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Research Article

Pomological and physicochemical properties of traditional pear cultivars in Karlovac County, Croatia

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Abstract

Traditional pear cultivars are mainly found as hereditary single trees in backyards, yards, gardens, or as solitary trees in parks, along roads and on forest edges. The aim of this study was to evaluate the pomological and physicochemical characteristics of 13 traditional Croatian pear cultivars, studied in Karlovac County area, in central Croatia, and to filter out potential cultivars for further cultivation or breeding. The analyzes traits showed that the cultivars differed significantly in the characteristics studied, i.e., fruit weight, height and width, fruit index, peduncle length and thickness, fruit firmness, number of sound and empty seeds in relation to the weight of sound seeds, soluble solids content, acidity, ratio of soluble solids to total acidity, pH. The cultivars 'Krasanka' and 'Dugačka' stood out for their fruit size and harmonious ratio of soluble solids and acids, while the cultivar 'Tepka' stood out for its high soluble solids content, which makes it a valuable raw material for distilling. Considering the diversity of pomological characteristics, their potential as sources of genetic variation, and their possible tolerance to abiotic and biotic stress factors, it is important to preserve traditional pear cultivars as a source of quality fruit for consumption or processing, protecting these valuable genetic resources together to the biodiversity of the area where they grow.

Keywords: genetic variability; pear; quality; traditional cultivars

Introduction

Nowadays, pear is a neglected and underutilized fruit species in Croatia, despite the diverse climatic conditions favorable for growing pears with different ripening periods (Skendrović Babojelić, 2019). Due to its importance, pears should be immediately after apples in Croatian fruit production, as they have a large cultivation area, but despite this, pears are not sufficiently cultivated and are imported in Croatia (Krpina *et al*., 2004).

With the introduction of new high-yielding commercial cultivars, traditional cultivars are neglected, which are an important source of genetic material (Skendrović Babojelić *et al*., 2015). Old cultivars are "gene donors" responsible for certain traits, such as tolerance to diseases and pests, tolerance to abiotic environmental factors, color, aroma, storage characteristics and more. Resistance and tolerance are the result of natural selection and adaptation to agro-ecological conditions over the centuries (Keserović *et al*., 2017). Old trees usually do not have great commercial value, but they contribute to biodiversity and typical appearance of the

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rural landscape (Skendrović Babojelić and Fruk, 2016). Their fruits sometimes have unusual pomological characteristics, but they are characterized by a different fullness of flavor, a different ratio of sugars and acids, and some cultivars have a particularly intense fruit aroma (Skendrović Babojelić *et al*., 2014). Today, the fruits of traditional cultivars are no longer commercially available (Vrbanac, 2007).

Pears are rarely the subject of research, and there is generally less knowledge about their composition and less literature comparing different cultivars (Đurić *et al*., 2015). Inventory of a given area and determination of morpho-pomological characteristics and genetic diversity of pear genome is of great importance for its conservation and sustainable use (Brewer and Palmer, 2011; Puskás *et al*., 2016; Brewer and Volz, 2019; Kajkut Zeljković, 2019; Li *et al*., 2022). Research on traditional pear cultivars is important because this genetically heterogeneous material is a source of genes for high quality pomological traits and tolerance to biotic and abiotic stresses, because it is known that commercial breeding programs use only a limited number of high-quality cultivars for the development of new cultivars, which leads to a gradual narrowing of the pear genetic base (Kellerhals *et al*., 2004). Breeding and creation of new cultivars is not possible without genetic diversity, and the growing demand of the population for food cannot be met without successful breeding programs (Jarebica and Kurtović, 1997).

Both globally and in Croatia, the demand for organically grown fruit that has not been treated with various chemical preparations, or has been treated only to a small extent, is increasing (Zovko *et al*., 2010). For this reason, old cultivars of fruit species are of great importance for integrated and organic production, but also as source material for breeding new quality cultivars resistant to diseases and pests (Keserović *et al*., 2017). At Karlovac County, there are still centuries-old trees of traditional pear cultivars that are threatened with decay. Among them, there are many fruits of forgotten sweet, juicy and delicious cultivars that enthusiasts and lovers try to preserve in their orchards. This area has a tradition of growing fruit trees, including pears, as evidenced by backyards with many old, often inherited, but still preserved trees. These are native autochthonous cultivars, domesticated cultivars, old cultivars mostly of unknown origin, with local names. The fruits of these trees are accepted by people as a kind of symbol of environmental friendliness, special taste and tradition, which have a sentimental value for the owners.

The aim of this work was to determine the pomological and physicochemical characteristics of traditional pear cultivars from the area of Karlovac County. Based on the results of this research, we recommend potential cultivars for cultivation and as gene donors in breeding programs, which also contributes to the conservation of traditional pear cultivars.

Materials and Methods

Object of the research

The research was conducted in the area of Karlovac County, Croatia. Fruits of researched cultivars (Figure 1) were harvested from old pear trees in orchards and backyards in different locations (Table 1).

Laboratory analyzes

Fruits were delivered to the laboratory of the Department of Pomology of the University of Zagreb, Faculty of Agriculture, where they were analyzed. Only healthy and undamaged fruits were isolated and then photographed with a digital camera (Nikon D 5300) and the analyzes of pomological and physicochemical properties of the fruits were performed according to Skendrović Babojelić and Fruk (2016). Fruit weight was determined on a digital laboratory balance with two decimal places (OHAUS Adventurer AX2202, Ohaus Corporation Parsippani, NJ, USA) and expressed in grams (g). The height (H) and width (W) of the fruit were measured using a digital caliper (Somet, Czech Republic) and expressed in mm. From the data obtained, the fruit shape index was calculated as the ratio of height to width. Fruit firmness was determined using a digital

penetrometer (PCE-PT200, PCE Instruments, Southampton, UK) with a piston diameter of 8 mm and a measuring scale to read the penetration force in kg/cm^2. The length and thickness of the stem were measured with a digital caliper (Somet, Czech Republic) and expressed in millimeters (mm). After cross-sectioning the fruit, the number of sound and empty seeds and the mass of sound seeds were determined in grams (g) on a digital laboratory balance with two decimal places (OHAUS Adventurer AX2202, Ohaus Corporation Parsippani, NJ, USA).

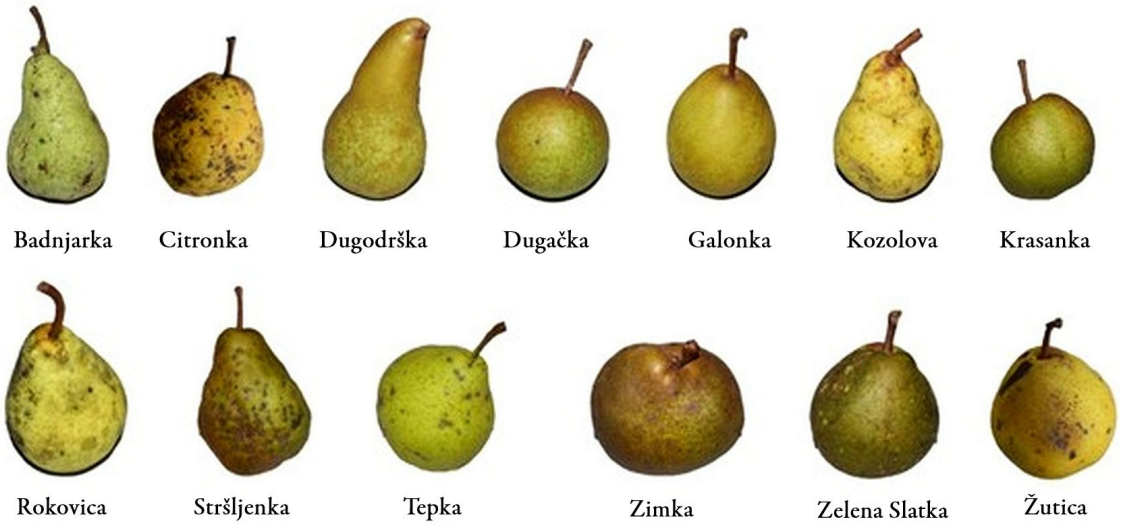

Figure 1. Researched old cultivars of pears

Table 1. Locations of Karlovac County, where pear fruits were collected, with the coordinates of GPS

Cultivars	GPS coordinates
'Badnjarka'	45°26'41.5"N
'Citronka'	45°27'14.5"N
'Dugačka'	45°29'53.0"N
'Dugodrška'	45°29'53.0"N
'Galonka'	45°30'22.2"N
'Kozolova'	45°29'53.0"N
'Krasanka'	45°29'53.0"N
'Rokovica'	45°25'18.4"N
'Stršljenka'	45°30'22.2"N
'Tepka'	45°27'06.1"N
'Zelena Slatka'	45°30'24.2"N
'Zimka'	45°27'41.3"N
'Žutica'	45°29'53.0"N

The fruit was crushed, and the juice squeezed from which the basic chemical composition was determined. Soluble solids content (SSC) was determined using ATAGO 3810 PAL-1 a digital refractometer (ATAGO, Tokio, Japan) and expressed in degrees Brix (°Brix). The percentage of total acids (TA) was determined by the standard titration method (NaOH) using the indicator bromothymol blue was determined. A digital continuous burette (Boeco DCB 5000, Germany) was used for titration. The percentage of TA is calculated according to the formula:

$$\%Total\ acids \quad = \frac{0.1\ m\mathrm{NaOH}\ (ml) \times\ 0{,}067\ \times\ 10}{The\ amount\ of\ sample\ in\ the\ titrated\ liquid(ml)}$$

and expressed as a percentage as malic acid. The juice reaction (pH) was determined using a digital pH meter (Testo 205, Hampshire, UK).

Statistical data processing

After the analyzes, the data obtained were statistically processed using SAS software system, version 9.4 (SAS / STAT, 2013). Analysis of variance (ANOVA) was performed. The mean values were compared using the LSD test. Different letters added to the means indicate that the cultivars differ significantly in the studied trait according to Fisher LSD test. A standard deviation is also given, indicating the average deviation of the results from the mean of the characteristic under study.

Results and Discussion

Pomological characteristics of the fruit

The results of the study of pomological characteristics (fruit weight, fruit height and width, fruit index, stem length and thickness, number of sound and empty seeds, weight of sound seeds) of traditional pear cultivars are presented in Table 2.

Fruit weight is one of the most important pomological traits, on which several other traits significantly depend (Kulina *et al.,* 2017). Statistically significantly higher average fruit weight was found in cultivars 'Krasanka' (202.23 g) and 'Dugačka' (185.38 g), which did not differ significantly from each other in fruit weight. They are followed by cultivars 'Zimka' and 'Badnjarka' with slightly lower values of fruit weight, while the significantly lowest average fruit weight was found in cultivar 'Tepka' (85.55 g).

According to Stančević (1980), the weight of a pear fruit varies from 14.04 g ('Vidovača') to 1000 g ('Lepa Anževika'). Gliha (1997) divides pear cultivars into five classes according to fruit size: very small fruit (below 40 g), small fruit (41-120 g), medium fruit (121-200 g), large fruit (201-280 g) and very large fruit (above 280 g). According to the studies of Skender (2007), the average fruit weight of native pear genotypes ranged from a maximum of 177.41 g to only 24.32 g. In the research of Đurić *et al*. (2015), the average fruit weight ranged from 109.04 g to 31.10 g, while the study of Selamovska (2014) showed an average fruit weight ranging from 13.80 to 214.10 g.

The results obtained in this study are partially in agreement with the studies of other authors. Very small and very large fruits were not found among the studied cultivars in this study. The fruits studied were medium to very large in size. Fruit weight determined for the cultivar 'Krasanka' agrees with data obtained by other researchers (Stančević, 1980; Mratinić, 2016). Jemrić *et al*. (2012) state that fruit size is influenced by many factors, and when trees grow under similar growing conditions, differences may be related to cultivar type and genetic characteristics. Therefore, the differences in fruit weight between the studied cultivars may be related to the genetic characteristics of the cultivar.

Significantly, the highest fruit height was recorded for the cultivar 'Dugačka' (11.09 cm), which is to be expected given its name (meaning 'long'), followed by 'Badnjarka', while the cultivars 'Tepka', 'Zelena Slatka' and 'Dugodrška' (4.87 cm) had the lowest fruit height. Similar data on total fruit height can be found in studies by other authors. Selamovska (2014) gives height values from 3.1 cm to 7.9 cm; Đurić *et al*. (2015) from 3.7 cm to 6.8 cm; Skender (2007) from 3.5 cm to 7.7 cm; Kajkut Zeljković (2019) from 2.7 cm to 8.5 cm. For the cultivar 'Krasanka', the obtained data are the same as those of Stančević (1980). According to a study by Selamovksa (2014), fruit width is divided into small fruits with diameter up to 5 cm, medium fruits with diameter 5.1-10 cm and large fruits with diameter more than 10 cm. According to Selamovska (2014), the cultivars studied in this work have medium-sized fruits. Statistically, the cultivar 'Krasanka' has a slightly larger fruit width (7.15 cm), which is consistent with the data reported by Stančević (1980) for the same cultivar (7.5 cm).

The fruit shape index is defined as the ratio between the height and the width of the fruit. A value greater than 1 means that the fruit is elongated, a value equal to 1 means that the fruit is round, and a value less than 1

means that it is flattened (Brewer *et al.,* 2006). The highest value of fruit shape index was found in cultivar 'Dugačka' (1.82), followed by 'Badnjarka' (1.44), while cultivars 'Zimka', 'Krasanka', 'Tepka' and 'Dugodrška' (0.89) had the lowest value of fruit shape index. According to the research of Nenadović Mratinić *et al.,* (2007), the shape index for 'Tepka' is 0.91, which means no discrepancy with the value determined in this study for the same cultivar. According to the classification of Brewer *et al*. (2006), most fruits are elongated, while four cultivars ('Zimka', 'Krasanka', 'Tepka' and 'Dugodrška') have a round, slightly flattened fruit shape.

Table 2. Pomological characteristics of fruits of the studied traditional pear cultivars

Cultivar	Fruit weight (g)	Fruit height (cm)	Fruit width (cm)	Fruit shape index	Stem length (mm)	Stem thickness (mm)
'Badnjarka'	140.62±31.21 ^{bc}	8.35±0.85 ^{ab}	5.82±0.53 ^{cd}	1.44±0.16 ^{b}	29.70±6.42 ^{a}	3.20±0.75 ^{d}
'Citronka'	117.40±15.23 ^{cdef}	6.88±1.93 ^{cde}	5.86±0.28 ^{bcd}	1.17±0.09 ^{d}	17.80 ±3.37 ^{e}	2.60±0.49 ^{ef}
'Dugačka'	185.38±58.69 ^{a}	11.09±1.33 ^{a}	6.08±0.67 ^{cd}	1.82±0.09 ^{a}	21.70 ±4.22 ^{cde}	4.10±0.70 ^{a}
'Dugodrška'	90.09±18.56 ^{fg}	4.87±0.34 ^{gh}	5.49±0.48 ^{de}	0.89±0.07 ^{e}	29.80±3.52 ^{a}	3.10±0.30 ^{de}
'Galonka'	97.49±23.57 ^{defg}	5.85±0.69 ^{fg}	5.36±0.31 ^{de}	1.09±0.11 ^{d}	21.10±4.04 ^{cde}	3.70±0.46 ^{bc}
'Kozolova'	126.90±27.27 ^{bcde}	7.54±0.48 ^{bc}	5.67±0.44 ^{cd}	1.33±0.06 ^{c}	26.50±6.44 ^{ab}	3.40±0.66 ^{cd}
'Krasanka'	202.23±20.51 ^{a}	6.70±0.36 ^{de}	7.11 ±0.33 ^{a}	0.94±0.06 ^{e}	25.40±1.80 ^{de}	3.00±0.45 ^{de}
'Rokovica'	95.18±21.85 ^{efg}	6.70±0.90 ^{de}	5.04±0.44 ^{e}	1.33±0.13 ^{c}	19.20±6.21 ^{ab}	3.60±0.80 ^{bc}
'Stršljenka'	128.80±27.64 ^{bcd}	7.52±0.61 ^{cd}	5.85±0.54 ^{cd}	1.29±0.11 ^{c}	26.30±3.80 ^{ab}	3.00±0.45 ^{de}
'Tepka'	85.55±19.55 ^{g}	5.03±0.59 ^{fgh}	5.50±0.48 ^{de}	0.92±0.10 ^{e}	25.40±4.98 ^{abc}	2.90±0.54 ^{def}
'Zelena Slatka'	100.78±56.25 ^{defg}	5.61±0.91 ^{fgh}	5.47±1.31 ^{de}	1.07±0.23 ^{d}	17.40±4.59 ^{e}	3.30±0.46 ^{cd}
'Zimka'	152.70±50.15 ^{b}	6.17±0.73 ^{ef}	6.46±0.64 ^{b}	0.96±0.08 ^{e}	29.90 ^{a} ±6.60	4.40±0.66 ^{a}
'Žutica'	119.09±24.14 ^{cdef}	6.74±0.49 ^{cde}	5.71±0.42 ^{cd}	1.18±0.09 ^{d}	23.40 ^{bcd} ±3.23	2.30±0.46 ^{f}
Pr > F	P ≤0.0001	P ≤0.0001	P ≤0.0001	P ≤0.0001	P ≤0.0001	P ≤0.0001

Note: Average values ± SD (standard deviation) are shown. Different letters added to the average values indicate that the cultivars differ significantly in the investigated trait according to the Fisher LSD test.

According to the descriptor for pears (Szalatnay, 2006), pears are classified into four groups based on peduncle length: short (length 15-24 mm), medium (length 25-34 mm), long (length 35-44 mm) and very long peduncle (length over 45 mm). The results of the stem length study show that the highest average stem length was found in the cultivar 'Dugodrška' [eng. 'Long-stem'] (29.80 mm), which can be interpreted as a peculiarity of this cultivar, after which it received its name. According to statistics, the cultivars 'Zimka' and 'Badnjarka' do not differ from each other, which means that they have the same stem length. They are followed by 'Kozolova', 'Rokovica', 'Stršljenka' and 'Tepka', which in comparison do not show significant differences in the average length of the stem. The cultivars 'Citronka' and 'Zelena Slatka' (17.40 mm) have the shortest average stem length.

Short-stemmed cultivars hold well to the branch and are easy to pick, while long-stemmed cultivars are more prone to fruit falling off the branch (Mratinić, 2016), making them unsuitable for growing in windy and unsuitable conditions (Dimitrovski,1974). According to the descriptor for pears (Szalatnay, 2006), the studied cultivars belong to the group of cultivars with medium and short stems, which indicates adaptation to growing conditions in continental climates. According to the thickness of the pear stem, Gliha (1997) divides pears into five classes: thin (less than 3.0 mm), medium (3.1-4.0 mm), strong (4.1-5.0 mm), very strong (5.1-6.0 mm), extremely strong (more than 6.0 mm). The results of the study of stem thickness show that the highest significant average stem thickness was found in the cultivar 'Zimka' (4.40 mm) and the cultivar 'Dugačka' (4.10 mm), between which there is no significant statistical difference, while the cultivar 'Žutica' (2.30 mm) has the thinnest stem with statistical significance. According to the classification of Gliha (1997), most of the studied cultivars belong to the group of cultivars with medium stem. The obtained results do not agree with the research of Đurić *et al*. (2015), who found that cultivars with thick and even very thick stems predominate in some native pear cultivars.

The content of seeds in the fruit speaks for the fertility of the genotype, i.e., diversity. A low value for the number of seeds indicates a tendency to parthenocarpy. Depending on the number of seeds in the fruit, pear cultivars have a very low number (0.1-1), small (1.1, -3), medium (3.1-5) or a large number of seeds (5.1-10) (Nyeki and Soltesz, 1998). The number of normally developed seeds is of particular importance from the point of view of generative mode of reproduction (Kulina *et al*., 2017). A large number of seeds were found in the studied cultivars, with a significant variation in the cultivar 'Zelena Slatka' with a very small number of seeds, which are also empty, which may be due to the presence of false parthenocarpy. The cultivar 'Tepka' also has a significantly higher proportion of empty seeds in relation to the total number of seeds. The results of the study of number and mass of seeds are presented in Table 3.

Table 3. Number and weight of seeds of the investigated pear cultivars

Sort	Number of healthy seeds	Number of empty seeds	Total number of seeds	Average weight of one seed (g)
'Badnjarka'	2.0 ± 0.16 ^{b}	4.0 ± 0.58 ^{a}	6.0± 0.65 ^{a}	0.05± 0.03 ^{c}
'Citronka'	3.0 ± 0.43 ^{ab}	2.0 ± 0.96 ^{b}	5.0± 0.50 ^{ab}	0.14± 0.02 ^{b}
'Dugačka'	3.0± 0.13 ^{ab}	3.0 ± 0.46 ^{ab}	6.0 ± 0.49 ^{a}	0.13 ± 0.10 ^{b}
'Dugodrška'	2.0± 0.86 ^{b}	4.0± 0.66 ^{a}	6.0 ± 0.70 ^{a}	0.04± 0.04 ^{c}
'Galonka'	3.0 ± 0.69 ^{ab}	2.0± 0.41 ^{b}	5.0 ± 0.61 ^{ab}	0.04± 0.04 ^{c}
'Kozolova'	4.0 ± 0.18 ^{a}	2.0 ± 0.57 ^{b}	6.0± 0.94 ^{a}	0.07 ± 0.04 ^{bc}
'Krasanka'	2.0 ± 0.01 ^{b}	4.0 ± 0.34 ^{a}	6.0± 0.16 ^{a}	0.10± 0.05 ^{b}
'Rokovica'	2.0 ±0.25 ^{b}	2.0 ± 0.01 ^{b}	4.0± 0.25 ^{b}	0.04± 0.01 ^{c}
'Stršljenka'	3.0 ± 0.04 ^{ab}	2.0 ± 0.94 ^{b}	5.0 ± 0.55 ^{ab}	0.05 ± 0.03 ^{c}
'Tepka'	1.0 ± 0.66 ^{c}	5.0± 0.90 ^{a}	6.0 ±0.32 ^{a}	0.26± 0.28 ^{a}
'Zelena Slatka'	2.0 ± 0.66 ^{b}	2.0± 0.49 ^{b}	4.0± 0.25 ^{b}	0.05± 0.06 ^{c}
'Zimka'	4.0± 0.33 ^{a}	2.0± 0.62 ^{b}	6.0± 0.05 ^{a}	0.10± 0.07 ^{b}
'Žutica'	5.0 ± 0.42 ^{a}	1.0 ± 0.54 ^{c}	6.0 ± 0.81 ^{a}	0.07 ± 0.04 ^{bc}
Pr > F	P ≤0.0001	P <0.0144	P <0.491	P <0.0008

Note: Average values ± SD (standard deviation) are shown. Different letters added to the average values indicate that the cultivars differ significantly in the investigated trait according to the Fisher LSD test.

Physio-chemical properties of the fruit of the pear cultivars studied

The results of the study of physio-chemical properties (fruit firmness, soluble solids content, total acids content, soluble solids/total acids ratio, pH) of the traditional pear cultivars are presented in Table 4.

The average firmness values of the fruit flesh of the studied pear cultivars ranged from 2.78 to 10.41 kg/cm^2, which is consistent with the pomological studies of native pear cultivars in Bosnia and Herzegovina by Kajkut Zeljković (2019). The highest statistically significant fruit firmness was found in the cultivar 'Zimka' (10.46 kg/cm^2). Slightly lower firmness was found in cultivar 'Dugodrška' (8.23 kg/cm^2), followed by 'Krasnka' and 'Tepka'. Higher firmness value may be a positive characteristic and predisposition of the cultivar for long-term storage and transportation. Significantly, the lowest fruit firmness was exhibited by 'Kozolova' (2.89 kg/cm^2) and 'Galonka' (2.78 kg/cm^2) cultivars, which did not differ statistically significantly from each other in their firmness values.

Pear cultivars with soft flesh and medium firmness flesh, like most cultivars in this study, are recommended for organic cultivation and immediate consumption (Beširević, 2009). Processing of traditional cultivars results in much higher quality products than the processed fruits of newer cultivars from intensive cultivation (Bašić, 2017), which indicates the great potential of the studied cultivars as raw materials in the food industry for the production of compotes, juices, brandy, dried fruit, etc.

Table 4. Statistical differences of the studied physicochemical properties of the fruits of the studied pear cultivars

Cultivar	Fruit firmness (kg/cm^2)	Soluble solids content (°Brix)	Total acids (% as malic acid)	Soluble solids content/total acids	pH value
Badnjarka	5.23±0.92 ^{dc}	13.83±0.84 ^{b}	0.50±0.07 ^{c}	27.84±3.33 ^{ef}	3.60±0.05 ^{f}
Citronka	4.49±1.05 ^{e}	12.97±0.96 ^{c}	0.34±0.17 ^{ef}	42.98±12.74 ^{cd}	3.66±0.06 ^{ef}
Dugačka	4.49±1.05 ^{e}	13.13±0.57 ^{bc}	0.22±0.12 ^{g}	72.84±24.72 ^{a}	4.31±0.05 ^{a}
Dugodrška	8.23±1.50 ^{b}	9.48±0.43 ^{e}	0.40±0.10 ^{d}	24.83±5.74 ^{g}	3.77±0.05 ^{d}
Galonka	2.78±1.42 ^{f}	12.79±0.34 ^{c}	0.26±0.10 ^{fg}	55.31±15.34 ^{b}	3.83±0.05 ^{c}
Kozolova	2.89±1.57 ^{f}	11.59±1.37 ^{d}	0.38±0.16 ^{e}	33.35±8.35 ^{ef}	3.76±0.08 ^{d}
Krasanka	6.31±0.77 ^{c}	11.55±0.65 ^{d}	0.42±0.06 ^{c}	27.98±5.13 ^{ef}	3.85±0.11 ^{c}
Rokovica	5.11±1.84 ^{dc}	9.91±0.81 ^{e}	0.39±0.05 ^{e}	26.09±2.79 ^{cfg}	3.62±0.08 ^{f}
Stršljenka	4.97±0.50 ^{e}	15.82±1.59 ^{a}	0.90±0.08 ^{b}	17.77±2.27 ^{g}	3.63±0.06 ^{f}
Tepka	6.36±0.58 ^{c}	16.14±0.98 ^{a}	0.48±0.08 ^{cd}	34.78±5.73 ^{de}	3.63±0.07 ^{f}
Zelena Slatka	6.02±0.81 ^{d}	12.89±0.61 ^{c}	0.39±0.08 ^{e}	34.19±5.95 ^{e}	3.71±0.07 ^{e}
Zimka	10.46±1.03 ^{a}	13.28±0.67 ^{c}	0.29±0.04 ^{g}	47.13±8.35 ^{bc}	3.95±0.06 ^{b}
Žutica	4.49±1.05 ^{e}	13.60±0.66 ^{bc}	1.82±0.09 ^{a}	7.55±0.16 ^{h}	3.61±0.04 ^{f}
Pr > F	P ≤0.0001	P ≤0.0001	P ≤0.0001	P ≤0.0001	P ≤0.0001

Note: Average values ± SD (standard deviation) are shown. Different letters added to the average values indicate that the cultivars differ significantly in the investigated trait according to the Fisher LSD test.

In fruit juice, sugars have the largest proportion of soluble solids content (SSC), so the amount of SSC can be determined as an estimate of the sugar content in fruit juice (Voća *et al*., 2011). The significantly highest amount of SSC was found in fruit of the cultivar 'Tepka' (16.14 °Brix) and 'Stršljenka' (15.82 °Brix), which did not differ statistically significantly in the studied trait. Due to the high SSC content, these cultivars are suitable genotypes for the production of brandy, as the amount of ethanol produced during fermentation depends on the sugar content (Berry and Slaughter, 2003). Most of the cultivars studied have SSC values between 12 and 14 °Brix and do not differ much statistically from each other. Given the SSC values, they can be used in the food industry for some form of processing and to obtain quality pear products. The minimum soluble solids value for pears used in processing into individual food industry products must be at least 10 °Brix (Skender *et al*., 2008). Significantly, the lowest percentage of SSC was found in the cultivars 'Dugodrška' (9.48 °Brix) and 'Rokovica' (9.91 °Brix). The obtained results do not show great deviations from the studies of other authors on traditional pear cultivars. In their study, Skender *et al.* (2008) determined the percentage of SSC in the range of 10.75 to 16.00 °Brix. Đurić *et al.* (2015) determined the SSC content in the range of 11.12 to 18.72 °Brix, which agrees with the values obtained in the study of Kajkut Zeljković (2019), which ranged from 11.41 to 18.52 °Brix.

According to Stančević (1980), the percentage of total organic acids in pear fruits ranges from 0.21% to 1.82%, which is in agreement with the values obtained for the studied cultivars. A significantly high proportion of TA was found in the cultivar 'Žutica' (1.82%), followed by the cultivar 'Stršljenka' (0.90%). Cultivars 'Dugačka' (0.22%), 'Galonka' (0.26%) and 'Zimka' (0.29%) had the lowest proportion of TA, between which no statistically significant difference in the proportion of TA was found. None of the studied cultivars was characterized by significantly low proportion of TA. The pear cultivars studied showed a relatively high total acidity value, partly due to the lower fruit illumination in the lush canopy and to the poorer weather conditions in the harvest year (fewer sunny days, more rain and cloud cover). However, the obtained values are in accordance with the results of authors who studied other traditional cultivars (Skender, 2007; Đurić *et al*., 2015; Selamovska *et al*., 2014).

The SSC/TA ratio is statistically highest for the cultivar 'Dugačka' (72.84), followed by the cultivars 'Galonka' (55.31) and 'Zimka' (47.13). These are sweet pear cultivars, as they have the lowest percentage of total acids. Cultivars whose soluble solids to total acids ratio is less than 20 are suitable for processing (Jemrić

et al., 2012). According to the obtained results, the most favorable sweet-sour cultivars for processing are 'Stršljenka' (17.77) and 'Žutica' (7.55), for which values of less than 20 were obtained, as they have a high proportion of total acids.

The sweet and sour cultivars 'Krasanka' (27.98), 'Rokovica' (26.09) and 'Badnjarka' (27.84) were found to have a particularly harmonious SSC/TA ratio. As such, they can be recommended for the broad consumer market. The highest pH of the juice was found in the cultivar 'Dugačka' (4.31), and the lowest in the cultivars 'Badnjarka' (3.60), 'Žutica' (3.61), 'Rokovica' (3.62), 'Stršljenka' (3.63) and 'Tepka' (3.63), which did not differ statistically significantly from each other. From the obtained results, it can be concluded that the studied cultivars have pH ranging from 3.60 to 4.31, which is within the limits of optimal acidity of fruits suitable for fresh consumption or processing. According to Stančević (1980), the pH of pear fruits ranges from 3.48 to 4.40, which is in agreement with the research results. The obtained pH results of pear fruits also agree with the data of the authors who studied other old cultivars (Đurić *et al*., 2015), and there are no significant deviations from the standard values.

Conclusions

The fruits of the traditional pear cultivars on Karlovac County differ significantly in the pomological and physicochemical properties studied. The results of the analyzes show that the fruits are of good quality and that they are in agreement with the research results of other authors. When choosing a pear in the store, consumers expect high quality fruits, medium to large size with regular pear shape, attractive color and pleasant taste. Traditional cultivars have most of these characteristics, but none has them all. Based on the conducted study of pomological and physicochemical properties, the cultivars 'Krasanka' and 'Dugačka' could be singled out for the size of the fruit and harmonious sweet-sour taste in terms of the required characteristics. Other cultivars did not stand out for the examined characteristics, but should not be excluded from cultivation, as they also have their own varietal characteristics. Some cultivars are characterized by a high content of soluble dry matter, such as the cultivar 'Tepka', which has always been used in this area for the production of brandy and represents something patriarchal in the villages and backyards. Some of the cultivars show genetic tolerance to various biotic and abiotic stresses and are adapted to the conditions of the site where they grow. Their cultivation does not require the use of chemical inputs and is therefore a source of healthy food and suitable for organic farming. The traditional cultivars studied in this work can serve as useful genetic material for breeding and contribute to biodiversity in nature, expanding the range of pears and preserving the appearance of the typical landscapes they embellish.

Authors' Contributions

Conceptualization: RV and MSB; Data curation: RV and MSB; Formal analysis: RV and MSB; Funding acquisition: RV and MSB; Investigation: RV; Methodology RV; Project administration MSB; Resources RV and MSB; Software MSB; Supervision MSB; Validation MSB; Visualization RV and MSV; Writing - original draft: RV; Writing - review and editing: MSB. All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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