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EFFECT OF SUN DRYING ON PHYTOCHIMICAL QUALITY AND ANTIOXIDANT ACTIVITY OF FIVE FIG VARIETIES (*Ficus caricaL.*) FROM NORTH ALGERIA.

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ABSTRACT

The fig has been a typical fruit component of the health-promoting Mediterranean diet for a very long time. Due to its perishable and seasonal aspect, it must be kept in its dry form, which can be obtained by several drying processes, including sun-drying. It is known to provide many dietary elements and beneficial phenolic compounds that have good antioxidant properties. This study contributes to assess the impact of sun-drying on phytochemical quality and on the antioxidant activity of five fig varieties from Jijel region (North Algeria). The results show that drying has a positive effect on the content of various phytochemical compounds, in particular total polyphenols, which reached a value of 398.8 ± 2.39 mg AGE/100 g of dried fig, on the content of flavonoids (increase from 17.71± 0.55 to 22.96 ± 0.18 mg QE / 100 g of fig), and proanthocyanidines (from 0.65 ± 0.07 to 2.93 ± 0.17mg CE/100 g of fig). On the other hand, a decrease in the content of anthocyanins (from 4.27 ±0.13 to 1.59±0.07 mg Q3GE/100 g of fig), and carotenoids (from 464.78±1.74 to 140.96±1.41 ug βCE/100 g of fig) is recorded. The *in vitro* evaluation of the antioxidant activity of extracts by DPPH free radical scavenging test, iron reduction, and H_2O_2 scavenging showed that dried figs have significant antioxidant activity dependent on polyphenols content.

1. Introduction

Fruits and vegetables containing high concentrations of bioactive compounds have attracted considerable interest over the past three decades, due to their potentially beneficial properties for health and their richness in antioxidant substances that play a major role in the prevention of various pathologies such as cancer, cardiovascular and neurodegenerative diseases that would be associated with oxidative stress (Bachir Bey *et al.,* 2017; Ercisli *et al.,* 2012).The latter is defined as a profound imbalance in the equilibrium between pro-oxidants and antioxidants, which leads to irreversible cellular damage. The univalent reduction of oxygen results in the formation of reactive oxygen species (ROS) including free radicals

(superoxide anion, hydroxyl radical), hydrogen peroxide, and singlet oxygen (Pincemail *et al.,* 1999; Xu *et al.,* 2017).

The ability of different fruits and vegetables to neutralize free radicals and restore oxidative balance *in vivo* is attributed to their richness in polyphenols, natural antioxidants with high antioxidant and cytoprotective potential (Akbari *et al.,* 2022). Among these fruits and vegetables, we stand out the fig. The fig is the fruit of the fig tree which belongs with the olive tree and the citrus fruits to the trilogy of the main fruit productions of Algeria. This importance is mainly linked to a multiplicity of uses and exchanges of genetic material, which led to its diversification and spread (Chouaki *et al*., 2006). It is considered as a "functional food", thanks to its richness in vitamins, essential minerals, dietary fibers, phenolic compounds, proteins and calories in large quantities (Zidi *et al*., 2020). However, they are seasonal and highly perishable due to their short shelf life of two days at room temperature (Sharifian *et al.,* 2012), and 7–10 days if stored at 0–2°C (Veberic *et al.,* 2008). Given the fact that they are highly perishable, which limits storage for long periods, and in order to increase potential markets, most of the production is intended for drying (Bouzo *et al.,* 2012). Once dried, figs can be stored for 6-8 months (Slatnar *et al.,* 2011).

Drying of fruits and vegetables is one of the oldest forms of food preservation. The major objective of drying agricultural products is to reduce the humidity to a level that allows safe storage for a long period of time. In Algeria, figs are traditionally dried by exposing them directly to the sun. This method of drying has advantages on the quality of these fruits. Drying leads to a reduction in weight and volume, thus minimizing the costs of packaging, storage and transport. Despite some drawbacks, sun drying is still used in several regions around the world. Solar energy is an important alternative source of energy and is preferred over other sources because it is inexhaustible, economical, non-polluting and renewable (Doymaz, 2005).

Studies dealing with fresh or dried figs in Algeria are few; especially since no study dealing with figs from Jijel region (North Algeria) has been undertaken. With this in mind, we are interested in studying the impact of sun drying on the phytochemical composition (content of polyphenols and various antioxidants) and in particular on the antioxidant activity of five varieties of figs (*Ficuscarica L.*) from Jijel region.

2. Materials and Methods

2.1. Plant material

In this study, five yellow varieties of fig were used in the fresh and dried states. The samples were collected in August 2020 from five different sites in Jijel city (North Algeria) namely: Chekfa, Ouled Askar, DjamaaBniHbibi, Milia and Mzayer.

Two separate batches were harvested from each variety. A batch of fresh harvested figs that were ripe, firm and healthy (not infected by insects) was intended for analysis in fresh state. The second batch intended for sun-drying, includes very ripe figs, with easily detachable peduncles.

For sun-drying process, fruits were uniformly arranged in sample trays in a single layer to be exposed to the sunlight, they were turned over each day. To avoid night humidity, the fruits were placed indoors during the. Sun-drying was completed within one week.

2.2. Extraction process

In the present study and after an optimization step carried out by several authors(Chan *et al.,* 2009;Uma *et al.,* 2010; Bey and Louaileche, 2015); acetone 70% was chosen for the extraction of phenolic compounds. For this, 6 grams of ground figs were mixed with 300 ml of acetone 70% (V/V). After 72 hours of stirring at ambient temperature, the mixture was filtered on filter paper and then centrifuged at 3000 rpm/20 min. The supernatant was recovered and then stored at 4°C in dark and hermetically sealed bottles.

2.3. Quantification of antioxidants

2.3.1. Total phenolic contents

The total polyphenol assay was performed by colorimetry using the Folin–Ciocalteu reagent (Siham *et al.,* 2019). For the assay, a volume of 1 ml of Folin-Ciocalteu reagent (1/10) and a volume of 800 µl of sodium

carbonate (7.5%) were added to 200 µl of extract. After 30 minutes of incubation in the dark, the absorbance was measured at 750 nm. The contents of phenolic compounds are determined by referring to a calibration curve established using gallic acid as a standard. The results are expressed in milligrams of gallic acid equivalent per 100 g of fig (mg AGE/100g) (Bey and Louaileche, 2015).

2.3.2. Flavonoids

The quantitative estimation of total flavonoids contained in the extracts was carried out using the aluminum trichloride ($AlCl_3$) method (Kosalec *et al.,* 2004). Briefly, 1 ml of the polyphenolic extract was added to an equal volume of a 2% $AlCl_3$ solution. The mixture was shaken vigorously, and the absorbance was read at 430 nm, after 10 minutes of incubation at room temperature. The amount of flavonoids in the extracts was determined using a calibration curve with quercetin as the standard. The results are expressed in milligram equivalent of quercetin per 100 g of fig (mg QE/100g).

2.3.3. Carotenoids content

The determination of the carotenoid content was carried out according to the method described by Sass-Kiss *et al.*(2005). 0.5 g of ground figs was added to 10 ml of the hexane/acetone/ethanol mixture (2/1/1). After 30 min of stirring the mixture was filtered and the upper phase was recovered (phase 1). Subsequently, 5ml of hexane was added to the lower phase for a second extraction and after 30 min of agitation, the upper phase was recovered (phase 2). The mixture of the two phases (1 and 2) was used for the determination of carotenoids by measuring absorbance at 430 nm. The results are expressed in milligram equivalent of β-carotene per 100 g of fig (ug βCE /100g).

2.3.4. Antocyanins

The anthocyanin concentration was determined according to the procedure described by Ganjewala *et al*.(2008). An appropriate extraction was carried out: 1g of ground figs was mixed with 10 ml of a methanol/HCl mixture (V/V). After shaking for 10 min, the extract was centrifuged at 5000 rpm for 20 min. The supernatant was recovered and 5ml of it was mixed with 5ml of a methanol/HCl (V/V) mixture then the absorbance was measured at 530 nm. The results are expressed in mg of quercetin-3-glucoside equivalent per 100g of figs (mg Q 3-GE/100g), and are calculated by referring to the following formula:

$$C = A.MM.FD.1000/ \varepsilon.L. \quad (1)$$

Where:

- A: Absorbance;
- MM: Molar mass of quercetin-3-glucoside (478.3598 g/mol);
- FD: Dilution factor;
- L: Optical path;
- ε: Molar extinction coefficient of quercetin-3-glucoside (38000 mol.cm).

2.3.5. Proanthocyanidins assay

The proanthocyanidin content of fig extracts was estimated according to the method described by Porter *et al.* (1985) as developed by Nasseri *et al*. (2019). The assay consists of mixing of 200 µl of extract were added to 2 ml of iron sulfate. The mixture was then incubated at 95°C for 15 minutes. Absorbance was measured at 530 nm. The results are expressed in mg equivalent of cyanidin (CE) /100 g of fig, and are calculated by referring to the formula:

$$C=A.MM.FD.1000/ \varepsilon. L. \quad (2)$$

Where:

A: Absorbance;
MM: Molar mass of cyanidin (287.24g/mol);
FD: Dilution factor;
L: Optical path;
ε: Molar extinction coefficient (ε=34700mol.cm).

2.4. Antioxidant activities

2.4.1. DPPH free radical test

The evaluation of the scavenger effect of fig extracts on the DPPH radical is carried out according to the method described by Brand-Williams *et al*.(1995). Using this method, it possible to follow spectrophotometrically the kinetics of discoloration of radical DPPH of violet color at 517 nm.

For this, 100 µl of each extract were incubated with 2.9 ml of a methanolic solution of DPPH at 0.025 g/l. After an incubation period of 30 minutes, the absorbances at 517 nm were recorded. The anti-radical activity

was estimated according to the following equation:

$$\text{Anti-radical activity (\%)} = [\{Ao-A1/Ao\}]x100. \quad (3)$$

Where:
Ao: Absorbance at 517 nm of the control (DPPH+Acetone 70%);
A1: The absorbance of the DPPH solution• in the presence of the extract.

2.4.2. Iron-reducing power test

This method is based on the ability of extracts to reduce ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}). The mechanism is known as an indicator of electron donor activity, characteristic of the antioxidant activity of polyphenols (Yıldırım *et al.,* 2001).

The reducing power of the samples was determined according to the method of Gulcin *et al*. (2002). This method consists of mixing 1 ml of the extract with 2.5 ml of phosphate buffer (0.2M, pH 6.6) and 2.5 ml of a solution of potassium ferricyanide [$K_3Fe(CN)_6$] at 1% (m/v). The mixture was incubated at 50° C. for 30 min, then 2.5 ml of 10% trichloroacetic acid (CCl_3 COOH) are added to stop the reaction. The mixture was centrifuged at 3000 g for 10 min at room temperature. To 2.5 of the supernatant are added 2.5 ml of distilled water and 500 µl of iron chloride (Fe Cl_3) at 0.1%. The absorbance of the reaction medium was determined at 700 nm.

The increase in absorbance in the reaction medium indicates an increase in the reducing power of the extracts tested. The results are expressed in mg of ascorbic acid equivalent/100g of figs (Bougandoura and Bendimerad, 2013), referring to a calibration curve established with ascorbic acid.

2.4.3. Hydrogen peroxide scavenging test

The capacity of the extracts to scavenge hydrogen peroxide was determined according to the method of Ruch *et al.*(1989). A solution of hydrogen peroxide (40 mM) was prepared in phosphate buffer (pH 7.4). 1.5 ml of the extract was added to 1 ml of the H_2O_2 solution.

The absorbance of the reaction mixture was measured at 230 nm against the blank containing phosphate buffer without H_2O_2. The percentage of hydrogen peroxide scavenging by the tested extracts was calculated according to the following equation:

$$H_2O_2 \text{ scavenging (\%)} = [\{Ao–Al/Ao\}] x100. \quad (4)$$

Where:
Ao: The absorbance of H_2O_2;
Al: The absorbance of H_2O_2 in the presence of the extract.

2.5. Statistical Analysis

Results were reported as mean ± standard deviation (three replicates); and the data were compared based on the values of the means. Differences between means were tested using the Tukey-Kramer HSD test (JMP version 7.0 software) with a significance level of 0.05.

3. Results and Discussion

3.1. Determination of phytochemical compounds

3.1.1. Total phenolic contents (TPC)

The total phenolic contents (TPC) of fig extracts varied significantly ($p < 0.05$) from 37.38 ± 1.54 to199.99 ± 1.72 mg AGE/100 g of fresh figs and from 80.47 ± 0.86 to 398.8 ± 2.39 mg AGE/100 g of dried figs (figure 1, table1)**.** These results showed clearly that a higher content of polyphenols was obtained in dried figs compared to fresh fig.

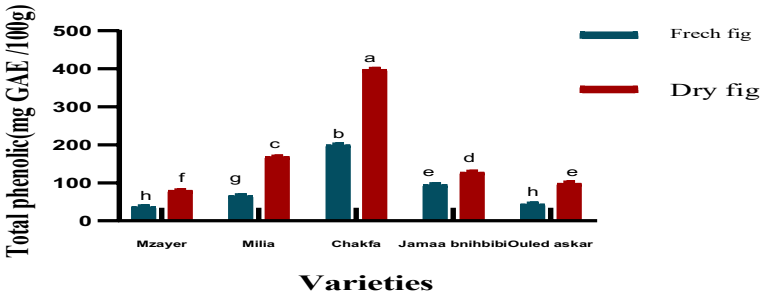

Figure1. Total phenolic contents of the fresh and dry fig varieties

The results are expressed as mean values ± standard deviation (n=3). Bars labeled with different letters are significantly different ($p < 0.05$).

Table1. Total phenolic contents of the fresh and dry fig varieties

Varieties	Total phenolic (mg AGE/100g)			
	Fresh		Dry	
Mzayer	37.38±1.54	80.47±0.86	37.38±1.54	80.47±0.86
Milia	66.09±1.84	169.36±0.81	66.09±1.84	169.36±0.81
Chakfa	199.99±1.72	398.80±2.38	199.99±1.72	398.80±2.38
DjamaaBni Hbibi	95.40±1.35	128.33±1.56	95.40±1.35	128.33±1.56
Ouled Askar	44.04±1.86	99.25±2.65	44.04±1.86	99.25±2.65

Fruit drying is an ancient food preservation technique that is still widely used today. In the literature, there are several reports on the effects of drying on phenolic compounds of various fruits including figs(Bachir Bey *et al.,* 2017; Manoj *et al.,* 2018; Arvaniti *et al.,* 2019).The findings in this study showed that sun drying has a positive effect on the polyphenol content of the five fig varieties studied. These results are consistent with those found by Manoj *et al*. (2018) who measured the total polyphenol content of fresh and dried figs from some varieties grown in India. Their results showed that the polyphenol contents in the extracts of fresh figs were 4.58 mg AGE/100 g of fig and 4.92 mg AGE/100 g of dried fig. In addition, in the research conducted by Slatnar *et al*. (2011) on a fig variety grown in Slovenia, a total phenol content of 7.49 mg AGE/100 g was reported in fresh fig fruits with a significant increase after drying (49.5 mg AGE/100 g).

Many studies report that the phenolic content can be related with drying method where Lohani and Muthukumarappan (2015) reported that the phenolic compounds can be liberated by heat treatment, in this regard, the strong accumulation of phenolic in fig fruit after drying has been correlated with the hydrolysis of complex phenolic compounds such as tannins and lignins under the effect of the rise in temperature during drying and due to a release of other simpler and more numerous compounds (Al-Farsi *et al.,* 2005). Also, the drying can hasten the release of phenolic compounds bound to the membranes of heat-damaged cell organelles (Arslan and Özcan, 2010).

In a study by Vinson *et al.*(2005)on fresh and dried figs in California, conflicting findings were obtained. They found 486 mg AGE per 100 g of fresh figs and 320 mg per 100 g of dry figs (dry state). The same outcomes were reported by Bey *et al*.(2017)who examined three local Algerian fig varieties. They showed a decline in the amount of total phenols, which ranged from 107.08 to 181.06 mg AGE/100 g of fresh figs to amounts between 30.81 and 40.91 mg AGE/100 g of dried figs. According to Shahidi(2004), drying can lead to polyphenol oxidase's oxidative breakdown of phenolic substances (PPO). Moreover, it may result in non-enzymatic degradation of phenolic compounds.

3.1.2. Flavonoids content (TFC)

Flavonoids are commonly provided by fruits and vegetables and had been reported to have multiple biological effects including anti-inflammatory, anti-allergic, anti-tumor,immuno-modulatory and antioxidant activities. They can also inhibit some enzymes such as lipoxygenase, xanthine oxidase, phospholipase, etc…. which is directly responsible for to their great antioxidant capacity (Ullah *et al.,* 2020).

The total flavonoid contents (TFC) of five varieties of fig in the fresh and dried states were measured and compared as shown in table 2, figure 2. The results showed significant differences in flavonoid

accumulation in the five fig varieties in fresh and dried states ($p < 0.05$).TFC in dry fig extracts was higher than that in fresh fig extracts in all varieties, with values varying from 13.39 ± 0.9 to 22.96 ± 0.18mg QE/ 100 g and from 10.06± 0.32 to 17.71±0.55 mg QE/100 g of fig, respectively.

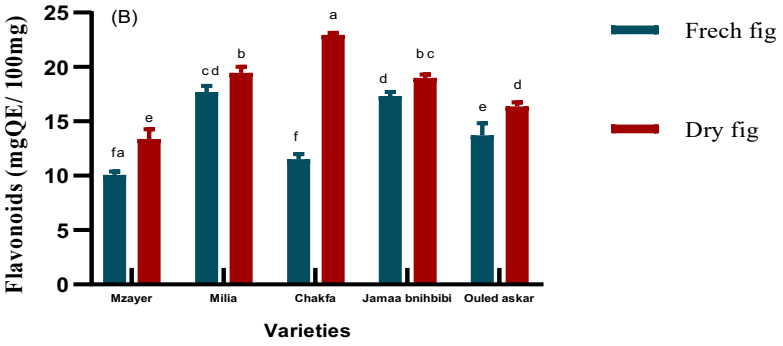

Figure 2. Flavonoid contents of the fresh and dry fig varieties

The results are expressed as mean values ± standard deviation (n=3). Bars labeled with different letters are significantly different ($p < 0.05$).

Table 2. Antioxidant contents of the fresh and dry fig varieties

	Flavonoid (mg QE /100g)		Proanthocyanidin (mg CE/100g)		Anthocyanin (mg Q3GE /100g)		Carotenoid (ug βCE /100g).	
Varieties	**Fresh**	**Dry**	**Fresh**	**Dry**	**Fresh**	**Dry**	**Fresh**	**Dry**
Mzayer	10.06±0.32	13.39±0.9	0.37±0.04	2.90±0.23	3.24±0.23	0.69±0.03	158.78±0.77	51.88±1.54
Milia	17.71±0.55	19.45±0.57	0.72±0.08	2.75±0.14	4.27±0.13	1.44±0.06	237.78±0.88	84.07±0.53
Chakfa	11.54±0.45	22.96±0.18	0.31±0.01	1.32±0.03	3.07±0.10	1.26±0.02	176.23±1.39	81.75±1.68
Jamaa Bni Hbibi	17.32±0.36	19.00±0.29	0.93±0.03	2.04±0.02	3.44±0.01	1.59±0.06	336.00±1.88	140.96±1.41
Ouled Askar	13.72±1.1	16.39±0.35	0.65±0.07	2.93±0.17	2.30±0.09	1.28±0.04	464.78±1.74	130.75±1.27

TFC in dry fig extracts was higher than that in fresh fig extracts in all varieties, with values varying from 13.39 ± 0.9 to 22.96 ± 0.18mg QE/ 100 g and from 10.06± 0.32 to 17.71±0.55 mg QE/100 g of fig, respectively. In the comparison with the findings in this study, Bey and Louaileche (2015) reported a superior flavonoid content of 126.55 mg QE/100g in methanolic extracts of dried figs from Bejaia (Northern Algeria).

Previous studies have reported a decrease in flavonoid contents in dried fig, which is contradictory with our results (Kamiloglu and Capanoglu, 2015; Manoj *et al.,* 2018).This can be explained by accumulation of high levels of antioxidants in fruit skin, which is the part most exposed to sun during process. In this regard, the decrease in flavonoids after drying is not surprising, since these compounds act as UV filters, protecting certain cellular structures, such as chloroplasts, against the harmful effects of UV radiation (Treutter, 2006).

3.1.3. Proanthocyanidin contents

Numerous health advantages of proanthocyanidins (tannins) have been demonstrated, most notably their capacity to prevent cardiovascular disorders (Teixeira, 2002).

The proanthocyanidin contents (condensed tannins) of the analyzed fig samples showed significant differences between both fresh and

dry states ($p < 0.05$). Indeed, in the fresh state, the content of condensed tannins varies between 0.31±0.017 and 0.93±0.031 mg CE /100 g of fig. After drying, contents ranging from 1.33±0.03 to 2.93±0.17 mg CE/100 g of fig are recorded (table 2, figure3). This increase can be explained by the rupture of the membrane of cell organelles by heat, so drying can accelerate the release of condensed tannins (Arslan & Özcan, 2010).

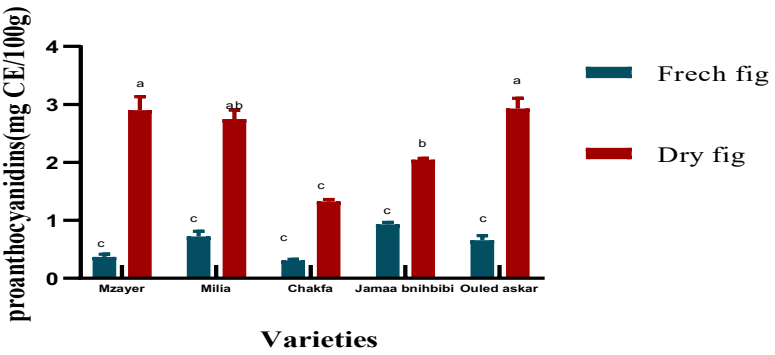

Figure 3. Proanthocyanidin contents of the fresh and dry fig varieties
The results are expressed as mean values ± standard deviation (n=3). Bars labeled with different letters are significantly different ($p < 0.05$).

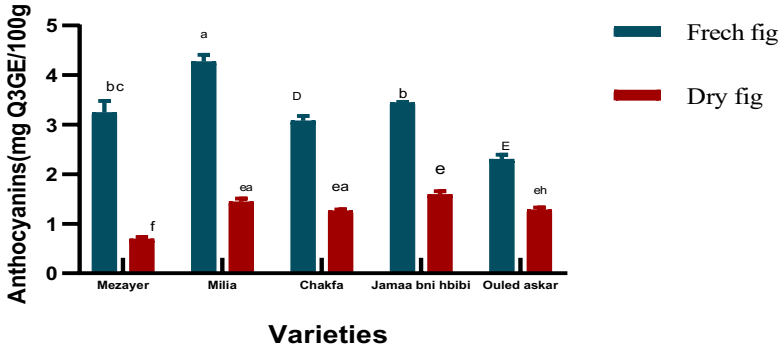

Figure 4. Anthocyanin contentsof the fresh and dry fig varieties
The results are expressed as mean values ± standard deviation (n=3). Bars labeled with different letters are significantly different ($p < 0.05$).

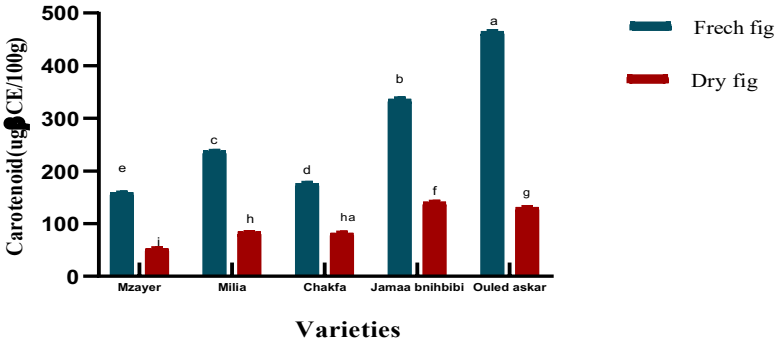

Figure 5. Carotenoid contents of the fresh and dry fig varieties
The results are expressed as mean values ± standard deviation (n=3). Bars labeled with different letters are significantly different ($p < 0.05$).

3.1.4. Anthocyanin contents

Anthocyanins also belong to the class of phenolic compounds, and are responsible for the orange, pink, red, purple and blue colors of several fruits and vegetables (Khoo *et al.*, 2017). The overall anthocyanin content is

considered a differentiating mark for figs, which possess a diversity of colors, ranging from dark purple to green (Solomon *et al.*, 2006)

As indicated in the table 2 and figure 4, the anthocyanin contents of fresh and dried fig varieties investigated in the present study, which varied significantly ($p < 0.05$). Fresh fig varieties have a higher content of anthocyanins, with values varying from 2.3±0.09 (Ouled Askar variety) to 4.27±0.13 mg Q3GE/100 g (Milia variety) than dry figs which gave values from 0.69±0.03 (Mzayer variety) to 1.59±0.07 mg Q3GE/100 g (Djemaa Beni Hbibi variety).

Our results are lower than those reported by Chauhan *et al*.(2015) with contents of 4.78 4.67 mg Q3GE/100 g for dry fig. Kamiloglu and Capanoglu(2015) indicated a decrease in anthocyanins after drying, and they recorded levels of 4.6 mg Q3GE/100g and 0.1 mg Q3GE/100g for fresh and dried figs, respectively. It is reported in the literature that anthocyanins are very sensitive to high temperatures (Steyn, 2008). Thus, these pigments are rapidly destroyed during drying (Al-Farsi *et al.,* 2005; Mazza & Miniati, 2018).

In addition, several other factors such as light, storage and temperature are responsible for the degradation of anthocyanins in sun-dried fruits. The anthocyanin compounds can be degraded by enzymatic browning by glycosidase and polyphenol oxidase or non-enzymatic browning phenomenon(Al-Farsi *et al.,* 2005; Shahidi, 2004).This hypothesis may perhaps help to explain the anthocyanins' reduction after drying in the current investigation.

3.1.5. Carotenoid contents

Plants produce the fat-soluble pigments known as carotenoids. They are in charge of giving colors like yellow, orange, and red (Ferreiro-Vera *et al.,* 2011).

According to the results of total carotenoids amount analysis, fresh figs contained more carotenoids than dry figs (figure 5). Among the fresh figs, the highest concentration was recorded for Ouled Askar variety (464, 78 ug βCE/100g). For the dry figs, we noted that Djemaa Beni Hbibi variety has the highest content (140, 96 ugβCE/100g), while the lowest amount is recorded for Mzayer variety in both dry and fresh states (table 2).

Our findings are in line with numerous earlier investigations on various fruits and vegetables, including figs(Yemiş *et al.,* 2012;Fratianni *et al.,* 2013;Loizzo *et al.,* 2013;Liu *et al.,* 2014).It is apparent that these studies confirm that the total carotenoid content of fruits and vegetables mainly decreases after various drying treatments.

The degradation of carotenoids during drying has been attributed to their high sensitivity to oxidation. The oxidation reactions are stimulated by light and heat, which activates enzymes. Thus, the oxidation reactions are most likely the primary reason of carotenoid loss. In this regard, compared to other transformation processes including heat treatment, drying leads to a greater degradation of carotenoids with the higher in porosity (Türkyılmaz *et al.,* 2014)**.**

3.2. Study of antioxidant activity

To assess in vitro antioxidant activity, three distinct techniques based on different mechanisms of action were used. The composition of extracts using a variety of assays act through a variety of mechanisms including the prevention of chain initiation, binding of transition metal ion catalysts, decomposition of peroxides, prevention of continued hydrogen abstraction, reductive capacity, and radical scavenging (Li *et al.,* 2008)**.**

3.2.1. Free radical DPPH reducing

By calculating the percentage of inhibition for each variety of fresh and dried figs, we established the antiradical activity profiles presented in figure 6 and table 3. The results showed that this activity differed significantly between the five fig varieties in fresh and dried states ($p < 0.05$). For the fresh and the dry fig, Chakfa variety was more efficient against DPPH (57.33%) and (62.41±0.83%) respectively.

Many papers have reported the antioxidant activity of fig extract using DPPH. In a study of Aljane(2018)working on several varieties of fresh Tunisian figs, the author reported inhibition percentages ranging from 11.36% to 64.737%. In another study conducted by Ayoub *et al*. (2019), it has been reported that

the inhibition percentages varied between 11.31% and 87.03% for fig varieties in Morocco.

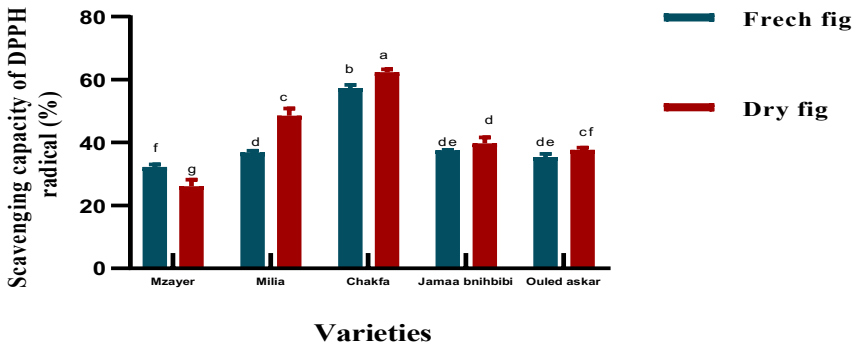

Figure 6. DPPH radical scavenging effect against the Extract of fresh and dry fig varieties
The results are expressed as mean values ± standard deviation (n=3). Bars labeled with different letters are significantly different ($p < 0.05$).

Table3. Antioxidant activities of the fresh and dry fig varieties

	DPPH (%)		FRAP (mg AAE/ 100g)		Hydrogen Peroxide Scavenging (%)	
Varieties	**Fresh**	**Dry**	**Fresh**	**Dry**	**Fresh**	**Dry**
Mzayer	32.24±0.77	26.13±2.09	41.87±1.69	38.86±0.98	38.68±0.34	17.22±0.72
Milia	36.86±0.55	48.50±2.35	99.56±0.69	213.22±1.83	55.24±1.53	60.96±0.05
Chakfa	57.33±1.00	62.41±0.83	499.90±2.46	668.86±2.20	68.98±0.18	79.56±0.41
Jamaa Bni Hbibi	37.60±0.1	39.71±1.87	142.16±2.40	174.09±2.11	55.95±1.23	60.02±0.21
Ouled Askar	35.36±0.06	37.67±0.71	46.73±0.62	115.70±1.35	32.94±1.98	36.91±0.47

For dry fig, we noted that our results are superior to those of Bey and Louaileche (2015)who reported that the scavenging radical capacity of six varieties of light dried figs from Bejaia (Algeria) was ranging from 28.33% to 35.15%. Besides,Pourghayoumi *et al.*(2016) have also reported the DPPH scavenging activity of nine varieties of Irannian dry fig extracts (37.70% to 70.02%).

Overall, the statistical analysis showed a significant increase in the anti-radical activity by dried figs for the majority of the varieties studied with the exception of the Mzayer variety where a decrease in the percentage of inhibition was noted. Our results are consistent with the review paper on natural fig antioxidants by Arvaniti *et al.*(2019)that reported the consistent influence of sun-drying process on the antioxidant capacity of figs.

In some studies, the antioxidant capacity of dried figs has been reported to be higher than that of fresh figs(Chauhan *et al.,* 2015; Kamiloglu and Capanoglu, 2015; Konak *et al.,* 2015).This increase may be due to the quantity of phenolic compounds resulting from drying, which can be explained by a greater generation of these compounds and/or the release of sequestration due to the rupture of the cell walls(Capanoglu, 2014).Also the Maillard reaction products can be a possible explanation for this increase which can occur as a result of heat treatment or lengthy storage and often exhibit significant antioxidant capacity (Nicoli *et al.,* 1999). By contrast, sun-drying can reduce the antioxidant capacity of

figs by degradation or transformation of the active phenolic compounds of the fruits into a non-antioxidant form, leading to degradation of flavonoids, particularly anthocyanins despite the increase in the rate of total phenolic compounds(Bachir Bey *et al.,* 2017; Nakilcioğlu and Hışül, 2013). Indeed, the anthocyanin content is closely linked to the anti-radical activity (Steyn, 2008).

3.2.2. Iron-reducing power test

Iron ions reduction property of the tested samples is expressed in mg of ascorbic acid equivalents/100g.

As seen in figure 7 and table 3, in fresh figs, the reducing activity of the analyzed fig varieties varies between 41.87±1.69 mg AAE/100g (Mzayer) and 499.90±0.69 (Chakfa). For dried figs, the reducing power of iron varies between 38.86 ± 0.98 mg AAE/100g (Mzayer) and 668.86 ± 2.20 mg AAE/100g (Chakfa).

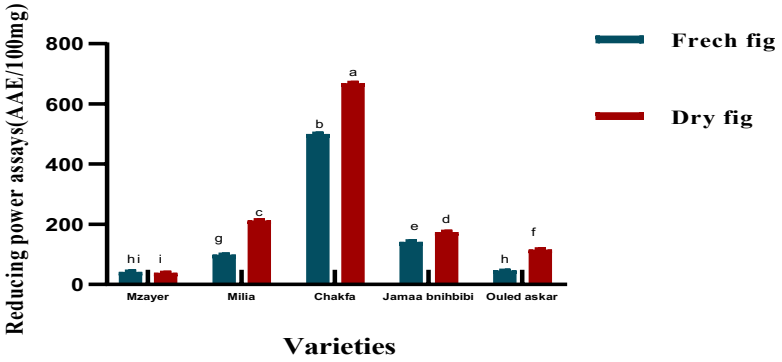

Figure7. Reducing power assay of fresh and dry fig varieties

The results are expressed as mean values ± standard deviation (n=3). Bars labeled with different letters are significantly different ($p < 0.05$).

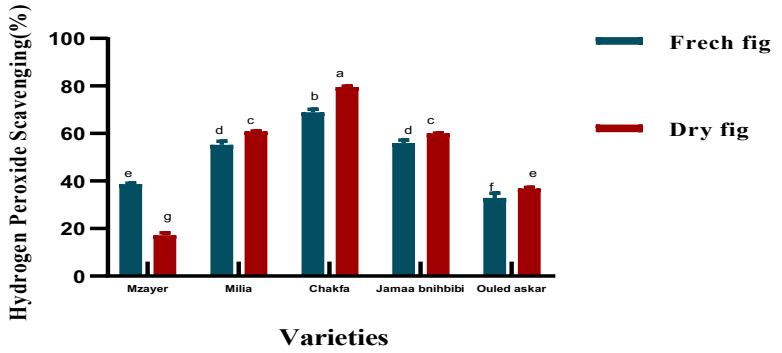

Figure8. Hydrogen Peroxide scavenging inhibition of fresh and dry fig varieties

The results are expressed as mean values ± standard deviation (n=3). Bars labeled with different letters are significantly different ($p < 0.05$).

The mechanism of this activity is based on the ability of extracts especially to their polyphenols to reduce ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}) by electron-donating (Yıldırım *et al.,* 2001).

Previous studies on reducing power activity of dry fig extracts has been adopted in different works including that carried out by Nakilcioğlu and Hışül (2013), where they reported an average reducing activity of 222.71 mg $FeSO_4$/100 g (mg of iron sulphate / 100g MS)of Turkish fig variety.

In another study carried out by Capanoglu(2014) on the same Turkish dried fig varieties, iron reducing capacity was of 117 mg ET/100g. This value is lower than that obtained by Kamiloglu and Capanoglu (2015)(140 mg ET/100 g) or those reported by Reddy et al.(2010) on Indian fig varieties, where they recorded an inhibition with value of 3578.69 mg $FeSO_4$/100 g of fig.

Overall, the statistical analysis reveals a significant increase in iron-reducing activity after drying for the four varieties of Milia, Chakfa, Ouled Askar and Djemaa Beni Hbibi, inversely, we noted a slowly decrease in this activity in Mzayer variety. In this regard, the best drying method leads to the least alteration in phenolic content and enhances antioxidant activity of the sample. The high drying temperature gave a product with better polyphenol content with enhanced antioxidant activity(Madrau *et al.,* 2009). Similar effects of drying on antioxidant capacity of fruits and vegetables including sage and Enicostemma littorale (Blume) have been reported (Hamrouni-Sellami *et al.,* 2013; Sathishkumar *et al.,* 2009).

3.2.3. Hydrogen Peroxide Scavenging

The determination of the hydrogen peroxide detoxification capacities of the different fig extracts is based on their ability to trap this radical, presented as the percentage value (figure 8, table 3).

The values of scavenging effect of tested extracts were ranged from 32.94 ± 1.98% to68.98 ± 1.18% in fresh fig; while dry fig extract gave values varying between 17.22±0.72% and 79.56±0.49%. According to these findings, we can note a significant increase in hydrogen peroxide scavenging activity after drying for the majority of the studied varieties, with the exception of the Mzayer variety, which showed a weaker capacity.

Our results agree with those of certain authors who have treated the role of sun-drying process on the antioxidant capacity of figs. In fact, these authors reported that hydrogen peroxide scavenging activity in dry fruit extracts was higher than those of fresh fruits(Qusti *et al.,* 2010; Slatnar *et al.,* 2011; Igual *et al.,* 2012). This increase can be explained as being the consequence of the formation of new active molecules induced during drying, especially Maillard reaction products known by their antioxidant activity (Qusti et *al.,* 2010;Igual *et al.,* 2012). In contrast, the decrease in activity recorded for the Mzayer variety can be explained by the decrease in the abundance of flavonoids that are sensitive to the high temperature. Moreover, A good correlation was recorded between inhibitory activity and anthocyanins content in the study conducted byGorinstein *et al*.(2004).

4. Conclusion

Our study was carried out in order to evaluate the effect of sun-drying on polyphenol composition, as well as on the antioxidant activity of five varieties of figs from five Jijel regions (Chakfa, Milia, Mzayer, Djemaa Beni Hbibi and Ouled Askar). In fact, the phytochemical composition and particularly the content of total polyphenols, of flavonoids, andof pro-anthocyanidins (condensed tannins) showed a significant increase after sun-drying. On the other hand, a significant decrease ($p<0.05$) was noticed in the content of anthocyanins and of carotenoids of the five studied varieties of fig.

The *in vitro* evaluation of the antioxidant activity of the extracts showed that sun-drying had a positive influence on this activity (the scavenging of DPPH radical, the reducing power of iron and the scavenger effect of H_2O_2). This significant increase is due to their high content of bioactive substances. So, we can say that the dried fig is a good source of various antioxidants; it could be used in pharmaceutical field to prevent the lifestyle-related diseases in which free radicals are involved and to promote human health. Further researches should be carried out to complete this study by determination of other biological activities *in vitro* and *in vivo*, and by realizing of a comparative study by evaluating the impact of several drying processes (in the sun, in the oven and in the microwave) on the attributes of the quality of the figs, namely the physicochemical, nutritional, phytochemical quality and in particular the antioxidant activity.

5. References

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