Voćarstvo, 58, 221–222 (2024), 69–80
Journal of Pomology, 58, 221–222 (2024), 69–80
https://doi.org/10.18485/pomology.2024.58.221_222.1

UDC: 634.13 (497.11)
Originalni naučni rad
Original scientific paper

In situ evaluation of autochthonous pear *(Pyrus communis L.)* genotypes grown in the central and southwest Serbia region

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Received: 08 November 2024; Accepted: 15 November 2024

Abstract. This study presents the results of *in situ* evaluation of the main biological properties in 15 traditional pear cultivars and landraces grown in the regions of central and southwest Serbia. The assessed properties of these genotypes include: phenological properties (flowering phenophase and harvest maturity), pomological properties (physical, chemical – including bioactive compounds, and organoleptic) and field resistance to causal agents of diseases (pear scab and fire blight). The earliest onset of flowering was recorded in ‘Vodenjaja’ (April 02nd) and the latest in ‘Kantaruša’ (April 21st), with a 19-day interval between them. In terms of harvest maturity, the genotypes were classified into groups ranging from extremely early (‘Beli Mednjak’ – July 23rd) to late (‘Kantaruša’ and ‘Takiša’, both October 05th). The highest fruit weight was recorded in ‘Kantaruša’ (364.86 g), while the lowest was in ‘Takiša’ (20.49 g). The cultivar ‘Takiša’ exhibited the best fruit quality among the assessed genotypes, as determined by its chemical composition (soluble solids – 14.85%; total sugars – 10.33%). Regarding bioactive compounds, ‘Kantaruša’ was characterized by the highest values for total phenols (174.50 mg GAE 100 g^{-1} FW), antioxidant activity (70.97%) and Trolox equivalent antioxidant capacity (358.10 mmol TE 100 g^{-1} FW). The highest total anthocyanin content was found in ‘Lubeničarka’ (2.71 mg C3G 100 g^{-1} FW). All studied genotypes showed field resistance to fire blight, and most of them exhibited resistance to pear scab. Thus, Serbian pear genotypes appear to possess valuable traits that offer significant potential for use in future breeding programmes and production with reduced chemical inputs.

Key words: *Pyrus communis* L., indigenous cultivar, landrace, fruit quality, resistance

Introduction

The pear (*Pyrus communis* L.) is one of the oldest and most commercially significant fruit species grown worldwide (Pérez-Sánchez & Morales-Corts, 2023). According to Hancock & i Lobos (2008), the Caucasus region, located between the Black and Caspian seas, is the place of origin for the pear, from where it later spread across Europe and Asia through Indo-European tribes. European pears include over 20 species, primarily cultivated by *Pyrus communis* L., with all species native to Europe, North and South America, and Africa (Bell et al., 1996; Silva et al., 2014; Yamamoto & Terakami, 2016). The world’s largest *Pyrus* collection, consisting of 2,793 *Pyrus* accessions from 37 species, is maintained in the National Clonal Germplasm Repository (NCGR) in Corvallis, part of the USDA-ARS National Plant Germplasm System (Waite et al., 2024). Although pear exhibit significant genetic diversity, with over 3,000 documented cultivars, Dondini & Sansavini (2012) reported that only eight cultivars (‘Conference’, ‘Williams’, ‘Abbé Fétel’, ‘Blanquilla’, ‘Doyenne du Comice’, ‘Mantecosa Bosc’, ‘Dr Jules Guyot’ and ‘Coscia’) account for 80% of European production. During the 2018–2022 period, the average annual world pear production was 24.98 million tonnes, with China contributing 71.5%, or 17.86 million tonnes (FAOSTAT, 2024). The USA, Argentina, Turkey, Italy and South Africa followed, together accounting for approximately 11% of world production. With an average annual pear production of 58.30 thousand tonnes during this period, Serbia ranked eleventh in Europe (FAOSTAT, 2024); the predominant cultivars are ‘Williams’ and ‘Carmen’, followed by ‘Santa Maria’, ‘Abbé Fétel’ and ‘Kieffer’ (Đurović et al., 2024). The widespread reliance on a limited number of commercial cultivars has led to the gradual replacement of autochthonous cultivars with those that are more productive, achieve better economic returns, and align with consumer preferences. On the other hand, significant changes in production methods and the abandonment of rural areas have resulted in a rapid reduction in pear genetic diversity.

The Balkan Peninsula is recognized for its abundance of fruit genetic resources (Đurić et al., 2009: Marić et al., 2019, 2020, 2022; Radičević et al., 2019; Glišić et al., 2023), particularly in pear genetic resources (Selamovska et al., 2014, 2015; Kajkut Zeljković et al., 2021). These fruit genotypes hold enormous significance, as they are characterized by unique properties and are adapted to the region’s specific edapho-climatic conditions. Van der Zwet et al. (1987) reported that 150 pear cultivars (excluding synonyms) of *Pyrus communis* L. were collected and described in central and southern Yugoslavia (in total 279 accessions of different *Pyrus* species), mainly from Serbia, North Macedonia, Montenegro, and Bosnia and Herzegovina. High levels of polymorphism and uniqueness in pear germplasm originating from Bosnia and Herzegovina were revealed using simple sequence repeat (SSR) markers (Kajkut Zeljković et al., 2021). Pear germplasm is still present in Serbia, primarily in home gardens and on old farms. Therefore, it is necessary to avoid the loss of this genetic variability and utilize it in developing new cultivars. Access to a diverse array of genotypes, including foreign and local cultivars, landraces and wild species, is essential for breeders. Apart from the pear breeding work that has resulted in the release of five cultivars (‘Šampionka’ in 1977, ‘Junsko Zlato’ in 1978, ‘Trevlek’ in 1984, and ‘Julijana’ and ‘Anđelija’ in 2014; Glišić et al., 2021) and the evaluation of *ex situ* genotypes, the Fruit Research Institute, Čačak (FRI) has focused in recent years on assessing genetic variability in autochthonous material.

To conserve and promote the use of Serbian autochthonous material, it is crucial to continue collecting and characterizing the available pear old cultivars and landraces. Consequently, this study was conducted primarily to examine the phenological (flowering phenophase and harvest date) and pomological (physical and chemical properties, including bioactive compounds) traits, as well as resistance to major causal agents of economically important diseases, in fifteen *in situ* pear genotypes grown across various regions of central and southwestern Serbia.

Materials and Methods

Plant material. Fifteen autochthonous pear genotypes (Table 1), corresponding to old cultivars or landraces of unknown origin, were characterized *in situ* and sampled in individual growers’ orchards during 2020/2021 in central and southwestern Serbia, specifically in the regions of Čačak (village Jezdina), Gornji Milanovac (town), Kraljevo (village Samaila) and Aranđelovac (village Progoreoci). The names assigned to unknown pear landraces (‘K-GM/1’ and ‘K-ČaJ/1’ to ‘K-ČaJ/7’) were based on geographical determinants (city, municipality and village) and a numbering system related to the harvest date of the genotype in the respective region.

Phenological properties. The flowering phenophase was recorded according to Wertheim (1996) by monitoring the onset and end of flowering (10% fully open flowers and 90% fallen petals, respectively). Samples of 20 fruits, taken in three replicates per pear genotype, were randomly harvested based on the fruit taste, changes in ground colour and overcolour, and the first preharvest drop of healthy fruit.

Pomological properties. The main physical properties, namely fruit weight (FW), height (FH) and width (WF), were determined using standard methods with an Adventurer Pro AV812M technical scale (Ohaus Corporation, Switzerland) and a digital caliper (Kronen, Germany). The following parameters were assessed to determine the fruit's chemical properties, including bioactive compounds: soluble solids content (SSC), expressed as a percentage and measured using a portable refractometer (Hanna Instruments, Germany); total and invert sugars content (TSC and ISC, respectively), expressed as a percentage and determined by the Luff-Schoorl method (Egan et al., 1981); sucrose content (SUC), expressed as a percentage and calculated as the difference between total and invert sugars, multiplied by a coefficient of 0.95; total acids content (TA), expressed as a percentage of malic acid and measured by titration with 0.1 N NaOH in the presence of phenolphthalein indicator; pH of the fruit juice (pH), measured using the CyberScan 510 pH meter (Eutech Instruments Pte Ltd, Singapore); ripening index (RI), calculated as the ratio of soluble solids content to total acids content (SSC/TA); total phenol content (TPC), expressed as mg gallic acid equivalents per 100 g of fresh weight (mg GAE 100 g^{-1} FW) and measured using a spectrophotometer (Jenway 6300, United Kingdom) based on the Folin–Ciocalteu method (Singleton & Rossi, 1965); antioxidant activity (AA), expressed as the percentage of the inhibition of the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical, measured using the DPPH free radical assay (Sanchez-Moreno et. al., 1998; Trolox equivalent antioxidant capacity (TEAC), expressed in mmol Trolox equivalent per 100 g of fresh weight (mmol TE 100 g^{-1} FW) and determined using ABTS [2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)] test; total anthocyanin content (TAC), expressed in mg of cyianidin-3-glucoside per 100 g of fresh weight (mg C3G 100 g^{-1} FW), determined by the pH differential method.

The sensory properties, specifically fruit symmetry (FS), fruit attractiveness (FA), ground colour (GC), over colour (OC), flesh colour (FC) and fruit firmness (FF) were evaluated following the Pear (*Pyrus communis* L.) – Guidelines for the Conduct of Tests for Distinctness, Uniformity and Stability (TG/15/1 and TG/15/3) by the International Union for the Protection of New Varieties of Plants (UPOV, 1974, 2000), aligned with the latest version of the ECPGR Characterization and Evaluation Descriptors for Pear Genetic Resources (Lateur et al., 2022).

Susceptibility to causal agents of scab and fire blight under field conditions. Susceptibility to causal agents of scab [*Venturia pirina* Aderh.] and fire blight [*Erwinia amylovora* (Burnill)] was assessed according to the Pear Descriptors (IBPGR, 1983), using a scale from 1 to 9 (where 1 indicates very low, 3 low, 5 medium, 7 high and 9 very high susceptibility): 1=03%, 2=46%, 3=712%, 4=1325%, 5=2650%, 6=5175%, 7=7688%, 8=8999%, 9100% (the 19 scale corresponds to the Van der Zwet scale and the portion of the tree blighted).

Statistical analysis. Data analyses were conducted using the SPSS statistical software package, Version 8.0 for Windows (SPSS Inc., Chicago, IL). A one-way analysis of variance (ANOVA) was applied to evaluate the effect of genotype on fruit physical parameters and bioactive compounds. When the F test indicated significance, the arithmetic means were compared using the test of Least Significant Differences (LSD test) for significance threshold of $P \leq 0.05$.

Results and Discussion

This study presents a phenotypic evaluation of major biological traits, such as phenological, physical, chemical and sensory characteristics, as well as field susceptibility to primary causal agents of scab and fire blight, in fifteen autochthonous pear genotypes. These genotypes comprise old cultivars and landraces that have been historically grown in central and southwestern Serbia.

Phenological properties. Most of the studied autochthonous pear genotypes flowered in April, with the exception of three landraces ('K-ČaJ/1', 'K-ČaJ/5' and 'K-ČaJ/6') and two cultivars ('Kantaruša' and 'Takiša'), which ended blooming at the beginning of May (from the 02^{nd} to the 04^{th}). The flowering phenophase of the assessed pear cultivars and landraces is presented in Figure 1. With a 19-day interval, the earliest onset of flowering was recorded in 'Vodenjaja' (April 02^{nd}) and the latest in 'Kantaruša' (April 21^{st}). The earliest end of flowering was noted in 'Vodenjaja' (April 19^{th}), and the latest in 'Takiša' (May 04^{th}), with a 15-day interval between them. Among the nine assessed traditional pear cultivars from the western

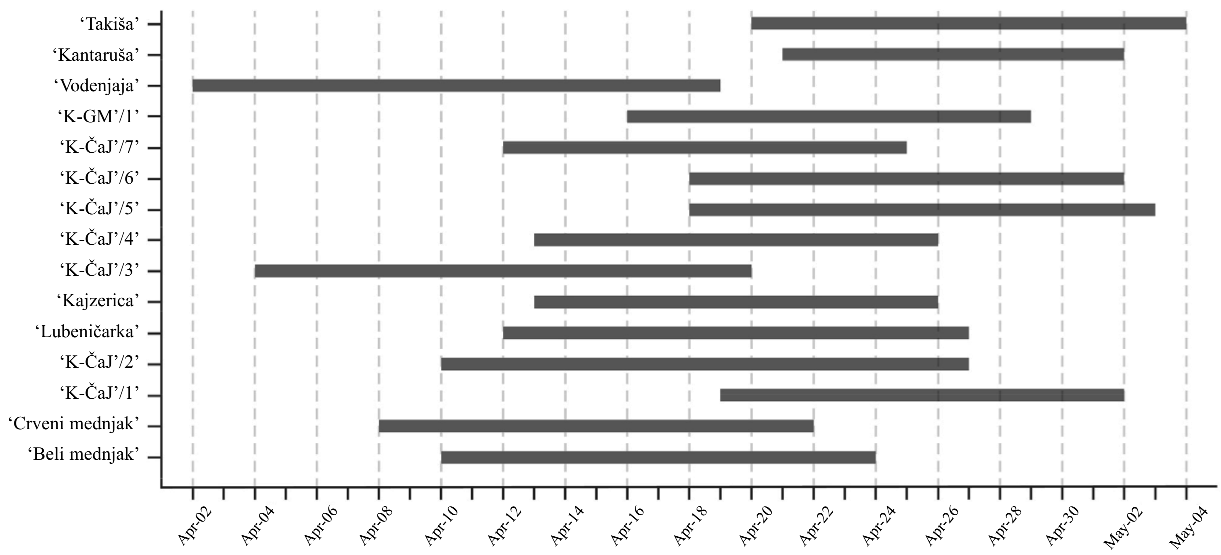

Figure 1. Flowering phenophase of the autochthonous pear genotypes
Slika 1. Fenofaza cvetanja autohtonih genotipova kruške

region of North Macedonia, Selamovska et al. (2014) stated that these cultivars flower from the first decade to the end of April. Additionally, Selamovska et al. (2015) observed that six autochthonous pear cultivars in the Prespa region flower from the second half of April to the end of April. Our results suggested that flowering depends on the genotype as well as the environmental conditions where the genotypes were grown and monitored. Additionally, Radivojević (2020) reported that an elevation increase of 33–34 meters postpones flowering by one day. In this study, the duration of blooming period ranged from 11 days ('Kantaruša') to 17 days ('K-ČaJ/2' and 'Vodenjaja'), with a 13-day duration being the most common, recorded in five genotypes ('Kajzerica', 'K-ČaJ/1', 'K-ČaJ/4', 'K-ČaJ/7' and 'K-GM/1'). The average duration of the flowering phenophase in autochthonous pear genotypes was 14.13 days. According to Radivojević (2020), the flowering phenophase in fruit trees can be classified as very short or explosive (3–5 days), medium (5–10 days), long (10–15 days) and very long (over 15 days). All collected pear genotypes in this study were characterized by long flowering, while the very long flowering was observed in three genotypes ('Vodenjaja', 'K-ČaJ/2' and 'K-ČaJ/3').

The fruits of the cultivar 'Beli Mednjak' were characterized by the earliest harvest date (July 23rd), while the latest harvest time was recorded for the fruits of the cultivars 'Kantaruša' and 'Takiša' (October 5th) (Table 1). Therefore, the assessed pear genotypes were classified into groups ranging from extremely early (July–early August) to late (early October) according to Lateur et al. (2022). The ripening time of Macedonian traditional pear genotypes ranged from the first half of July to the end of October/beginning of November in the western part of the country, while in the Prespa region it occurred from beginning of August to the end of October (Selamovska et al., 2014, 2015). Bayazit et al. (2016) reported that the ripening time of 25 Turkish pear accessions varied by genotype and year, ranging from June 25th to November 08th in 2009 and from June 23rd to November 05th in 2010. Among 115 Spanish local pear accessions, harvest data ranged from August 16th to September 14th (Pereira-Lorenzo et al., 2012). The fruit ripening period of 150 pear cultivars collected during pear germplasm explorations across the former Yugoslavia varied from late June to late October, with a general peak occurring from late August to early September (Van der Zwet et al., 1987).

Physical fruit properties. The studied pear cultivars and landraces differed significantly in terms of FW, FH and WF (Table 2). The FW varied from 20.49 g ('Takiša') to 364.86 g ('Kantaruša'), and the genotypes were classified into groups ranging from very small to very large according to Lateur et al. (2022). The FH and WF were highest in 'Kantaruša' (92.18

Table 1. Locality and harvest date of the autochthonous pear genotypes
Tabela 1. Lokalitet i vreme berbe autohtonih genotipova kruške

Locality *Lokalitet*	Genotype *Genotip*	Coordinates and altitude *Koordinate i nadmorska visina*	Harvest date *Vreme berbe*
Progoreoci	‘Beli Mednjak’	44°20'412"N; 20°24'916"E; 197 m	July 23rd
Progoreoci	‘Crveni Mednjak’	44°20'406"N; 20°24'916"E; 198 m	July 24th
Jezdina	‘K-ČaJ/1’	43°51'587"N; 20°18'069"E; 392 m	July 28th
Jezdina	‘K-ČaJ/2’	43°51'106"N; 20°17'936"E; 452 m	July 28th
Jezdina	‘Lubeničarka’	43°51'151"N; 20°17'902"E; 446 m	July 28th
Samaila	‘Kajzerica’	43°46'09"N; 20°30'44"E; 266 m	August 06th
Jezdina	‘K-ČaJ/3’	43°51'631"N; 20°18'322"E; 395 m	August 12th
Jezdina	‘K-ČaJ/4’	43°51'656"N; 20°18'295"E; 394 m	August 15th
Jezdina	‘K-ČaJ/5’	43°51'126"N; 20°17'975"E; 432 m	August 19th
Jezdina	‘K-ČaJ/6’	43°51'500"N; 20°18'031"E; 413 m	August 19th
Jezdina	‘K-ČaJ/7’	43°51'140"N; 20°17'917"E; 446 m	August 19th
Gornji Milanovac	‘K-GM/1’	44°01'191"N; 20°26'831"E; 358 m	August 20th
Jezdina	‘Vodenjaja’	43°51'646"N; 20°18'295"E; 393 m	September 11th
Jezdina	‘Kantaruša’	43°51'38"N; 20°18'18"E; 399 m	October 05th
Jezdina	‘Takiša’	43°51'626"N; 20°18'281"E; 404 m	October 05th

Table 2. Fruit physical characteristics of the autochthonous pear genotypes
Tabela 2. Fizičke osobine ploda autohtonih genotipova kruške

Genotype *Genotip*	FW (g)	FH (mm)	WF (mm)
‘Beli Mednjak’	66.79 ± 0.50 j	54.32 ± 0.23 j	50.74 ± 0.58 i
‘Crveni Mednjak’	60.09 ± 0.41 k	58.45 ± 0.47 i	46.13 ± 0.43 j
‘K-ČaJ/1’	73.23 ± 0.62 i	73.18 ± 0.41 e	51.73 ± 0.51 hi
‘K-ČaJ/2’	91.83 ± 0.49 g	66.50 ± 0.45 g	54.13 ± 0.51 fg
‘Lubeničarka’	26.55 ± 0.50 l	38.37 ± 0.08 k	37.42 ± 0.15 k
‘Kajzerica’	77.68 ± 1.39 i	60.39 ± 0.50 h	53.11 ± 0.28 gh
‘K-ČaJ/3’	132.56 ± 1.34 e	80.68 ± 0.49 d	64.60 ± 0.16 cd
‘K-ČaJ/4’	82.81 ± 0.29 h	58.70 ± 0.08 hi	55.55 ± 0.22 f
‘K-ČaJ/5’	163.63 ± 1.61 c	83.22 ± 0.52 c	66.25 ± 0.07 c
‘K-ČaJ/6’	239.86 ± 1.70 b	87.12 ± 0.34 b	78.20 ± 0.53 b
‘K-ČaJ/7’	84.29 ± 0.94 h	68.83 ± 0.64 f	54.88 ± 0.15 fg
‘K-GM/1’	137.96 ± 1.51 d	82.05 ± 0.53 cd	62.05 ± 1.29 d
‘Vodenjaja’	99.79 ± 0.87 f	67.29 ± 0.47 fg	58.11 ± 0.44 e
‘Kantaruša’	364.86 ± 1.50 a	92.18 ± 0.48 a	92.00 ± 0.35 a
‘Takiša’	20.49 ± 0.10 m	31.12 ± 0.17 l	34.93 ± 0.11 l

The different lower-case letters assigned to columns show significant differences for P≤0.05 after applying LSD test/*Različita mala slova u kolonama označavaju značajne razlike na nivou P≤0.05 primenom LSD testa*
FW: fruit weight/*masa ploda*; FH: fruit height/*visina ploda*; WF: fruit width/*širina ploda*

mm and 92.00 mm, respectively), while the lowest values for both parameters were found in ‘Takiša’ (31.12 mm and 34.93 mm, respectively); these properties were related with FW. In addition, according to the classification by Mratinić (2000), the collected pear genotypes can be divided into seven categories: i) genotypes with very small fruits (up to 25 g; ‘Takiša’); ii) genotypes with small fruits (26–50 g; ‘Lubeničarka’); iii) genotypes with medium-small fruits (51–100 g; ‘Beli Mednjak’, ‘Crveni Mednjak’, ‘Kajzerica’, ‘Vodenjaja’, ‘K-ČaJ/1’, ‘K-ČaJ/2’, ‘K-ČaJ/4’ and ‘K-ČaJ/7’), iv) genotypes with medium fruits (101–150 g; ‘K-ČaJ/3’ and ‘K-GM/1’); v) genotypes with medium-large fruits (151–200 g; ‘K-ČaJ/5’); vi) genotypes with large fruits (201–300 g; ‘K-ČaJ/6’); and vii) genotypes with very large fruits (over 300 g;

‘Kantaruša’). Variability in FW, one of the most important traits determining the economic and breeding value of a genotype, was also observed in autochthonous pear cultivars and landraces grown in North Macedonia (ranging from 13.80 g to 214.10 g in the western part and 60.80 g to 165.40 g in the Prespa region Selamovska et al., 2014, 2015), Turkey (28.29 g to 160.02 g, Bayazit et al., 2016; 10.48 g to 140.63 g, Kalkisim et al., 2018) and the Iberian Peninsula (68.30 g to 142.56 g; Pérez-Sánchez & Morales-Corts, 2023).

Chemical fruit properties. The collected autochthonous pear genotypes also differed in terms of fruit chemical composition (Table 3). The highest SSC and TSC were found in ‘Takiša’ (14.85% and 10.33%, respectively), while ISC was highest in ‘K-ČaJ/7’ (8.60%) and SUC in ‘Crveni Mednjak’ (2.98%). The landrace ‘K-ČaJ/7’ was characterized by the lowest SSC, TSC and ISC values (10.05%, 6.00% and 4.98%, respectively). The lowest SUC (0.29%) and TA (0.06%), along with the highest pH value of the fruit juice (4.85) were defined in the cultivar ‘Kajzerica’. With respect to TA, ‘Lubeničarka’ and ‘Vodenjaja’ stand out with values of 0.38% and 0.36%, respectively. Variability in SSC was also identified in autochthonous pear cultivars grown in the western part of North Macedonia and the Prespa region, ranging from 12.80% to 18.30% (Selamovska et al., 2014, 2015), with most cultivars characterized by SSC levels exceeding 14%. This variability was similarly observed in Turkish pear accessions, where SSC ranged from 10.00% to 18.50% (Bayazit et al., 2016). In contrast, Pérez-Sánchez & Morales-Corts (2023) reported that SSC in fruits of Iberian pear cultivars exhibited low variation, ranging from 12.67° Brix to 14.92° Brix, with a balanced sweetness-to-acidity ratio (RI) between 3.77 and 5.09 (these RI values were calculated as the ratio between total soluble solids and titratable acidity, with titratable acidity expressed as grams of malic acid per litre). Al-Dairi et al. (2021) reported that the taste and flavour of fresh fruit result from the interaction between SSC and TA, depending highly on the fruit’s maturity stage. Additionally, a high SSC and low TA increase the RI (SSC/TA ratio), which is associated with the good flavour. Chen et al. (2007) stated that achieving the right balance of sweetness and acidity in pear cultivars requires a relatively high ratio, as seen in the cultivar ‘Kuerle Fragrant’ that has value of 125. In our study, the RI in autochthonous pear genotypes (Table 3) varied between 30.92 (‘Lubeničarka’) to 113.64 (‘K-ČaJ/4’), with the exception of ‘Kajzerica’, which had a ratio of 218.33. Notably, ‘Kajzerica’ had a high SSC (13.10%) but very low TA (0.06%), making it an ideal cultivar for fresh consumption.

Phenolic compounds are important natural secondary metabolites widely distributed in fruits and

Table 3. Fruit chemical composition of the autochthonous pear genotypes
Tabela 3. Hemijski sastav ploda autohtonih genotipova kruške

Genotype *Genotip*	SSC (%)	TSC (%)	ISC (%)	SUC (%)	TA (%)	pH	RI
‘Beli Mednjak’	14.75	9.36	7.23	2.02	0.17	4.64	86.76
‘Crveni Mednjak’	13.05	9.12	5.98	2.98	0.13	4.82	100.38
‘K-ČaJ/1’	13.15	7.92	6.85	1.02	0.21	4.00	64.29
‘K-ČaJ/2’	14.40	8.76	7.38	1.31	0.34	3.93	42.35
‘Lubeničarka’	11.75	7.68	5.79	1.80	0.38	3.92	30.92
‘Kajzerica’	13.10	6.72	6.41	0.29	0.06	4.85	218.33
‘K-ČaJ/3’	13.15	9.00	6.10	2.76	0.27	4.16	48.70
‘K-ČaJ/4’	12.50	8.16	5.48	2.55	0.11	4.80	113.64
‘K-ČaJ/5’	10.05	6.00	4.98	0.97	0.32	3.86	31.41
‘K-ČaJ/6’	10.95	7.44	6.35	1.04	0.27	3.81	40.56
‘K-ČaJ/7’	14.10	9.83	8.60	1.17	0.27	4.12	52.22
‘K-GM/1’	13.10	8.40	7.60	0.76	0.28	3.67	46.79
‘Vodenjaja’	11.65	6.72	5.91	0.77	0.36	3.80	32.36
‘Kantaruša’	11.45	8.52	5.85	2.54	0.29	3.81	39.48
‘Takiša’	14.85	10.33	7.42	2.76	0.24	4.22	61.87

SSC: soluble solids content/*sadržaj rastvorljivih suvih materija*; TSC: total sugars content/*sadržaj ukupnih šećera*; ISC: invert sugars content/*sadržaj invertnih šećera*; SUC: sucrose content/*sadržaj saharoze*; TA: total acids content/*sadržaj ukupnih kiselina*; pH: pH value of the fruit juice/*pH vrednost soka ploda*; RI: SSC/TA ratio/*odnos sadržaja rastvorljivih suvih materija i ukupnih kiselina* vegetables (Lattanzio, 2003). They influence the sensory quality of fruit, including color, astringency, bitterness and flavor, as well as their health-promoting properties. According to Kolniak-Ostek (2016), phenolic compounds are generally more concentrated in the peel than in the fruit flesh. Pears are a good source of phytochemicals, and the health benefits of polyphenol consumption arise from their antioxidant and anti-inflammatory properties (Kolniak-Ostek, 2016; Brahem et al., 2017). Therefore, determining TPC, TAC, AA, and TEAC in Serbian autochthonous pear old cultivars and landraces is crucial for recognizing them as valuable sources of health-promoting compounds. In our study, these parameters varied greatly among the studied pear genotypes and the obtained results are shown in Table 4. The cultivar 'Kantaruša' was characterized by the highest values for TPC (174.50 mg GAE 100 g^{-1} FW), AA (70.97%) and TEAC (358.10 mmol TE 100 g^{-1} FW). The highest TAC value (2.71 mg C3G 100 g^{-1} FW), which was expected due to its distinctive pinkish red flesh, and the lowest TPC (46.00 mg GAE 100 g^{-1} FW) were found in the cultivar 'Lubeničarka'. The lowest values for AA (15.49%) and TEAC (42.54 mmol TE 100 g^{-1} FW) were identified in the landrace 'K-ČaJ/4', while the lowest TAC (0.22 mg C3G 100 g^{-1} FW) was found in the landrace 'K-ČaJ/2'. For four pear cultivars grown in Eastern Anatolia, Turkey, Coskun Topuz & Bakkalbasi (2022) showed that TPC varied between 622.56–3,718.43 mg GAE kg^{-1} d.m., while the antioxidant activities, assessed using the ABTS and DPPH assays ranged from 18.35 to178.90 mmol Trolox eq g^{-1} d.m., and 149.49–366.07 mmol Trolox eq g^{-1} d.m., respectively. Among 19 pear cultivars (eight Tunisian local dessert cultivars, eight European dessert cultivars and three French perry pear cultivars), Brahem et al. (2017) reported that TPC ranged from 0.1 g kg^{-1} FW ('Conference') to 8.6 g kg^{-1} FW ('Plant De Blanc') in the flesh and from 1.6 g kg^{-1} FW ('William Vert') and 40.4 g kg^{-1} FW ('Arbi Chiheb') in the peel.

Sensory fruit properties. Fruit quality encompasses various properties, including sensory attributes (appearance, texture and flavor), nutritional value, chemical constituents, mechanical properties, functional properties and defects (Abbott, 1999). According to Barrett et al. (2010), consumers first evaluate visual appearance and colour, followed by taste, aroma and texture. Thus, the attractiveness of the fruit influences the initial impression of consumers, while the flavour ensures their preference and encourages repeat purchases. The results of the sensory properties of the assessed autochthonous pear genotypes are presented in Table 5. Based on fruit symmetry, the evaluated genotypes were characterized by regularly symmetric

Table 4. Content of bioactive compounds in the fruit of the autochthonous pear genotypes
Tabela 4. Sadržaj bioaktivnih komponenti u plodu autohtonih genotipova kruške

Genotype *Genotip*	TPC (mg GAE 100 g^{-1} FW)	TAC (mg C3G 100 g^{-1} FW)	AA (%)	TEAC (mmol TE 100 g^{-1} FW)
'Beli Mednjak'	87.00 ± 1.55 d	0.83 ± 0.11 def	29.18 ± 0.58 e	120.41 ± 3.28 ef
'Crveni Mednjak'	51.50 ± 0.13 j	1.04 ± 0.05 cd	17.41 ± 0.10 i	53.49 ± 0.55 j
'K-ČaJ/1'	65.00 ± 0.62 h	0.83 ± 0.04 def	26.38 ± 0.64 f	111.17 ± 4.69 fg
'K-ČaJ/2'	76.00 ± 0.26 fg	0.22 ± 0.00 g	35.20 ± 0.29 d	148.00 ± 1.76 d
'Lubeničarka'	46.00 ± 1.29 k	2.71 ± 0.16 a	15.62 ± 0.17 i	43.28 ± 0.99 jk
'Kajzerica'	78.50 ± 1.42 ef	0.63 ± 0.03 ef	23.20 ± 0.11 g	86.39 ± 0.64 h
'K-ČaJ/3'	72.50 ± 2.71 g	0.49 ± 0.08 fg	17.94 ± 0.43 h	56.47 ± 2.43 i
'K-ČaJ/4'	58.00 ± 0.26 i	0.91 ± 0.06 cde	15.49 ± 0.13 i	42.54 ± 0.74 k
'K-ČaJ/5'	103.50 ± 1.94b	1.46 ± 0.01 b	43.80 ± 0.94 b	203.60 ± 1.27 b
'K-ČaJ/6'	81.50 ± 0.39 e	1.25 ± 0.03 bc	30.42 ± 0.48 e	127.46 ± 2.74 e
'K-ČaJ/7'	49.50 ± 0.13 jk	0.63 ± 0.09 ef	17.41 ± 0.33 i	53.49 ± 1.87 j
'K-GM/1'	95.50 ± 0.13 c	0.63 ± 0.05 ef	37.74 ± 0.44 c	169.12 ± 2.52 c
'Vodenjaja'	65.00 ± 0.77 h	1.46 ± 0.04 b	26.08 ± 0.52 f	102.80 ± 2.96 g
'Kantaruša'	174.50 ± 1.16 a	0.78 ± 0.03 def	70.97 ± 0.58 a	358.10 ± 3.28 a
'Takiša'	72.00 ± 0.77 g	1.25 ± 0.22 bc	21.40 ± 0.02 g	76.15 ± 0.11 h

The different lower-case letters assigned to columns show significant differences for P≤ 0.05 after applying LSD test/*Različita mala slova u kolonama označavaju značajne razlike na nivou P≤ 0.05 primenom LSD testa*

TPC: total phenol content/*sadržaj ukupnih fenola*; TAC: total anthocyanin content/*sadržaj ukupnih antocijana*; AA: antioxidant activity/*antoksidativna aktivnost*; TEAC: Trolox equivalent antioxidant capacity/*Trolox ekvivalent antoksidativni kapacitet*

Table 5. Fruit sensory characteristics of the assessed autochthonous pear genotypes
Tabela 5. Senzoričke karakteristike ploda ispitivanih autohtonih genotipova kruške

Genotype *Genotip*	FS	FA	GC	OC	FC	FF
‘Beli Mednjak’	regularly symmetric *simetričan*	intermediate *srednja*	green-yellow *zeleno-žuta*	red *crvena*	yellowish *žućkasta*	soft *mek*
‘Crveni Mednjak’	regularly symmetric *simetričan*	high *visoka*	green *zelena*	red *crvena*	white *bela*	firm *čvrst*
‘K-ČaJ/1’	regularly symmetric *simetričan*	intermediate *srednja*	green *zelena*	red *crvena*	yellowish *žućkasta*	soft *mek*
‘K-ČaJ/2’	regularly symmetric *simetričan*	high *visoka*	green *zelena*	red *crvena*	white *bela*	firm *čvrst*
‘Lubeničarka’	regularly symmetric *simetričan*	intermediate *srednja*	green-yellow *zeleno-žuta*	pink (red) *ružičasto crvena*	pinkish red *ružičasto crvena*	firm *čvrst*
‘Kajzerica’	regularly symmetric *simetričan*	intermediate *srednja*	green *zelena*	red *crvena*	white *bela*	firm *čvrst*
‘K-ČaJ/3’	regularly symmetric *simetričan*	high *visoka*	green *zelena*	red *crvena*	white *bela*	firm *čvrst*
‘K-ČaJ/4’	regularly symmetric *simetričan*	very high *veoma visoka*	green *zelena*	red *crvena*	yellowish white *žućkasto bela*	intermediate *srednje čvrst*
‘K-ČaJ/5’	regularly symmetric *simetričan*	intermediate *srednja*	green *zelena*	absent *odsutna*	yellowish white *žućkasto bela*	firm *čvrst*
‘K-ČaJ/6’	regularly symmetric *simetričan*	high *visoka*	green *zelena*	red *crvena*	yellowish white *žućkasto bela*	intermediate *srednje čvrst*
‘K-ČaJ/7’	regularly symmetric simetričan	intermediate srednja	green zelena	absent odsutna	white bela	intermediate srednje čvrst
‘K-GM/1’	regularly symmetric *simetričan*	high *visoka*	green-yellow *zeleno-žuta*	red *crvena*	yellowish *žućkasta*	soft *mek*
‘Vodenjaja’	highly asymmetric *asimetričan*	intermediate *srednja*	green *zelena*	absent *odsutna*	yellowish *žućkasta*	soft *mek*
‘Kantaruša’	highly asymmetric *asimetričan*	intermediate *srednja*	green *zelena*	absent *odsutna*	white *bela*	firm *čvrst*
‘Takiša’	regularly symmetric *simetričan*	low *niska*	green *zelena*	absent *odsutna*	yellowish *žućkasta*	firm *čvrst*

FS: fruit symmetry/*simetričnost ploda*; FA: fruit attractiveness/*atraktivnost ploda*; GC: ground colour/*osnovna boja pokožice*; OC: over colour/*dopunska boja pokožice*; FC: flesh colour/*boja mezokarpa*; FF: flesh firmness/*čvrstina mezokarpa*

fruits, with the exception of two cultivars, ‘Kantaruša’ and ‘Vodenjaja’, which had highly asymmetric fruits. In terms of fruit attractiveness, the cultivars and landraces were mostly classified as intermediate (eight genotypes), while low attractiveness was recorded for ‘Takiša’. Very high attractiveness was observed in the landrace ‘K-ČaJ/4’, whereas five cultivars and landraces (‘Crveni Mednjak’, ‘K-ČaJ/2’, ‘K-ČaJ/3’, ‘K-ČaJ/6’ and ‘K-GM/1’) were characterized by highly attractive fruits. The predominant ground colour was green (12 genotypes), while green-yellow was observed in the cultivars ‘Beli Mednjak’ and ‘Lubeničarka’, as well as in the landrace ‘K-GM/1’. In nine genotypes, red over colour was observed, while the cultivar

'Lubeničarka' was characterized by a pink (red) over colour. No over colour was noted in 'Kantaruša', 'Takiša', 'Vodenjaja', 'K-ČaJ/5' and 'K-ČaJ/7'. White (six genotypes), yellowish white (three genotypes), yellowish (five genotypes) and pinkish red ('Lubeničarka') flesh colours were identified in the assessed autochthonous pear material. Regarding flesh firmness, the genotypes were classified into three groups: soft (four genotypes), intermediate (three genotypes) and firm (eight genotypes).

Susceptibility to causal agents of scab and fire blight under field conditions. All assessed autochthonous pear cultivars and landraces displayed resistance or very low susceptibility to fire blight (rated 1 on the scale) and exhibited a narrow range of susceptibility to scab under field conditions (Figure 2). In terms of scab susceptibility, the genotypes can be classified into two groups: 0–3% (scale rating of 1) and 7–12% (scale rating of 3). Five cultivars ('Kajzerica', 'Kantaruša', 'Lubeničarka', 'Takiša' and 'Vodenjaja') and three landraces ('K-ČaJ/4', 'K-ČaJ/6' and 'K-ČaJ/7') showed resistance or very low susceptibility to scab; therefore, these eight genotypes exhibited the best performance regarding resistance to *Venturia pirina* Aderh. Low scab susceptibility was recorded in two cultivars and five landraces: 'Beli Mednjak', 'Crveni Mednjak', 'K-ČaJ/1', 'K-ČaJ/2', 'K-ČaJ/3', 'K-ČaJ/5' and 'K-GM/1'. Among 279 indigenous pear genotypes collected in central and southern Yugoslavia, Van der Zwet et al. (1987) observed that 64 genotypes demonstrated a high degree of resistance to leaf diseases and insects. Maresi et al. (2023) reported that the evaluation of 53 genotypes (32 local genotypes, 19 bred Romanian cultivars and three foreign cultivars) from the pear germplasm collection at the Research Institute for Fruit Growing in Pitești-Maracineni, Romania, revealed that 50 genotypes showed no visible symptoms of fire blight. Regarding scab susceptibility of these genotypes, only one local cultivar, 'Tomnatice', exhibited symptoms, while the others were rated 1 on the scale.

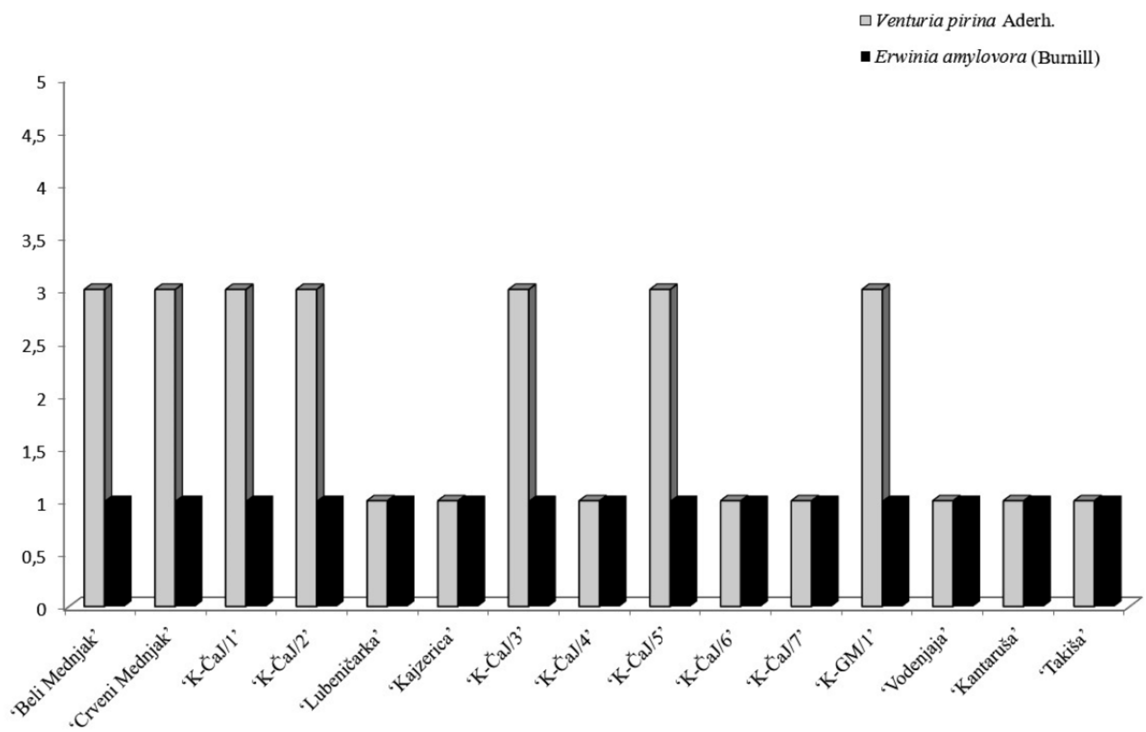

Figure 2. Susceptibility of the autochthonous pear genotypes to scab and fire blight under field conditions
Slika 2. Osetljivost autohtonih genotipova kruške na prouzrokovače čađave pegavosti lista i krastavosti plodova, kao i bakteriozne plamenjače u poljskim uslovima

Conclusion

This study provides essential preliminary information about the diversity of biological traits in Serbian autochthonous pear genotypes. Future studies should focus on advancing the collection, genotypic characterization, phenotypic evaluation and utilization of these traditional cultivars and landraces for various purposes. Access to accurately identified and diverse *Pyrus* germplasm will ensure that advances in breeding and genetic research continue into the future. Additionally, as climate conditions change and pressures from pests and diseases increase, along with consumer demand for fruit production with reduced chemical inputs, growing well-adapted local pear genotypes with enhanced resistance to abiotic and biotic stresses is needed.

Acknowledgements

This research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract number: 451-03-66/2024-03/200215).

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In situ EVALUACIJA AUTOHTONIH GENOTIPOVA KRUŠKE (*Pyrus communis L.*) GAJENIH NA PODRUČJU CENTRALNE I JUGOZAPADNE SRBIJE

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Rezime

Intenziviranje voćarske proizvodnje prilagođene zahtevima globalnog tržišta neminovno vodi zapostavljanju autohtonog materijala, što može prouzrokovati drastičan ili nepovratan gubitak ovog vrednog dela genofonda voćaka. Prepoznatljivost Instituta za voćarstvo u Čačku ogleda se upravo u korišćenju raznovrsnosti autohtonog genofonda voćaka u oplemenjivačkim programima, kao i u programima za direktno uvođenje u proizvodnju. U cilju daljeg proučavanja autohtonog materijala voćaka, u radu su prikazani rezultati ispitivanja najznačajnijih bioloških osobina 15 *in situ* genotipova kruške gajenih na različitim lokalitetima centralne i jugozapadne Srbije: Beli mednjak, Vodenjaja, Kajzerica, Kantaruša, Lubenjaja, Takiša, Crveni mednjak, K-GM/1, K-ČaJ/1, K-ČaJ/2, K-ČaJ/3, K-ČaJ/4, K-ČaJ/5, K-ČaJ/6 i K-ČaJ/7. Primenom međunarodno priznatog deskriptora (Pear Descriptors, IBPGR) i tehničkih uputstava za krušku (TG/15/1 i TG/15/3, UPOV), kao i korišćenjem standardnih laboratorijskih metoda ispitane su fenološke osobine (fenofaza cvetanja i vreme berbe), pomološke osobine (fizičke, hemijske – uključujući i sadržaj bioaktivnih jedinjenja, i senzoričke) i otpornost na prouzrokovače čađave pegavosti lista i krastavosti plodova [*Venturia pirina* Aderh.], kao i bakteriozne plamenjače [*Erwinia amylovora* (Burnill)] u poljskim uslovima. Najranije cvetanje zabeleženo je kod sorte ‘Vodenjaja’ (02. april), a najkasnije kod sorte ‘Kantaruša’ (21. april), sa razmakom od 19 dana između njih. Plodovi ispitivanih genotipova su sazrevali od 23. jula (Beli Mednjak; grupa izrazito ranih sorti) do 05. oktobra (Kantaruša i Takiša; grupa kasnih sorti). Najkrupnijim plodom odlikovala se sorta ‘Kantaruša’ (364,86 g; 92,18 mm; 92,00 mm), dok je najsitniji plod utvrđen kod sorte ‘Takiša’ (20,49 g; 31,12 mm; 34,93 mm). Sorta ‘Takiša’ je, na osnovu hemijskog sastava, pokazala najbolji kvalitet ploda (rastvorljive suve materije – 14,85%; ukupni šećeri – 10,33%). U pogledu bioaktivnih komponenti, sortu ‘Kantaruša’ karakterišu najviše vrednosti za ukupne fenole (174,50 mg galne kiseline na 100 g sveže mase ploda), antioksidativnu aktivnost (70,97%) i antioksidativni kapacitet izražen u Trolox ekvivalentima (358,10 mmol TE na 100 g sveže mase ploda). Najviši sadržaj ukupnih antocijana utvrđen je u plodu sorte ‘Lubeničarka’ (2,71 mg cijanidin-3-glukozida na 100 g sveže mase ploda). Genotip K-ČaJ/4 odlikuje se veoma atraktivnim plodovima. Simptomi karakteristični za prouzrokovača bakteriozne plamenjače kruške nisu uočeni u periodu ispitivanja kod proučavanih genotipova, dok su najviši stepen otpornosti na *Venturia pirina* Aderh. u poljskim uslovima ispoljile pet sorti (Kajzerica, Kantaruša, Lubeničarka, Takiša i Vodenjaja) i tri genotipa (K-ČaJ/4, K-ČaJ/6 i K-ČaJ/7). Sveobuhvatno posmatrano, autohtoni genotipovi kruške na prostoru Republike Srbije koji poseduju poželjne biološke osobine pružaju značajan potencijal za buduće programe oplemenjivanja, kao i za programe direktnog uvođenja u proizvodnju sa smanjenom upotrebom hemijskih sredstava u zaštiti.

Ključne reči: *Pyrus communis* L., autohtona sorta, genotip, kvalitet ploda, otpornost