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Postharvest Chemical, Sensorial and Physical-Mechanical Properties of Wild Apricot (*Prunus armeniaca* L.)

Evica MRATINIĆ[1], Bojan POPOVSKI[2], Tomo MILOŠEVIĆ[3*], Melpomena POPOVSKA[4]

[1]*University of Belgrade, Faculty of Agriculture, Nemanjina 6, 11080 Belgrade-Zemun, Serbia*

[2]*University of "Sts. Cyril and Methodius", Faculty of Agricultural Sciences and Food, Avenue Aleksandar Makedonski bb, 1000 Skopje, Macedonia*

[3]*University of Kragujevac, Faculty of Agronomy, Cara Dusana 34, 32000 Cacak, Serbia; tomom@tfc.kg.ac.rs (*corresponding author)*

[4]*Fruit Growing Institute, Avenue Aleksandar Makedonski bb, 1000 Skopje, Macedonia*

Abstract

Some chemical, sensorial and physical-mechanical properties of 19 apricot genotypes and 'Hungarian Best' (control) such as moisture content, soluble solids content, titratable acidity ratio and their ratio, fruit and stone mass, flesh/stone ratio, fruit dimensions (length, width, thickness), arithmetic and geometric mean diameter, sphericity, surface area and aspect ratio were determined. Their application is also discussed. The highest moisture content and stone mass observed in 'X-1/1/04' and 'X-1/2/04', soluble solids content in 'ZO-1/03', titratable acidity in 'ZL-2/03', SS/TA ratio in 'ZL-1/03', and fruit mass and flesh/stone ratio in 'DL-1/1/04' genotype. The most number of genotypes have orange and deep orange skin and flesh colour, respectively, whereas sweet kernel taste was predominant in most genotypes. Regarding physical-mechanical properties, the superior fruit dimensions (length, width, thickness), arithmetic and geometric mean diameter and surface area observed in 'DL-1/1/04' genotype, whereas the highest sphericity and surface area observed in 'X-1/1/04' and 'X-1/2/04' genotypes. Also, the series of genotypes evaluated have better chemical, sensorial and physical-mechanical properties than 'Hungarian Best' (control). Finally, information about these properties is very important for understanding the behaviour of the product during the postharvest operations.

Keywords: chemical, fruit, sensorial and physical properties, wild apricot genotypes

Introduction

Apricots are cultivated worldwide mainly for their high-quality fruit, which is consumed fresh, processed by the food industry, or preserved by drying (Ghita, 2008; Haciseferogullari *et al.*, 2007). Native apricot in Macedonia has a long history of cultivation and is propagated by seedlings. Characterized with numerous types and forms are well adapted to local agro-ecological conditions, and called "zerdelija" (from Turkish "zerdali"-wild apricot). In this country, especially in the Region of Skopje, apricot plays a significant role in regional economic development (Ristevski and Mitreski, 1986). However, fruits produced in traditional orchards are not appropriate for the modern market (Milošević *et al.*, 2010).

Apricot has an important place in human nutrition. The fruit of apricot is not only consumed fresh but also used to produce dried apricot, frozen apricot, jam, jelly, marmalade, pulp, juice, nectar, extrusion products. Apricot is rich in minerals such as K, Ca, Mg, Na, Fe, Zn (Wills *et al.*, 1983), and vitamins such as β-carotene which is the pioneer substance of mineral A, is necessary for ephithelia tissues covering our bodies and organs, eye-health, bone and teeth development and working of endocrine glades (Haciseferogullari *et al.*, 2007). It is also widely used for traditional medicinal purposes. Moreover, apricot kernels are use in the production of oils, benzaldehyde, cosmetics, active carbon, aroma perfume, and consumption (Mandal *et al.*, 2007).

Fruit quality was defined by Kramer and Twigg (1966) as the conjunction of physical and chemical properties which give good appearance and acceptability to the consumable product. Abbott (1999) indicated that quality is a human concept, which includes sensory properties (appearance, texture, taste and aroma), nutritional values, chemical compounds, mechanical properties and functional properties. Many studies have reported on the chemical (Akin *et al.*, 2008; Milošević *et al.*, 2010; Ruiz *et al.*, 2005; Ruiz and Egea, 2008), sensorial (Egea *et al.*, 2006; Krška *et al.*, 2009) and physical-mechanical properties of apricot fruits (Haciseferogullari *et al.*, 2007; Jannatizadeh *et al.*, 2008; Kan and Asma, 2010).

Agricultural crops and food products have several unique characteristics, which set them apart from engineering materials, and these properties determine the quality of the fruit. In addition, the determination of physical properties of agricultural materials is important to design machines and processes for harvesting, handling and storage of these materials and requires understanding for converting these materials into food and feed (Celik and Er-

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cisli, 2009). For fruits, vegetables and grapes, dimensions (length, diameter and thickness) are widely used properties to describe them. Information regarding to dimensional attributes is used in describing fruit shape which is often necessary in horticultural research for a range of differing purposes, including cultivar descriptions in applications for plant variety rights or cultivar registers (Beyer *et al.*, 2002), evaluation of consumer preference, investigation of heritability of fruit shape traits (White *et al.*, 2000), and/or analysis of stress distribution in the fruit skin (Considine and Brown, 1981). For example, fruit shape is very important in sorting, sizing and determination of how many fruits can be placed in shipping containers or plastic bags of a given size (Keramat Jahromi *et al.*, 2008). Other physical properties such as fruit mass and flesh/stone ratio, as one of the most important external quality parameters for consumer acceptability (Milošević *et al.*, 2010; Ruiz and Egea, 2008) are important to design fluid velocities for transportation (Mohsenin, 1986). For these reasons, the physical properties of apricot can be important for design of equipments for processing, transportation, sorting, separating and also packing.

There are two specific objectives of this study. The first is to determine the chemical, sensorial and physical-mechanical properties of 19 apricot genotypes ("zerdelija") widely grown in Macedonia. The second is to produce a convenient reference table with chemical, sensorial and physical-mechanical information suitable for the evaluation of nutritional information, design of equipments for harvesting, transportation, sorting, separation and packing.

Materials and methods

Study area and plant material

The study was conducted in the Skopje Region (42°N latitude, 21°E longitude, 240-460 m altitude), Macedonia. The material used for studies included previously selected wild apricot (*Prunus armeniaca* L.) trees during harvest seasons of years 2003 and 2004. A total of 19 promising genotypes, candidates for new cultivars, having superior fruit properties were selected from over 1,100 native seedling trees of wild apricot (local name "zerdelija"). The first selection from a diverse gene pool was conducted by local farmers in order to obtain certain desirable traits. These apricot trees were grown in agricultural fields or parcels, where the farmer has permitted their development for any reason. Now, the farmer uses these trees, but he does not perform agricultural maintenance (e.g. pruning or fertilization) on them. 'Hungarian Best' was used as control cultivar.

Chemical and sensorial analyses

The chemical and sensorial properties of apricot genotypes were determined by the AOCS Official method (AOAC, 1984) and by the IBPGR descriptor for apricot, respectively. Ripe fresh apricot fruits of 19 genotypes and control were used for all the experiments discussed in this study. Apricot fruits were kept in cooled bags for transport to the laboratory. The fruits were cleaned in an air screen cleaner to remove all foreign matter such as dust, dirt, immature and damaged fruits.

For moisture content (M), samples were prepared for analysis by grinding about 100 g of fruit to pass through a sieve with circular openings of 1 mm diameter and mixed thoroughly. Two grams of the comminuted material were dried in a hot-air ST-01/02 (Instrumentaria, Zagreb, Croatia) oven at 80°C for 10 h, cooled in desiccators and weighed. Weight loss on drying to a final constant weight was recorded as moisture content of the material. Data are given in %. Soluble solids content (SSC) was determined by Milwaukee MR 200 (ATC, Rocky Mount, USA) hand digital refractometer and expressed as Brix°. Titratable acidity (TA), as malic acid (%), was determined by titration to pH 8.1 with N/10 NaOH. On the basis of the measured data, soluble solids/titratable acidity ratio (SS/TA ratio or ripening index-RI) was calculated. The described skin ground colour (SGc), flesh colour (FC) and kernel taste (KT) were categorized according to IBPGR descriptors for apricot (Guerriero and Watkins, 1984).

Physical-mechanical properties

Fifty fruits were individually analyzed for each physical-mechanical property. Fruit mass (FM) and stone mass (SM) were determined using a Tehnica ET-1111 technical scale (Iskra, Kranj, Slovenia) to an accuracy of 0.01 g. Data are given in g. For determining flesh/stone ratio (FSr), fruits were cut in half horizontally with a stainless-steel knife and the stones were removed and weighed. The flesh content was calculated by subtracting the stone mass from the whole apricot fruit mass. Data are given in %. For each apricot fruit, three linear dimensions, length (L), width (W), and thickness (T), were measured by using a digital caliper gauge with a sensitivity of 0.001 cm. The measurement of length was made on the polar axis of fruit, i.e. between the apex and stem. The arithmetic mean diameter (D_a), geometric mean diameter (D_g), sphericity (φ) and surface area (S) was calculated by using the following relationships (Mohsenin, 1986):

$$D_a = \frac{L + W + T}{3} \qquad (1)$$

where: D_a-arithmetic mean diameter (cm), L-length of apricot fruit (cm), W-width of apricot fruit (cm), T-thickness of apricot fruit (cm),

$$D_g = LWT^{\frac{1}{3}} \qquad (2)$$

where: D_g-geometric mean diameter (cm),

$$\varphi = \frac{D_g}{L} \quad (3)$$

where: φ-sphericity (%),

$$S = \pi D_g^{\,2} \quad (4)$$

where: S-surface area (cm^2).

The aspect ratio (R_a) was calculated (Maduako and Faborode, 1990) as:

$$R_a = \frac{W}{L} 100 \quad (5)$$

where: R_a-aspect ratio (%).

The above experiments were performed in 50 replicates.

Statistical analysis

Data obtained were statistically analyzed using analysis of variance (ANOVA), while the treatment means, compared with LSD test at P ≤ 0.05, using the MSTAT-C statistical computer package (Michigan State University, East Lansing, MI, USA). Data in tables are mean±SE for two successive years.

Results and discussion

Evaluation of chemical and sensorial properties

The chemical and sensorial properties of apricot fruits are given in Tab. 1. The average M ranged from 85.60±1.66% ('K-3/1/04') to 88.30±1.34% ('X-1/1/04'). On the other hand, 11 genotypes have higher M than control, whereas other differences were insignificant. In addition, the present range values are in a good accordance with previous works carried out in apricot (Akin *et al.*, 2008; Wills *et al.*, 1983), whereas higher than those obtained by Haciseferogullari *et al.* (2007) who reported that in some group of Turkish apricot cultivars moisture content varied from 76.37 to 82.27%. The differences between the present results and those of the Haciseferogullari *et al.* (2007) could be due to the different eco-geographical groups. This indicates that the drying process should be faster in the genotypes with lower moisture content. Also, the genotypes with ≤83% moisture content have a desired good fruit property for dried apricot, as previously reported by Ruiz and Egea (2008). In addition, all colour characteristics of dried apricot were affected by the moisture content. For example, as the moisture contents increased, the lightness and yellowness color values increase, while the redness value decreased for the dried apricots at all moisture levels (Özkan *et al.*, 2003).

Regarding SSC, values ranged between 11.70±0.41 °Brix ('X-1/1/04') and 14.40±0.55 °Brix ('K-3/1/04') (Tab. 1). All genotypes, excepting 'X-1/1/04' and control, had a SSC >12 °Brix. Ruiz and Egea (2008) reported that SSC is a very important quality attributes influencing notably the sweetness and taste of fruits. In another study, 37 apricot varieties cultivated in Spain were tested and soluble solid content of ripe fruits reported to vary in the range of 10.4-17.0% (Ruiz *et al.*, 2005).

The present SSC results are within these limits, but generally were lower than those of a Turkish genotypes' group's (Asma *et al.*, 2007; Kan and Asma, 2010). The differences between the present results and those of the above authors were likely due to the different eco-geographical groups of apricot genotypes. The TA ranged from 0.89±0.12% to 1.89±0.13%; it was lower than 1% in 5 genotypes ('X-1/2/04', 'ZO-1/03', 'DL-1/2/04', 'D-1/04' and 'ZL-1/03') (Tab. 1). Moreover, the 6 genotypes had significantly lower, and 10 genotypes had significantly higher TA than 'Hungarian Best', respectively. Ruiz *et al.* (2005) reported that TA in the fruit of 37 apricot cultivars grown in Spain varied from 0.90 to 2.44%, which supports the present findings. However, the present range values were higher than those obtained by Haciseferogullari *et al.* (2005), Akin *et al.* (2008), Kan and Asma (2010) for Turkish apricot cultivars, probably due to the different eco-geographical group of cultivars studied. Moreover, according to the present results, 'K-3/1/04', 'VB-1/04', 'T-7/04', 'T-9/03' and 'ZL-2/03' were found to be outstandingly acidic genotypes in comparison with other apricot genotypes studied. Acidity plays an important role in selecting proper preservation method for fruits. Due to the increasing concentration of organic acids in fruit mass with decreasing water content, above genotypes were expected to become extremely sour after dried, as previously obtained by Durmaz *et al.* (2010). In general, fruit maturity stage at the harvest date is the principal factor affecting fruit acidity also the soluble solids content.

In the present case soluble solids/titratable acidity ratio (RI), values ranged from 6.63±0.33 ('DL-1/1/04') to 14.94±0.95 ('ZL-1/03') (Tab. 1). In four genotypes, this ratio was significantly higher than in the control cultivar at P ≤ 0.05. On the other hand, in eleven genotypes SSC/TA ratio was lower than in the control (Gurrieri *et al.*, 2001). Fruit maturity controls the quality attributes, such as SSC, TA, firmness, and market life potential. The relationship between SSC and TA (RI) has an important role in consumer acceptance of fresh apricot, peach, nectarine and plum cultivars, as it has been previously mentioned (Crisosto *et al.*, 2004). Above authors stated that in the case of cultivars with TA >0.90% and SSC <12.0%, consumer acceptance was controlled by the interaction between TA and SSC rather than SSC alone.

Regarding sensorial traits, the most of genotypes have orange (8 genotypes), deep orange (9 genotypes) and sweet (11 genotypes) SGc, FC and KT, respectively, as previously described by Milošević *et al.* (2010). Orange to deep orange colour is considered desirable, as it corresponds to an ideal type of apricot fruit (Egea *et al.*, 2006;

Tab. 1. Chemical, sensorial and some physical-mechanical properties of 19 apricot genotypes and control cultivar

Genotypes	Moisture content (%)	Soluble solids (°Brix)	Titratable acidity (%)	SS/TA ratio	SGc*	FC*	KT*	Fruit mass (g)	Stone mass (g)	Flesh/stone ratio (%)
'X-1/1/04'	88.30 ± 1.34 a	11.70 ± 0.41 h	1.32 ± 0.02 f	8.86 ± 0.88 gh	4	3	1	36.12 ± 2.56 ij	2.37 ± 0.14 q	93.47 ± 2.49 ab
'X-1/2/04'	87.90 ± 1.98 a	12.10 ± 0.54 h	0.96 ± 0.02 jk	12.60 ± 0.63 c	1	3	1	52.53 ± 3.32 cd	4.85 ± 0.17 a	90.77 ± 1.43 hi
'K-5/04'	86.90 ± 2.01 bc	13.10 ± 0.57 fg	1.46 ± 0.04 cd	8.97 ± 0.93 gh	5	6	3	39.25 ± 2.44 hi	2.71 ± 0.42 o	93.09 ± 2.13 b-e
'ZO-1/03'	85.70 ± 1.65 h	14.30 ± 0.59 a	0.98 ± 0.02 ij	14.59 ± 0.66 ab	5	5	3	23.40 ± 1.62 k	1.81 ± 0.13 r	92.26 ± 1.66 def
'VB-1/04'	85.90 ± 1.73 gh	14.10 ± 0.60 ab	1.52 ± 0.05 c	9.28 ± 0.78 g	6	8	3	40.78 ± 3.38 gh	2.52 ± 0.14 p	93.82 ± 1.11 a
'DL-1/2/04'	86.40 ± 1.91 def	13.60 ± 0.43 cde	0.99 ± 0.01 ij	13.74 ± 0.72 b	6	8	1	53.56 ± 3.32 cd	3.93 ± 0.17 f	92.66 ± 1.09 c-f
'ZL-1/3/04'	86.70 ± 1.87 cde	13.30 ± 0.39 def	1.43 ± 0.05 de	9.30 ± 0.81 fg	6	8	3	40.98 ± 2.55 gh	3.36 ± 0.16 k	91.69 ± 1.89 f-i
'K-3/1/04'	85.60 ± 1.66 h	14.40 ± 0.55 a	1.51 ± 0.04 c	9.53 ± 0.83 fg	6	8	1	47.11 ± 3.43 ef	3.22 ± 0.15 m	93.17 ± 1.99 bcd
'T-7/04'	86.70 ± 1.86 cde	13.30 ± 0.46 def	1.60 ± 0.05 b	8.31 ± 0.49 h	1	3	1	51.79 ± 3.32 cd	3.91 ± 0.16 g	92.36 ± 1.55 c-f
'G-12/04'	86.90 ± 1.89 bc	13.10 ± 0.56 fg	1.05 ± 0.02 i	12.48 ± 0.59 c	7	8	1	35.23 ± 2.24 j	2.94 ± 0.15 n	90.60 ± 1.57 ij
'T-9/03'	86.40 ± 1.43 def	13.60 ± 0.73 cde	1.66 ± 0.05 b	8.19 ± 0.80 h	7	8	3	38.64 ± 2.87 hij	3.37 ± 0.15 k	91.06 ± 1.54 ghi
'N-4/03'	86.80 ± 2.11 bcd	13.20 ± 0.39 efg	1.21 ± 0.03 gh	10.91 ± 0.75 ef	6	8	1	40.75 ± 3.21 gh	3.24 ± 0.15l l	91.95 ± 2.01 efg
'D-1/04'	86.20 ± 1.33 fg	13.80 ± 0.43 bc	0.97 ± 0.01 j	14.23 ± 0.65 ab	4	8	2	39.78 ± 2.48 hi	4.28 ± 0.17 c	88.66 ± 1.22 j
'ZL-2/03'	86.30 ± 1.78 efg	13.70 ± 0.53 bcd	1.89 ± 0.02 a	7.25 ± 0.0.43 i	6	7	3	44.26 ± 3.77 fg	3.25 ± 0.15 l	92.54 ± 1.13 c-f
'N-2/03'	86.80 ± 1.76 bcd	13.20 ± 0.49 efg	1.16 ± 0.05 h	11.38 ± 0.49 de	6	8	1	49.94 ± 3.46 dc	3.97 ± 0.17 e	91.85 ± 1.88 fgh
'ZL-1/03'	86.70 ± 2.33 cde	13.30 ± 0.58 def	0.89 ± 0.01 k	14.94 ± 0.95 a	5	5	3	51.30 ± 3.77 d	3.88 ± 0.16 h	92.42 ± 1.97 c-f
'DL-1/1/04'	86.80 ± 1.83 bcd	13.20 ± 0.48 efg	1.37 ± 0.04 ef	6.63 ± 0.33 i	7	7	1	89.29 ± 2.98 a	4.70 ± 0.18 b	94.50 ± 2.71 a
'L-2/04'	86.00 ± 1.77 fgh	14.00 ± 0.71 abc	1.24 ± 0.03 g	11.29 ± 0.48 de	4	6	1	55.59 ± 3.42 c	3.64 ± 0.16 i	93.42 ± 2.57 abc
'T-5/04'	87.20 ± 1.85 b	12.80 ± 0.33 g	1.34 ± 0.04 f	9.55 ± 0.85 fg	5	6	3	52.32 ± 2.95 cd	3.61 ± 0.16 j	93.11 ± 2.69 bcd
'HB'**	85.95 ± 1.83 fgh	14.05 ± 0.58 abc	1.18 ± 0.03 gh	11.91 ± 0.54 cd	6	6	1	61.11 ± 3.78 b	4.13 ± 0.17 d	93.18 ± 1.88 bcd

*IBPGR Descriptor list for apricot (Guerriero and Watkins, 1984): Skin ground colour (SGc): 1=green-yellowish, 2=light cream, 3=cream, 4=yellow, 5=light orange, 6=orange, 7=dark orange; Flesh colour (FC): 1=white-greenish, 2=white, 3=light cream, 4=cream, 5=yellow, 6=light orange, 7=orange, 8=deep orange, 9=red, and Kernel taste (KT): 1=sweet, 2=weak bitterness, 3=strong bitterness; **'HB'-The control apricot cultivar 'Hungarian Best'; Values in the same column followed by different small letters indicate significant differences between means (P ≤ 0.05) by LSD test

Krška *et al.*, 2009). In addition, the most representative apricot cultivar. 'Hacýhaliloğlu' from Malatya (Turkey), had yellow skin and flesh colour (Kan and Asma, 2010). Some authors reported that quality indicators as color parameters are useful to decide fruit maturity stage and the appropriate harvest time (Petrisor *et al.*, 2010). Apricot kernel is an important edible by-product of apricot production (Durmaz and Alpaslan, 2007; Yilmaz, 1994), this data could be important in estimating the kernel rate of different apricot cultivars. Regarding KT, in cultivars belonging to the European group, sweet taste predominates (Badenes *et al.*, 1998), which supports the preseent findings. Similar data was reported by Kan and Asma (2010) for 'Hacýhaliloğlu' Turkish cultivar.

Evaluation of physical-mechanical properties

The FM, SM, FSr and fruit linear dimensions (L, W, T) of 19 apricot genotypes and control cultivar are summarized in Tab. 2. According to the results, the most of the above fruit characteristics of the different apricot genotypes were found to be statistically significant. The FM varied between 23.40±1.62 g ('ZO-1/03') and 89.29±2.98 g ('DL-1/1/04'). It can be said that 12 genotypes have FM less than 50 g. It is well known that FM within the same apricot genotypes is very variable. However, the FM was significantly higher in 'DL-1/1/04' than control, and significantly lower in rest genotypes.

Attractive medium-sized fruits are desired for apricot cultivar breeding (Guerriero *et al.*, 2006), and important quality characteristic in respect of the harvest yield and consumer acceptance (Durmaz *et al.*, 2010; White *et al.*, 2000). In general, the present range values were higher than those for a group of Turkish (Asma *et al.*, 2007) and Iranian cultivars (Jannatizadeh *et al.*, 2008). The differences between the present results and those of the above authors could be due to the different eco-geographical groups of apricot cultivars studied. Previous study on apricot also suggested a high variability among genotypes regarding this parameter (Milošević *et al.*, 2010; Ruiz and Egea, 2008). In addition, this property may be useful in the separation and transportation of the fruit by hydrodynamic means in water canals (Jannatizadeh *et al.*, 2008), and other processes related to apricot fruits (Khanali *et al.*, 2007). According to the obtained results in Tab. 2, the mean SM ranged from 1.81±0.13 g ('ZO-1/03') to 4.85±0.17 g ('X-1/2/04'), whereas FSr varied from 88.66±1.22% ('D-1/04') to 94.50±2.71% ('DL-1/1/04'). In the present study SM was significantly lower in 16 genotypes than 'Hungarian Best', and FSR was significantly higher in 2 genotypes than control. It is a well-known fact that apricot stones are used in genotype identification (Depypere *et al.*, 2007) and had a high utilization value (Mandal *et al.*, 2007). The higher FSr is a desired fruit property in apricot, as previously reported by Milošević *et al.* (2010).

Regarding fruit dimensions, the apricot genotypes have a range of 3.82±0.07-5.65±0.09 cm, 3.46±0.04-5.57±0.06 cm and 3.33±0.02-5.11±0.07 cm for average L, W and T, respectively (Tab. 2). The highest values registered in 'DL-1/1/04', whereas the lowest fruit dimensions had 'X-1/1/04', which is in agreement with previous study in apricot belonging to the European group (Milošević *et al.*, 2010; Ristevski and Mitreski, 1986;). It seems that fruit mass and dimensions are important properties that distinguish apricot cultivars. Moreover, the importance of dimensions is in the determination of the aperture size of machines, particularly in separation of materials as discussed by Mohsenin (1986). These dimensions could be used for designing machine components and parameters. For example, to design a mechanism for mechanical harvesting of apricot cv. 'Hacthaliloglu', Erdogan *et al.* (2003) reported length, width, and thickness of the fruit as 38.94, 40.92, and 35.21 mm, respectively. However, in the present study, only genotypes 'X-1/1/04' and 'ZO-1/03' have similar values when compared with cv. 'Hacthaliloglu', whereas the rest of the genotypes, including the control, have greatly higher dimensions. In addition, the characteristics that correlate best with fruit attractiveness include fruit dimensions (Badenes *et al.*, 1998).

Data in Tab. 2 showed that D_a and D_g values were very similar. In general, the D_a values were a little higher than D_g values in genotypes 'K-5/04', 'VB-1/04', 'K3-/1/04', 'T-7/04', 'G-12/04', 'D-1/04', 'N-2/03', 'ZL-1/03', 'L-2/04' and 'G-12/04'. Moreover, values regarding D_a and D_g ranged from 3.42±0.03 cm ('ZO-1/03') to 5.44±0.07 cm ('DL-1/1/04'). These values were significantly lower only in 'ZO-1/03' than the control. In a study conducted by Jannatizadeh *et al.* (2008), the highest geometric mean diameter for apricot found in 'Djahangiri' and 'Shams', with means of 45.27 and 44.06 mm, respectively, but the lowest ones were for 'Sefide Damavand' and 'Nakhjavan', with average of 38.83 and 37.35 mm, respectively. In addition, the above authors reported that knowledge related to geometric mean diameter would be valuable in designing the grading process. Moreover, the D_g results for set of apricot genotypes are within the limits of these studies. The fruit shape is determined in terms of its sphericity and aspect ratio. The φ values differed significantly among the tested genotypes (Tab. 2). The highest values observed in 'X-1/1/04' and 'X-1/2/04' (1.02±0.02), and the lowest in 'G-12/04' (0.91±0.01). Also, the present results showed that φ value was significantly lower than 'Hungarian Best' only in one genotype ('G-12/04'). Other differences among control and rest genotypes were not observed. Previous study on apricot reported that sphericity values in Iranian apricot cultivars varied from 0.875 to 0.973 (Jannatizadeh *et al.*, 2008). The differences between the present results and those of the above authors were likely due to the different eco-geographical group of apricot genotypes. The R_a of fruit significantly varied between 92.76±0.05% ('G-12/04') and 103.66±0.04% ('X-1/1/04'), but only two genotypes have lower values than control, whereas other differences were insignificant. Generally, sphericity

Tab. 2. Fruit linear dimensions, arithmetic mean diameter, geometric mean diameter, sphericity, aspect ratio and surface area of apricot genotypes

Genotypes	Fruit length (mm)	Fruit width (mm)	Fruit thickness (mm)	Arithmetic mean diameter (mm)	Geometric mean diameter (mm)	Sphericity	Aspect ratio (%)	Surface area (mm²)
'X-1/1/04'	38.2 ± 0.7 n	39.6 ± 0.2 de	38.9 ± 0.2 kl	38.90 ± 0.4 bc	38.89 ± 0.4 bc	1.02 ± 0.02 a	103.66 ± 4.3 a	4751.48 ± 198.3 i
'X-1/2/04'	48.1 ± 0.6 e	49.5 ± 0.8 ab	49.6 ± 0.4 b	49.10 ± 0.6 ab	49.16 ± 0.6 ab	1.02 ± 0.02 a	102.91 ± 7.2 a	7569.12 ± 311.1 b
'K-5/04'	42.1 ± 0.6 k	40.8 ± 0.5 cde	36.1 ± 0.3 l	39.67 ± 0.5 bc	39.58 ± 0.5 bc	0.94 ± 0.01 b-e	96.91 ± 5.0 def	4919.05 ± 201.1 hi
'ZO-1/03'	34.7 ± 0.2 o	34.6 ± 0.4 e	33.3 ± 0.2 m	34.20 ± 0.3 c	34.19 ± 0.3 c	0.98 ± 0.01 a-d	99.71 ± 3.3 a-e	3670.52 ± 119.3 j
'VB-1/04'	42.5 ± 0.5 j	42.1 ± 0.3 b-e	38.9 ± 0.3 kl	41.17 ± 0.4 bc	41.13 ± 0.4 bc	0.97 ± 0.01 a-e	99.06 ± 4.9 a-e	5311.86 ± 211.8 fgh
'DL-1/2/04'	46.8 ± 0.7 f	48.0 ± 0.7 abc	45.0 ± 0.5 d	46.60 ± 0.6 ab	46.58 ± 0.6 ab	0.99 ± 0.02 abc	102.56 ± 7.2 a	6812.85 ± 261.9 cd
'ZL-1/3/04'	41.5 ± 0.5 m	42.3 ± 0.2 b-e	41.3 ± 0.4 h	41.70 ± 0.4 bc	41.70 ± 0.4 bc	1.00 ± 0.02 ab	101.93 ± 3.3 abc	5460.11 ± 286.2 fg
'K-3/1/04'	44.0 ± 0.8 g	45.5 ± 0.3 bcd	42.7 ± 0.6 g	44.07 ± 0.6 abc	44.05 ± 0.6 abc	1.00 ± 0.02 ab	103.41 ± 5.6 a	6092.86 ± 239.5 e
'T-7/04'	48.2 ± 0.9 e	49.2 ± 0.7 ab	43.6 ± 0.6 ef	47.00 ± 0.7 ab	46.93 ± 0.7 ab	0.97 ± 0.01 a-e	102.07 ± 8.0 ab	6915 ± 298.4 cd
'G-12/04'	42.8 ± 0.6 i	39.7 ± 0.4 de	35.4 ± 0.3 l	39.30 ± 0.4 bc	39.18 ± 0.04 bc	0.91 ± 0.01 e	92.76 ± 5.4 f	4820.13 ± 199.3 i
'T-9/03'	44.4 ± 0.7 f	43.2 ± 0.5 bcd	39.4 ± 0.2 j	42.33 ± 0.5 abc	42.28 ± 0.5 abc	0.95 ± 0.01 b-e	97.30 ± 6.6 c-f	5613.06 ± 268.3 f
'N-4/03'	41.8 ± 0.4 l	40.8 ± 0.4 cde	37.8 ± 0.2 l	40.13 ± 0.3 bc	40.10 ± 0.3 bc	0.96 ± 0.01 a-e	97.61 ± 4.8 b-f	5049.15 ± 235.1 ghi
'D-1/04'	42.7 ± 0.4 ij	44.1 ± 0.7 bcd	38.1 ± 0.3 l	41.63 ± 0.5 bc	41.55 ± 0.5 bc	0.97 ± 0.01 a-e	103.28 ± 5.2 a	5420.90 ± 300.2 fg
'ZL-2/03'	43.5 ± 0.6 h	41.5 ± 0.5 b-e	39.2 ± 0.3 jk	41.40 ± 0.5 bc	41.36 ± 0.5 bc	0.95 ± 0.01 b-e	95.40 ± 5.5 ef	5371.44 ± 209.7 fgh
'N-2/03'	49.1 ± 0.7 d	48.8 ± 0.8 abc	46.0 ± 0.4 c	47.97 ± 0.6 ab	47.94 ± 0.6 ab	0.97 ± 0.01 a-e	99.39 ± 7.1 a-e	7216.48 ± 314.3 bc
'ZL-1/03'	48.0 ± 0.6 e	46.4 ± 0.7 bcd	43.8 ± 0.3 e	46.06 ± 0.5 abc	46.03 ± 0.5 abc	0.96 ± 0.01 a-e	96.67 ± 6.3 def	6652.91 ± 254.7 d
'DL-1/1/04'	56.5 ± 0.9 a	55.7 ± 0.6 a	51.1 ± 0.7 a	54.43 ± 0.7 a	54.38 ± 0.7 a	0.97 ± 0.01 a-e	98.58 ± 8.8 a-e	9285.56 ± 348.7 a
'L-2/04'	51.0 ± 0.5 b	48.8 ± 0.5 abc	42.9 ± 0.5 fg	47.57 ± 0.5 ab	47.44 ± 0.5 ab	0.93 ± 0.01 cde	95.69 ± 5.9 def	7066.74 ± 317.2 cd
'T-5/04'	50.3 ± 0.8 c	48.4 ± 0.5 abc	40.2 ± 0.2 i	46.30 ± 0.5 abc	46.08 ± 0.5 abc	0.92 ± 0.01 de	96.22 ± 7.3 def	6667.37 ± 257.3 d
'HB'*	49.1 ± 0.7 d	49.2 ± 0.5 ab	46.4 ± 0.5 c	48.23 ± 0.6 ab	48.21 ± 0.6 ab	0.98 ± 0.01 a-d	100.20 ± 6.5 a-d	7298.00 ± 303.6 bc

*'HB'-The control apricot cultivar 'Hungarian Best'; Values in the same column followed by different small letters indicate significant differences between means ($P \leq 0.05$) by LSD test

is an expression of the shape of a solid related to that of a sphere of the same volume while the aspect ratio relates the width to the length of the fruit, being the indicative of its tendency toward its oblong shape (Celik and Ercisli, 2009; Omobuwajo *et al.*, 1999).

According to the results, the S significantly differed among genotypes (Tab. 2). The highest value was observed in 'DL-1/1/04' (9285.56±348.7 mm^2), and the lowest in 'ZO-1/03' (3670.52±119.3 mm^2). On the other hand, 14 genotypes have significantly lower S than the control. The results for the S are due to the differences in values of dimensional properties (Celik and Ercisli, 2009; Jannatizadeh *et al.*, 2008; Ozturk *et al.*, 2009), because 'DL-1/1/04' and 'ZO-1/03' have the highest and the lowest dimensional properties, respectively. In comparison with previous studies, average surface area values of different apricot cultivars were between 2646.27 and 5351.69 mm^2 for Turkish apricot cultivars (Hacisefrogullari *et al.*, 2007), and/or between 4395.25 and 6458.35 mm^2 for Iranian apricot cultivars (Jannatizadeh *et al.*, 2008). The 8 studied genotypes in the present study, including the control, have higher S values than 6458.35 mm^2, whereas other values were within the limits of above studies. The S values may be important for apricot drying because could be beneficial in proper prediction of apricot drying rates and hence drying times in the dryer, especially in the drying equipment simulation models for apricot.

Conclusions

Data obtained in this research are the first ones for the wild apricot fruits grown in Macedonia. These properties may help to select a set of genotypes with better fruit quality performances for growing in orchard under modern cultural practices. On the other hand, these data will have a real potential usage in harvest, transportation, classification, processing, storing, packaging, drying and other processes related to apricot fruits.

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