and Methods

Standards and reagents

Folin-Ciocalteu and aluminium chloride were from Biochem, Chemopharma (Montreal, Quebec); sodium carbonate, sodium hydrogen phosphate and sulfuric acid were from Biochem, Chemopharma (Georgia, USA); gallic acid, acetone, butanol and methanol were from VWR, Prolabo (CE-EMB); all other chemicals were from Sigma Chemical (Sigma–Aldrich GmbH, Germany).

Sample preparation

Nine dried fig varieties (with three samples for each), harvested in the region of Beni Maouche locality (Bejaia Department, North of Algeria) were used in this investigation. Six varieties were characterized by a light skin color (*Abiarous*, *Azegzaw*, *El-bakour*, *Taamriwth* (green), *Tahyounte* and Taghanimt (yellow), while other varieties have a dark skin color *Aberkane* (black), *Azandjar* and *Bouankik* (purple). The samples were sun dried using the traditional method, cut into small pieces, lyophilized (Alpha1-4 LD_{plus}, Christ, Osterode, Germany), then, ground (A11 basic grinder, IKA, Germany). The obtained powders were stored at -20°C until analysis.

Extract preparation

The dried fig extracts were prepared according to our previous study.[6] Briefly, the fig powder was weighed into the screw cap tube and 10ml of 60% acetone (v/v) were added. The extraction was carried out using a water-bath equipped with a shaker (WB 22, Memmert, Osterode, Germany), at 40°C during two hours. Then, the solid was separated by centrifugation at 2250 *g* for 10 min (NF 200, Nüve, Turkey) and the extract was filtered. The residue was re-extracted using the same conditions. The two extracts were combined.

Determination of phytochemicals

Total phenolic compounds (TPC)

The total phenolic content of the extracts was assessed according to Singleton and Rossi.[7] The Folin-Ciocalteu reagent (750 µL) and sodium carbonate (400 µL, 7.5%) were added to 200 µL of the extract. After 90 min, the absorbance was measured at 720nm (UV-Vis spectrophotometer mini 1240, Shimadzu, China). The total phenolic content was expressed as mg of gallic acid equivalent (GAE)/100 g of dry matter (DM).

Total flavonoïds

The total flavonoïd content was estimated in the extracts using the assay described by Lamaison and Carnat.[8] One milliliter of the extract was added to 1ml of aluminium chloride solution (2% of $AlCl_3$ in methanol). The absorbance was measured 10 min later at 430nm. The results were expressed as mg of quercetin equivalent (QE)/100g DM.

Anthocyanins and flavonols

The extract (900 µL) was added to 900 µL methanol-0.1 N HCl. The anthocyanin concentration was determined from the absorbance at 530nm using a molar extinction coefficient (ε) of 38,000 L. mol^{-1}. cm^{-1}. The amount of flavonols was determined at 360nm (ε=20,000 $L.mol^{-1}.cm^{-1}$). The anthocyanin and flavonol contents were expressed as mg of quercetin 3-glucoside equivalent (Q3GE)/100 g DM.[9]

Proanthocyanidins

The proanthocyanidin contents were determined according to Vermerris and Nicholson.[10] The extract (500 µL) was mixed with 5ml of reagent ($FeSO_4$ + HCl-butanol) and then incubated at 95°C in a water-bath for 50 min. After cooling, the absorbance was read at 550nm. The proanthocyanidin content was determined using a molar extinction coefficient of cyanidin (ε=34700 L. mol^{-1}. cm^{-1}) and was expressed as mg of cyanidin equivalent (CyE)/100 g DM.

Antioxidant activities

DPPH radical-scavenging activity

The scavenging activity of fig extracts against the radical 2,2-diphenyl-1-picryl-hydrazyl (DPPH) was measured as described by Shimada *et al*.[11] An aliquot (200 µL) of the extract was added to 1ml of methanolic DPPH solution (60 µM). The decolorizing process was recorded at 515nm after 30 min of reaction and compared to a control (extraction solvent and DPPH reagent).

Superoxide scavenging activity

The superoxide anion radical was generated by a pyrogallol autoxidation system.[12] To 150µL of the extract were added 2ml of tris-HCl buffer (50mM, pH 8.2) and 80µL of pyrogallol solution. After incubation for 3 min at 25°C, 100µL of ascorbic acid solution were added and the absorbance was measured at 420nm.

Hydrogen peroxide scavenging activity

The ability of the extracts to scavenge hydrogen peroxide was determined according to the method of Ruch *et al*. [13] A solution of hydrogen peroxide (40mM) was prepared in phosphate buffer (pH 7.4). The extract was added to 1ml of H_2O_2 solution. The absorbance of the reaction mixture was recorded at 230nm.

Phosphomolybdenum antioxidant assay

The antioxidant activity of the extracts was evaluated by the phosphomolybdenum method according to the procedure of Prieto *et al*. [14] Briefly, the extract (300 µL) was combined with 3ml of reagent solution (0.6 M sulfuric acid, 28mM sodium phosphate and 4mM ammonium molybdate). The reaction mixture was incubated at 95°C for 90 min and the absorbance was measured at 695nm.

The DPPH scavenging activity was expressed as a percentage; all other antioxidant activities were expressed as mg gallic acid equivalent/100 g of dry matter (mg GAE/100 g DM).

Statistical analysis

The results were analyzed using statistical software (statistica version 5.5.fr). All values were expressed as mean ± standard deviation (SD). One-way analysis of variance (ANOVA) with LSD (Least Significant Difference) test was used to determine the significant differences ($p < 0.05$) among the means. In addition, Principal Component Analysis (PCA) was performed by computing the data matrix. This analysis allowed distinguishing between the dried fig varieties on the basis of the phytochemicals and antioxidant activities.

Results and Discussion

Phytochemical profile

The extraction procedure is carried out according to our study on the optimization of the extraction of phenolic compounds and antioxidant activity of figs.[6, 15] Acetone-water mixtures have been largely used to extract the antioxidant substances from several fruits such as dates[16] and olives[17]

Total phenolic compounds (TPC)

The phenolic compounds have been reported to be the main phytochemicals responsible for the antioxidant activity of fruits. The total phenolic levels of fig varieties were determined using the Folin-Ciocalteu assay. The total phenolics content (TPC) of the studied figs varied from 482.62 (*Aberkane*) to 644.11 mg/100g (Taghanimt) (Fig. 1a). The TPC of the darker varieties was higher than that of the light ones, with average values of 618.85 mg/100g and 514.72 mg/100 g, respectively. *Abiarous*, *Azegzaw*, *El-bakour* and *Taamriwth* varieties present similar phenolic contents.

The results of the present investigation are in accordance with the data obtained in our previous study[18] but are higher than that found by Vijaya Kumar Reddy *et al*. [19] and Capanoglu [20] who reported contents of 331.93 and 169.4 mg GAE/100g, for Indian and Turkish dried fig, respectively. These differences could be due to many parameters such as the geographical origin, varieties, extraction conditions, and postharvest storage conditions.[6, 17]

The TPC of the studied fig varieties was also higher than those obtained by Vijaya Kumar Reddy *et al*. [19] for apricots (304.63 mg GAE/100g) and dates (241.61 mg GAE/100g), Ghiaba *et al*. [21] for Algerian date varieties (41.80-84.73), Capanoglu [20] for Turkish dried fruits including apple (76 mg GAE/100g) and yellow raisin (85 mg GAE/100g) and Al Juhaimi [22] for dates (0.94-1.98 mg GAE/100g).

Our findings are in agreement with Debib *et al*. [23], Solomon *et al*.[24] and Çalişkan and Polat[25] who showed that the dark-purple fresh fig contains higher level of phenolics than the green and yellow ones.

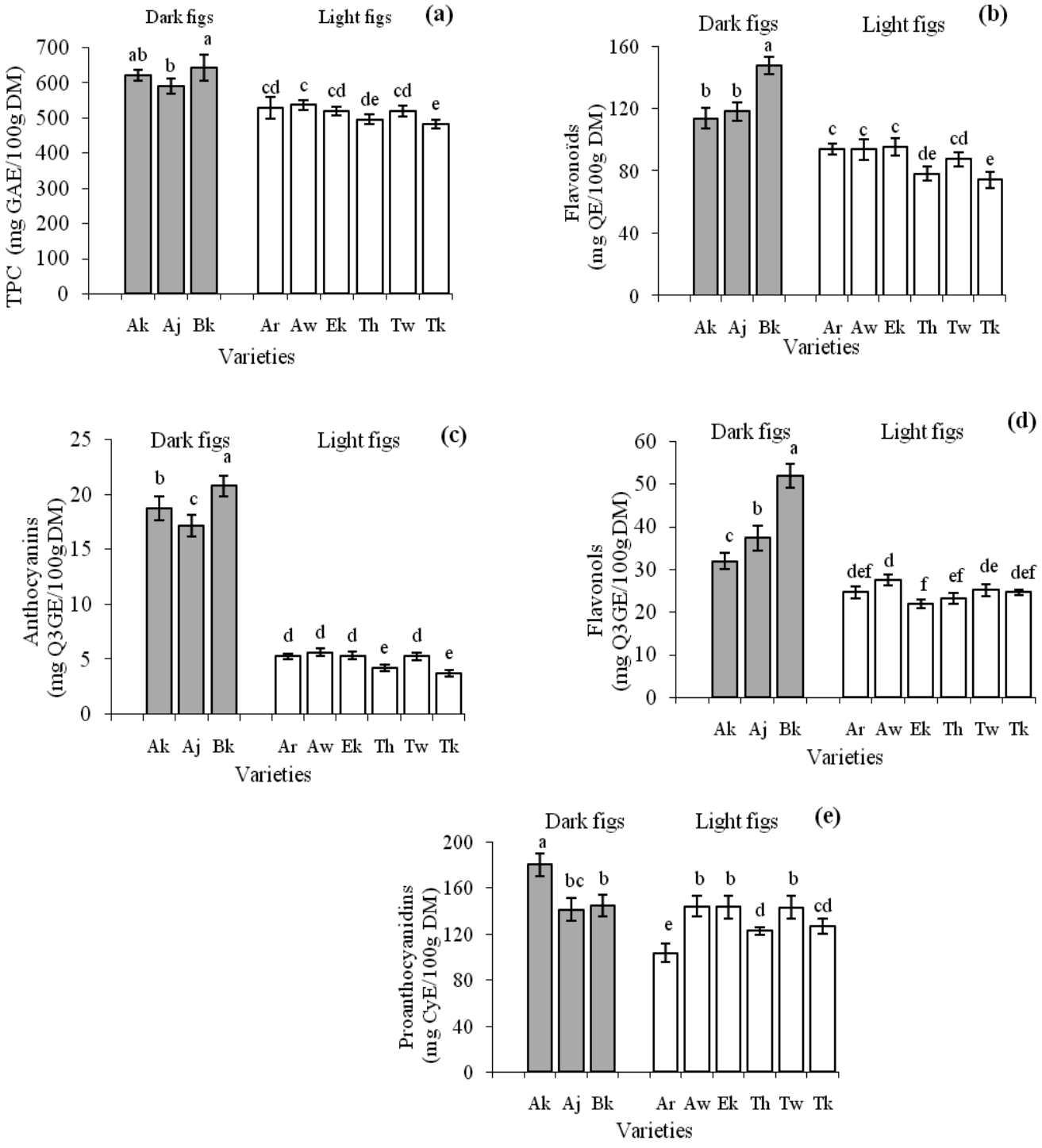

Figure 1: Antioxidant contents of the dark and light skin dried fig varieties. (a) TPC, mg GAE/100 g DM; (b) flavonoïds, mg QE/100 g DM; (c) anthocyanins, mg Q3GE/100 g DM; (d) flavonols, mg Q3GE/100 g DM and (e) proanthocyanidins, mg CyE/100 g DM. Results with different letters are significantly different at $p < 0.05$; a > b > c > d > e > f. Vertical bars present the standard deviation (number of repetition n = 3). Ak: *Aberkane*, Aj: *Azandjar*, Bk: *Bouankik*, Ar: *Abiarous*, Aw: *Azegzaw*, Ek: *El-bakour*, Th: *Tahyounte*, Tw: *Taamriwth*, Tk: *Taghanimt*.

Total flavonoïds

Flavonoïds are phenolic substances isolated from a wide range of vascular plants. It has been recognized that flavonoïds showed antioxidant activity; their effects on human nutrition and health are crucial.

The flavonoïd contents of the studied fig varieties are presented in Fig 1.b. As for TPC, the statistical analysis revealed that dark varieties (*Bouankik*, *Azandjar* and *Aberkane*) contained more flavonoïds than light ones, with mean values of 126.55 and 87.24 mg/100 g, respectively. In our previous investigation on some dried fruits[18] we reported a value of 105.6 mg QE/100 g in the black fig. These amounts were higher than those obtained by Ghiaba *et al*. [21] for Algerian date varieties (7.52-14.10 mg/100g DM), and Ouchemoukh *et al*. [18] for some dried fruits consumed in Algeria, including apricots, raisins and prunes. However, these results are in line with those of Solomon *et al*. [24] who found that total flavonoïd levels of dark-purple fresh fig varieties were greater than those of light ones.

Anthocyanins and flavonols

The anthocyanins are natural pigments belonging to the flavonoïd family and are responsible for the red, blue and purple colors of many fruits and flowers. Color is one the most important indicator of maturity and quality in many fruits and is mainly influenced by the concentration and distribution of various anthocyanins.[26] Recent and renewed interests in anthocyanins are due not only to their use as natural food colorants but mainly to their potential health benefits as antioxidants and anti-inflammatory substances

Fig. 1c showed the anthocyanin contents of dried fig varieties used in the present study. The highest concentration was recorded for *Bouankik* variety (20.78 mg/100 g) followed by *Aberkane* (18.73 mg/100 g), then *Azandjar* (17.18 mg/100 g) varieties. Dark fig varieties have about four times more anthocyanins (18.90 mg/100g) than light ones (4.92 mg/100g). Solomon *et al*. [24] reported that the fresh fig dark Mission variety has eight times higher anthocyanins (10.9 mg cyn-3-glu/100 g fresh weight) than red brown-Turkey one (1.3 mg cyn-3-glu/100 g fresh weight), while these compounds are not detected in light varieties. The anthocyanin content of the investigated dark varieties is higher than that found by Ouchemoukh *et al*. [18] in the black fig (5.9 mg CyE/100 g), prune (4 mg/100 g), raisins (2 mg/100 g) and apricots (0.5 mg/100 g).

Flavonols are of particular interest as they are potential antioxidants; their consumption is associated with a reduced risk of cancer and support human health by serving as anti-inflammatory, anti-histaminic and anti-viral agents.[27] The flavonol amounts of the studied dried fig samples varied from 21.94 to 51.93 mg/100 g (Fig. 1d). *Bouankik* variety had the highest concentration followed by *Azandjar* (37.35 mg/100 g), and then *Aberkane* (31.97 mg/100 g). It is apparent that dark fig varieties contain more flavonols than light ones, with average values of 40.42 and 24.52 mg/100 g, respectively. These levels were higher than those obtained in our previous study[16], for Algerian dates varieties (6.73-36.64 mg rutin equivalent/100 g).

Proanthocyanidins

Proanthocyanidins have been shown to possess many health benefits, particularly their ability to protect against cardiovascular diseases.[28] Fig. 1e showed the proanthocyanidin contents of the studied fig varieties. *Aberkane* variety has the highest content (179.84 mg CyE/100 g) while the lowest amount (103.35 mg CyE/100 g) is recorded for *Abiarous* variety. Concentrations from 73 to 120 mg CyE/100 g DM were reported by Bucić-Kojić *et al*. [29] in some Croatian fresh fig varieties. The proanthocyanidin amounts of the studied figs were higher than those found by Ouchemoukh *et al*. [18] in other dried fruits such as prune, apricots and raisins. Our findings revealed that proanthocyanidins accounted for about 20 (*Abiarous*) to 29% (*Aberkane*) of total phenolic compounds of dried figs.

Antioxidant activities

The antioxidant potential of the studied dried fig varieties were evaluated using DPPH, hydrogen peroxide, superoxide, and phosphomolybdenum assays.

DPPH radical-scavenging activity

The DPPH radical is a stable free radical and accepts an electron or hydrogen radical to become a stable molecule. Analytical data presented in Table 1 indicated that the scavenging capacity against DPPH differed significantly between varieties. The best antiradical effect was achieved by *Bouankik* variety (45.25%), whereas Taghanimt variety displayed the lowest activity (28.33%). The results showed clearly that dark varieties exhibited stronger DPPH scavenging activity than light ones, with mean values of 41.63 and 31.38%, respectively.

The study conducted by Ouchemoukh *et al*. [18] revealed that DPPH radical-scavenging activity depends on the extraction solvent and fruits; the values obtained for aqueous and 50% methanol extracts of dried figs were of 28.1% and 53.0%, respectively. Our findings are in agreement with Savikina *et al*. [30] who reported that antiradical activities of black currant varieties were statistically significantly different.

The fruit and vegetable color can indicate their antioxidant activities. According to Gui and Ryu [31], the DPPH radical-scavenging activity of red ginseng (46.39%) was significantly higher than that of white ginseng (23.00%). Also, the study conducted by Nayak *et al*. [32] revealed that the DPPH scavenging effect of dried potatoes with different color showed variable activities; the purple potato exhibited the highest activity while potatoes with yellow and white colors have the lowest activities.

Superoxide scavenging activity

It is well known that superoxide anions damage bio-molecules directly or indirectly by forming hydrogen peroxide, hydroxyl radical and peroxynitrite or singlet oxygen during aging and pathological events such as ischemic reperfusion injury. Superoxide has also been observed to directly initiate lipid peroxidation.[33, 34] The results of our study showed that the superoxide radical scavenging effect of dark fig varieties (274.84-315.70 mg GAE/100 g) was higher than that of light ones (137.42-237.70 mg GAE/100 g). The strongest superoxide scavenging activity was showed for *Azandjar* and *Bouankik* varieties, while *Tahyounte* and Taghanimt varieties displayed the lowest activities. Statistically, similar activities were recorded for *Abiarous*, *El-bakour*, *Taamriwth* and *Azegzaw* varieties (Table 1).

The best superoxide scavenging activity recorded for the dark fig varieties, 113.63, 118.20, and 147.82 mg QE/100 g DM for *Aberkane*, *Azandjar*, and *Bouankik*, respectively, could mainly be attributed to their highest flavonoïd contents. Several studies have indicated that flavonoïds are strong scavengers of superoxide radicals.[35, 36]

Hydrogen peroxide scavenging activity

Hydrogen peroxide is a weak oxidizing agent and can inactivate enzymes directly, usually by oxidation of essential thiol groups. It can cross cell membranes rapidly; once inside the cell, it can react with Fe^{2+} and Cu^{2+} ions to form hydroxyl radical. This may be the origin of its toxic effects.[37]

The results of hydrogen peroxide scavenging activity were showed in Table 1. Two dark skin varieties, *Bouankik* and *Azandjar*, exhibited a remarkable scavenging effect against hydrogen peroxide, with a mean value of 207 mg GAE/100 g, followed by *Aberkane* (182 mg GAE/100 g) and *Taamriwth* (169 mg GAE/100 g) varieties with no significant difference ($p < 0.05$). The lowest H_2O_2 scavenging power was recorded for *Tahyounte* and Taghanimt varieties.

Several studies have shown that the phenolic compounds, flavonoids particularly, can directly scavenge reactive oxygen species (hydrogen peroxide, hydroxyl radical, singlet oxygen or peroxyl radical). The antioxidant action of these compounds resides mainly in their ability to donate electrons or hydrogen atoms. Polyphenols possess ideal chemical structure for this activity and have been shown to be more effective *in vitro* than vitamins E and C.[34] In the present investigation, the highest flavonoïd content in dark figs could explain their best scavenging effect against hydrogen peroxide.

Table 1: Antioxidant capacities of the dark and light dried fig varieties.

Variety	DPPH (%)	Superoxide (mg GAE/100g)	H_2O_2 (mg GAE/100g)	Phosphomolybdenum (mg GAE/100g)
Dark fig varieties				
Aberkane	38.73±1.12^{c}	274.84± 17.02^{b}	181.79± 7.90^{b}	999.82± 29.60^{a}
Azandjar	40.93±1.11^{b}	315.70± 17.02^{a}	202.86± 18.25^{a}	1024.37± 27.17^{a}
Bouankik	45.25±1.25^{a}	289.70± 22.28^{ab}	210.77± 18.25^{a}	1012.96± 60.66^{a}
Range	*38.73-45.25*	*274.84- 315.70*	*181.79- 210.77*	*999.82- 1024.37*
Mean	*41.63*	*293.41*	*198.47*	*1012.39*
Light fig varieties				
Abiarous	29.36±1.14^{ef}	219.13± 6.43^{c}	113.29± 4.56^{d}	810.55± 37.67^{b}
Azegzaw	33.68±0.87^{d}	237.70± 17.02^{c}	118.56± 7.90^{d}	785.11± 35.54^{bc}
El-bakour	30.64±0.50^{e}	226.56± 17.02^{c}	150.17± 7.90^{c}	821.80± 47.20^{b}
Tahyounte	31.13±0.62^{e}	137.42± 6.43^{d}	92.21± 4.56^{e}	621.72± 31.59^{d}
Taamriwth	35.15±0.75^{d}	218.76± 17.63^{c}	168.61± 4.56^{b}	787.98± 37.59^{bc}
Taghanimt	28.33±0.72^{f}	144.85± 11.14^{d}	105.38± 9.13^{de}	720.20± 44.66^{c}
Range	*28.33-35.15*	*137.42- 237.70*	*92.21- 168.61*	*621.72- 821.80*
Mean	*31.38*	*197.40*	*124.70*	*757.89*

The results expressed as the mean ± standard deviation (number of repetition n = 3). For each column, values with different letters are significantly different at P<0.05; a>b>c>d>e>f.

Table 2: Correlation matrix between antioxidant parameters of the dark and light skin dried fig varieties.

	TPC	Flavonoïds	Anthocyanins	Flavonols	Proantho-cyanidins	DPPH	Superoxide	H_2O_2
Flavonoïds	0.88							
Anthocyanins	0.92	0.89						
Flavonols	0.81	0.91	0.86					
Proanthocyanidins	0.47**	0.41**	0.57*	0.30**				
DPPH	0.88	0.87	0.91	0.89	0.51*			
Superoxide	0.82	0.79	0.80	0.67	0.45**	0.78		
H_2O_2	0.79	0.83	0.84	0.76	0.56*	0.85	0.84	
Phosphomolybdenum	0.88	0.85	0.88	0.74	0.48**	0.80	0.90	0.88

Coefficient of correlation with ** were significant at P<0.05, with * were significant at P<0.01, and results without asterisk were significant at P<0.001.

Phosphomolybdenum antioxidant activity

The antioxidant activity of the dried figs was also evaluated by the phosphomolybdenum assay, which is based on the reduction of Mo (VI) to Mo (V) by the antioxidants present in the extract and the subsequent formation of green phosphate/Mo (V) complex with a maximum absorption at 695nm. The results showed that dark fig varieties exhibited similar molybdenum reduction activities, with a mean value of 1012 mg GAE/100 g DM (Table 1), while the lowest antioxidant capacity was recorded for *Tahyounte* variety (622 mg/100 g). Using the same test, the black fig extracts prepared with water, 50% ethanol and 50% methanol indicat activities of 22.1, 17.2 and 14.1 mg ascorbic acid equivalent/100g DM, respectively.[18] The phosphomolybdenum activity of 70% acetone extract of date cultivars varied from 75 to 85 mg ascorbic acid equivalent/g.[38]

Correlations between antioxidant compounds and antioxidant activities

As indicated in Table 2, there were good positive correlations between the studied parameters. Our findings are in accordance with previous reports on other fruit matrix.[18, 19] All the antioxidant assays investigated were highly correlated with total phenolic (0.84), anthocyanin (0.86), flavonoïd (0.88) and flavonol (0.77) contents. Significant but moderate correlation was established between proanthocyanidin contents and other parameters.

Principal component analysis

The principal component analysis is a multivariate technique used for reducing the dimensionality of a data set. The PCA was applied to the results of phytochemical contents and antioxidant activities in order to determine the possible grouping of analyzed dried fig varieties.

The factor loading matrix obtained for the two factors and the variance explained by each of them were indicated in Table 3. The first principal component accounts for 79.72% of the variance and the second for 7.18%. The cumulative variance is of 86.91%; it indicates that the fig varieties were well distinguished by their phytochemical levels and antioxidant activities. It can be seen from Table 3 that most of variables (total phenolics, flavonoïd, anthocyanin and flavonol contents, DPPH radical, superoxide and hydrogen peroxide scavenging activities and phosphomolybdenum test) present a high correlation with the first factor, while proanthocyanidin contents were correlated with the second factor. This indicated that proanthocyanidin content was not a good indicator of the antioxidant activity.

According to factor scores (Table 3), it can be suggested that the anthocyanin followed by phenolic and flavonoïd contents may be a useful mean to discriminate the dried fig varieties on the basis of their phytochemicals. The DPPH scavenging assay was the best antioxidant activity allowing differentiating the studied dark dried figs. Wang and Hu [39] found also that the DPPH test may be more useful for assessing the antioxidant activity in mulberry fruits than both FRAP (Ferric Reducing Ability of Plasma) and ORAC (Oxygen Radical Antioxidant Capacity) methods.

Fig. 2 represents the graphic distribution of the dried fig varieties according to their factor scores and shows that the dark varieties were differentiated from light ones; the first were regrouped at the right side of the graph, whereas, the seconds at the left. Taking account of the obtained results (phytochemical contents and antioxidant activities), it can be seen from Fig. 2 that the three dark skin varieties (*Aberkane*, *Azandjar* and *Bouankik*) were different. Also, the light skin varieties can be subdivided into three subgroups. The first includes *El-bakour*, *Azegzaw* and *Taamriwth*; the second contains *Tahyounte* and Taghanimt, while the third is represented by *Abiarous* variety.

To assess the variation within three phenotype groups of Tunisian dried figs (black, green, and red phenotypes), PCA was performed on the basis of the phenolic composition. The results showed that the phenolic composition does not allow to distinguish the different phenotypes, since all varieties contained the same compounds, with similar amounts, without significant difference.[40] However, in our study, using nine parameters relative to phytochemical contents and antioxidant activities, PCA applied for the studied fig fruits revealed that the three dried dark fig and *Abiarous* varieties can be distinguished, unlike to the other varieties. Also, using PCA, Wang and Hu [40] found that the scores plot allowed to discriminate the mulberry genotypes.

Table 3: Principal component analysis factor scores for the first two axes and explained and cumulative variances.

Variable	Factor 1	Factor 2
TPC	0.94	-0.07
Flavonoïds	0.94	-0.18
Anthocyanins	0.96	0.01
Flavonols	0.88	-0.32
Proanthocyanidins	0.57	0.80
DPPH	0.94	-0.06
Superoxide	0.89	0.02
Hydrogen peroxide	0.92	0.10
Phosphomolybdenum	0.93	0.00
Variance explained (%)	*79.73*	*7.18*
Cumulative variance (%)	*79.73*	*86.91*

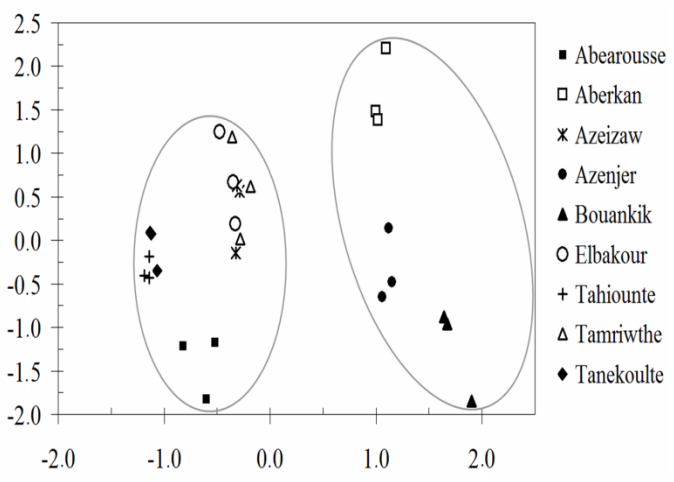

Figure 2: Distribution plot of the dark and light skin dried fig varieties according to the two first axes of the principal component analysis based on their antioxidant contents and antioxidant capacities.

Conclusion

To our knowledge, this investigation represents the first study comparing the secondary metabolite contents and antioxidant potential of Algerian fig varieties. Our results indicated that the dried fig is a good source of various non-enzymatic antioxidants that improve the human health. The fig varieties with a dark skin contain

higher levels of polyphenols, flavonoïds, flavonols, anthocyanins and proanthocyanidins, and exhibit better antioxidant activity than light ones. PCA plot showed a net separation between these two groups of fig varieties. The correlation matrix reveals high relationships between the analyzed parameters. Due to their high content of bioactive substances and strong antioxidant activities, the dried figs particularly dark varieties, could be used in pharmaceutical field to prevent the lifestyle-related diseases in which free radicals are involved and to promote health, and in the food industry as an alternative for antioxidant additives. Further researches should be carried out to complete the present study by identifying and quantifying the predominant bioactive phenolics involved in the antioxidant potential of the fig extracts.

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