

PHENOLOGY AND FRUIT CHARACTERISTICS OF AUTOCHTHONOUS APPLE CULTIVARS

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Abstract: In 2014, we evaluated the main phenological and fruit physical-chemical characteristics of apple cultivars grown in western Serbia. The 'Idared' cultivar had the earliest start of flowering on March 30, immediately followed by the 'Kožara' cultivar on March 31. The cultivars 'Kiseljaja', 'Budimka' and 'Kolačara' cultivars began flowering at the same time on April 3. The 'Idared' cultivar was the first to reach full bloom on April 4, followed by the 'Kožara' cultivar on April 5. The other cultivars reached full flowering 3 to 4 days after the control cultivar. The results showed significant differences between cultivars in all fruit sizes, fruit weight (g), flesh firmness (kg cm⁻²), TSS (°Brix), TA (%) and RI.

Key words: flowering, leaf, apple fruit characteristics.

Introduction

Serbia is a country with a very long tradition of fruit growing, in which autochthonous apple cultivars play a very important role. Their share and importance were very high, in the past. However, old autochthonous cultivars have disappeared throughout the Balkans because not enough attention is paid to them (Vujević, 2016).

In the Čačak area, various autochthonous apple cultivars are grown both in gardens and orchards. Their importance is reflected in the fact that they are very suitable for organic cultivation. The indigenous cultivars have genes responsible for certain traits such as resistance to pathogens and pests, color, aroma, resistance to abiotic environmental factors (Skendrović Babojević et al., 2014), suitability for processing into juices, fruit wine, fruit vinegar, brandy and for drying (Milenković and Lukić, 2008).

The aim of this study is to investigate the most important characteristics of autochthonous apple cultivars in the Čačak area, with a special focus on phenological and pomological characteristics.

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Materials and methods

The experiment was conducted in 2014 in an apple orchard in the village of Gornja Gorevnica, 9 km northwest of Čačak (20°57'48" N; 20°19'31" E; 396 m above sea level). In the orchard, the usual care measures carried out in intensive apple orchards were applied, with no irrigation.

The study included four autochthonous apple cultivars ('Kožara', 'Kolačara', 'Budimka' and 'Kiseljaja'), which were compared with the 'Idared' cultivar, the most commonly cultivated cultivar in Serbia (control). The cultivars were grafted onto a rootstock M.9 and planted in 2010 with a planting distance of 4 × 1 m, which corresponds to a planting density of 2,500 trees ha⁻¹.

The dimensions of the leaf (mm) and the length of the petiole (mm) were measured with a ruler. The fruit dimensions were determined with an INOX brand 1/20 mm caliper. The fruit weight (g) was measured with a KERN FCB technical balance (Kern & Sohn GmbH, Bellingham, Germany), measuring range 6100 g, with an accuracy of ±0.2 g. Flesh firmness (kg cm⁻²) was measured with a Bertuzzi FT-327 manual penetrometer (Facchini, Alfonsine, Italy). Arithmetic fruit diameter (mm), geometric fruit diameter (mm), sphericity and fruit surface area (cm²) were calculated according to the formulas proposed by Mohsenin (1986). Fruit elongation (Ra) was calculated as the ratio between length and width (L/W ratio). The content of TSS (°Brix) in the fruit was determined using a Milwaukee MR 200 handheld refractometer (ATC, Rocky Mount, USA) and the content of total acids (%) was determined by titration with 0.1N NaOH. The ripening index (RI) of the fruit was determined as a quotient between the content of TSS and TA.

Differences between data were determined separately by two-way analysis of variance (ANOVA) using the GenStat software package (VSN International, Harpenden, UK). Mean values were compared using the LSD test at $P \leq 0.05$

Results and discussion

The results of the work with regard to the start, full flowering and end of flowering are shown in Table 1.

The 'Idared' cultivar had the earliest onset of flowering and the earliest full flowering, immediately followed by the 'Kožara' cultivar. The cultivars 'Kiseljaja', 'Budimka' and 'Kolačara' started flowering at the same time. The approximate duration of the flowering period was between 15 and 17 days for all cultivars.

The flowering phase of the apple is the most important and critical phase in the annual cycle as yield often decreases or does not occur at all due to the

occurrence of late frosts in spring (Milošević, 1997). Beber (2009) also agrees, stating that knowledge of the flowering time of apple cultivars is of great importance for successful production. This is due to the frequent occurrence of spring frosts, which can damage up to 70% of the blossoms on the tree.

Table 1. Flowering characteristics of different apple cultivars

Cultivar	Flowering			
	The beginning	Full flowering	The end	Duration
'Kožara'	March 31	April 05	April 15	16
'Kolačara'	April 03	April 09	April 20	17
'Budimka'	April 03	April 08	April 19	16
'Kiseljaja'	April 03	April 08	April 18	15
'Idared'	March 30	April 04	April 15	17

Under our conditions, when the years are with usual climatic factors, the apple blossoms from April 15 to May 10, according to Milošević (1997). However, it can be seen from Table 1 that the cultivars started flowering much earlier, which may be a consequence of the climatic conditions in the year of the study. On the other hand, our results are in agreement with the results of Božović et al. (2015).

The results related to the dimensions of the leaf and its petiole are presented in Table 2.

Table 2. Leaf characteristics of different apple cultivars

	Leaf dimensions			Leaf petiole
	Length (mm)	Width (mm)	C ¹ (mm)	Length (mm)
'Kožara'	79.45±2.11 b	64.65±2.07 a	30.65±1.17 b	26.78±1.17 b
'Kolačara'	76.70±2.43 b	60.01±1.88 a	29.60±1.08 b	28.15±1.09 b
'Budimka'	73.90±3.07 b	47.00±1.35 b	35.60±1.44 b	29.58±1.90 b
'Kiseljaja'	92.60±3.32 a	64.40±2.39 a	46.38±1.98 a	34.80±2.03 b
'Idared'	100.50±3.50 a	57.18±2.50 a	44.60±1.56 a	43.03±2.05 a
ANOVA	*	*	*	*

Different lowercase letters in a column indicate significant differences between means for P ≤ 0.05 by LSD test; C¹ distance of the maximum width of the leaf from the base of the leaf plate

In terms of the leaf length, the cultivars 'Idared' and 'Kiseljaja' had the highest values. In contrast, cultivars 'Kožara', 'Kolačara' and 'Budimka' had a significantly shorter leaf length than the control cultivar. The cultivars 'Kožara', 'Kiseljaja', 'Kolačara' and 'Idared' had the greatest width, although the

differences between them were not significant. 'Budimka' had a significantly smaller leaf width than the other cultivars. 'Kiseljaja' and 'Idared' had the greatest distance of the largest leaf width from the base of the leaf surface. The longest petiole was found in the 'Idared' cultivar.

High values of leaf dimensions in 'Idared' cultivars were also reported by Živaljević (1986).

Table 3. Physical characteristics of fruit and fruit petiole

Cultivar	Fruit length (mm)	Fruit width (mm)	Fruit weight (g)	Length of fruit petiole (mm)	Flesh firmness (kg cm ⁻²)
'Kožara'	81.95 ± 3.17 a	95.05 ± 3.71 a	347.90 ± 14.20 a	16.40 ± 0.78 a	4.90 ± 0.17 a
'Kolačara'	61.82 ± 2.27 b	92.40 ± 3.56 a	231.60 ± 12.29 b	4.10 ± 0.23 c	4.26 ± 0.23 b
'Budimka'	63.70 ± 2.50 b	87.47 ± 3.02 ab	247.00 ± 10.56 b	12.77 ± 0.65 b	4.42 ± 0.25 b
'Kiseljaja'	73.47 ± 3.38 ab	79.57 ± 2.90 b	200.30 ± 9.09 c	9.30 ± 0.45 b	3.85 ± 0.12 c
'Idared'	68.02 ± 3.14 b	82.50 ± 3.44 b	225.07 ± 9.98 b	22.10 ± 1.03 a	3.86 ± 0.15 c
ANOVA	*	*	*	*	*

Different lowercase letters in a column indicate significant differences between means for P ≤ 0.05 by LSD test

The 'Kožara' and 'Kiseljaja' cultivars had the longest fruit. Fruit width ranged from 79.57 ± 2.90 mm in the 'Kiseljaja' cultivar to 95.05 ± 3.71 mm in the Kožara cultivar, but the differences were not significant. Our results are consistent with the results found by Radunić et al. (2011) and Đorđević et al., (2013) in 'Idared' and Tomić et al. (2011) in 'Kolačara'.

Fruit weight is a very important quality trait that influences both yield and consumer acceptance (Durmaz et al., 2010). In terms of fruit weight, the 'Kožara' cultivar had the highest fruit weight and the 'Kiseljaja' cultivar the lowest.

Several authors dealt with testing the fruit weight of apples. Vujević (2016) cites the fruit weight values of the 'Kolačara' cultivar, which were lower than in our study. This deviation can be attributed to the age of the orchard, as in the research conducted by Vujević (2016), the orchard is over 50 years old. However, the studies of other authors such as Gvozdenović et al. (1991), Đorđević et al. (2013) and Milatović et al. (2012) are similar to our results.

The highest flesh firmness was found in the 'Kožara' cultivar, the lowest in the 'Kiseljaja' and 'Idared' cultivars. These results do not agree with the results of Radunić et al. (2011), who measured higher penetrometer values for 'Idared', which could be due to the different harvest times.

Regarding the results of fruit petiole length, which can be very short, short, medium long, long and very long (Adamič, 1963), the 'Idared' and 'Kožara' cultivars had the highest values and the 'Kolačara' cultivar the lowest. These values are similar to the results found by Čmelik et al. (1999).

Table 4. Fruit physical characteristics of defferent apple cultivars

Cultivar	Arithmetic mean diameter (mm)	Geometric mean diameter (mm)	Sphericity	Length/Diameter ratio	Surface area (cm ²)
'Kožara'	88.5 ± 0.01 a	90.46 ± 0.05 a	1.10 ± 0.00 c	1.15 ± 0.01 b	256.97 ± 3.20 a
'Kolačara'	77.11 ± 0.02 b	80.81 ± 0.02 b	1.30 ± 0.01 a	1.49 ± 0.02 a	205.07 ± 2.97 b
'Budimka'	75.58 ± 0.01 b	78.69 ± 0.05 b	1.23 ± 0.01 b	1.37 ± 0.02 a	194.46 ± 1.85 b
'Kiseljaja'	76.52 ± 0.02 b	77.48 ± 0.02 b	1.05 ± 0.00 d	1.08 ± 0.00 c	188.51 ± 1.56 b
'Idared'	75.26 ± 0.01 b	77.35 ± 0.01 b	1.13 ± 0.02 c	1.21 ± 0.07 b	187.91 ± 1.40 b
ANOVA	*	*	*	*	*

Different lowercase letters in a column indicate significant differences between means for P ≤ 0.05 by LSD test

The 'Kožara' cultivar achieved significantly higher values for arithmetic and geometric fruit diameter as well as higher sphericity than the other cultivars. The best sphericity was found in 'Kolačara'. 'Kolačara' and 'Budimka' cultivars had the longest fruits, while the fruits of 'Kiseljaja' were the least elongated (Photos 1-4).



Photo 1: 'Kožara'



Photo 2: 'Kolačara'



Photo 3: 'Kiseljaja'



Photo 4: 'Budimka'

Significant and consistent differences were found between the cultivars in terms of SSC and TA (Table 5).

The cultivar 'Kožara' had the highest SSC value. The other cultivars had significantly lower SSC values.

Table 5. Fruit chemical characteristics of different apple cultivars

Cultivar	SSC (°Brix)	TA (%)	RI
'Kožara'	17.70±0.90 a	0.17±0.01 a	104.12±5.01 b
'Kolačara'	12.62±0.55 b	0.07±0.01 c	180.28±9.22 a
'Budimka'	12.65±0.51 b	0.06±0.01 c	210.83±7.33 a
'Kiseljaja'	14.01±0.59 b	0.14±0.01 ab	100.07±5.65 b
'Idared'	12.25±0.50 b	0.11±0.01 b	111.36±9.32 b
ANOVA	*	*	*

Different lowercase letters in a column indicate significant differences between means for $P \leq 0.05$ by LSD test

Our results for SSC are similar to those of Radunić et al. (2011) and Bostan (2009). On the other hand, Božović et al. (2015) found higher SSC content in 'Kolačara' than in our orchard. Large differences in SSC are not only the result of genotypic characteristics, and maturity stage but also depend on environmental factors and geographical region (Asif et al. 2004).

It is known that acidity plays an important role in the perception of fruit quality, as acidity balances fruit flavor (Schmitzer et al., 2011) and high acidity often reduces fruit quality.

The highest total acid content was found in the 'Kožara' and 'Kiseljaja' cultivar (Table 5). The lowest contents were found in 'Budimka' and 'Kolačara' cultivars.

Similar studies were carried out by Kołodziejczyk et al. (2009) and Radunić et al. (2011). In their studies, the 'Idared' cultivar had a slightly higher total acid content (0.14%) than in our study. In their research, Hecke et al. (2006) found that old apple cultivars in organic production in Austria have a higher content of total acids (from 8.3 g kg⁻¹ to 17.85 g kg⁻¹) than commercial cultivars. It seems that the geographical region with its specific weather conditions also plays an important role in the biosynthesis of compounds that determine TA.

The ratio between SSC and TA (SSC/TA ratio or RI) plays an important role in consumer acceptance of fruit (Crisosto et al., 2005). In the current study, the highest RI value was observed in 'Budimka' and 'Kolačara' (Table 5).

Conclusion

The autochthonous cultivars generally showed good results and some of them even showed better characteristics than the control cultivar 'Idared'. Particularly noteworthy is the 'Kožara' cultivar, which showed the most

positive characteristics. However, all cultivars showed relatively good characteristics, so they can be recommended for cultivation, especially for organic production, but also for the preservation of genetic material to obtain new cultivars for breeding.

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