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Assessment of the organic fruit quality of local and introduced apricot cultivars grown in Tunisia: morphological and physico-chemical attributes

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ABSTRACT

Purpose Organic farming system was considered to increase fruit quality and improve food safety. Moreover, many consumers prefer organic products due to their better taste. Among the Prunus species, apricot is well grown in the world due to its good taste and multi uses. Tunisian apricot cultivars are cultivated in many areas, well adapted and characterized by varied pomological characteristics. In fact, due to the demand of the fresh market, there is growing introduction of commercial cultivars with firmness, visual appeal and flavor as principal traits demanded. Here, we aimed to assess the quality of organic apricot among local and introduced cultivars, in order to identify the cultivar(s) with better fruit quality performances. **Research method:** For this purpose, morphological (attractiveness, shape, surface, ground color of skin, etc.) and physico-chemical (weight, width, TSS, titrable acidity, etc.) attributes of fruit were studied according to the international descriptors of apricot and to the other investigations on fruit quality. **Findings**: Few differences of morphological attributes but high significant differences for most physico-chemical attributes of organic fruit were observed between local and introduced apricot cultivars. The organic cultivation system promotes the production of high fruit quality (high value of TSS: > 13°Brix, low value of acidity and big size) for the 3 local cultivars. **Limitations:** No limitations were founded. **Originality/Value:** Compared to the introduced apricot cultivars, the local ones are characterized by the performances of their fruit quality and also by their best adaptation under organic cultivation system.

INTRODUCTION

In recent years, there has been an increasing interest in organic farming. One of the main benefits of organic production is its environmentally friendly approach. Organic farming aims to eliminate the use of agricultural chemicals and replace them with natural materials in plant protection products as well as in animal nutrition. (Kouřimská et al., 2014). Moreover, low intensity agriculture, such as integrated and organic farming, may help to preserve biodiversity in agricultural land (Hole et al., 2005; Gibson et al., 2007). In 2017, 69.8 million hectares of organic agricultural land (including in-conversion areas) were recorded, up from 11 million hectares in 1999 (Willer & Lernoud, 2019). Australia had the highest proportion of organic agricultural land (35.6 million hectares). There were nearly 2.1 million hectares of certified organic agricultural land in Africa, with Tunisia having the largest organic area (with almost 306.500 hectares) (Willer & Lernoud, 2019).

In the world, the area of organic apricots was 14.792 hectares in 2017 (2.6% of the total organic temperate fruit in the world) (Willer & Lernoud, 2019).

Apricots are cultivated world-wide mainly for their high-quality fruit and are consumed fresh, processed, or preserved by drying (Mratinić et al., 2011).

Many consumers base their preference for organic products because of the perceived better taste (Hughner et al., 2007). Many factors as the biological characteristics of the tree, agronomic and environmental conditions and their correlation affected the fruit quality performances (Ledbetter et al., 2006; Ruiz & Egea, 2008a; Ruiz & Egea, 2008b).

The concentrations of organic acids and sugars have an important impact on fruit flavor and quality (Borsani et al., 2009). Sweetness and sourness are major determinants of taste sensory attributes that humans perceive and they are largely dependent on soluble sugars and organic acid content (Colaric et al., 2005). The dominant sugars in stone fruits include fructose, glucose, and sucrose, along with some individual saccharide (Cantín et al., 2009; Kovács & Németh-Szerdahelyi. 2002; Ledbetter et al., 2006). Previous studies reported the composition of organic acids and sugars in apricot (Akin et al., 2008). In *Prunus* fruits, oxalic acid, quinic acid, malic acid, shikimic acid, citric acid and fumaric acid are important organic acids (Haejin et al., 2014). In apricot, malic acid and citric acid are unequally distributed in the different varieties. They do not have the same influence on organoleptic sensations as on certain biochemical transformations, in particular the degradation of pectic substances responsible for the integrity and firmness of fruits (Souty & André, 1975).

The goal of this study was to compare the quality of organic apricots from three local cultivars, 'Oud Rhayem', 'Oud Hmida' and 'Oud Aouicha', to that of two introduced cultivars, 'Mogador' and 'Ninfa', during the same year and under the same organic conditions.Therefore, some morphological (attractiveness; shape; symmetry in ventral view; suture; depth of stalk; shape of apex; presence of mucro; surface; pubescence; ground color of skin; over color: relative area, hue of over, intensity and pattern; color of flesh; stone: adherence to flesh and shape in lateral view) and physico-chemical attributes (weight; height; lateral width; ventral width of fruit; flesh and stone percentages; total soluble solids; total sugars; titrable acidity; total acidity; pH; ripening and sweetness index) of organically grown fruits were analyzed, in order to select the cultivar(s) with highly organic fruit quality.

MATERIALS AND METHODS

Plant material

The plant material used in this study included three local apricot cultivars ‘Oud Rhayem’, ‘Oud Hmida’ and ‘Oud Aouicha’ and also two introduced cultivars ‘Mogador’ and ‘Ninfa’ (Fig 1). These studied cultivars are grown at Testour region (Northwest of Tunisia: 36°33’N and 09°26’ E) which is characterized by annual temperature of 20°C, rainfall of 390 mm and humidity of 58%.

The three local apricot cultivars are characterized by early flowering time (between the end of February and the beginning of March) as the two introduced cultivars. The set of studied cultivars has medium-early ripening time (medium to the end of May).The trees were managed according to organic cultivation system: treated during April with organically insecticides (acadien and simplex) against aphids and fertilized with compost as organic fertilizer. The trees were 15 years old, grafted on mech-mech seedling rootstock (good vigor, relatively tolerant to chlorosis, delays the start of production and the time of maturity but improves productivity and size), spaced at 5 x 5 m and a drip irrigation system was applied from April to October.

Methods

In 2017, 50 ripe fruits/cultivar from three trees were harvested at the same date in May (22/05/2017) and at the commercial maturity (less than 10% green color mainly around the suture) as defined by Lichou et al. (1998). Furthermore, the fruits were picked on the tree periphery and with the average height of the observer because the light and the sun exposure increase the metabolic activity of the fruits, being more colorful with important over color and with advance of maturity as reported by Lichou et al. (1998). Immediately after picking, the ripe fruits were placed in a cooler until they are stored in a cold room (4°C) at the Regional Research Centre on Horticulture and Organic Agriculture (Chott-Mariem, Sousse, Tunisia). For each cultivar, physico-chemical attributes of organic apricots were analyzed. In the laboratory, thirty ripe fruits/cultivar were selected (from 50 ripe harvested fruits) according to their uniformity and the absence of visible symptoms of rot or decay on their surface. According to the international descriptors for apricot (Guerriero & Watkins, 1984; UPOV, 2007), some morphological (attractiveness; shape; symmetry in ventral view; suture; depth of stalk; shape of apex; presence of mucro; surface; pubescence; ground color of skin; over color: relative area, hue of over, intensity and pattern; color of flesh; stone: adherence to flesh and shape in lateral view) and some physical (weight “FW”, height “FH”, lateral width “FLwi”, and ventral width “FVwi” of fruit; flesh “Fl (%)”and stone “St (%)” percentages) attributes of fruits were studied. Afterward, for each cultivar, these same studied fruits, were divided in 3 lots of 10 fruits. Each 10 fruits were mixed by mixer-centrifuge and 7 chemical attributes (Total soluble solids “TSS”, total sugars “TOTS”, titrable acidity “TA”, total acidity “TOTA”, pH, ripening index “TSS/TA” and sweetness index “TOTS/TA”) were analyzed according to previous studies (Benaziza & Lehbid, 2007; Milosevic et al., 2012; Ruck, 1963; Vénien, 1998).

Statistical analysis

For each studied apricot cultivar, codes have been assigned to the morphological attributes of fruit according to the international descriptors of apricot (Guerriero & Watkins, 1984; UPOV, 2007) and inserted in the matrix. Frequencies have been calculated for all qualitative morphological attributes of fruit. For physico-chemical attributes of apricot, means values and respective standard error of means were determined. General Linear Model (GLM) was performed for the analysis of variance and to establish the effect of cultivar on these cited characteristics.The means of each physico-chemical fruit attribute were compared by the Duncan test at 5% to establish cultivar groups. PCA analysis was used to establish relationships between cultivars and to select the cultivars with high quality performances. All these statistical analyses were performed using the SPSS 17.0 and Excel Stat softwares.

RESULTS

Morphological attributes of organic apricot

The morphological attributes of organic apricots (fruit, flesh and stone) of local and introduced cultivars are close (Table 1). In fact, the attractiveness of fruits was extremely good for 'Oud Rhayem' and 'Oud Aouicha'. While, the fruits of 'Oud Hmida' were less attractive as those of 'Mogador' and 'Ninfa' (the attractiveness was good). In lateral view, the shape of fruit was oblique rhombic for the three local cultivars and elliptic for the two introduced ones. In ventral view, the two introduced cultivars showed an oblate shape of the fruit. 'Oud Hmida' was individualized by triangular shape of its fruits. Whereas, 'Oud Aouicha' and 'Oud Rhayem' were characterized by an ovate shape of their fruits (Table 1) (Fig. 1). The suture of fruit was slightly sunken for 'Oud Aouicha', 'Oud Rhayem'and 'Mogador'. It was slightly to moderatley sunken for 'Oud Hmida' and raised for 'Ninfa' (Table 1). The apricots of this latter and 'Oud Rhayem' were symmetric. While those of 'Oud Aouicha', 'Oud Hmida' and 'Mogador' were slightly asymmetric (Table 1) (Fig. 1). For all studied apricot cultivars, the depth of stalk cavity, the surface and pubescence were respectively deep, smooth and present (Table 1). The mucron was present for most apricot cultivars, except 'Mogador'. The shape of apex for this latter was rounded-truncate. It was rounded for 'Ninfa' and truncate for the three local cultivars (Table 1) (Fig. 1).

Fig. 1. Morphological attributes of fruit for local and introduced apricot cultivars grown under the same organic cultivation system

Table 1. Morphological attributes of fruit (fruit, flesh and stone) for local and introduced apricot cultivars grown under the same organic cultivation system

Cultivar	Fruit Attractiveness	Shape in lateral view	Shape in ventral view	Symmetry in ventral view
Oud Aouicha	Extremely good	Oblique rhombic	Ovate	Slightly asymmetric
Oud Hmida	Good	Oblique rhombic	Triangular	Slightly asymmetric
Oud Rhayem	Extremely good	Oblique rhombic	Ovate	Symetric
Ninfa	Good	Elliptic	Oblate	Symetric
Mogador	Good	Elliptic	Oblate	Slightly asymmetric

Table 1. Continued.

Cultivar	Fruit					
	Suture	Depth of stalk cavity	Shape of apex	Presence of mucro	Surface	Pubescence
Oud Aouicha	Slightly sunken	Deep	Truncate	Present	Smooth	Present
Oud Hmida	Slightly to moderatley sunken	Deep	Truncate	Present	Smooth	Present
Oud Rhayem	Slightly sunken	Deep	Truncate	Present	Smooth	Present
Ninfa	Raised	Deep	Rounded	Present	Smooth	Present
Mogador	Slightly sunken	Deep	Rounded-Truncate	Absent	Smooth	Present

Table 1. Continued.

Cultivar	Fruit				Flesh		Stone	
	Ground color of skin	Relative area of over color	Pattern of over color	Intensity of over color	Hue of over color	Color of flesh	Adherence of stone to flesh	Shape in lateral view of stone
Oud Aouicha	Light orange	Medium	Very small dots	Dark	Purple	Light orange	Medium	Ovate
Oud Hmida	Yellowish	Medium to large	Very small dots	Dark	Purple	Cream	Strong	Ovate
Oud Rhayem	Medium orange	Very small	Very small dots	Dark	Purple	Medium orange	Weak	Elliptic
Ninfa	Medium orange	Medium	Isloated flecks (spots)	Dark	Purple	Light orange	Absent or very weak	Elliptic
Mogador	Medium orange	Medium	Solid flush	Dark	Purple	Light orange	Weak	Ovate

For the ground color of skin, we found difference between the three local cultivars as well as for the color of flesh (Table 1) (Fig. 1). While, the two introduced cultivars were characterized by the same color of skin (medium orange) color and also the same color of flesh (light orange) (Table 1) (Fig. 1). The fruits of the two introduced cultivars were characterized by medium relative area of over color. Whereas, the pattern of the over color was different between these two cultivars. It was in spots for 'Ninfa' and in solid flush for 'Mogador'. This fruit parameter was similar (very small dots) between the local cultivars (Table 1) (Fig. 1). According to international apricot descriptors (UPOV, 2007), no difference of the hue of over color was obtained between all studied apricot cultivars. It was purple with dark intensity for all organic apricots (Table 1). In organic farming system, the color of the flesh was respectively cream and medium orange for 'Oud Hmida' and 'Oud Rhayem' (Table 1) (Fig. 1). While, the two introduced cultivars were characterized by light orange flesh like the local one 'Oud Aouicha' (Table 1) (Fig. 1).

For the shape of the stone, some difference and similarity were obtained between local and introduced apricot cultivars. In fact, the stone of 'Oud Aouicha', 'Oud Hmida' and 'Mogador' had an ovate shape (in lateral view). While, that of 'Oud Rhayem' and 'Ninfa' had an elliptic shape (Table 1). The adherence of the stone to flesh was absent (or very weak) for 'Ninfa'. It was weak for 'Oud Rhayem' and 'Mogador'. That of 'Oud Aouicha' and 'Oud Hmida' was respectively medium and strong (Table 1).

Physical attributes of organic apricot

Highly significant difference ($p \leq 0.01$) was observed between the different apricot cultivars for all the physical attributes of organic fruit (weight; height; lateral width; ventral width; percentage of flesh and stone, respectively) (Fig. 2 & 3).

In our study, the weight of organic fruit ranged between 32.44 and 41.64 g. In organic cultivation system, 'Oud Aouicha' produced the biggest fruits. Those of 'Ninfa' were the smallest ones but they were statistically similar to the fruits of 'Mogador' and the 2 others local cultivars ('Oud Rhayem' and 'Oud Hmida') (Fig. 2).

For lateral width of organic fruit, we obtained similar variation to that of weight. The values varied from 31.30 ('Ninfa') to 40.58 mm ('Oud Aouicha'). Whereas, 'Mogador', 'Oud Hmida' and 'Oud Rhayem' were statistically similar ($p \leq 0.05$) in terms of lateral width of their organic fruits (Fig. 2). The lowest values of height and ventral width of organic apricot were observed in introduced cultivar 'Ninfa' (32.70 mm and 30.57 mm, respectively). 'Mogador' was individualized by its longest fruits (38.61 mm) (Fig. 2).

For ventral width (thickness) of organic fruit, the highest value was found in 'Oud Aouicha' and 'Oud Hmida' (they were statistically similar) (Fig. 2). While, the lowest ventral width (thickness) of organic fruits was observed in 'Ninfa'. 'Mogador' and 'Oud Rhayem' have relatively low thickness (Fig. 2).

The results related to percentages of flesh and stone are presented in Figure 3. Statistically ($p \leq 0.05$), the highest percentage of flesh was obtained in the two introduced cultivars and in the local one 'Oud Rhayem' (the values ranged between 92% and 93%). These latter three cultivars characterized by higher percentage of flesh can be suitable for processing into jam, juice and jellies. The lowest percentage of flesh was observed in 'Oud Hmida' (80.94%) (Fig. 3).

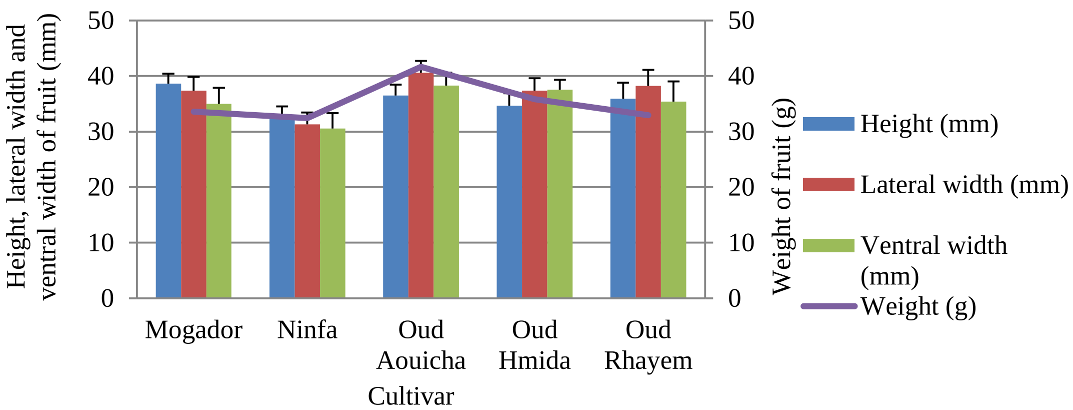

Fig. 2 .Some physical attributes of fruit for local and introduced apricot cultivars grown under the same organic cultivation system

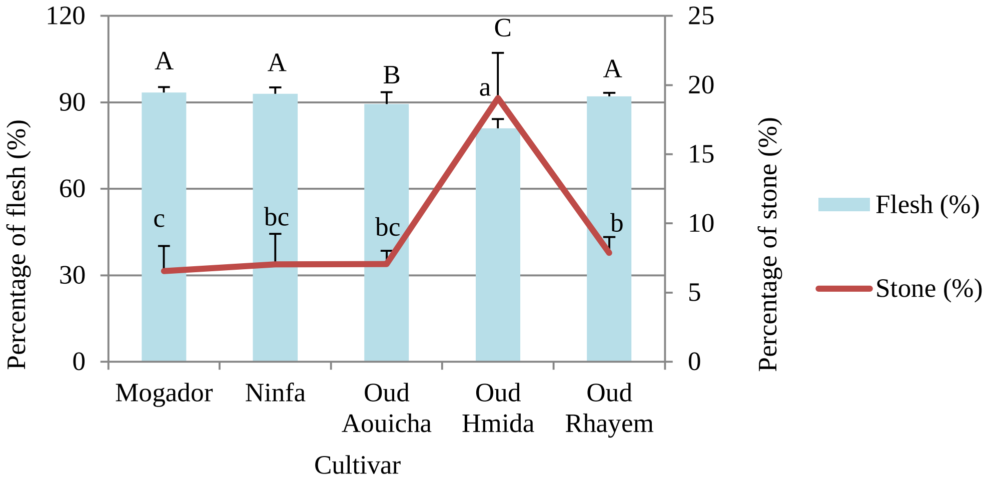

Fig. 3. Percentage of flesh and stone of local and introduced apricot cultivars grown under the same organic cultivation system

Chemical attributes of organic apricot

Among the studied apricot cultivars, significant differences ($p \leq 0.01$ and $p \leq 0.05$) were found for the most chemical attributes, and pH values of organic fruit, respectively.

In this study, some chemical attributes of organic apricot as the percentage of juice, total soluble solids, pH and titratable acidity were presented in Table 2.

In organic cultivation system, the percentage of juice varied between 32.67% ('Ninfa') and 73.13% ('Oud Aouicha'). 'Oud Rhayem' showed a close percentage of juice to that of 'Oud Aouicha'. Similarity was also observed for this chemical characteristic between 'Oud Hmida' and 'Mogador' (Table 2).

Regarding the total soluble solids (°Brix), the highest value was observed in 'Oud Hmida' (14.73°Brix) and the lowest one was obtained in 'Ninfa' (9.70°Brix) (Table 2). Therefore in organic cultivation system, the three local apricot cultivars were the sweetest ones (14 to 15°Brix) (Table 3). According to Lichou et al. (1998), these local cultivars were very sweet (TSS > 13°Brix). Whereas, 'Mogador' was moderately sweet (TSS: 11.47°Brix) and 'Ninfa' was insufficiently sweet (TSS: 9.7°Brix) (Table 2).

The highest titratable acidity was found in 'Oud Aouicha' (38.71 meq/100g Fresh mass) followed by 'Oud Hmida' (31.94 meq/100g Fresh mass), 'Mogador' (28.89 meq/100g Fresh mass), 'Oud Rhayem' and 'Ninfa' (20.49 and 21.96 meq/100g Fresh mass, respectively) (Table 2). According to Lichou et al. (1998), 'Oud Aouicha' and 'Oud Hmida' were characterized by the acidity of their organic fruits (TA: 30 to 40 meq/100g Fresh mass). 'Mogador' produce acidulated organic fruits (TA: 25 to 35 meq/100g Fresh mass). While, the organic apricots of 'Oud Rhayem' and 'Ninfa' are sweet (TA: 20 to 30 meq/100g Fresh mass).

Table 2. Some chemical fruit attributes of introduced and local apricot cultivars grown under the same organic cultivation system.

Cultivar	Juice (%)	TSS (° Brix)	pH	TA (meq/100 g Fresh mass)
Mogador	50.27 ± 3.69 bc	11.47 ± 0.06 b	4.70 ± 0.09 b	28.89 ± 1.02 c
Ninfa	32.67 ± 12.43 c	9.70 ± 0.53 c	5.34 ± 0.57 a	21.96 ± 0.67 d
Oud Aouicha	73.13 ± 17.87 a	13.87 ± 1.57 a	4.55 ± 0.16 b	38.71 ± 1.84 a
Oud Hmida	43.55 ± 10.48 bc	14.73 ± 0.21 a	4.73 ± 0.11 b	31.94 ± 0.42 b
Oud Rhayem	58.83 ± 1.41 ab	14.27 ± 0.87 a	4.74 ± 0.09 b	20.49 ± 1.96 d

Regarding pH values of the organic apricots, they were higher in 'Ninfa' than in the others cultivars (Table 2). Some others chemical attributes as total sugars, total acidity, total sugars/titratable acidity (TOTS/TA=Sweetness index) and total soluble solids/titratable acidity (TSS/TA=Ripening index) are shown in Figure 4.

As the total soluble solids, high and similar amounts of the total sugars in the organic fruits were obtained between the local apricot cultivars (total sugars ranged between 12 and 13%). Whereas, the introduced cultivar 'Ninfa' presented the lowest amounts of total sugars (7.80%) followed by 'Mogador' (9.68%) (Fig. 4). For the total acidity in organic apricots, the highest percentage was found in 'Oud Aouicha' (1.72%) followed by 'Mogador' (1.59%), 'Oud Hmida' (1.50%), 'Ninfa' (0.97%) and 'Oud Rhayem' (0.80%) (Fig. 4). The variation of ripening index and sweetness index was similar among apricot cultivars in the same organic farming system. The highest ratios were obtained in 'Oud Rhayem' and the lowest ones were found in 'Mogador' (Fig. 4). Although, our results showed that differences between 'Mogador', 'Ninfa', 'Oud Aouicha' and 'Oud Hmida' were not significant, respectively for ripening and sweetness index. So, 'Oud Rhayem' could be used in a functional breeding program as a donor cultivar for high ripening and sweetness index (Fig. 4).

For PCA, the results showed that the three first components (PC1, PC2 and PC3) performed on physico-chemical attributes of organic apricot among five cultivars (local and introduced) explained 94.60% of the total variability (Table 3). PC1, PC2 and PC3 accounted for 51.63%, 25.27%, and 17.69%, respectively of the variability (Table 3).

This latter showed that PC1 was positively correlated to physical attributes of organic apricot (weight, height, lateral width and ventral width). Positive correlation was found also between PC1 and some chemical attributes of organic apricot (juice percentage, total soluble solids, titratable acidity, total sugars and total acidity). Whereas, PC1 was negatively correlated to pH value. Regarding the PC2 component, positive correlation was observed between PC2 and ripening index (TSS/TA) and sweetness index (TOTS/TA) (Table 3).

Figure 5 shows that the highest positive PC1 value correspond to the local cultivar 'Oud Aouicha' characterized by the highest physical attributes (weight, height, lateral width and ventral width) of its fruit. Also, it has the highest juice percentage and the highest titratable acidity. According to PC1, 'Oud Aouicha' and 'Oud Hmida' showed higher total sugars but lower value of pH (Table 2) (Fig. 4).

Table 3. PCA analysis performed on physico-chemical fruit attributes among local and introduced apricot cultivars as explained by the 3 first principal components (Proportion of cumulative variability; Component loading for physico-chemical fruit traits)

	Component loading		
Percent of variance	PC1, λ= 51.63	PC2, λ= 25.27	PC3, λ= 17.69
Cumulative (%)	51.63	76.90	94.60
Physico-chemical fruit traits			
Lateral width	0.93	0.17	0.31
Weight	0.82	-0.35	-0.02
Height	0.54	-0.13	0.63
Ventral width	0.99	0.14	-0.05
Stone (%)	0.32	0.30	-0.87
Flesh (%)	-0.52	-0.19	0.83
Juice (%)	0.78	0.06	0.54
TSS	0.80	0.58	-0.15
pH	-0.93	-0.13	-0.26
TA	0.83	-0.52	-0.16
TOTS	0.80	0.57	-0.15
TOTA	0.72	-0.65	-0.12
TOTS/TA	-0.12	0.97	0.19
TSS/TA	-0.22	0.95	0.21

The lowest negative PC1 value correspond to the introduced cultivar 'Ninfa' (Fig. 5). This cultivar is distinguished by the lowest values of physical characteristics (weight, height, lateral width and ventral width) of its organic fruit (Fig. 2), the lowest juice percentage and the lowest values of: TSS, TOTS and TOTA (Table 2) (Fig. 4). Moreover, it showed lower value of TA. Whereas, it was characterized by the highest value of pH (Table 2) (Fig. 4).
Regarding the PC2 component, 'Oud Rhayem' had the highest positive value of PC2 and it is distinguished by the highest ratios of TOTS/TA and TSS/TA (Fig. 4 & 5). While, the introduced cultivar 'Mogador' had the lowest value of PC2 and the lower ratios of TOTS/TA and TSS/TA (Fig. 4 & 5).

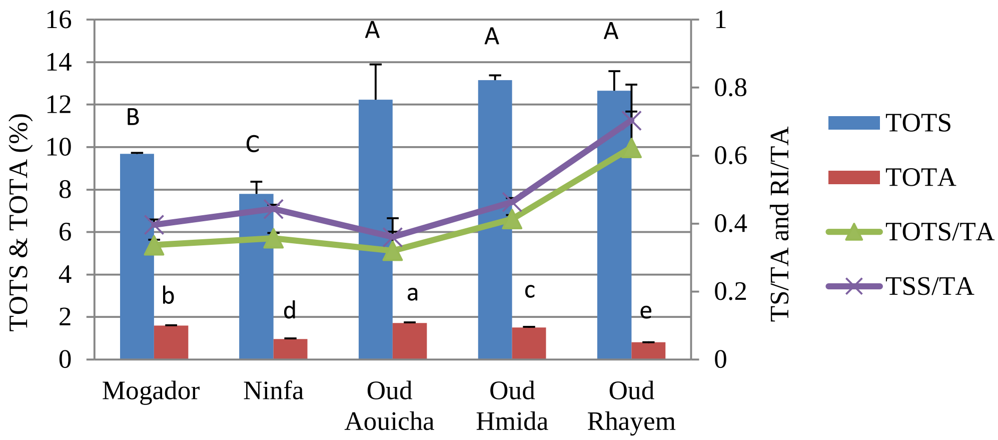

Fig. 4. Some chemical attributes of fruit for introduced and local apricot cultivars grown under the same organic cultivation system.
For the total sugars (TOTS), the values with the same uppercase letters are not statically different at p ≤0.05. For the total acidity (TOTA), the values with the same lowercase letters are not statically different at p ≤0.05.

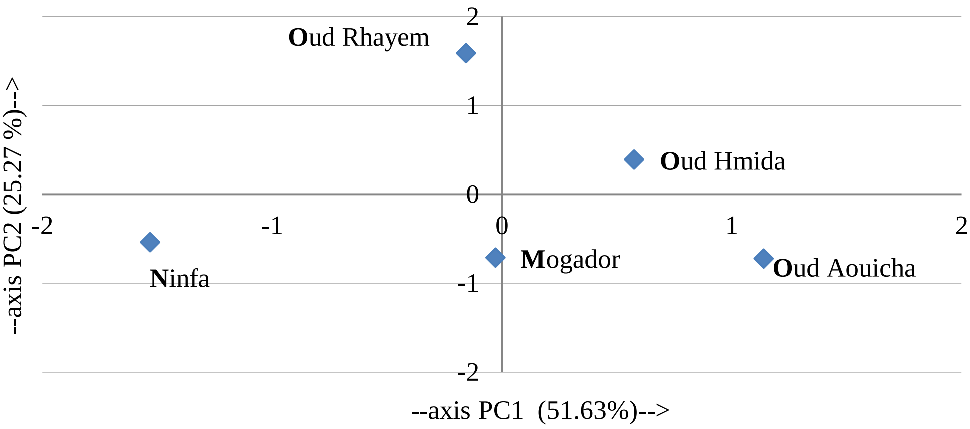

Fig. 5. PCA analysis among local and introduced apricot cultivars grown under the same organic cultivation system as explained by the 2 first principal components

DISCUSSION

The results showed few differences of morphological attributes of organic fruits (fruit, flesh and stone) between local and introduced apricot cultivars. Leccese et al. (2010), reported that a large source of variability defining apricot qualitative traits has to be related to the genotype effect. Therefore, choice of cultivar is a essentially based on the best fruit performances in order to select genotypes with high fruit quality.

Regarding the ground color of skin, the two introduced cultivars have the same color (medium orange) and they show also the same color of flesh (light orange). Whereas, we found differences between the three local cultivars for the ground color of skin as well as for the color of flesh. In fact, similar to the two introduced apricot cultivars, 'Oud Rhayem' was characterized by medium orange ground color of skin and 'Oud Aouicha' was characterized by light orange color of flesh. Similar investigations were done by Ruiz et al. (2005) in order to study the relationship between the content of carotenoids and the skin and the flesh color of some Spanish apricot cultivars. This relation was cited to be linear, showing that apricot color has a large influence not only on consumer perception of quality but also on nutritional recognition for their vitamin A content.

Concerning physical attributes of organic fruit, highly significant difference ($p \leq 0.01$) was observed between studied apricot cultivars. These results agree with those of Ali et al. (2011), who found similar difference ($p \leq 0.05$) of the physical characteristics of apricot among the Pakistan varieties. It was reported that fruit dimensions are important features that distinguish apricot cultivars (Miloševic et al., 2013). Additionally, the greatest variations of the weight in apricots have been previously reported (Hegedűs et al., 2010; Hernandez et al., 2010; Lo Bianco et al., 2010; Miloševic et al., 2012; Mratinić et al., 2011). According to Guerriero et al. (2006), attractive medium-sized fruits are desired for apricot cultivar breeding. Whereas, Hegedűs et al. (2010), reported that larger fruits are commonly preferred by consumers and apricot markets in recent years. Generally, fruit weight is a major criterion of apricot fruit quality, yield, and consumer acceptance (Durmaz et al., 2010).

The variation of the percentages of flesh and stone was in accordance with previous studies. Miloševic et al. (2010 & 2013) reported significant differences for stone weight among apricot cultivars. It is well known that apricot stones are used in genotype identification (Depypere et al., 2007) and the higher fresh/stone ratio is a desired property in apricot (Gezer et al., 2003; Miloševic et al., 2012). Also, the higher flesh percentage was considered as a desired fruit property in apricot (Mratinić et al., 2011).

Regarding the suitability of the apricot cultivars for processing, Ali et al. (2011) reported that the Pakistan cultivars with highest average fruit weight, fruit volume, and thickness are suitable for fresh consumption. Also, these same cultivars with higher pulp/pit ratio are suitable for processing into jam, juice and jellies. Whereas, those characterized by relatively low weight and volume, respectively and higher amount of dry matter are suitable for consumption in dried form.

According to Ali et al. (2011), we can deduce in this study that 'Oud Aouicha' which was characterized by the highest physical attributes of its organic fruits (Fig. 2) and 'Oud Hmida' which was presented close average of these properties (Fig. 2) can be both suitable for fresh consumption. Whereas, 'Oud Rhayem' and the 2 introduced cultivars ('Ninfa' and 'Mogador') characterized by higher percentage of flesh could be suitable for processing into jam, juice and jellies. Also, these latter 3 cultivars characterized by low weight and ventral width could be also suitable for dry. It was reported that the physical properties of fruit are important to be taken under consideration for value addition and mechanization of fruit industry (Demir & Kalyoncu 2003).

Similar variations of chemical attributes (total soluble solids, titratable acidity, pH and ripening index) of apricots were reported by Miloševic et al. (2012). Ruiz and Egea (2008b) showed that SSC content is a very important quality attribute, influencing notably the fruit taste. Some authors reported that apricot accessions with SSC content >12°Brix were characterized by an excellent gustative quality (Gurrieri et al., 2001). In apricot genotypes, sucrose and reducing sugars (glucose and fructose) were the major sugars (Dolenc-Šturm et al., 1999; Mratinic et al., 2011).

Generally, our range of TSS values was in agreement with previous works on apricot (Audergon et al., 1990; Mratinic et al., 2011; Ruiz and Egea, 2008b). Whereas, they are generally lower than those of Turkish apricot genotypes (Asma & Ozturk, 2005; Asma et al., 2007; Balta et al., 2002; Kalyoncu et al., 2009) and also than those of Serbian apricot cultivars (Miloševic et al., 2012). These differences could be due to the apricot cultivars, local environmental conditions and cultural practices (Demirtas et al., 2010; Lo Bianco et al., 2010; Mratinic et al., 2011). In organic farming system, there is a lower availability of nitrogen which can affect fruit composition (Berry et al., 2002).

The relationship between SSC and TA has an important role in consumer acceptance of some stone fruits such as apricot, peach, nectarine, and plum cultivars. With the cultivars with TA> 0.90% and SSC < 12° Brix, consumer acceptance was controlled by the interaction between TA and SSC rather than SSC alone (Crisosto et al., 2004). Ruiz and Egea (2008b) showed that the fruit maturity stage at the harvest date is the principal factor affecting fruit acidity and also the soluble solids content. Likewise, Lo Bianco et al. (2010) reported that fruit maturation stage affects quality parameters, and maturation rate depends strongly on air temperature. Therefore, changes in climatic conditions, including air temperature, from year to year may cause differences between indicated and real ripening times of cultivar (Lo Bianco et al., 2010).

Similar to the total soluble solids, high and similar amounts of the total sugars in the organic fruits were obtained between the local apricot cultivars. The values of total sugars were lower than obtained by Miloševic et al. (2012).

The variation of ripening index and sweetness index was similar among apricot cultivars in the same organic farming system. Schmitzer et al. (2011) reported that sweetness index is an important factor contributing to the internal quality and one of the most important objectives in apricot breeding. These authors showed that cultivars with higher values of sugars and lower values of acidity should be promoted. Relationship between TSS and TA or RI has an important role in consumer demand of some stone fruits, including apricot (Ruiz & Egea, 2008b).

Concerning the Principal component analysis (PCA), a positive correlation of physical attributes of organic apricots and some chemical attributes was obtained with PC1. While, PC2 was positively correlated with ripening index (TSS/TA) and sweetness index (TOTS/TA). According to this analysis, relationship between apricot cultivars was established in order to identify the cultivar(s) with high fruit quality. In this study, the 3 local apricot cultivars were selected with better fruit quality performances in organic farming system compared to the introduced commercial cultivars.

CONCLUSION

Through statistical analysis, we can distinguish between apricot cultivars grown in organic cultivation system and select that or those with high quality performances. This cultivation system promotes the production of high fruit quality (high value of TSS: > 13°Brix, low value of acidity and big size) for the 3 local cultivars ('Oud Rhayem', 'Oud Hmida' and 'Oud Aouicha').

In fact, 'Oud Rhayem' was characterized by the highest values of TSS and the lowest values of acidity. This cultivar could be promoted as donor in breeding programs for its highest ripening and sweetness index. In the other hand, 'Oud Rhayem' and the 2 introduced cultivars ('Ninfa' and 'Mogador'), could be suitable for dried organic apricot consumption due to lower thickness of fruit and highest percentage of flesh. Likwise, they could be suitable for processing into jam, juice and jellies.

While, 'Oud Aouicha' and 'Oud Hmida' were characterized by the highest values of physical attributes of their fruit. They are fresh consumed and they could be used as donors in breeding programs for high physical properties of their fruits.

Conflict of interest

The authors have no conflict of interest to report.

REFERENCES

Akin, E. B., Karabulut, I., & Topcu, A. (2008). Some compositional properties of main Malatya apricot (*Prunus armeniaca* L.) varieties. *Food Chemistry, 107,* 939-948. https://doi.org/10.1016/j.foodchem.2007.08.052.

Ali, S., Mesud, T., & Abbasi, K. S. (2011). Physicochemical characteristics of apricot (*Prunus armeniaca* L.) grown in northern areas of Pakistan. *Scientia Horticulturae, 130,* 386-392. https://doi.org/10.1016/j.scienta.2011.05.040.

Asma, B. M., & Ozturk, K. (2005). Analysis of morphological,pomological and yield characteristics of some apricot germplasm in Turkey. *Genetic Resources and Crop Evolution, 52,* 305-313. https://doi.org/10.1007/s10722-003-1384-5

Asma, B. M., Kan, T., & Birhanli, O. (2007). Characterization of promising apricot *(Prunus armeniaca* L.) genetic resources in Malatya, Turkey. *Genetic Resources and Crop Evolution, 54,* 205-212. https://doi.org/10.1007/s10722-005-3809-9.

Audergon, J. M., Souty, M., & Breuils, L. (1990, December). Amélioration génétique pour l'obtention d'abricots de qualité. In. *Neuvième Colloque sur les Recherches Fruitières*, Avignon, France (pp. 217-228).

Balta, F., Kaya, T., Yarilgaç, T., Kazankaya, A., Balta, M. F., & Koyuncu, M. A. (2002). Promising apricot genetic resources from the Lake Van Region. *Genetic Resources and Crop Evolution, 49,* 409-413. https://doi.org/10.1023/A:1020682116689.

Benaziza, A., & Lebid, H. (2007). Caractérisation de quelques variétés d'abricotier (*Prunus armeniaca* L.) dans la région de m'chouneche wilaya de biskra. *Courrier du Savoir, 8,* 101-110.

Berry, P. M., Sylvester-Bradley, R., Philipps, L., Hatch, D.J., Cuttle, S.P., Rayns, F.W., & Gosling, P. (2002). Is the productivity of organic farms restricted by the supply of available nitrogen? *Soil Use and Management, 18,* 248-255. https://doi.org/10.1111/j.1475-2743.2002.tb00266.x

Borsani, J., Budde, C. O., Porrini, L., Lauxmann, M. A., Lombardo, V. A., Murray, R., Andreo, C. S., Drincovich, M. F., & Lara, M. V. (2009). Carbon metabolism of peach fruit after harvest: changes in enzymes involved in organic acid and sugar level modifications. *Journal of Experimental Botany, 60,* 1823-1837. https://doi.org/10.1093/jxb/erp055

Cantín, C. M., Gogorcena, Y., & Moreno, M. Á. (2009). Analysis of phenotypic variation of sugar profile in different peach and nectarine [*Prunus persica* (L.) Batsch] breeding progenies. *Journal of the Science of Food and Agriculture, 89,* 1909-1917. https://doi.org/10.1002/jsfa.3672

Colaric, M., Veberic, R., Stampar, F., & Hudina, M. (2005). Evaluation of peach and nectarine fruit quality and correlations between sensory and chemical attributes. *Journal of the Science of Food and Agriculture, 85*, 2611-2616. https://doi.org/10.1002/jsfa.2316

Crisosto, C. H., Garner, D., Crisosto, G. M., & Bowerman, E. (2004). Increasing 'Blackamber' Plum (*Prunus salicina* Lindley) consumer acceptance. *Postharvest Biology and Technology, 34*, 237-244. https://doi.org/10.1016/j.postharvbio.2004.06.003

Demir, F., & Kalyoncu, I. H. (2003). Some nutritional, pomological and physical properties of cornelian cherry (*Cornus mas* L.). *Journal of Food Engineering, 60,* 335-341. https://doi.org/10.1016/S0260-8774(03)00056-6

Demirtas M.N., Bolat I., Ercisli S., Ikinci A., Olmez H.A., Sahin M., Altindag M., Celik B., 2010. The effects of different pruning treatments on the growth, fruit quality and yield of 'Haci-haliloglu' apricot. *Acta Scientiarum Polonorum Hortorum Cultus, 9,* 183–192.

Depypere, L., Charle, P., Vander-Mijnsbrugge, K., & Goetghebeur, P. (2007). Stony endocarp dimension and shape variation in *Prunus* section *Prunus*. *Annals of Botany, 100*, 1585-1597. https://doi.org/10.1093/aob/mcm260

Dolenc-Šturm, K., Štampar, F., & Usenik, V. (1999). Evaluating of some quality parameters of apricot cultivars using HPLC method. *Acta Alimentaria, 28,* 297-309. https://doi.org/10.1556/aalim.28.

Durmaz, G., Çam, M., Kutlu, T. & Hişil, Y. (2010). Some physical and chemical changes during fruit development of five common apricot (*Prunus armeniaca* L.) cultivars. *Food Science and Technology Research, 16*(1), 71-78. https://doi.org/10.3136/fstr.16.71

Gezer, İ., Haciseferogullar, H., & Demir, F. (2003). Some physical properties of Hacıhaliloglu apricot pit and its kernel. *Journal of Food Engineering*, *56*(1), 49-57. https://doi.org/10.1016/S0260-8774(02)00147-4

Gibson, R. H., Pearce, S., Morris, R. J., Symondson, W. O. C., & Memmott, J. (2007). Plant diversity and land use underorganic and conventional agriculture: awhole-far approach. *Journal of Applied Ecology, 44,* 792-803. https://doi.org/10.1111/j.1365-2664.2007.01292.x

Guerriero, R., & Watkins, R. (Eds.). (1984*). Apricot descriptors: revised descriptor list for apricot (Prunus armeniaca L.)*. Rome: IPGRI.

Guerriero, R., Lomi, F., & D'Onofrio, C. (2006). Influence of some agronomic and ecological factors on the constancy of expression of some descriptive characters included in the UPOV apricot descriptor list. *Acta Horticulturae, 717,* 51-54. https://doi.org/10.17660/ActaHortic.2006.717.6

Gurrieri, F., Audergon, J. M., Albagnac, G., & Reich, M. (2001). Soluble sugars and carboxylic acids in ripe apricot fruit as parameters for distinguishing different cultivars. *Euphytica*, *117*, 183-189. https://doi.org/10.1023/A:1026595528044

Haejin, B., Seok, K. Y., Ji, H. J., Ik, K. Y. (2014). Assessment of organic acid and sugar composition in apricot, plumcot, plum, and peach during fruit development. *Journal of Applied Botany and Food Quality, 87*, 24-29. https://doi.org/10.5073/JABFQ.2014.087.004

Hegedűs, A., Engel, R., Abrankó, L., Balogh, E., Blázkovics, A., Hermán, R., Halász, J., Ercisli, S., Pedryc, A, & Stefanovits-Bányai, E. (2010). Antioxidant and antiradical capacities in apricot (*Prunus armeniaca* L.) fruits: variations from genotypes, years, and analytical methods. *Journal of Food Science, 75*(9), 722-730. https://doi.org/10.1111/j.1750-3841.2010.01826.x

Hernández, F., Pinochet, J., Moreno, M. A., Martínez, J. J., & Legua, P. (2010). Performance of *Prunus* rootstocks for apricot in Mediterranean conditions. *Scientia Horticulturae*, *124*(3), 354-359. https://doi.org/10.1016/j.scienta.2010.01.020

Hole, D. G., Perkins, A. J., Wilson, J. D., & Alexander, I. H. (2005). Does organic farming benefit biodiversity? *Biological Conservation*, *112*(1), 113-130. https://doi.org/10.1016/j.biocon.2004.07.018

Hughner, R. S., McDonagh, P., Prothero, A., Shultz, C. J. II & Stanton, J. (2007). Who are organic food consumers? A compilation and review of why people purchase organic food. *Journal of Consumer Behaviour, 6,* 94-110. https://doi.org/10.1002/cb.210

Kalyoncu, I. H., Akbulat, M., & Çoklar, H. (2009). Antioxidant capacity, total phenolics and some chemical properties of semi-matured apricot cultivars grown in Malatya, Turkey. *World Applied Sciences Journal*, *6*(4), 519-523.

Kouřimská, L., Kubaschová, K., Sus, J., Nový, P. Dvořáková, B., & Koudela, M. (2014). Comparison of the carbohydrate content in apples and carrots grown in organic and integrated farming systems. *Potravinarstvo (Scientific Journal for Food Industry), 8(*1), 178-183. https://doi.org/10.5219/362.

Kovács , E., & Németh-Szerdahelyi , E. (2002). ß-Galactosidase activity and cell wall break down in apricots. *Journal of Food Science*, *67*, 2004-2008. https://doi.org/10.1111/j.13652621.2002.tb09492.x

Leccese, A., Bureau, S., Reich, M., Renard C. M. G. C., Audergon J. M., Mennone, C., Bartolini, S., & Viti, R. (2010) Pomological and nutraceutical properties in apricot fruit: cultivation systems and cold storage fruit management. *Plant Foods for Human Nutrition*, *65*, 112-120. https://doi.org/10.1007/s11130-010-0158-4

Ledbetter, C., Peterson, S., & Jenner, J. (2006). Modification of sugar profiles in California adapted apricots (*Prunus armeniaca* L.) through breeding with Central Asian germplasm. *Euphytica*, *148*, s

Lichou, J., Albagnac, G., Audergon, J.M., Broquaire, J.M., Chamet, C., & Pinet, C. (1998). *Abricot : les variétés, mode d'emploi*. Centre Technique Interprofessionnel des Fruits et Légumes (CTIFL), Paris, 254p.

Lo Bianco, R., Farina, V., Indelicato, S. G., Filizzola, F., & Agozzino, P. (2010). Fruit physical, chemical and aromatic attributes of early, intermediate and late apricot cultivars. *Journal of the Science of Food and Agriculture. 90*, 1008-1019. https://doi.org/10.1002/jsfa.3910

Milošević, T., Milošević, N., Glišić, I., & Krška, B. (2010). Characteristics of promising apricot (*Prunus armeniaca* L.) genetic resources in central Serbia based on blossoming period and fruit quality. *Horticultural Science., 37*(2), 46-55. https://doi.org/10.17221/67/2009-HORTSCI

Miloševic, T., Miloševic, N., Glišic, I., & Mladenovic, J. (2012). Fruit quality, phenolics content and antioxidant capacity of new apricot cultivars from Serbia. *Acta Scientiarum Polonorum Hortorum Cultus*, *11*(5), 3-15.

Milošević, T., Milošević, N., & Glišić, I. (2013). Dynamic of fruit growth and internal fruit quality of apricot trees grafted on rootstock or with interstem. *Journal of Agricultural Science and Technology, 15*, 311-321.

Mratinić, E., Popovski, B.,Milošević, T., & Popovska, M. (2011). Evaluation of apricot fruit quality and correlations between physical and chemical attributes. *Czech Journal of Food Sciences., 29*, 161-170.

UPOV (2007). Apricot (*Prunus armeniaca* L.). Guidelines for the conduct of tests for distinctness, uniformity and stability, TG/70/4 Rev.

Ruck, J. A. (1963). *Chemical methods for analysis of fruit and vegetable products.* Canada. Canadian Department of Agriculture.

Ruiz, D., Egea, J., Toamas-Barberan, F. A., & Gil, M. I. (2005). Carotenoids from new apricot (*Prunus armeniaca* L.) varieties and their relationship with flesh and skin color. *Agricultural and Food Chemistry*, *53*, 6368-6374.

Ruiz, D., & Egea, J. (2008a). Analysis of the variability and correlations of floral biology factors affecting fruit set in apricot in a Mediterranean climate. *Scientia Horticulturae, 115*(2), 154-163. https://doi.org/10.1016/j.scienta.2007.08.016

Ruiz, D., & Egea, J. (2008b). Phenotypic diversity and relationships of fruit quality traits in apricot (*Prunus armeniaca* L.) germplasm. *Euphytica, 163*, 143-158. https://doi.org/10.1007/s10681-007-9640-y

Schmitzer, V., Slatnar, A., Mikulic-Petkovsek, M., Veberic, R., Krska, B., & Stampar, F. (2011). Comparative study of primary and secondary metabolites in apricot (*Prunus armeniaca* L.) cultivars. *Journal of the Science of Food and Agriculture*, *91*(5), 860-866. https://doi.org//10.1002/jsfa.4257

Souty, M., & André, P. (1975). Composition biochimique et qualité des pêches. *Annales de Thechnologie Agricole*, *24*(2), 217-236.

Vénien, S. (1998). Les unités de mesures de qualité. *Info. Centre Technique Interprofessionnel des Fruits et Légumes (Ctifl)*, *141*, 34-36.

Willer, H., & Lernoud, J. (Eds.) (2019). *The world of organic agriculture. Statistics and emerging trends.* Rheinbreitbach, Germany. https://www.organic-world.net/yearbook/yearbook-2019/pdf.ht.