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PHYSICAL AND CHEMICAL CHARACTERISTICS OF POMEGRANATE (*Punica granatum* L.), CULTIVAR KARAMUSTAFA

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Abstract

Pomegranate is fruit species well-adapted to arid and semi-arid conditions and highly valued crop widely cultivated in Mediterranean and Near Asia countries. The most important pomegranate cultivars in Macedonia are "Bejnarija", "Lifanka" and "Karamustafa". The objective of this study was to evaluated physical and chemical parameters of pomegranate cultivar "Karamustafa", collected from two different location of the R. Macedonia. The physical parameters include fruit fresh weight, percentage of grain (%), weight of 100 berries (g), and percentage of juice (%). The cultivar "Karamustafa" (239.57- 304.79 g) belongs to a group of large fruits. The yield juice ranged from 47.83 % (Valandovo) to 50.63 % (Josifovo). Based on the content of the total acids (TA), the cultivar "Karamustafa" belongs to a group of sweet cultivar (TA<1).

Based on the results we found significant differences in the weight of the fruit, the content of the total acids and the content of the total polyphenols in the juice.

Key words: *Punica granatum L., fruits, juice, total acids, total polyphenols*

INTRODUCTION

The pomegranate (*Punica granatum* L.) belongs to the *Punicaceae* family, the genus *Punica* L. (Fond Quer, 1979). It is a diploid species whose somatic number is 2n=16, and haploid chromosomes = 8 (Westwood, 1982) or 2n=16 or 18 (Mars, 1998).

Pomegranate (*Punica granatum* L.) is an important commercial fruit crop that is extensively cultivated in port of Asia, Nort Africa and the more Mediterranean regions. All parts of the tree (leaves, flowers, and roots) are used for medical purposes for centuries (Godwa et al., 2009).

The total area of pomegranate cultivation in the world is well above 300.000 ha, which, more than 76% is found in these countries: India, Iran, China, Turkey and the USA (Melgarejo et al., 2012) with production higher than 3.000.000 t. The fruits are consumed fresh or processed into juice, jams, syrup and sauce (Fawole et al., 2011).

Consumption of pomegranate fruit and juice in the words is increasing very fast, because of its health benefits, high antioxidant capacity and the high content of polyphenols and anthocyanins (Zarei et al., 2010). Pomegranate juice is extremely nutritious, it has medicinal properties that include: sugars, citric and boric acid, pectin, vitamins, iodine, iron and other useful ingredients (Zarei et al., 2011).

Recent studies suggest that pomegranate juice contains anticancer, antimicrobial and antiviral components (Schwartz et al., 2009; Reddy et al., 2007; Kotwal, 2007). Pomegranate fruits' maturity is estimated by the skin colour, juice colour, and juice acidity (Al-Said et al., 2009), all of which vary by cultivar. Pomegranate fruits can be harvested when they reach a suitable size and the colour of skin achieves the desired pigment. The main parameters of maturity are TSS (total soluble solids), TA (total acids) and TSS/TA ratio (Pekmezci and Erkan, 2004). In the production of pomegranate pesticides and fertilizers are not used which means that fruits represent a very healthy food rich in natural nutritional and medicinal properties (Hassan et al., 2012).

In Macedonia, the pomegranate is grown on an area of 50 ha, and it has 700 tons annual production. The most of the area are orchards and some individual trees in the gardens. The pomegranate is traditionally grown in Valandovo region, which is under the influence of Mediterranean climate. In this region, climatic soil conditions (length of 240 vegetation days, annual average temperature > 14,8 C°, the annual temperature sum > 5.200 C°, soils fertile, etc.), enable the successful cultivation of pomegranate, which is present in this area for centuries.

To the best of our knowledge there are no published results about the determination of physical, morphological and chemical properties of pomegranate fruits, arils and juices in the R. Macedonia. Therefore, the main object of this study was the determination of physical, morphological and chemical parameters of pomegranate cultivar "Karamustafa", grown in two different location of R. Macedonia.

MATERIALS AND METHODS

Pomegranate fruits of "Karamustafa" species were collected from pomegranate orchards located in 10 year old orchard in Valandovo and 20 year old orchard in Josifovo area in R. Macedonia. Trees were planted at the spacing of 2.5 x 3.0 m.

Eight fruits of three different flower levels or a total of 24 per cultivar from Josifovo and Valandovo location were taken for analysis (Tab. 1, Tab. 3; I, II and III repetition).

Physical characteristics

Fruit weight (g) and the weight of 100 arils (g) were measured using the analytical laboratory scale (Mettler Toledo XS). The percentage of peel (%) is calculated as the ratio between the peel weight and fruit weight multiplied by 100. The juice yield (%) is the squeezed juice (ml) of 100 g of fruit. Fruit color was determined by organoleptic method (Koppel et al., 2010). The juice analyzed the pH value, total soluble solids, the total acid content expressed in citric acid, the maturity index and the total phenolic compounds of the juice.

Statistical processing of the results of all three repetitions was performed. The correlation is represented by the statistical analysis of the results, using the software package for statistical data processing, SPSS 19.

Chemical analyses

Measurements were performed on fresh aril juice. Total soluble solids (°Brix) and salinity (%) were determined by using a digital refractometer (Krüss optronic DR 301-95) at 20°C, calibrated by using water distilled. Titratable acidity was estimated in titration with 0.1 N NaOH to the titration point of pH 8.3, monitored with a pH meter and expressed as citric acids content (g/L). Maturity index was calculated by dividing total soluble solids to titratable acidity. Juice's pH is measured with a pH meter ((100 ATC). Total polyphenolic content was measured by using the Folin-Ciocalteau method (Makkar et al., 1993).

The obtained results are processed by analyzing the variance using the programme package STATVIEW (SAS Institute Version 5.0). The differences between the mean values tested are LSD test for $p \leq 5$.

RESULTS AND DISCUSSION

The physical characteristics of the pomegranate fruit are presented in Table 1. From the results presented in the study, the fruits from the first repetition (I-first level of flowers) of "Karamustafa" cultivar from both locations (Valandovo, Josifovo) were the largest. On the other hand, the lowest fruits were determined from the third repetition (III level of flowers). In general, the average weight of fruits is 239.57 g in Valandovo and 304.79 g in Josifovo. According to the descriptor list for pomegranate (Bellini and Giordani, 1998), they belong to the group of large fruit cultivars (225-375 g). The difference in the weight of the fruit between the location is due to the age structure of the trees. The juice yield (%) varies from 47.83% in location Valandovo to 50.63% in Josifovo location, which is almost identical to some Croatian cultivars, 43.18-53.99% (Radunic and Gadze, 2011).

Table 1. Physical characteristics of pomegranate fruit of cultivar "Karamustafa" at the two locations.

Location	Repetition	Fruit weight (g)	Weight of 100 arils (g)	Juice yield (%)	Percentage of peel (%)	Color of fruit
Valandovo	I	285.43	27.86	48.26	42.14	Reddish yellow
	II	235.00	27.86	46.48	35.56	
	III	198.28	29.28	48.76	37.10	
	I-III	239.57	28.33	47.83	38.27	
Josifovo	I	421.25	38.75	50.36	33.68	Reddish yellow
	II	251.25	36.25	53.68	34.82	
	III	241.88	33.75	47.85	40.83	
	I-III	304.79	34.58	50.63	36.44	

The fruits of "Karamustafa" variety from the two sites were red in color, which is a characteristic of the variety.

The results of the correlation between the weight of the fruit, the weight of 100 arils, the percentage of peel and the juice yield were presented in Table 2.

Table 2. Pearson's coefficient of correlation between fruit weight ant weight of 100 arils, percentage of peel and yield of juice

Pearson's coefficient of correlation (ρ)					
Valandovo			Josifovo		
Fruit weight / Juice yield	Fruit weight / Percentage of peel	Fruit weight / Weight of 100 arils	Fruit weight / Juice yield	Fruit weight / Percentage of peel	Fruit weight / Weight of 100 arils
-,119	,791	-,817	-,034	,659	-,888

According to the Pearson correlation coefficient, we can conclude that there is a high correlation between the parameters. Negative values denote inverse proportional connection.

Among the physical parameters of the "Karamustafa" variety from the first location (Valandovo) shows a high correlation value. Both cultivars are highly dependent on the weight of the fruit and the percentage of the bark. The cultivar of the Valandovo location, ρ =, 791, while in the variety of the Josifovo location ρ =, 659. The dependence between the weight of the fruit and the juice yield is the lowest and the same is inversely proportional. The variety of the Valandovo is ρ = -, 119, while in the variety of the second location ρ = -, 034. Similarly, there is inverse relationship between the weight of the fruit and the weight of 100 arils. The variety of the Valandovo is ρ = -, 817, while for the variety of the Josifovo location ρ = -, 888.

Figure 1. Pomegranate "Karamustafa" (Valandovo).

Figure 2. Pomegranate "Karamustafa" (Josifovo).

Table 3. Chemical characteristics of pomegranate juice.

Location	Repetition	pH	TSS (^{0}Brix)	TA % (citric acid)	MI ^{0}Brix/TA	Salinity (%)	Total phenolic (mg/L)	Color of juice
Valandovo	I	3.31^{a}	13.8^{b,c}	0.56^{a}	2.49^{c}	12.7^{a,b}	978^{b}	Light pink
	II	3.30^{a}	13.5^{b,c}	0.55^{a}	2.44^{c}	12.5^{a,b}	981^{b}	
	III	3.32^{a}	12.1^{d}	051^{a,b}	2.20^{d}	12.8^{a,b}	980^{b}	
Josifovo	I	3.30^{a}	15.4^{a}	0.35^{c}	4.37^{a}	13.8^{a}	1014^{a}	Pink
	II	3.33^{a}	14.2^{b}	0.35^{c}	4.06^{a}	13.5^{a}	1015^{a}	
	III	3.32^{a}	14.0^{b}	0.35^{c}	3.94^{a}	13.5^{a}	1017^{a}	

Mean values followed by different lower-case letters in each column indicate significant difference among results at P≤ 0.05 by LSD test.
TSS - Total soluble solids, TA - titratable acids, MI - maturity index.

The results for the pH, total soluble solids (TSS), titratable acidity, maturity index, total polyphenolic of the pomegranate "Karamustafa" cultivar from the two different locations, are presented in Table 3. Significant differences (P≤ 0.05) were revealed among location for pH, total soluble solids, titratable acidity, maturity index and polyphenolic content.

As shown in Table 3, the highest total soluble solids content was in Josifovo, I (15.4 ^{0}Brix) and the lowest was in Valandovo, III (12.1 ^{0}Brix). The total acids content (equivalent to citric acid) is significantly higher in all fruits on the location Valandovo than Josifovo. Some of the Turkish cultivars range from 14.70^{0}Brix to 17.90^{0}Brix TSS and from 0.5% to 2.4% TA (Ozgen et al., 2008), Croatian autochthonous cultivars contain TSS from 13.0^{0}Brix to 15.55^{0}Brix TSS and from 0.44 to 1.64% total acids (Radunić et al., 2011), while Iranian cultivars from 12.85^{0}Brix to 15.05^{0}Brix TSS and 0.33% 2.44% total acids (Tehranifar et al., 2010). Based on the total acid content, the cultivars of pomegranate are divided into groups: sweet cultivars with <1 total acids, sweet-sour cultivars with 1-2% total acids and sour cultivars with> 2% total acids content (Bellini and Giordani, 1998).

The highest level of total phenolic compounds (1014-1017 mg/L gallic acid) was quantified in Josifovo. The level of the total phenolic content in Valandovo varied from 978 to 981 mg/L gallic acid. According to the results from our study, we can indicate that "Karamustafa" cultivar had higher value for total phenolic components than cultivar "Valencia" but significantly lower value than cultivars "Akko", "Hershkovitz" and "Wonderful" (Di Nunzio et al., 2013). However, the total phenolic content in pomegranate juice of 'Karamustafa" is higher in Turkish pomegranate juice 500-916 mg/L gallic acid equivalent (Tehranifar et al., 2010) but lower than in pomegranate juice found in Turkish markets (up to 2000 mg/L) (Tezkan et al., 2009).

CONCLUDING REMARKS

On the basis of the obtained results, we can conclude that the autochthonous cultivar "Karamustafa" belongs to the group of cultivars with large fruits, and according to the content of total acids in the group of sweet cultivars. A higher juice yield and higher content of the total phenols was obtained on the location Josifovo.

This is the first research for autochthonous cultivars pomegranate in the Republic of Macedonia. The research will continue in the direction of determining the potential of this and other pomegranate autochthonous cultivars for fresh consumption and for the production of juices.

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ФИЗИЧКИ И ХЕМИСКИ КАРАКТЕРИСТИКИ НА КАЛИНКАТА (*PUNICA GRANATUM* L.), СОРТА КАРАМУСТАФА

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Резиме

Калинките се добро адаптирани овошни видови во суви и полупустински услови и високоценети култури кои се одгледуваат во земјите на Медитеранот и во Азија. Најважните сорти калинка во Македонија се *бејнарија, лифанка* и *карамустафа*. Целта на оваа студија е да се евалуираат физичките и хемиските параметри на калинката сорта *карамустафа*, собрани од две различни локации во Република Македонија. Физичките параметри вклучуваат тежина на свежо овошје, процент на зрно (%), тежина од 100 бобинки (г), процент на сок (%). Сортата *карамустафа* (239.57- 304.79 g) припаѓа на група големи плодови. Сокот од родот се движи од 47,83% (Валандово) до 50,63% (Јосифово). Врз основа на содржината на вкупните киселини (ТС), сортата *карамустафа* ѝ припаѓа на групата со слатка сорта (ТА <1).

Врз основа на резултатите пронајдовме значителни разлики во тежината на овошјето, содржината на вкупните киселини и содржината на вкупните полифеноли во сокот.

Клучни зборови: *Punica granatum* L, *овошје, сок, вкупни киселини, вкупно полифеноли*