

Preliminary Results of Fruit Quality of Eight Croatian Local Apple Cultivars

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Summary

The quality of the eight local apple cultivars ('Alvanija', 'Kardinal', 'Križara', 'Majdofija', 'Muškatnica', 'Slastica', 'Slatka srčika' and 'Punika') was studied. Cultivar 'Kardinal' had the highest fruit mass, and the cultivar 'Slastica' had the lowest. There was no significant difference in fruit mass between the cultivars 'Kardinal' and 'Majdofija'. Cultivar 'Alvanija' had the highest fruit height and cultivar 'Križara' had the smallest. Cultivar 'Kardinal' had the widest fruits, and cultivar 'Križara' had the narrowest. Cultivar 'Alvanija' had the highest shape index, and cultivars 'Križara' and 'Majdofija' had the lowest. The highest firmness had cultivars 'Majdofija' and 'Slastica', between which there was no statistically significant difference. Cultivars 'Kardinal', 'Križara' and 'Punika' had significantly lower fruit firmness but still significantly higher than cultivar 'Muškatnica'. Cultivar 'Slastica' had the highest soluble solids content, and cultivar 'Križara' had the lowest. Cultivar 'Križara' received significantly lower panelist score for crispness, texture and juiciness than cultivar 'Majdofija'. Cultivars 'Kardinal' and 'Majdofija' received better scores for taste attributes than other cultivars. Panelist scores for fruit shape and general impression were the highest for the cultivars 'Kardinal' and 'Majdofija'. There was no significant difference in panelist scores for fruit size between these cultivars and cultivars 'Alvanija' and 'Križara'. It was concluded that the most promising cultivars are 'Majdofija' and 'Kardinal'. However, to fully evaluate their potential, comparison with other cultivars in the standard growing conditions during long-term research is needed.

Key words

Malus x domestica Borkh., fruit quality, sensory analysis, conservation, pomology, biodiversity

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Introduction

The range of apple cultivars in the European market is significantly reduced to no more than twelve cultivars (Hecke, 2006). In contrast to this small number, there are many old apple cultivars having a wide range in flavour, aroma, sugar and acid-content as well as phenolic compounds (Hecke et al., 2006). Consumers indicated that flavour, taste and texture were the main reason for purchasing apples (Harker, 2002a). Internal quality (flavour, taste, crispness, etc.) ranks above appearance in importance among apple characteristics (Redalen, 1988).

Old apple cultivars are generally characterized by quite unusual pomological traits and have sometimes a lower external appeal with respect to the standard apples (Bignami et al., 2003). Some of them, such as cultivar 'Wagener' have high yielding potential (Mitre et al., 2009) that make them excellent gene donors for this trait. In comparison with other cultivars, they had the higher firmness as well as total polyphenol and flavonoid content (Hecke et al., 2006; Radunić et al., 2011). Polyphenols and flavonoids are important for prevention of cardiovascular diseases and cancer (Kron and Williamson, 2005).

Apart from quality aspects, old cultivars serve as a stock and a source of basic material for fruit breeding (Fischer and Fischer, 2004; Mitre et al., 2009), especially for obtaining resistance (Fischer and Fischer, 2004).

Croatian apple germplasm was quite unexplored until recently. Radunić et al (2011) found old apple 'Žrnovska' in the Mediterranean part of Croatia having better internal quality in comparison to standard cultivars. Croatian territory was exposed to the different civilizations and culture influences through the long period in history (Ottoman Empire, Austro-Hungarian Empire, etc.). According to that there are certain assumptions that in the region plant material was vastly mixed during long time period. In the case of apple it is known that different empires used to bring their own material to the newly ruled countries and places. Thereafter apple germplasm from different origins was also vastly mixed during long time. This makes Croatia an important and unique biological reservoir of apple gene pool in Europe. SEEDNet project funded by SIDA included partners from eight countries with the aim of pomological description and inventory of apple germplasm enabled research trips that discovered nine new cultivars in Adžamovci, eight of which are described in this paper.

To the best of our knowledge, cultivars studied in this research have not been described anywhere else yet, so it is reasonable to assume that they are native Croatian cultivars.

This paper brings first preliminary pomological and fruit quality data of these cultivars.

Materials and methods

Studied cultivars ('Alvanija', 'Kardinal', 'Križara', 'Majdofija', 'Muškatnica', 'Punika', 'Slastica' and 'Slatka srčika') have been collected in near Adžamovci in the eastern Croatia. Trees were grafted on seedling rootstocks and, despite to age and the lack of proper management practices, they were still in good condition.

A sample of randomly picked 30 fruits per cultivar was harvested. The fruits were transported to the laboratory and visually

inspected for damage and other defects. After determining fruit mass (expressed in g) on an analytical balance (Mettler Toledo P1210) and pomometrical analysis [measuring fruit height and width with a digital calliper (expressed in mm) and calculating fruit shape index as height : width ratio], ten fruits were selected for determining fruit firmness and soluble solids content (SSC). The rest of 20 fruits were selected for sensory analysis.

Firmness (expressed in kg·cm⁻²) was measured using Effegi FT 327 penetrometer with 11 mm probe as an average value from four measurements made at opposite fruit sides at equatorial fruit zone.

The juice from each fruit was extracted with electric juicer and was used for determination of SSC (expressed in °Brix) with refractometer (ATAGO PAL-1, Japan) Mitcham et al. (1996).

Sensory analysis was performed according to Miller et al. (2005). Crispness, texture, juiciness, sugar : acid ratio, aroma, flavour richness, general impression, shape, size and colour were scored using a bipolar 5-point (1 to 5) hedonic scale. On the scale the 1-unit intervals were considered: dislike, dislike slightly, like, like very much, and like extremely.

Data analysis was conducted with SAS software, version 9.2 (SAS Institute, Cary, NC, USA) using one way ANOVA and LSD test at P<0.05 level.

Results and discussion

Cultivar 'Kardinal' had the highest fruit mass, while 'Slastica' had the lowest (Table 1). There was no significant difference in fruit mass between the cultivars 'Kardinal' and 'Majdofija'. Fruit mass was comparable to results obtained for other old cultivars published by Mitre et al. (2009).

Cultivar 'Alvanija' had the highest fruit height, and cultivar 'Križara' had the smallest. Between cultivars 'Kardinal' and 'Punika' there was no significant difference in fruit height, as well as among cultivars 'Slatka srčika', 'Slastica' and 'Majdofija'. Cultivar 'Kardinal' had the widest fruits, and cultivar 'Križara' had the narrowest. Cultivar 'Alvanija' had the highest fruit shape index, and cultivars 'Križara' and 'Majdofija' had the lowest. There were no significant differences in fruit shape index among cultivars 'Kardinal', 'Križara', 'Majdofija' and 'Slatka srčika'. Fruit size is affected by exogenous (water availability and ambient temperature), and endogenous factors (crop load and genetic differences) (Corelli Grappadelli and Lakso, 2004). The most important factors affecting fruit size in this study were crop load and genetic differences since trees were grown in the same location in similar growing conditions. Trees used for this study were grafted on seedling rootstock, which is vigorous and can cause biennial bearing resulting with differences in crop load (Raese et al., 2007).

The highest fruit firmness had cultivars 'Majdofija' and 'Slastica', between which there was no statistically significant difference. Cultivars 'Kardinal', 'Križara' and 'Punika' had significantly lower fruit firmness but still significantly higher than cultivar 'Muškatnica'. Firmness of this cultivar was only 3.92 kg cm⁻². This might be a result of overmaturity since firmness is decreased as maturity increases (Iglesias et al., 2008). Another contributing factor might be low crop load (Saei et al., 2011; De Salvador et al., 2006).

Table 1. Pomological and chemical characteristics of eight old Croatian apple cultivars

Cultivars	Fruit mass (g)	Fruit weight (mm)	Fruit width (mm)	Fruit shape index	Fruit firmness (kg·cm ⁻²)	Soluble solids content (° Brix)
'Alvanija'	165.81 b	79.08 a	69.49 b	1.14 a	7.05 bc	14.97 cd
'Kardinal'	209.85 a	65.63 b	85.23 a	0.77 d	5.98 c	15.47 bcd
'Križara'	120.80 cd	35.52 d	48.56 e	0.73 d	5.63 c	14.60 d
'Majdofija'	177.39 ab	52.46 c	71.93 b	0.73 d	11.33 a	16.87 ab
'Muškatnica'	86.54 ef	53.45 c	57.15 d	0.94 bc	3.92 d	16.35 abc
'Punika'	111.48 de	63.01 b	63.86 c	0.99 b	6.35 c	16.13 bcd
'Slastica'	75.15 f	50.25 c	56.07 d	0.90 c	10.93 a	17.90 a
'Slatka srčika'	147.71 bc	54.30 c	72.85 b	0.75 d	8.17 b	15.63 bcd
Pr > F	<.0001	<.0001	<.0001	<.0001	<.0001	0.0090

Note: Means followed by the same letter do not differ significantly at $P \leq 0.05$ according to LSD test

Table 2. Sensory quality of eight old Croatian apple cultivars

Cultivar	Crispness	Texture	Juiciness	Sugar/acidity ratio	Aroma	Flavour richness	General impression	Shape	Size	Colour
'Alvanija'	3.83 a	3.67 ab	2.92 bc	2.42	2.92	3.08	3.00 b	3.67 ab	3.92 a	3.75 ab
'Kardinal'	3.92 a	3.92 a	3.75 ab	4.00	3.75	4.08	4.00 a	4.00 a	4.25 a	4.17 a
'Križara'	2.50 b	2.33 c	2.08 c	2.83	3.42	3.42	2.83 b	3.00 bc	3.33 ab	4.17 a
'Majdofija'	4.00 a	3.83 ab	4.42 a	4.00	3.83	3.75	4.00 a	4.25 a	3.67 a	4.50 a
'Muškatnica'	3.75 a	3.33 ab	2.83 bc	3.33	2.92	2.83	3.00b	2.50 c	2.58 bc	2.25 c
'Punika'	3.50 a	3.17 abc	3.08 bc	2.83	3.25	3.17	3.25ab	2.50 c	2.67 bc	3.00 bc
'Slastica'	3.50 a	2.92 bc	2.58 bc	3.00	2.75	2.92	3.00b	2.75 c	2.33 c	3.08 bc
'Slatka srčika'	3.50 a	3.08 abc	3.33 ab	3.17	2.92	3.33	3.33ab	3.00 bc	3.25abc	3.08 bc
Pr > F	0.023	0.014	0.004	0.072	0.262	0.328	0.041	<0.0001	0.001	<.0001

Note: Means followed by the same letter do not differ significantly at $P \leq 0.05$ according to LSD test

Cultivar 'Slastica' had the highest SSC, and cultivar 'Križara' had the lowest (Table 1). SSC was similar to other studies with old apple cultivars (Mitre et al., 2009) but higher than in standard cultivars (Iglesias et al., 2008). However, some modern standard cultivars, such as 'Braeburn' (Mikulič Petkovšek et al., 2009) and 'Fuji Kiku 8' (Drogoudi and Pantelidis, 2011) achieve SSC values similar to those in our study. Beside genetic factor, the differences in crop load (De Salvador et al., 2006) might also contribute to the differences in SSC among cultivars.

Sensory analysis helps in characterization and evaluation of apple germplasm giving supplementary information on fruit quality. Such data helps in the evaluation of the level of acceptance and of the perception capacity of the distinctive traits of the fruit by the consumer (Bignami et al., 2003). Cultivar 'Križara' had significantly lower panelist scores for crispness, texture and juiciness than cultivar 'Majdofija' (Table 2). Panelist scores for the sugar : acidity ratio, aroma and flavour richness were not significantly different among cultivars due to the high variation among panelists. Taste, aroma and freshness were in this order the three most important attributes taken into account by consumers when choosing an apple (Péneau et al., 2006). Beside taste, flavour and crispness are also important traits, ranking above appearance in importance among apple characteristics (Redalen, 1988). Despite of non-significant differences, the trend in panelist scores allows conclusion that cultivars 'Kardinal' and 'Majdofija' received better scores for taste attributes than other cultivars. Panelist scores for the general impression and shape were higher for cultivars 'Kardinal' and 'Madofija'. There was

no significant difference in panelist scores for fruit size between these cultivars and cultivars 'Alvanija' and 'Križara'.

Cultivars 'Kardinal', 'Križara' and 'Majdofija' have received the highest panelist scores for colour. These cultivars have attractive red colour, which might be a reason for such result (Miller et al., 2005).

Conclusion

On the basis of this preliminary research, it can be concluded that cultivars 'Kardinal' and 'Majdofija' have the highest quality and might be good candidates for multiplication. The lowest quality had cultivar 'Križara'. However, to fully evaluate their quality, comparison with other cultivars in the standard growing conditions during long-term research is needed. *Ex situ* conservation and preparation for pomological and genotypic characterization for the purpose of their preservation is currently under way.

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