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FRUIT SENSORY EVALUATION AND CHEMICAL COMPOSITION OF BULGARIAN PLUM CULTIVARS, BRED AT THE FRUIT GROWING INSTITUTE-PLOVDIV

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Abstract

European plums (*Prunus domestica* L.) are preferred by the fruit growers because of the species' great adaptability. The fruits have been known as food for people since ancient times and could be consumed in various ways - fresh, dried or processed. Nowadays, due to the fruit and cultivars import the consumers' demand for fruit taste and quality is constantly increasing. The present study was conducted in 2023 and 2024 and aimed to provide information on the sensory characteristics that determine the taste of several Bulgarian plum cultivars - Sirma, Pagane, Ulpiya, Plovdivska Renkloda and the candidate cultivar Alesina. In addition, the chemical composition of sugars and organic acids in the fruits was evaluated. During the two experimental years, variation in the taste qualities of the fruits was observed. Despite that, the final scores of the fruits of the candidate cultivar Alesina and Ulpiya cv. were assessed as very good in both years. Although early-ripening cultivars are typically characterised by lower TSS content, in our study Sirma and Alesina exhibited average TSS levels. The data from the chemical analyses show that there are differences in the qualitative composition of sugars in the fruits of the different cultivars, with the cultivar Stanley distinguished by the highest sugar content (15.63%). Invert sugar was dominant in all cultivars. Comparing the results from the sensory evaluation and the chemical properties, no clear connection could be found between the analyses. Based on our research, it could be concluded that all studied cultivars are suitable for fresh consumption.
Keywords: fruit quality, plum cultivars, sensory evaluation, sugar composition, total soluble solids

INTRODUCTION

The European plum (*Prunus domestica* L.), commonly called the domestic plum in Bulgaria, is a fruit species of strategic importance to the country. This highly adaptable species performs well across various agro-climatic regions of

Bulgaria. In terms of fruit production, it is the leading species for 2024, and in cultivated area, it ranks second only to sweet cherry (*Prunus avium* L.) (Agrostatistics, 2024). The strong interest in this crop is mainly due to the high quality of its fruit, which is suitable for both fresh consumption and processing. In the past, the most popular plum cultivar grown in Bulgaria was Kyustendilska sinya sliva, which is highly susceptible to the viral disease Plum pox virus (PPV, "Sharka"). The cultivar offered excellent taste qualities, suitable for fresh consumption and processing. However, because of its high susceptibility to PPV and the widespread presence of the virus in the country, Kyustendilska sinya sliva is no longer cultivated. Currently, breeding objectives are aligned with growers' and consumers' demands and include resistance to PPV, cultivars with larger fruits, and improved chemical composition and sensory traits (Bozhkova, 2014). The breeding programme of the Fruit Growing Institute was launched in 1987. Since then, nine cultivars of European plum (*Prunus domestica* L.) have been developed (Zhivondov and Bozhkova, 2010; Zhivondov and Milusheva, 2016; Nesheva and Bozhkova, 2020). This study describes the sensory and chemical properties of the newest registered cultivars and one candidate cultivar, currently under registration.

MATERIALS AND METHODS

The subject of the study includes the European plum cultivars bred at the Fruit Growing Institute-Plovdiv, Bulgaria - Ulpiya, Plovdivska Renkloda, Sirma, Pagane, and the candidate cultivar Alesina (Elite 1-14). Stanley was used as a standard cultivar. Five trees of each cultivar were planted in 2013 in a collection orchard. The cultivars were grafted onto the standard seedling 'Myrobalan' (*Prunus cerasifera* L.) rootstock and trained in a free-growing canopy shape. The current study was conducted in 2023 and 2024, and the sensory and chemical characteristics of the cultivars were investigated. Sensory analyses of the fruits were organized in both experimental years. The taste quality was evaluated by a group of consumers – trained researchers and experts from the Fruit Growing Institute. Sensory evaluation was performed individually by each member of the group. A five-point scale was used for the following sensory characteristics of the fruits: appearance determined by the size, shape and colour of the fruits, aroma attractiveness and intensity, sweetness, sour taste, bitterness, balance between flavours, texture and juiciness of the fruit flesh. To determine the importance of the evaluated sensory characteristic, the following assessment was used: 0 - absent, 1 - very bad to bad; 2 - satisfactory; 3 - good, 4 - very good and 5 - excellent. Each characteristic was multiplied by a coefficient according to its importance: 0.09 for size and shape, 0.085 for colour, 0.05 for aroma attractiveness and 0.225 for aroma intensity, 0.200 for sweetness, 0.125 for sour taste, 0.200 for balance between flavours and 0.150 for texture and juiciness. The bitterness of the fruits is a negative characteristic, and the coefficient given to it was -0.125 to lower the total score. The coefficients were discussed and agreed upon by the research staff of the Breeding, Genetic Resources and Biotechnology Department at the Fruit Growing Institute. After calculating the overall score, the fruits' sensory quality was evaluated using the scale: 4.00 - 5.0 – very good, 3.00 - 3.99 – good, 2.00 - 2.99 – fair, 1.00 - 1.99- poor and < 1.00 – very bad. They reflect a generalised

characterisation of desirable qualities in plum breeding. Chemical analyses were also performed in 2023 and 2024. The total soluble solids (TSS) content was determined using a Kern ORF 2WM refractometer. Sugar content was determined according to the Schoorl-Regenbogen method. Total acidity was measured by titrimetric analysis, and active acidity (pH) was determined potentiometrically using a calibrated pH meter. Statistical data analysis was performed using Duncan's Multiple Range Test, with the statistical software IBM SPSS Statistics 26.

RESULTS AND DISCUSSION

European plums intended for fresh consumption are usually harvested when their skin colour and firmness are optimal for the specific cultivar. There are no strict market requirements for plums meant for fresh consumption. According to Regulation (EU) No. 1580/2007 for European plum (*Prunus domestica* L.), the fruit diameter should exceed 35 mm. Smaller fruits are typically sweeter and more suitable for processing, especially for the production of dried fruits, such as prunes (Maghlakelidze et al., 2017; Wolf et al., 2020). The quality of plums is also influenced by external characteristics, such as the size and color of the pulp and skin, which are linked to their chemical composition (Kitzberger et al., 2017). However, consumer preferences may vary in different countries and regions around the world (Bujdosó et al., 2020). That is why sensory evaluations are important for growers and breeders to understand consumer acceptance of new cultivars and the characteristics that consumers prefer. According to Zmarlicki, 1996 the taste of a plum is considered the most important factor when purchase decision is taken and also the good taste qualities are main objective of each breeding program.

Fruit quality characteristics can be influenced by genotype-environment interactions, determining fruit acceptance by the end consumer (Cervantes et al., 2020). Variation in the taste qualities of the fruits of the studied plum cultivars was observed during the two years. In 2023, the fruits of the candidate cultivar Alesina were rated the highest in terms of almost all evaluated characteristics - color, attractiveness and intensity of aroma, sweet taste, balance between flavors, texture and juiciness of the fruit flesh (Fig. 1). In 2024, some deterioration in the taste qualities of the fruits was reported for all cultivars (Fig. 2). This is most probably due to the unfavorable climatic conditions during fruit ripening in this year – extreme drought and high temperatures.

Sensory evaluation combines the external appearance and taste qualities, with taste having greater importance for the final score (Bozhkova, 2014). In our study, the evaluation card includes seven indicators describing the taste and three indicators describing the appearance of the fruits, out of a total of nine. Additionally, when calculating the final score from the sensory analysis of the fruits, correction coefficients are used to assign greater weight to taste qualities. Fruit size influences buyers' and consumers' opinions, with larger fruit size always preferred in plums. Fruit colour, together with fruit size, contributes to fruit attractiveness. After averaging data from both experimental years and conducting statistical analyses, Pagane received the highest score, indicating the most desirable fruit size, though Alesina and Sirma were comparable (Table 1).

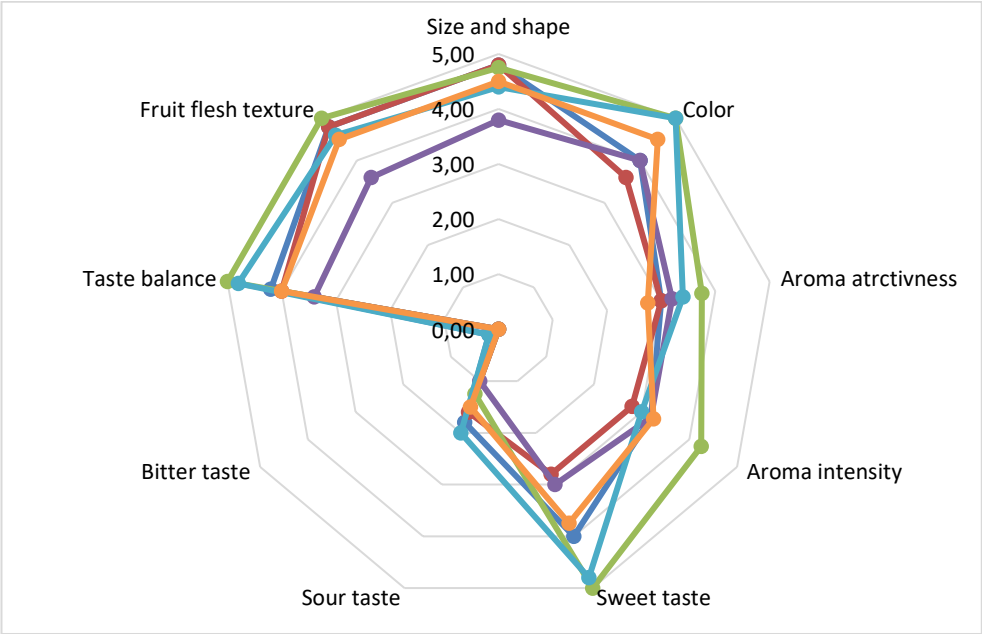

Fig. 1 Fruits sensory analyses in 2023

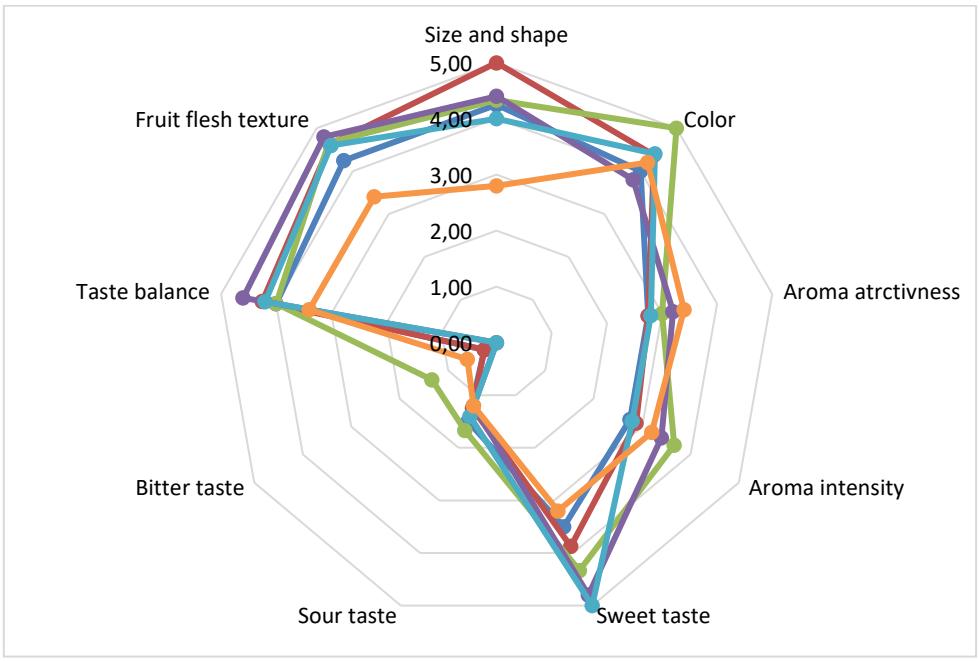

Fig. 2 Fruits sensory analyses in 2024

Plovdivska renkloda and Pagane belong to the group of Gage plums and have light violet colouration, which consumers in Bulgaria do not prefer. The fruit colour of Alesina was the most attractive and the candidate cultivar had the highest score for this attribute. The differences in aroma among all tested cultivars were statistically non-significant, indicating a generally pleasant aroma profile. The sweetest cultivar was Ulpiya, followed by Alesina and Plovdivska renkloda, with no significant differences between them. All cultivars exhibited similarly low sourness values, indicating mild acidity, with no significant differences. Bitterness is undesirable in plum fruits. A slight bitter taste was recorded in Stanley, Sirma, Alesina, and Ulpiya, which is attributed to deteriorated taste qualities in 2024. All plum fruits had a balanced taste, with harmonious proportions of sweetness and acidity, according to the panel of trained consumers.

Table 1. Sensory evaluation of the fruits average for 2023-2024

	Fruit appearance		Aroma	Taste					
Cultivar	Size and shape	Color	Attractiv-ness	Intensity	Sweet	Sour	Bitter	Balance	Fruit flesh texture and juiciness
Stanley	0,32 c	0,37 bc	0,16 a	0,73 a	0,69 c	0,17 a	-0,04 a	0,73 a	0,58 b
Sirma	0,41 ab	0,34 c	0,14 a	0,68 a	0,76 bc	0,21 a	-0,03 a	0,82 a	0,68 ab
Pagane	0,44 a	0,34 c	0,15 a	0,63 a	0,70 c	0,19 a	0,00 a	0,86 a	0,71 a
Alesina	0,41 ab	0,43 a	0,17 a	0,90 a	0,94 ab	0,18 a	-0,07 a	0,91 a	0,73 a
Ulpiya	0,38 abc	0,40 ab	0,16 a	0,65 a	0,98 a	0,21 a	-0,01 a	0,90 a	0,69 a
Pl. renkloda	0,37 bc	0,33 c	0,16 a	0,74 a	0,78 abc	0,14 a	0,00 a	0,80 a	0,63 ab

The soil and climatic factors play an important role, along with the subjective way of scoring (Bozhkova, 2014). The overall score combines all indicators and represents a generalized indicator of the taste qualities of each cultivar. Despite the slight variations in the final scores, the taste qualities of the candidate cultivar Alesina and the Ulpiya cv. were assessed as very good in both years, demonstrating their stability across the different climatic conditions in both years (Table 2). With a statistically significant difference, Alesina had the highest total score and the most appreciated by the consumers fruits.

Table 2. Total score and final sensory evaluation of the fruits

Cultivar	2023		2024		Average 2023-2024	
	Total score	Final evaluation	Total score	Final evaluation	Total score	Final evaluation
Stanley	4,07	Very good	3,4	Good	3,67 b	Good
Sirma	4,2	Very good	3,77	Good	4,01 ab	Good
Pagane	3,8	Good	4,05	Very good	4,01 ab	Good
Alesina	4,9	Very good	4,2	Very good	4,60 a	Very good
Ulpiya	4,5	Very good	4,21	Very good	4,35 ab	Very good
Pl. renkloda	3,51	Good	4,39	Very good	3,95 ab	Good

The results of the sensory analysis help the quality grading of the cultivars, and comparing those results with the chemical composition of fruits is important for evaluating the relationship between the two analyses. The cultivars Sirma and the candidate cultivar Alesina ripen at the end of July, while the other cultivars have a later ripening period, occurring in August. The high TSS content is associated with higher sugar levels in plums, which enhances the quality and yield of the product when the fruits are intended for processing (Akin et al., 2008). The measurement of TSS is a rapid method for assessing the biological value of the fruits. Its values vary widely among the different genotypes. According to Pangelova (1969) the TSS content is cultivars specific characteristic and could be significantly affected by the climatic conditions. In years with higher humidity and rainfall, the values are lower and vice versa. This explains the variation in the sensory characteristics in both years. In plums, TSS values have been reported to vary roughly from 12.7% up to nearly 29 %, depending on cultivar and growing conditions (Săpoi et al., 2025). Although early-ripening cultivars are typically characterised by lower TSS content, in our study Sirma and Alesina exhibited average TSS levels (Table 2). Based on the sensory evaluation, Ulpiya received the highest score for sweetness, which corresponded with its high total soluble solids (TSS) content. The data show that there are differences in the qualitative composition of sugars in the fruits of the different cultivars, with the cultivar Stanley distinguished by the highest sugar content (15.63%). In the studied fruits, sucrose content ranged from 1.63 to 5.98, with invert sugars being dominant in all cultivars. Invert sugar is also reported as the prevailing type of sugar in the plum fruits by various authors (Bozhkova, 2014; Stefanova et al., 2025). Organic acids of fruits have a good effect on the stomach and the intestinal tract, and they also determine the taste qualities of fruits. As a whole, the studied cultivars have a low acid content varying from 0.48 to 0.65%, with the highest levels recorded in Stanley and Sirma. The results for active acidity (pH) among the studied cultivars were similar (ranging from 3.73 to 3.90) and within the optimal range.

Soluble sugars and organic acids are key indicators of the quality and flavor of plums (Xiao et al., 2024). Generally, fruit ripening tends to decrease the organic acid content and increase the sugar content (Zhou et al., 2018). TSS content, titratable acidity and their ratio have been suggested as the most reliable maturation parameters for plums, since fruit sweetness gradually increases and acidity decreases during ripening (Bhutani and Joshi, 1995, Prasanna et al., 2007). TSS and TA content are analyses commonly used to indicate quality and to account for consumer acceptability of fruits (Crisosto et al., 2004). The TSS/TA ratio was the lowest in Stanley cv. indicating a sourer taste compared to the other cultivars included in the study.

A strong correlation was found between the total score from the sensory evaluation and the sweetness of the fruits (0.932**). The connection between the sweetness of the fruits and the consumer acceptance is also previously described by other authors (Crisosto et al., 2005; Delgado et al., 2013). However, when comparing the results from the sensory evaluation and the chemical analyses, no clear connection could be established between the chemical properties and the sensory evaluation. For instance, the ‘Stanley’ cultivar exhibited the highest sugar

content and a balanced acid profile, yet its taste score was not among the highest. This suggests that consumer preferences are highly specific and not necessarily determined by the chemical composition of the fruits. Even the total sugar content and the results from the sensory evaluation of sweetness do not show a direct relationship.

Table 3. Chemical analyses of the fruits

Cultivar	TSS (°Brix)	Total sugars	Invert sugar	Sucrose	Acids (TA) %	pH	TSS/TA
Stanley	18,11	15,63	10,98	4,21	0,65	3,90	27,86
Sirma	19,93	12,97	11,09	1,79	0,64	3,83	31,39
Pagane	19	13,16	10,58	2,45	0,46	4,10	41,76
Alesina	18,55	14,16	12,18	1,88	0,48	3,90	38,65
Ulpiya	20,89	13,32	11,60	1,63	0,60	3,73	34,82
Pl. renkloda	17,61	14,04	7,75	5,98	0,54	3,90	32,61

CONCLUSIONS

Based on the sensory evaluation of cultivars bred at the Fruit Growing Institute – Plovdiv, all are suitable for fresh consumption. The most appreciated by consumers were the fruits of Alesina and Ulpiya. Ulpiya had the highest TSS content. In all studied cultivars, invert sugar was dominant. However, no clear link was found between the chemical properties and the sensory evaluation of the fruits. Therefore, it can be concluded that both chemical and sensory analyses are essential for comprehensive cultivar characterisation. Conducting chemical analyses alone is insufficient to accurately describe the sensory profile of the fruits.

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