

## CHEMICAL COMPOSITION AND SENSORY EVALUATION OF PLUM FRUITS

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Received (Alınış) : 06 October 2014, Accepted (Kabul Ediliş) : 24 March 2015, Published (Basım): August 2015

**Abstract:** Plum fruits (*Prunus domestica* L.) have long been known as food for people since ancient times. They are consumed fresh, dried or processed. The increasing consumers' demand for quality of fruit is a relevant reason to present information about the differences in the chemical composition and the sensory characteristics between the widely spread and newly studied plum cultivars. The present study was carried out in the period 2009 - 2012 at the Fruit-Growing Institute – Plovdiv, Bulgaria on 12 plum cultivars. The results of chemical composition analysis showed that the fruits of 'Jojo', 'Topking', 'Topfive' and 'Mirabelle de Nancy' have a total soluble solid above 20 °Brix. The highest sugar content was found in the fruits of 'Jojo'. Fruits of 'Pacific' have the highest titratable acids content (1.28%) compared to the other cultivars. The highest vitamin C content (11.92 mg/100 g) was determined in the fruits of 'Stanley' cultivar. According to the sensory data, fruits of the cultivars 'Bellamira', 'President' and 'Tuleu Timpuriu' were grouped as the most delicious fruits and were regarded as suitable for fresh consumption. The general sensory evaluation showed that the fruits of 'Bellamira', 'Haganta', 'President' and 'Tuleu Timpuriu' are excellent in quality and they could be recommended to consumers and traders.

**Key words:** *Prunus domestica* L., chemical composition, fruit sensory evaluation.

### Erik Meyvelerinin Kimyasal Kompozisyonu ve Duyusal Değerlendirilmesi

**Özet:** Erik meyvelerinin antik zamanlardan bu yana insanlar tarafından bir besin olarak kullanıldığı bilinmektedir. Erik taze kurutulmuş ya da işlenmiş olarak tüketilmektedir. Tüketicilerin kaliteli meyve konusundaki artan talepleri geniş kitlelerce bilinen ve üzerinde yeni yeni çalışmalar yapılmakta olan erik çeşitlerinin kimyasal kompozisyonları ve duyusal özelliklerinin belirlenmesindeki etkili bir role sahiptir. Bu çalışma 2009-2012 yılları arasında Plovdiv Meyve Yetiştirme Enstitüsü'nde 12 erik çeşidi üzerinde gerçekleştirilmiştir. Kimyasal kompozisyon analizlerinin sonuçları 'Jojo', 'Topking', 'Topfive' ve 'Mirabelle de Nancy' çeşitlerinin 20 °Brix üzerinde bir toplam çözünebilir katı maddeye sahip olduklarını göstermiştir. En yüksek şeker oranı 'Jojo' meyvelerinde bulunurken, 'Pacific' meyvelerinin en yüksek titre edilebilir asitlik değerine (%1.28) sahip olduğu tespit edilmiştir. En yüksek vitamin C içeriği ise (11.92 mg/100 g) 'Stanley' çeşidinin meyvelerinde bulunmuştur. Duyusal değerlendirme verilen göre, 'Bellamira', 'President' ve 'Tuleu Timpuriu' çeşitleri en lezzetliler olarak gruplandırılmışlar ve taze tüketime uygun olarak ele alınmışlardır. Genel duyusal değerlendirmeler de 'Bellamira', 'Haganta', 'President' ve 'Tuleu Timpuriu' meyvelerinin çok iyi kalitede olduklarını göstermiştir ve tüketicilere ve tüccarlara önerilebilirler.

**Anahtar kelimeler:** *Prunus domestica* L., kimyasal kompozisyon, meyve duyusal değerlendirmesi.

### Introduction

Plum fruits have been known and used as food by people since ancient times as fresh, dried or processed fruits. According to Ramming and Cociu (1991), fresh plum fruits are quite similar to peaches and nectarines as food with their similar carbohydrate, acid, calorie and cellulose contents and they all belong to the energy fruit foods. Plum crop is the second ranking in planted area and in fruit production in Bulgaria. The 'Stanley' cultivar occupied 80% of the plum orchards in Bulgaria since 1980s and growers are looking for new cultivars are for grape diversifying. New commercial plum cultivars are distinguished by their fruit large sizes, dark colour of their skin and their resistance or tolerance to Plum pox virus. In many cases, however, the chemical and sensory characteristics are not

improved. Such cultivars are attractive to the producers but not acceptable to the consumers. The increasing consumers' demand for quality of fruit is a relevant reason to present information about the differences in the chemical composition and the sensory characteristics between the widely spread and newly studied plum cultivars.

### Materials and Methods

The study on the chemical composition of plum fruits of 12 cultivars was carried out in the period of 2009-2012 and the sensory evaluation was conducted in the period of 2010-2012 at the Fruit Growing Institute in Plovdiv. The fruits were harvested from trees in full fruiting stage, under non-irrigation

conditions. The standard cultivar 'Stanley' was used for comparison. Fruits in technological maturity were collected for the average samples and they were used for the chemical analysis and the sensory evaluation. Total soluble solid (TSS) content was determined, sugars were determined according to the method of Schoorl-Regenbogen, the acid contents were defined titrimetrically, active acidity (pH) was measured potentiometrically and the ascorbic acid (Vitamin C) was determined by the method of Tillmans.

Sensory evaluation was carried out individually by members of an authorized tasting panel. A nine-grade scale was used to evaluate the following seven sensory characteristics of the fruit: size, shape, colour, texture, taste, aroma and sweetness. The following scoring was used to define the strength of the sensory characteristic evaluated; 1-3 very poor to poor; 3-4 fair; 5-6 good and 7-9 very good to excellent. Every characteristic was multiplied by a specific weight coefficient as following: 0.43 for size, 0.43 for shape, 0.44 for colour, 0.6 for texture, 0.7 for taste, 0.7 for aroma and 0.7 for sweetness. The final score was obtained on the basis of the average grade of the total evaluation. According to the final evaluation, the fruits were divided as excellent or first class. Data of the chemical analysis were statistically analyzed following Duncan's multiple range test (Steele and Torrie 1980).

## Results and Discussion

### *Chemical Composition of Fruits*

The predominant number of investigated plum cultivars ripened in August. 'Tuleu timpuriu' matured in July, whereas 'President' and 'Stanley' matured from late August to early September (Table 1).

Total soluble solid (TSS) is a characteristic that gives the most rapid information about the biological value of a fruit. The TSS content in the present study varied from 15.6 in 'Tuleu Timpuriu' cultivar to 22.19 in 'Topking' cultivar. TSS content value was 17.95 in the standard cultivar 'Stanley' (Table 1).

The average values of total soluble solid were above 20 in only 4 of the 12 cultivars. These cultivars were 'Mirabelle de Nancy', 'Jojo', 'Topking' and 'Topfive' and the difference compared to all other cultivars was statistically significant only in 'Topking'. 'Tuleu Timpuriu', 'Serdika' and 'Pacific' fell in the group of cultivars having the lowest TSS content and the difference in their ripening is about a month and a half. Consequently, a correlation between the ripening time and the TSS content was not found, as all the trees were grown under the same conditions, which means that the TSS content is a cultivar specific characteristic. The TSS content data corresponded to the results of other studies in Bulgaria. According to Iliev et al. (1977), TSS content of 28 studied plum cultivars varied

**Table 1.** Chemical composition of plum fruits (2009-2012)

Cultivar	Ripening period*	Total soluble solid (°Brix) (TSS)	Sugar %			Acids (TA)%	pH	Ascorbic acid mg/100g	TSS/TA ratio
			Total	Invert	Sucrose				
<b>Bellamira</b>	15-20 Aug.	19.39 b	11.02 ab	6.18 bc	4.69 bc	0.55 b	3.34 a	6.11 b	35.25
<b>Haganta</b>	15-20 Aug.	19.75 b	10.05 b	7.26 b	2.65 c	0.60 b	3.30 a	8.85 b	32.91
<b>Jojo</b>	25-30 Aug.	20.5 ab	12.31 a	9.32 a	2.84 c	0.83 ab	3.32 a	6.48 b	24.69
<b>Miragrande</b>	18-22 Aug.	19.96 b	10.0 b	6.42 bc	3.12 c	0.67 b	3.49 a	nt**	29.79
<b>Mirabelle de Nancy</b>	13-20 Aug.	20.34 ab	11.74 ab	7.32 b	4.19 c	0.83ab	3.25 a	3.36 c	24.50
<b>Pacific</b>	18-25 Aug.	16.67 c	9.24 b	5.15 c	5.39 b	1.28 a	3.17 a	6.12 b	13.02
<b>President</b>	25 Aug. 01 Sept.	19.32 b	10.47 b	6.23 bc	4.07 c	1.02 ab	3.22 a	3.57 c	18.94
<b>Serdika</b>	15-25.Sept.	16.65 c	9.74 b	6.47 bc	3.38 c	0.61 b	3.24 a	9.47 ab	27.29
<b>Stanley</b>	27 Aug. 07 Sept.	17.95 b	10.29 b	6.16 bc	6.16 b	0.57 b	3.73 a	11.92 a	31.49
<b>Topking</b>	10- 20 Aug.	22.19 a	9.99 b	6.19 bc	3.61 c	0.58 b	3.15 a	7.7 b	38.25
<b>Topfive</b>	12-18 Aug.	22.0 ab	11.45 ab	7.20 b	4.03 c	0.81 ab	3.25 a	6.52 b	18.33
<b>Tuleu timpuriu</b>	10-16.July	15.6 c	6.96 c	2.71d	9.82 a	1.2 ab	3.31 a	nt**	13.0

Values followed by the same letter in a column were not statistically different ( $P < 0.05$ ).

\*The earliest and the latest data of three years observation

\*\*nt –not tested

from 14.5 to 26.3. According to Pangelova (1969) the climatic conditions in summer had an effect on TSS

values: when the weather is humid in summer, the values are lower and vice versa. Pangelova (1969) also

found that the chemical composition of fruits of some cultivars is relatively more stable. Other authors also reported data about the TSS content, which are similar for some plum cultivars (Milosevic and Milosevic 2012, Walkowiak-Tomczak 2008, Voca et al. 2009, Vangdal et al. 2007) and it could be said that it shows the potential of the cultivars of *P. domestica*, grown in Europe, in terms of TSS contents.

It is known that TSS and the total sugar contents are in a positive correlation, but this does not always mean that the cultivar with a higher soluble solid content has a higher sugar percentage. According to the studies of Pangelova (1969) and Iliev et al. (1977) the correlation coefficient calculated for 25 plum cultivars showed a higher degree of correlation ( $r = +0,852$ ), which necessitates the use of refractometers, even in field conditions, as they can give a more reliable information for evaluating the quality of fruit.

Sugars in plum fruits are inverted sugar and sucrose. The total sugar content of the cultivars included in the present study varied from 6.96% in 'Tuleu Timpuriu' to 12.31% in 'Jojo', the differences to the other cultivars being statistically significant. In a review study about the nutritive characteristics of plum cultivars, Walkowiak-Tomczak (2008) mentioned that the sugar content varied from 6.7% to 15%. The results of our study also revealed sugar content values falling into this range. Concerning the types of sugars, it should be noted that the amount of inverted sugar prevail in the studied cultivars and that tendency was not confirmed only for the early ripening cultivar 'Tuleu Timpuriu'.

Organic acids of fruits have a good effect on stomach and the intestine tract and they also determine the taste qualities of fruits. As a whole, the studied cultivars have a low acid contents varying from 0.55% and 1.28%. The highest statistically significant acid content was found for the cultivar 'Pacific' (1.28%), although it is a late ripening cultivar. The differences between the other cultivars were statistically insignificant. Voca et al. (2009) reported acid content values varying within 0.40% and 0.69% in the plum cultivars 'Top', 'Bistritsa' and 'Elena', i.e. the data are comparable with the results obtained in our study for other cultivars grown under different climatic conditions. Significantly higher values ranging from 0.9% to 2.3% were reported by Vangdal et al. (2007) who carried out a study on some plum cultivars in Norway. Probably the cooler climate had an effect on the values of this fruit characteristic. What is more, in our study, the cultivars having a higher dry matter content had a higher percentage of titratable acids. This tendency showing the influence of the climatic conditions on the chemical composition of fruits was also mentioned by Pangelova (1968) and it is expressed in obtaining fruits with a richer chemical composition

in the southern parts of Europe. According to the author, the way of collecting the average samples – whether the fruit is picked from the inner part of the tree crown or from the crown periphery, as well as the directions of the world – also have an effect on the values of chemical contents of fruits.

The pH value of the consumed fruits and juices could also affect the total pH balance in the human body. The cultivars included in the present study had pH values fruits ranging within 3.15% and 3.73%, but the differences between them were insignificant. Voca et al. (2009) reported data about three cultivars varying within 3.49% and 4.02%. Although the pH values of plums are low, plums are known as food with low acid content, which makes them useful for fresh consumption.

Fruits are also valuable for the vitamins they provide. The analyses about vitamin C content in plum showed that the 10 cultivars in the present study (in two of the cultivars this characteristic was not studied), the lowest vitamin C content was found in 'Mirabelle de Nancy' and 'President' – 3.36 and 3.57 mg/100 g, respectively, and the highest value was detected in 'Stanley' – 11.92 mg/100 g. Walkowiak-Tomczak (2008) reported average values ranging between 4 and 11 mg/100 g and the values they obtained are comparable with the results obtained in the present study. Walkowiak-Tomczak (2008) mentioned that fresh plums are poor in vitamin C but rich in antioxidants, beta-carotene and especially boron, which influences the calcium content and is important for prevention of osteoporosis. The daily demand of an organism for Ca is contained in 100 g of plum fruits.

#### Sensory Evaluation of Fruit

By virtue of Regulation (EC) No. 1580/2007, there are not specific market requirements for plum fruits, but following article 98, fruit diameter should be over 35 mm for the domestic plum cultivars and over 40 mm for the Japanese plum cultivars. In fact fruit quality is a complex of many different characteristics describing both external appearance and taste qualities, because fruits that are similar in external appearance could be absolutely different in taste and hence, accepted differently by consumers. That is why the sensory evaluation is as important as the chemical analysis for supplying the consumers with top quality fruits. The results of the sensory analysis help the quality grading of the separate cultivars and comparing those results with the chemical composition of fruits is important for evaluating the relationship between the two analyses. The results of the sensory analysis are presented in Table 2. Sensory evaluation is a combination of the external appearance and taste qualities, the latter having a greater importance for the final score.

**Table 2.** Sensory evaluation of fruits (2010-2012)

Cultivar	Appearance			Taste quality				Total Score	Final evaluation
	Fruit size	Fruit shape	Fruit colour	Texture	Taste	Aroma	Sweetness		
<b>Bellamira</b>	7.5	7.7	7.2	8.0	7.7	7.5	7.7	53.3	excellent
<b>Haganta</b>	8.6	7.6	8.5	7.5	7.2	7.1	7.3	53.8	excellent
<b>Jojo</b>	8.3	7.8	8.3	7.2	6.9	6.3	7.1	51.9	first class
<b>Miragrande</b>	6.5	8.0	6.2	7.2	6.6	6.5	6.2	47.2	first class
<b>Mirabelle de Nancy</b>	5.2	6.5	7.5	7.5	7.2	7.0	7.2	48.1	first class
<b>Pacific</b>	9.0	8.5	6.8	7.2	6.8	6.8	6.8	51.9	first class
<b>President</b>	8.5	8.0	7.3	7.4	7.4	7.1	7.3	53.0	excellent
<b>Serdika</b>	9.0	7.9	8.8	7.2	5.5	5.6	6.0	50.0	first class
<b>Stanley</b>	8.3	7.8	8.3	7.2	6.9	6.3	7.1	51.9	first class
<b>Topking</b>	6.3	7.1	7.1	6.2	5.5	5.6	5.3	43.1	first class
<b>Topfive</b>	7.0	7.8	8.5	7.6	7.1	6.6	7.3	51.9	first class
<b>Tuleu timpuriu</b>	8.7	8.6	7.3	7.6	7.4	6.8	7.0	53.4	excellent

Fruit size influences the opinion of the buyers and the consumers and the larger fruit size is always preferred for plums. Fruits of the cultivars 'Haganta', 'President' and 'Tuleu Timpuriu' were evaluated as extra quality and they comply with the requirements to this characteristic. The difference in the score between the studied cultivars was 3.8 points. Compared to fruit size, the score for fruit shape varied less and the biggest difference was 2.1 points. Judging by the score, it is difficult to link the preferences to a definite fruit shape, as all the fruits – round, oval and elongated in shape, got the same points. Fruit colour together with fruit size contributes to fruit attractiveness. Judging by the scores given for fruit coloration, it is obvious that the dark blue coloured fruits are preferred. As a whole, the studied plum cultivars have fruits of good coloration with an exception of 'Miragrande' and 'Pacific'. Observations show that this characteristic is affected slightly by the period of ripening and by the climatic factors, rendering an account of the fact that 'Pacific' is late ripening but it showed poorer fruit coloration during the years of the study, when the climatic factors were variable. 'Miragrande' cultivar belongs to Mirabelle plum type and the fruit is wax yellow in colour with insufficient colour intensity, which is partially due to the thick wax coating. Taste qualities combine the scores given for the texture, taste, aroma and sweetness. Usually the well-informed buyers pay great attention to taste qualities along with the external appearance of fruits. Out of the 12 studied cultivars, the highest score was given for the fruit texture of 'Bellamira' cultivar, which is of Mirabelle type, and, the lowest one – for the fruit texture of 'Topking'. The rest of the cultivars received very similar scores. As it could be assumed, the biggest difference was in the scores given for taste. This is the

characteristic of greatest importance for grading the cultivars in result of the sensory evaluation. The best taste was found in 'Bellamira', 'President' and 'Tuleu Timpuriu', although none was scored the maximum 9 points, i.e. the cultivars occupied the lower part of the excellent category. In a study carried out in Czech Republic (Blazek and Pistekova 2009) the score for taste in 'Topfive' cultivar corresponded to our study, the difference being only 0.3 points, but greater difference was observed for the cultivars 'Jojo' and 'President', which were given much lower score in Czech Republic compared to the present evaluation. The differences in 'Jojo' were about 0.9 points and in 'President' 1.3 points. Obviously the soil and climatic factors play an important role along with the subjective way of scoring. Looking at the values of the chemical analysis we could not find a correlation between the chemical properties and the result of the sensory evaluation. For example, 'Jojo' cultivar has the highest sugar content and a high TSS and a balanced acid content; however, its score for taste is not excellent. At the same time, the early ripening cultivar 'Tuleu Timpuriu' has the lowest TSS and sugar contents and a high acid content but still its final score is excellent. Even the content of total sugars and the results from the evaluation of sweetness do not show a direct relationship (the correlation coefficient is only +0.27). A lack of correlation was also found between the evaluation result of taste and TSS content ( $r = -0.30$ ). Similar results were obtained in the studies on the chemical content and sensory evaluation of apricot and peach fruits (Bozhkova 2009, Zhivondov and Malchev 2009). Obviously consumer's perceptions have their own specificity which leads to this difference. It could be concluded that data about the chemical composition of fruits, when used alone, is not enough for drawing

up the sensory profile. Both analyses should be discussed separately but both are equally important for characterizing biological and consumption value of the cultivars.

### Conclusion

Out of the 12 studied plum cultivars, the fruits of 'Jojo', 'Topking', 'Topfive' and 'Mirabelle de Nancy' have a total soluble solid higher than 20 °Brix. The highest content of sugars was found in the fruits of 'Jojo', 'Bellamira', 'Mirabelle de Nancy' and 'Topfive', of acids in 'Pacific' and 'Tuleu Timpuriu' and of vitamin C in the fruits of 'Stanley'. According to the results of the sensory analysis, the most delicious fruits were proved to be the fruits of the cultivars 'Bellamira', 'President' and 'Tuleu Timpuriu' and these results led us to consider them as suitable for fresh consumption. Final sensory evaluation showed that the fruits of the cultivars 'Bellamira', 'Haganta', 'President' and 'Tuleu Timpuriu' are excellent in quality and they could be recommended to consumers and traders.

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