ORIGINAL ARTICLE

Sodium metabisulfite dipping, hot water blanching and sulfur fumigation impact on the nutritional quality of dried apricot (*Prunus armeniaca* L.) cultivars

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ABSTRACT

Background: Fruit postharvest loss has become a major concern for apricot growers. Under this situation, fruit valorization will continue to challenge agricultural sustainability. **Aims:** The study aimed to evaluate the nutritional and sensorial quality of fresh and dried apricot fruits cultivars (*Amr Leuch*, *Bayoudhi*, *Canino*, *Khad Hlima*, *Khit el Oued*, and *Sayeb*) harvested from private orchards in Hajeb Laayoun- Kairouan Tunisia, during two growing seasons (2018/2019). **Material and Methods:** The pre-treatments consisted of sulfur fumigation, sodium metabisulfite dipping, and hot water blanching whereas the distilled water was used as a control. Fruit pomological traits, physic-chemical and biochemical parameters were evaluated in fresh and dried apricot fruits. Sensorial analysis (color, texture, taste, aroma and consumer satisfaction) was performed in fresh and dried apricot fruits. **Results:** Results showed that the drying process decreased the antioxidant compounds content in the apricot fruits. **Conclusions:** The sensorial analysis measured in global satisfaction showed that the cultivars *Bayoudhi* and *Khit el Oued* possess higher consumer acceptability as fresh fruits whereas the cultivars *Canino* and *Khad Hlima* were found to be promising varieties for apricot drying. The sulfur-fumigation and sodium metabisulfite dipping were efficient pre-treatments as it improved the color of the dried apricot fruits.

Keywords: Apricot, drying, color, antioxidants, sensorial quality.

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1 Introduction

Apricot fruits are rich in sugars, fibers, minerals, vitamins, phenolic compounds, and carotenoids, which are involved in various functions, including taste and color [1,2]. From the point of view of consumer acceptance, size, color, flavor, aroma, and firmness are among the most important pomological characteristics related to fruit quality along with sugars, organic acids, and volatile compounds [3]. The sensorial quality of fruit was reported to be affected by cultivar, maturity, total sugar, organic acids, sugar/acid ratio, volatile compounds, fruit color, size, and texture [4].

The apricot fruit has a short shelf life and loses its quality in a short time [5]. For this purpose, different transformation methods (canning, freezing, and drying) are frequently utilized to extend the shelf life of the product. In this line, Brasiello et al. [6] reported that fruit drying is a preservation technique to extend fruit consumption by reducing the moisture and the microbial load. The increased demand for fruits in the international markets implies continuous research and improvement of technologies to maintain quality and extend the shelf life of product [7]. There are different pre-treatments procedures used prior to apricot drying, including immersion in chemical solutions [8], blanching [9], and physical pre-treatments [10]. Combining the drying process with different pre-treatments such as sulfuring or blanching improves the dried product quality [9]. The untreated sun-dried fruits generally have low production costs. Guclu et al. [11] reported that sulfur dioxide is usually used in the food industry as antioxidants and antimicrobial agent, preventing color degradation and providing protection against enzymatic browning after drying. However, consumers' acceptability of sulfur dried fruits has been reduced in terms of food safety and taste because of the sulfur content in fruits [12]. The higher level of the permitted residual sulfur dioxide in dried fruits has been set as 2000 ppm [13]. The potassium metabisulphite ($K_2S_2O_5$) and sodium metabisulphite ($Na_2S_2O_5$) solutions are used also as pre-treatments prior to fruit drying process.

The main objective of this study was to investigate the impact of sulfur fumigation, sodium metabisulfite dipping and hot water blanching pre-treatments on nutritional and organoleptic quality of dried apricot fruits growing in west central Tunisia.

2 Material and Methods

2.1 Experimental site

The study was carried out in apricot private orchards located in Kairouan (lat. 35º00'56.3''N, long. 9º25'49.9''E, alt. 350 m), central Tunisia, during two growing seasons (2018 – 2019). The study was performed using six commercial apricot cultivars (Amor Leuch, *Bayoudhi*, *Canino*, *Khad Hlima*, *Khit el Oued*, and *Sayeb*) (Table 1). The production area is the semi-arid Mediterranean climate with a low annual rainfall of 200 mm irregularly distributed over the growing season and a reference evapotranspiration (ETo) of 1400 mm.

2.2 Fruits sampling

Fruits sampling was carried out on three trees per genotype. Trees were grown under standard conditions of irrigation, fertilization, pest, and disease control, ensuring a homogeneous harvest in the same experimental orchard as reported in Salazar et al. [3]. Fruits were manually harvested at optimum eating ripeness according to skin color and fruit firmness (Figure 1).

2.3 Drying pre-treatments

The fruits were selected according to the maturity stage, fruit size, fruit color and texture. The sulfur fumigated pre-treatment consists of burning SO_2 in an amount of 1.5 g sulfur per kg of fruit in a sulfuring room during 12 hours. Sodium metabisulfite pre-treatment consists of dipping fruits in a solution of 5% $Na_2H_2SO_5$ at room temperature for 5 min. The blanching pre-treatment consists of dipping fruits in hot water (80°C) for 1 min. Treated and untreated fruits were put on plastic meshed fruit boxes under direct sunlight with an overall maximum day time air temperature of around 30°C. Fruits were deseeded at fifth drying day (50% weight lost). Once the pits are removed, the fruits are re-dried for 5 days [14] up to final moisture content of 25% as described in Guclu et al. [11] with some modifications. Dried apricots were stored at 4°C until subsequent analysis.

2.4 Pomological and physicochemical measurements

At least 20 free of defects fruits were harvested at commercial maturity. Fruit weight was measured using an electronic analytical digital scale balance (GT 480, Ohaus, Korea). Ten fruits of each cultivar were randomly sampled and measured for length and width with a caliper (CD-20B, Mitutoyo Co., Japan). Color values on the peel of fresh and dried apricot fruits were measured using a CR-200 Minolta Chromameter (Chuo-Ku, Osaka, Japan). Fruit firmness was measured on opposite sides of each fruit by a hand penetrometer with an 8 mm probe and expressed in Newton (N). Flesh texture type (melting or non-melting), stone adhesion, and pit to stone ratio were assessed in each cultivar. Soluble solids content (SSC) was measured as ºBrix using a handheld refractometer (Atago, Tokyo, Japan). Then the pH was measured using pH meter (Thermo Fisher Scientific Inc., Germany). Electrical conductivity (CE) was determined with conductometer (Hanna, HI8424, Canada). Titratable acidity (TA) of the juice was measured in ten grams of homogenized samples diluted with 90 g of distilled water, microtitrated with 0.1 N NaOH until a pH of 8.1 and expressed as g malic acid/100 g FW [15]. The ripening index (RI) was calculated based on the SSC/TA ratio.

2.5 Pomological and physicochemical measurements

After the applied drying pretreatments, fruits were crushed using grinder in order to make powdered as described by Vega-Gálvez et al. [16]. Then 5 g of fruit powder was dissolved in 10 mL 80 % methanol. The rotary evaporator was used to remove the methanol at 40 °C. Then a 5 % solution (w/v) was prepared. The was shaken for 24 h using an electrical stirrer. Thereafter the mixture was filtered and centrifuged at 5000 rpm for 30 min at 4 °C and the supernatant was recovered. For the ascorbic acid extraction, 10 mL metaphosphoric acid 5% were added to the 5g flesh samples, homogenized, and centrifuged (SIGMA Laboratory centrifuges 3K18, UK) at 5000 rpm for 20 min at 4 °C. The supernatant was measured and used for vitamin C quantification. For carotenoids analysis, the freeze-dried fruits (5 g) were extracted twice with 100 mL of acetone/water (60/40, v/v). Extraction was performed at room temperature for two hours and under agitation. After centrifugation (20 min, 5000 rpm), the supernatants were combined and concentrated with a vacuum rotary evaporator at 40° C before being freeze-dried. The dried supernatants were dissolved in 20 mL methanol/water (30/70, v/v).

Table 1. Characterization of the studied apricot cultivars

Cultivar	*Amr Leuch*	*Bayoudhi*	*Canino*	*Khit el Oued*	*Khad Hlima*	*Sayeb*
Size	mid	mid	mid	mid	mid	mid
Harvest date	20 May	10 May	15 May	10 June	10 May	05 May
Ripening	MS	MS	MS	MS	MS	MS
Skin colour	orange	white	yellow	white	yellow	yellow
Pulp colour	yellow	white	yellow	white	white	yellow
Texture	M	M	NM	M	M	M
Stone	free	free	free	cling	free	Free

MS= mid-season; M= melting; NM=Non melting

2.6 Pomological and physicochemical measurements

Anthocyanins, flavonoids, total phenolics, vitamin C, carotenoids, and relative antioxidant capacity were evaluated with colorimetric methods using a spectrophotometer (Jenway 6300, Gransmore Green, Essex, England). The anthocyanin was measured in the hydroalcoholic extract at the absorbance of 535 and 700 nm using the molar extinction absorptivity coefficient ε = 25,965/cm M and expressed in mg of cyanidin 3-glucoside equivalents (C3GE) per kg of DW [15]. For flavonoid content, 1 mL of extract was diluted with 2 mL of distilled water and mixed with 0.3 mL of $NaNO_2$ for 5 min. The mixture was incubated with 0.3 mL of $AlCl_3$ for 2 min. Then 2 mL of NaOH was added and mixed. The absorbance measurement was done at 510 nm, and the results were expressed in mg of catechin equivalents (CE) per 100 g of DW [17]. Total phenolic was determined as reported in [18]. The method consisted of mixing 0.5 mL of the extract in 8 mL of distilled water. Then 0.5 mL of Folin-Ciocalteu reagent was added and the solution was mixed and incubated for 3 min. Then 1 mL sodium carbonate (Na_2CO_3) was added, and the samples were incubated at 25 °C in darkness for one hour. The absorbance was measured at 725 nm and the results were expressed in mg of gallic acid equivalents (GAE) per 100 g of DW. The ascorbic acid was determined as reported in [19]. One mL of the extract was mixed with 1 mL of trichloroacetic acid (TCA), 0.8 mL of orthophosphoric acid and 0.8 mL of 2,2'-bipyridyl. The solution was mixed and then 0.4 mL $FeCl_3$ was added. Then the solution was mixed, and the samples were incubated at 37 °C for 1 hour. The absorbance was measured at 525 nm and the results were expressed as mg of ascorbic acid (AsA) per 100 g of DW. For the carotenoid content, the extract was diluted with acetone-hexane (4:6), and measured at the absorbance of 663, 645, 505 and 453 nm as described in [20].

The content of β-carotene was estimated using the equation: Cβ-carotene (mg / 100mL) = 0,216*A663 - 1,22*A645 – 0,305*A505 + 0,452*A453, where A663, A645, A505 and A453 are the absorbance at 663, 645, 505 and 453 nm respectively. The total β-carotene content was expressed as mg of β-carotene per 100 g of dried weight (mg β-carotene /100 g DW). Free radical scavenging activity was assessed by the 1,1-diphenyl2-picrylhydrazyl (DPPH) assay using the method adapted from [21]. Fruit extracts (100 µL) were mixed with 2.9 ml DPPH and the reaction was incubated 10 min in darkness and the absorbance was measured at 515 nm. The antioxidant capacity was calculated using a Trolox standard curve and expressed as µg of Trolox equivalents (TE) per g of DW.

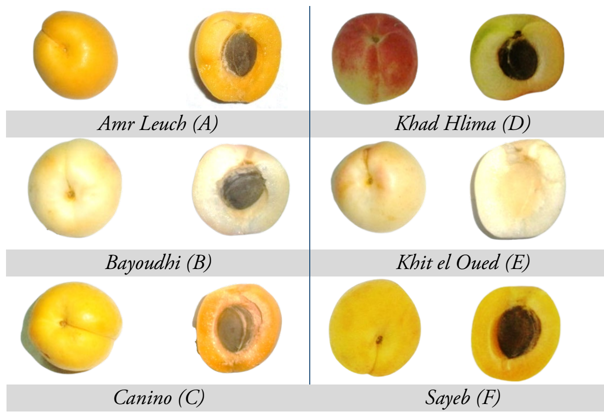

Figure 1. Apricot studied cultivars
A= *Amr Leuch*, B= *Bayoudhi*, C= *Canino*, D= *Khad Hlima*, E= *Khit el Oued*, F= *Sayeb*

2.7 Sensorial analysis

The sensory evaluation of fresh and dried apricot fruits for color, texture, taste, aroma, and global satisfaction was conducted using nine-point hedonic scale in accordance with the method described by Larmond [22]. A consumer panel was carried out with 60 consumers from the personal stuff and students of the Faculty of Sciences and Technology of Sidi Bouzid for fresh fruits and Higher Institute of Technology of Sidi Bouzid Tunisia for dried fruits in order to study the sensory properties of apricot. The panel members were selected on the basis of their ability to discriminate and scale abroad range of different attributes of fresh and dehydrated apricot. Consumers were 20 – 60 years old, had no diet restrictions or allergies. One fruit for each treatment was served, to each panelist, in odor-free disposable 50 mL covered plastic cups, coded using two-digit numbers, and at room temperature. Crackers and water were used between samples to clean the panelists' palate. Natural illumination was used during the test, and the testing room was at 25 °C. Consumers responded using a 9-point hedonic scale, where 9=Liked extremely; 8=Liked very much; 7=Liked moderately; 6=Liked slightly; 5=Neither liked nor disliked; 4=Disliked slightly; 3=Disliked moderately; 2=Disliked very much; 1=Disliked extremely. Consumers were, then, asked to indicate their order of preference for the samples, and mark the reasons of their preference regarding the attributes under study (color, texture, taste, and global satisfaction).

2.8 Statistical analysis

The physicochemical and biochemical traits were measured for each cultivar separately. Data for each cultivar were averaged, and mean values were used as estimated phenotypic values. Principal components analysis (PCA) of all the studied traits was carried out using SPSS 20.0.

3 Results

3.1 Agronomical and pomological attributes

The fresh fruits were analyzed for pomological, agronomical and basic biochemical fruit quality traits. The mean fruit weight, fruit dimension, fruit volume, pulp/stone ratio, juice yield, pH, SSC, TA and RI at harvest are presented in Table 2. The fruit weight varied from 31.9 g in *Amr Leuch* to 46.24 g in *Khit el Oued* showing statistically significant difference ($p < 0.05$) among the studied cultivars. The fruit size ranged from 22.64 to 47.04 mm. The lowest value of fruit volume was found to be 21.5 cm^3 in the cv. *Sayeb* and the highest value was 34.5 cm^3 in the cv. *Canino*. Fruit firmness varied among cultivars in the range of [18.93 to 35.48 N]. The cv. *Canino* showed high firmness (35.48 N) whereas the cv. *Bayoudhi* showed the highest value (34.0%) of juice content. The pH of juice extract ranged between 2.96 for the cv. *Sayeb* to 3.45 for the cv. *Khit el Oued*. The cvs. *Amr Leuch*, *Bayoudhi* and *Khad Hlima* presented values of conductivity (4.7, 4.6 and 4.8 ms/cm respectively) whereas the cvs. *Canino*, *Khit el Oued* and *Sayeb* presented values of 3.6, 3.3 and 3.0 ms/cm, respectively. The highest value of soluble solids content (14.1°Brix) was obtained in the cv. *Bayoudhi* whereas the cv. *Sayeb* showed the lowest value (9.4°Brix). The titratable acidity varied among genotypes showing the lowest value in the cv. *Canino* (0.51 mg/100g malic acid). This variability in SSC and TA, resulted in different values of ripening index (RI). The highest value of RI was observed in the cv. *Canino* (23.72) whereas the other studied cultivars presented quite similar values.

The chromatic parameters L*, a*, b*, C* and h° for fresh and dried apricot fruits were presented in Table 3. The color coordinates L*, a* and b* showed statistically significant differences ($P < 0.05$) among cultivars. The lightness (L*) values at harvest ranged from 50.5 for *Khad Hlima* to 65.9 for *Sayeb*. The cv *Canino* and *Sayeb* presented high values of L* (62.0 and 65.9 respectively) and showed statistically significant differences ($p < 0.05$) with the other studied cultivars. The degree of red blush (a* value) on the peel of apricot fruits varied among genotypes showing the highest value (32.3) in the cv. *Khad Hlima* whereas the lowest value (10.6) was registered in the cv. *Bayoudhi*. The degree of yellow blush (b* value) was in the range of [19.4 – 47.9]. Hence, the cv. *Bayoudhi* showed the lowest b* value (19.4) whereas the highest b* value (47.9) was obtained in the cv. *Sayeb*. The cv. *Khad Hlima* has the most orange-colored skin (highest a* and lowest L* and h° values), whereas the cv. *Bayoudhi* had the most white-colored skin (lowest a* and highest L* and h° values). After drying, our study revealed high variability of color parameters in all the applied pre-treatments. The dried apricot fruits showed lower L* and higher b* values. The untreated sun-dried fruits showed the lowest L* in the range of range [34.4-42.6].

3.2 Antioxidant compounds

3.2.1 Anthocyanins

The anthocyanins content (Figure 2a) in fresh fruits was in the range of [2.4 – 4.6 mg CEG Eq/ kg DW] showing statistically significant differences ($p<0.05$) among cultivars. Anthocyanins varied from 2.4 mg C3GE/kg of DW in the cv. *Bayoudhi* to 4.6 mg C3GE/kg of DW in the cv. *Khad Hlima*. The anthocyanins content decreased in the dried fruits as compared to fresh fruits. Regarding the influence of applied pre-treatment on anthocyanin content, the sulfur fumigated fruits maintained their anthocyanin content in the range of [1.8 – 3.8 mg C3GE/kg of DW]. The sun-dried apricot fruits showed the lowest values of anthocyanins [0.6 – 2.2 mg C3GE/kg of DW] followed by the blanching treatment [0.7 – 2.1 mg C3GE/kg of DW]. The sodium metabisulfite dipping and sulfur fumigation treatments showed similar behavior regarding the anthocyanin content.

3.2.2 Flavonoids

The flavonoids content (Figure 2b) in fresh fruits varied from 17.25 mg CE/100 g of DW (cv. *Khad Hlima*) to 22.53 mg CE/100 g of DW (cv. *Canino*). After sun drying, all the cultivars showed significant ($P<0.05$) decrease in flavonoids content. The flavonoids content decreased after drying presenting high values in the sulfur fumigated fruits [14.85 – 16.44 mg CE/100 g DW] followed by the metabisulfite treated fruits [12.72 – 14.23 mg CE/100 g DW] and then the blanching treatments [9.71 – 12.35 mg CE/100 g DW]. The sun-dried fruits showed the lowest range of flavonoids content [10.6 – 12.76 mg CE/100 g DW].

3.2.3 Total phenolics

A wide range of variability was found among the apricot cultivars with regard to the phenolic compounds content (Figure 2c). This trait ranged from 73.0 (cv. *Khit el Oued*) to 102.0 mg GAE/100 g of DW (cv. *Bayoudhi*). The drying process caused a reduction in total phenolics as compared to fresh fruits. Hence, the highest reduction was observed in the control treatment (untreated sun-dried fruits). The lowest values of total phenolics reduction were shown in the sulfur fumigated treatment [22.92 – 29.43%].

of carotenoids as compared to the sulfur fumigated fruits [2.1 – 2.9 mg β-carotene /100g DW] and the sodium metabisulfite solution [1.8 – 2.2 mg β-carotene /100g DW].

3.2.6 Relative antioxidant capacity (RAC)

The antioxidant capacity (Figure 2f) presented high variability between cultivars. This parameter varied from 312.5 µg Trolox Eq/g of DW in the cv. *Khit el Oued* to 450.0 µg Trolox Eq/g of DW in the cv. *Khad Hlima*. The fresh fruits presented significantly ($p < 0.05$) higher values of antioxidants capacity as compared to the dried fruits.

Table 2. Physicochemical fruit quality traits in the apricot cultivars

Traits	Apricot cultivars					
	Amr Leuch	*Bayoudhi*	*Canino*	*Khad Hlima*	*Khit el Oued*	*Sayeb*
FW	31.9 ± 1^{b}	35.8 ± 2^{b}	40.2 ± 2^{b}	32.5 ± 1^{b}	46.2 ± 2^{a}	25.3 ± 3^{c}
DW	4.9 ± 1^{b}	5.8 ± 2^{b}	6.2 ± 2^{b}	5.5 ± 1^{b}	4.2 ± 2^{a}	2.3 ± 3^{c}
Size	42.8 ± 5^{a}	38.7 ± 2^{a}	44.6 ± 3^{a}	45.5 ± 2^{a}	47.0 ± 1^{a}	22.6 ± 2^{b}
Volume	32.5 ± 3^{a}	27.0 ± 2^{b}	34.5 ± 2^{a}	30.0 ± 1^{a}	25.0 ± 4^{b}	21.5 ± 2^{b}
P/S	11.4 ± 2^{a}	12.7 ± 2^{a}	13.3 ± 2^{a}	12.8 ± 2^{a}	15.5 ± 2^{a}	14.5 ± 2^{a}
Firmness	28.4 ± 1^{b}	23.3 ± 2^{b}	35.4 ± 3^{a}	26.3 ± 2^{b}	25.6 ± 1^{b}	18.9 ± 2^{b}
Juice	27 ± 3^{b}	34 ± 2^{a}	20 ± 1^{b}	22 ± 2^{b}	24 ± 3^{b}	18 ± 2^{b}
pH	2.9 ± 0.2^{a}	3.3 ± 0.1^{a}	3.0 ± 2^{a}	3.0 ± 0.1^{a}	3.4 ± 0.2^{a}	2.9 ± 0.1^{a}
CE	4.7 ± 0.2^{a}	4.6 ± 0.2^{a}	3.6 ± 0.1^{b}	4.8 ± 0.3^{a}	3.3 ± 0.2^{b}	3.0 ± 0.1^{b}
SSC	09.6 ± 1^{b}	14.1 ± 2^{a}	12.1 ± 1^{a}	12.8 ± 1^{a}	13.4 ± 2^{a}	09.4 ± 1^{b}
TA	0.8 ± 0.1^{a}	0.9 ± 0.2^{a}	0. 5 ± 0.2^{b}	0.7 ± 0.2^{a}	0.8 ± 0. 2^{a}	0.7 ± 0.2^{a}
RI	11.7 ± 2^{b}	15.6 ± 3^{b}	23.7 ± 2^{a}	17.1 ± 1^{b}	15.8 ± 1^{b}	13.4 ± 2^{b}

FW=Fresh weight (g); DW=Dry weight (g); Size (mm); Volume (cm3); P/S = Pulp stone ratio; Firmness (N); Juice yield (%); CE= electrical conductivity (ms/cm); SSC= Soluble solids content (°Brix); TA= titratable acidity; RI= ripening index. Data are mean ± SE (n=3). Separation within columns was performed by Scheffe test ($p \leq 0.05$). Values are the means (n = 6) ± SE. Different letters a, b, c, indicate difference among treatments in the same cultivar.

3.2.4 Vitamin C

The vitamin C content (Figure 2d) ranged from 3.9 mg AsA/100 g of DW in the cv. *Canino* to 5.2 mg AsA/100 g of DW in the cv. *Amr Leuch*. The drying process caused a significant ($p < 0.05$) reduction in the vitamin C content as compared to fresh fruits. The sulfur fumigated fruits maintained a high content of vitamin C [2.1 – 2.8 mg AsA/100 g of DW] whereas the sun-dried apricot fruits presented the lowest vitamin C content [1.0 – 2.1 mg AsA/100 g of DW].

3.2.5 Carotenoids

The carotenoids content (Figure 2e) in the fresh fruit ranged from 2.8 in the cv. *Bayoudhi* to 6.3 in the cv. *Canino* showing statistically significant ($p < 0.05$) differences among cultivars. The drying process decreased the carotenoid content under all the applied pre-treatments. Hence, the untreated sun-dried fruits showed low values [1.0 – 1.4 mg β-carotene /100g DW]

3.3 Sensory evaluation of fresh and dried apricot fruits

The sensorial attributes such as fruit color, texture, taste, aroma and global satisfaction were studied in the fresh and dried apricot cultivars. Results showed that the cv. *Khad Hlima* presented the highest value (8.0) for skin color followed by the cv. *Bayoudhi* (7.5) whereas the cv. *Sayeb* showed the lowest value (5.2). Regarding flesh texture the panelist have signaled the highest value for the cv. *Canino* (8.3) whereas the lowest value (4.2) was observed in the cv. *Bayoudhi*. The highest fresh fruit taste value was observed in the cv. *Khit el Oued* (8.5) followed by the cv. *Bayoudhi* (8.0) whereas the cv. Sayed showed the lowest taste value (5.0). With respect to global satisfaction consumers have made the choice for the cv. *Bayoudhi* and *Khit el Oued* as the cultivars with the highest consumer acceptability (8.5).

The drying process has changed major sensorial characteristics such as color and texture which impacted the global

Table 3. Color of the fresh and dried apricot fruits for the studied cultivars

Fresh fruits (FF)					
Cultivars	**L***	**a***	**b***	**C***	**h°**
Amr Leuch	55.8 ± 2.6 b	27.6 ± 0.2 a	40.3 ± 0.3 a	48.9± 2.3 a	1.0± 0.0 a
Bayoudhi	53.3 ± 1.7 b	10.6 ± 0.4 b	19.4 ± 2.9 b	23.7 ± 2.3 b	0.7 ± 2.3 a
Canino	62.0 ± 1.5 a	18.5 ± 1.1 b	47.4 ± 0.2 a	49.6± 2.3 a	1.0± 2.3 a
Khad Hlima	50.5± 4.4 b	32.3 ± 6.8 a	28.6 ± 18.7 b	36.2± 2.3 a	0.8 ± 2.3 a
Khit el Oued	57.9 ± 3.0 b	12.4 ± 3.4 b	27.3 ± 0.8 b	28.5± 2.3 b	0.9 ± 2.3 a
Sayeb	65.9 ± 2.0 a	12.7 ± 3.4 b	47.9 ± 0.8 a	49.5 ± 2.3 a	0.7 ± 2.3 a
Sundried fruits (SD)					
Amr Leuch	37.6 ± 2.0 b	30.9 ± 1.5 a	19.6 ± 0.8 b	28.70± 2.0 b	1.06± 0.2 a
Bayoudhi	37.9 ± 1.0 b	19.7 ± 3.0 b	26.9 ± 2.0 a	33.34± 3.0 a	0.73± 0.1 a
Canino	35.7 ± 2.3 b	22.9 ± 0.5 b	19.5 ± 1.3 b	27.88± 2.3 b	1.02± 0.2 a
Khad Hlima	42.6 ± 2.0 b	39.9 ± 1.3 a	23.4 ± 2.5 a	30.72± 1.8 a	0.85± 0.1 a
Khit el Oued	34.4 ± 1.6 a	19.4 ± 1.0 b	19.5 ± 1.0 b	27.58± 1.0 b	0.99± 0.2 a
Sayeb	39.7 ± 1.3 b	23.5 ± 1.2 b	28.7 ± 1.2 a	35.32 ± 1.5 a	0.91 ± 0.2 a
Sulfur fumigated fruits (SS)					
Amr Leuch	28.2 ± 2.1 b	15.5 ± 1.8 b	15.9 ± 1.1 b	30.42± 1.8 a	0.40± 0.1 a
Bayoudhi	44.3 ± 1.6 a	25.3 ± 1.5 a	30.4 ± 0.5 a	24.37± 2.0 b	0.65± 0.1 a
Canino	29.1 ± 3.4 b	18.1 ± 1.0 b	11.1 ± 2.0 b	34.56± 2.0 a	0.13± 0.2 b
Khad Hlima	40.7 ± 1.8 a	21.1 ± 0.6 a	25.4 ± 0.8 a	35.46± 1.0 a	0.10± 0.3 b
Khit el Oued	36.6 ± 2.0 a	21.2 ± 1.0 a	22.3 ± 1.5 a	30.42± 1.0 a	0.40± 0.2 a
Sayeb	46.1 ± 1.6 a	27.1 ± 2.5 a	32.2 ± 1.3 a	26.35 ± 1.2 b	0.61 ± 0.1 a
Sodium metabisulfite dipping fruits (SM)					
Amr Leuch	34.7 ± 1.2 b	25.8 ± 1.4 a	23.7 ± 1.0 b	35.10± 1.0 a	0.76± 0.1 a
Bayoudhi	44.1 ± 1.0 a	24.3 ± 3.0 a	29.6 ± 1.2 a	38.34± 1.0 a	0.37± 0.2 a
Canino	34.9 ± 1.2 b	25.5 ± 2.0 a	20.3 ± 1.3 b	32.64± 1.2 b	0.98± 0.3 a
Khad Hlima	48.7 ± 1.3 a	23.2 ± 0.9 a	35.9 ± 1.1 a	42.79± 1.5 a	0.02± 0.1 b
Khit el Oued	43.5 ± 1.9 a	24.5 ± 1.9 a	28.0 ± 1.9 a	37.21± 2.0 a	0.46± 0.2 a
Sayeb	45.9 ± 1.0 a	26.1 ± 1.2 a	31.4 ± 1.2 a	40.32 ± 1.8	0.55 ± 0.1 a
Hot water blanching fruits (SB)					
Amr Leuch	36.7 ± 1.3 b	19.5 ± 1.4 a	23.2 ± 1.7 a	22.20± 2.0 b	0.57± 0.1 a
Bayoudhi	43.2 ± 1.1 a	15.4 ± 2.6 a	23.1 ± 1.6 a	39.65± 1.0 a	0.13± 0.1 b
Canino	32.2 ± 1.7 b	17.2 ± 1.0 a	17.2± 0.5 b	21.23 ± 1.2 b	0.53 ± 0.1 a
Khad Hlima	44.7 ± 0.3 a	19.7 ± 1.1 a	28.3 ± 1.3 a	33.09± 1.0 a	0.12± 0.1 b
Khit el Oued	45.7 ± 1.1 a	19.9 ± 1.6 a	29.3 ± 1.1 a	30.79± 1.1 a	0.50± 0.2 a
Sayeb	45.0 ± 1.2 a	17.2 ± 3.0 a	24.9 ± 1.2 a	41.63 ± 1.4 a	0.31 ± 0.1 a

Data are mean ± SE (n=3). Separation within columns was performed by Scheffe´s test ($p \leq 0.05$). Values are the means (n = 3) ± SE. Different letters a, b, c, indicate difference ($p < 0.05$) among treatments in the same cultivar.

satisfaction of consumers. Regarding the untreated sun-dried apricot fruits (SD), the color was significantly affected ($p<0.05$). Hence, the highest value was shown in the cv. *Bayoudhi* (5.6) whereas the cv. *Canino* showed the lowest score (4.25). The texture ranged from (4.5) in the cv. *Amr Leuch* and *Khad Hlima* to (6.8) in the cv. *Canino*. The fruit taste was slightly affected by the drying process showing values in the range of [5.25 – 6.75]. The consumers' acceptability was also affected by the drying process. The consumers' choice was pointed in the cv. *Bayoudhi* (6.75).

The sulfur-fumigated fruits presented an improvement of peel color as compared to the control. Hence, this trait varied from 5.0 in the cv. *Sayeb* to 7.5 in the cv. *Khad Hlima* and *Bayoudhi*. The flesh texture was affected by the open sun drying showing values in the range of [5.0 – 7.25]. The fruit taste was not affected by drying and showed values ranging from 5.5 in the cv. *Sayeb* to 7.8 in the cv. *Bayoudhi*. The cv. *Bayoudhi* (7.0) showed the highest aroma score whereas the lowest value (5.5) was observed in the cv. *Sayeb*. The highest global satisfaction score was (7.5) in the cv. *Bayoudhi* followed by the cv. *Khit el Oued* (6.75).

The sodium metabisulfite treated fruits showed a similar pattern of the sulfur-fumigated samples. The cv. *Khad Hlima* (6.9) showed the highest score of fruit color followed by the cv. *Bayoudhi* (6.8). The global satisfaction was found to be in the cv. *Canino* (7.5). The aroma score was highest in the cv. *Bayoudhi* (7.2) whereas the lowest value (5.0) was observed in the cv. *Sayeb*.

The blanching treated fruits did not show an improvement in the major sensorial analyzed traits, especially in the peel fruit color. Hence, this trait was 3.2 in the cv. *Sayeb* and 5.0 in the cv. *Bayoudhi*. The global satisfaction ranged from 7.0 in the cv. *Canino* to 4.5 in the cv. *Sayeb*. The aroma values were in the range of [4 – 6] with the highest value in the cv. *Amr Leuch* and *Bayoudhi*.

3.4 Principal component analysis (PCA) and cultivars suitability for drying

After drying, the PCA of the main biochemical and sensorial fruit quality traits were performed for each pre-treatment to evaluate the impact of the applied pre-treatments on postharvest quality of dried apricot fruits (Figure 3). The PCA for SD pretreatment accounted for 59.94% of total variance and three different groups were observed as shown in Figure 3 SD. The separation is mainly due to color, taste, and global satisfaction. A new grouping was observed with the sulfur fumigated fruits (Figure 3 SS) which explained 65.78% of total variance. Hence, the separation was due mainly to the color parameters such as L*, a* and b* (Figure 3 SS). The PCA performed with the sodium metabisulfite pretreatments explained 58.71% of total variance and presented a grouping similar to the sulfur fumigation pre-treatment and the separation is due to the color, carotenoids, and aroma (Figure 3 SM). The PCA performed after fruit blanching explained 59.73% of total variance and clearly separated the commercial cultivars based on their aroma, vitamin C, texture taste and global satisfaction. The observed grouping was similar to the untreated sun-dried fruits (Figure 3 SB).

4. Discussion

Regarding fresh fruit color parameters, our results were in line with the study of Hegedús et al. [23] reporting L* values in the range of [60.15 – 72.43]. In our study, the coordinate a* showed an increasing tendency with the drying process; this increase generally denotes a variation towards the red chroma, typical of the browning phenomena [24]. The b* values decreased in the dried apricot samples, indicating that the yellow color characteristic of fruit is affected by drying. Akin et al. [25] have reported similar changes in the chromatic parameters of different varieties of apricot. In general, the decrease in L* and h° reflects the darkening of apricot flesh and a shift from white to orange, respectively. Ramallo and Mascheroni [26] reported similar observations about hue angles and chroma values.

The antioxidant compounds content was evaluated in fresh and dried apricot fruits. The studied cultivars presented lower values of anthocyanins in fresh fruits. After drying, the anthocyanin content decreased in flesh fruits under all the

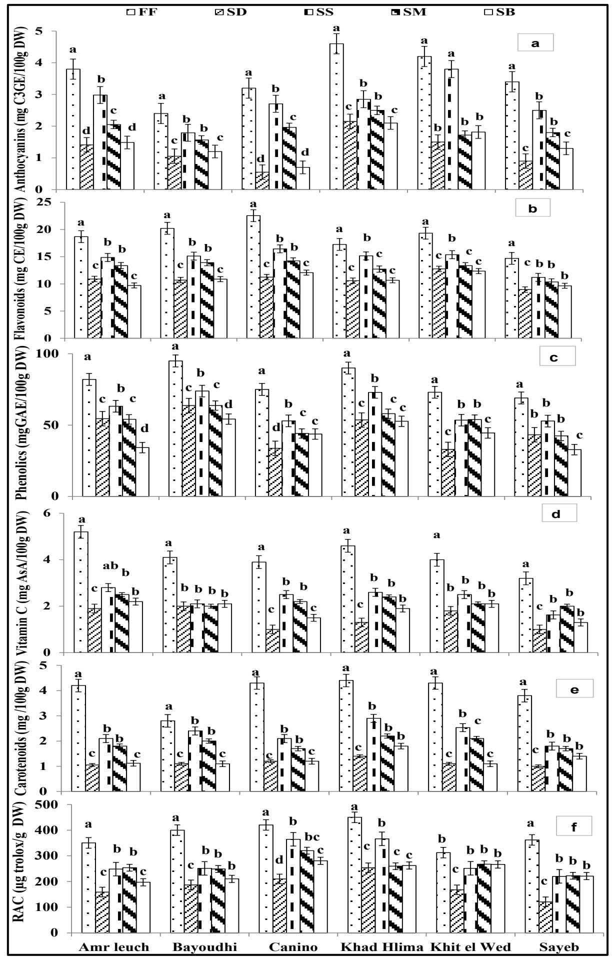

Figure 2. Influence of drying pretreatment on biochemical quality of fresh and dried apricot fruits

SD= sun dried fruits; SS= sulfur fumigated fruits; SM=sodium

applied pretreatments. This is in accordance with Bureau et al.[27] reporting that the anthocyanins are present in small amounts in apricot fruits. The range of anthocyanins reported in our study [2.4 – 4.6 mg CGE / 100 g DW] was found to be in line with previous study [28], reporting that the dried apricot contained 3.08 ± 0.40 mg CGE / 100 g DW. The flavonoids content decrease observed after the drying process is in accordance with the study of Derardja & Barkat [29] reporting a significant decrease [61 – 80%] in flavonoids after drying. The total phenolic compounds also decreased during drying. Bennett et al. [30] explained that the phenolic compounds present in fresh fruit and vegetables are susceptible to oxidative degradation by polyphenol oxidase (PPO) during drying, which leads to intermolecular condensation reactions and their level decreased. Derardja and Barkat [29] reported that the sun drying decreased remarkably the amount of total phenolics of apricot fruits and the drying methods may also affect these parameters. Our results showed a reduction in vitamin C content. These findings are in accordance with the previously cited study [29] reporting that the highest loss of vitamin C was around 74% of the original value, which may be due to the longer drying times and therefore a longer exposure to degradation. Our results of carotenoids content showed a significant decrease of this parameter after the drying process. The initial content of β-carotene [2.8 – 6.3 mg 100 g^{-1} DW] in our study in the fresh fruits was in accordance with the value (6.72 mg 100 g^{-1} DW) reported [31]. Derardja and Barkat [29] reported that the principal cause of carotenoids degradation, during the sun drying, was the direct exposure of apricot to oxygen and sunlight.

The fresh and dried apricot fruits of the studied cultivars were evaluated for the color, texture, taste, aroma, and global satisfaction of consumers. Samann [32] studying the apricot fruit during the drying process reported that the lower score in sensory evaluation in overall acceptability of open sun dehydration may be due to the color. The sensorial analysis permitted to select the cultivar *Canino* as the most appropriate cultivar for apricot drying. Our results are in accordance with the main apricot variety proposed for drying due to its flesh firmness, low water content, acid taste and aromatic flavor.

5. Conclusion

The fresh fruits were analyzed for pomological, agronomical, and physicochemical fruit quality traits. The fruit weight varied from 31.9 g in *Amr Leuch* to 46.24 g in *Khit el Oued*. The cv. *Canino* showed high firmness (35.48 N) whereas the cv. *Bayoudhi* showed high values of juice content (34.0%) and soluble solids content (14.1 °Brix). The variability in SSC and TA resulted in different values of ripening index (RI). The principal component analysis showed that the cvs. *Bayoudhi* and *Khit el Oued* are promising fruits for fresh consumption due to the higher consumer satisfaction. The drying process clearly reduced the bioactive compounds in dried apricot under all the applied pre-treatments. The sulfur fumigated fruits and the sodium metabisulfite treatments clearly permit to improve the color of dried apricot fruits as compared to the untreated sun-dried fruits. The sensorial analysis permitted to select the cultivars *Canino* and *Khad Hlima* as suitable cultivars for apricot drying based on the fruit size, firmness, flesh -texture and water content.

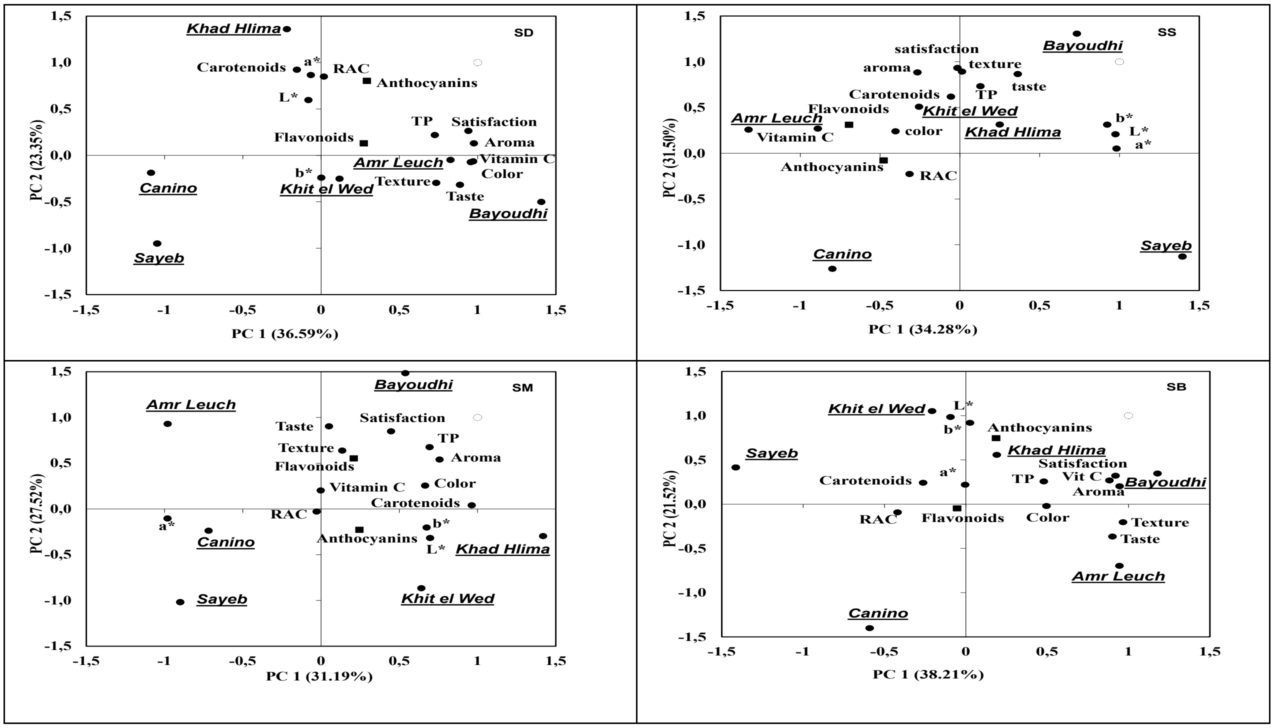

Figure 3. Principal component analysis of main agronomical, biochemical, and sensorial analysis in dried apricot fruits. Cultivars are underlined

SD= sun dried fruits; SS= sulfur fumigated fruits; SM= sodium metabisulfite dipping fruits; SB= hot water blanching fruits; Vit C= vitamin C; TP= total phenolics.

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