

## CHEMICAL CONTENT OF FRUITS OF SOME PERSPECTIVE STRAWBERRY VARIETIES CULTIVATED ON OPEN FIELD

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### Abstract

This research contains results concerning the chemical composition of 15 introduced varieties of strawberries in Macedonia: Idea, Camarosa, Belrubi, Evita, Honeoye, Tethis, Chandler, Onda, Miranda, Paros, Elsanta, Eris, Madalene, Favette and Marmolada and two control varieties: Pocahontas and Sengasengana. The analysis has been conducted on the following substances: soluble dry matter, sugars (total and reductive), acids, pulp's pH, sugar/acid ratio, vitamin C, anthocyanins and mineral matters. The percentage of soluble dry matter is between 8.5% with the Eris variety and 11% with Idea. Idea has the highest concentration of sugars with 8.80% of total and 6.16% of reductive sugars. Eris has the lowest concentration of 6.80% total and 4.76% reductive sugars. Lowest amount of acids is 0.79% (Onda and Madalene) and highest is 0.94% (Evita). The range of pH value goes from 3.5 (Tethis) to 4.2 (Chandler and Pocahontas). The Marmolada variety has the highest sugar/acid ratio with 10.4 and Evita has the lowest of 8.1. The concentration of vitamin C goes between the range of 72.49mg% (Pocahontas) and 113.73mg% (Camarosa). The anthocyanins concentration with the Favette is to be the lowest with 37.06mg/kg, whereas the Elsanta reaches the highest content with 48.88mg/kg. The content of mineral matter within the fruit is between 0.52% (Chandler and Onda) and 0.94% (Tethis).

**Key words:** *Fragaria ananassa* Duch., strawberry, variety, chemical content, open field.

### Introduction

The strawberry plant fruit poses an attractive fruit which is rich in important and essential nutritious matter (Wozniak et al., 1997). The fruit is composed of a wide variety of organic and mineral substances responsible for its high nutritional, medicinal, and dietary value (Stančević, Stanisavljević 1986; Gavrilović, 1986; Благојевиќ, 1998). The chemical composition points towards a real employable, alimentary, and technological value of the strawberries (Поповски, 2008).

The main nutritional substances within the fruit are soluble dry matters, sugars (glucose, fructose, and sucrose) as well as organic acids which account for the refreshing flavour strawberries are known for. The increased number of sugary components results in a less notable citrusy flavor. Strawberries are a known source of various numbers of other chemical substances with protective anti-oxidant characteristics, such as vitamins and

coloured matter, vitamin C and antocyanins in particular. (Mratinić-Nenadović, 1989,2003, 2006; Milivojević, 2003).

The chemical composition of the strawberry fruit varies greatly within the mass of varieties. Afore all, its composition depends on the variety, degree of ripeness of the fruit, the fecundity, the growth system, applied agro-technical and protective measures for during the produce period, climate factors and the like. (Kiprijanovski, 2001; Milivojević, 2003; Popovski, 2008).

The aim of this study is a firm analysis of the chemical composition of the fruit of 17 different varieties of strawberries laid with a modern technology under a polyethylenefoil in an open field. The growing of strawberries out on an open field has been a dominant trend within the Skopje region and has been widely adopted within the entire region of the Republic of Macedonia.

## Materials and methods

The analysis was performed in an experimental orchard of the Agricultural Institute in Skopje during 2002–2004. The experiment was established in the second half of September 2001, with a frigo virus-free planting material, in three repetitions in a line, consisting of 30 plants of each repetition. The cultivation system was an open field, in two-row lines (long plots method), on black polyethylene foil at distance of 40x30 cm. The plants were irrigated with controlled quantities of water, through the drop-by-drop system. The soil was homogeneous, alluvial, possessing a good water-air regime, suitable for strawberry growing. The agrochemical composition of the soil consisted of 0.93-2.05% hummus, 9.32-10.38mg/100g N, 14.3-21.1mg/100g P<sub>2</sub>O<sub>5</sub>, 10.06-22.2 mg/100g K<sub>2</sub>O, 6.49-7.25% CaCO<sub>3</sub>, pH 7.93-8.19 in H<sub>2</sub>O and 7.4-7.63 in KCl. Based on the analyses, the soil has been ameliorative fertilized with mineral fertilizer and organic fertilizer from California worms. According to data for meteorological parameters from the Hydrometeorological Office Petrovec, the climate of the Skopje Region featured warm dry muggy summer and foggy cold winters.

The chemical content was observed on 15 introduction strawberry varieties: Idea, Camarosa, Belrubi, Evita, Honeoye, Tethis, Onda, Chandler, Miranda, Paros, Elsanta, Eris, Madlen, Favette and Marmolada, and two standard varieties: Senga Sengana and Pocahontas. The analysis has been conducted on the following substances: soluble dry matter, sugars (total and reductive), acids, pulp's pH, sugar/acid ratio, vitamin C, anthocyanins and mineral matters.

The composition of soluble dry matters is determined with a Carl Zeiss™ binocular refractometer, the sugars (total and reductive) are determined by liquid chromatography, whereas the total acids are differentiated by means odd titration with 0.1 N/10 NaOH and indicated as malic acid. The Tilman's method was employed to extract the values of Vitamin

C by means of titration with 2,6 dichlorophenol–indophenol, while the anthocyanins (mg/kg) have been determined spectrophotometrically, where the pH has been established by a PHmeter, and the content of mineral matters through a 550 °C heat exposure. The elicitation index was reached through a relation between the total sugars content and the total number of acids.

Analyses of variance were performed for statistical analysis of the results. The results were processed using LSD-test to prove the statistical significance of the differences between the varieties, with significance levels of 0.05 and 0.01. Coefficient of variation (CV%) of investigated characteristics is also analysed.

## Results and discussion

The percentage of solvable dry matters within the tested varieties circles round a broad frame of 8.5% with Eris and 11.0% with Idea with the average content amounting to 10.0% (Table 1). In comparison to Pocahontas; Idea, Marmolada, S. Sengana, Favette and Paros show a greater number of soluble dry matters, while only Idea and Marmolada are richer in content than S. Sengana. Some statistically highly significant differences between dry matters content within the varieties have been established between the Idea and Belrubi, Tethis, Honeoye, Evita, Chandler, Onda, Camarosa and the Eris variety. Another set of differences have also been established between Marmolada, S. Sengana, Favette, Paros, Pocahontas, Miranda, Elsanta, Madlen, Belrubi and Tethis with Honeoye, Evita, Chandler, Onda, Camarosa and Eris.

The great variation between the varieties exists in terms of composition of sugars. The greatest content in total and reductive sugars has been established with Idea (7.17 and 5.02% respectively), whereas the lowest with Eris (6.80 and 4.76). The average for all the varieties amounts to 7.97% in total and 5.58% in reductive sugars.

Table 1. Chemical content of strawberry fruits

No.	Variety	Soluble dry matters, %	Sugars		Total acids, %	Pulp's pH	Sugar/acid ratio	Vitamin C, mg%	Anthocyanins, mg/kg	Mineral matters, %
			Total	Reductive						
1	Idea	11,0	8,80	6,16	0,87	3,9	10,2	100,46	40,94	0,88
2	Camarosa	9,0	7,17	5,02	0,80	3,7	9,0	113,73	38,94	0,84
3	Belrubi	9,9	7,89	5,53	0,86	3,8	9,2	82,01	45,20	0,77
4	Evita	9,4	7,55	5,28	0,94	4,1	8,1	87,58	43,11	0,87
5	Honeoye	9,6	7,68	5,38	0,85	3,7	9,0	101,88	40,06	0,90
6	Tethis	9,8	7,84	5,49	0,89	3,5	8,8	103,64	47,28	0,94
7	Chandler	9,3	7,41	5,19	0,91	4,2	8,2	86,60	38,06	0,52
8	Onda	9,2	7,33	5,13	0,79	4,2	9,3	77,20	39,07	0,52
9	Pocahontas	10,4	8,35	5,84	0,84	4,2	9,9	72,49	47,21	0,61
10	S.Sengana	10,6	8,51	5,95	0,86	4,0	9,9	75,03	47,96	0,72
11	Miranda	10,3	8,27	5,79	0,89	3,8	9,4	75,67	47,90	0,80
12	Paros	10,6	8,48	5,94	0,82	4,0	10,4	86,79	43,11	0,90
13	Elsanta	10,3	8,24	5,77	0,84	3,9	9,9	98,81	48,88	0,69
14	Eris	8,5	6,80	4,76	0,83	4,1	8,2	75,51	47,90	0,61
15	Madlen	10,3	8,21	5,75	0,79	3,6	10,4	89,32	41,06	0,69
16	Favette	10,6	8,51	5,95	0,92	3,7	9,3	82,91	37,06	0,66
17	Marmolada	10,7	8,53	5,97	0,82	3,9	10,4	89,72	47,21	0,70
Average		10,0	7,97	5,58	0,85	3,9	9,4	87,90	43,58	0,74
CV%		5,01	5,01	5,01	1,87	3,59	5,52	4,12	2,56	7,31

LSD <sub>0,05</sub>	0,83	0,66	0,47	0,03	0,23	0,86	6,03	1,86	0,09
LSD <sub>0,01</sub>	1,12	0,89	0,63	0,04	0,31	1,16	8,11	2,49	0,12

The S. Sengana and Pocahontas standards are high in almost the equal amount of sugars with only the Idea variety showing higher values than them. The greatest and statistically most significant differences are there in the relation between Idea and Belrubi, Tethis, Honeoye, Evita, Chandler, Onda, Camarosa and Eris as well as Marmolada, S. Sengana, Favette, Paros and Pocahontas and Evita, Chandler, Onda, Camarosa and Eris, between Miranda and Elsanta with Onda, Camarosa and Eris, between Elsanta, Madlen and Belrubi with Camarosa and Eris.

The total content of acids is 0.85% on average and moves from 0.79% with Onda and Madlen to 0.94% with Evita. Belrubi, Idea, Miranda, Tethis, Chandler, Favette and Evita show greater values in total acids than S. Sengana, while Pocahontas is characterized by lower values than all of the aforementioned with the Honeoye variety added to the list. The Evita variety has statistically highly significant content of total acids from all of the 15 tested varieties. A significant difference does not show only with the Favette variety. The differences between Favette and Chandler are similar, showing a highly significant higher values of total acids with 13 tested varieties.

The difference with S. Sengana is significant in relation to the Eris variety and highly significant with Paros, Marmolada, Camarosa, Onda and Madlen. The differences between Pocahontas and Camarosa, Onda and Madlen are highly significant.

The pulp acidity revolves around the figures of 3.5 (Tethis), and 4.2 (Chandler, Onda and Pocahontas). The average for all of the varieties is 3.9. Eris, Evita, Onda, Pocahontas and Chandler show greater pH values than S. Sengana. The Chandler and Pocahontas varieties show statistically higher pH than S. Sengana, Paros and Elsanta and a significantly higher value than the 9 varieties. No differences have been established only with Eris, Evita and Onda. Statistically significant differences of the S. Sengana variety have been noted with the Camarosa, Honeoye and Favette varieties and highly significant with Madlen and Tethis. The Tethis variety, which is characterized by the lowest pH value, shows statistically highly significant differences of its values in relation to 11 varieties. This variety shows no relations only with the Camarosa, Honeoye, Favette, Madlen and Tethis varieties.

Paros, Madlen и Marmolada show for the greatest elicitation index(10.4), whereas Evita the lowest(8.1). The average for all of the varieties amounts to 9.4. The controls' values prove to be within the range of the average and higher with a higher index established with the Marmolada, Madlen, Parosand Idea varieties. The Marmolada, Madlenand Parosvarieties show statistically significant differences in terms of mid values odd the elicitation index with Miranda, Favetteand Ondaand highly significant differences with Belrubi, Honeoye, Camarosa, Tethis, Eris, Chandler and Evita. The Pocahontas, S. Sengana and Elsanta standards, are varietie showing statistically significant differences within the mid values of the elicitation index withHoneoye, CamarosaandTethisand highly significant differences with Eris, Chandlerand Evita. Evitashows the lowest elicitation index and no significant differences have been establish apart from with Chandler, Erisand theTethis variety.

During the process of establishing the chemical composition of a fruit's flesh, the values of Vitamin C are of the utmost significance as fruits rich in Vitamin C are of a greater interest to anyone. The lowest in Vitamin C values are theS. Sengana (87.90 mg%) and Pocahontas(72.49 mg%) varieties whereas the highest figures are appointed to Camarosa(113.73mg%). The Camarosa variety shows a statistically highly significant difference in relation to all the other 16 varieties under analysis. Other highly significant differences are there between Tethis, Honeoye, Ideaand Elsantawith 12 varieties (Marmolada, Madlen, Evita, Paros, Chandler, Favette, Belrubi, Onda, Miranda, Eris, S. Senganaand Pocahontas). S. Sengana и Pocahontas show significant and highly significant lower values for Vitamin C to all the varieties with the exception of Onda, MirandaandEris.

The alluring red color of the fruit is owed to the antocyanins. The antocyanins and Vitamin C are a vital source of anti-oxidants. The Favette variety is the lowest in anthocyanin's (37.06mg/kg), and Elsantashows the highest concentration of anthocyanin's (48.88mg/kg). The average amounts to43.58mg/kg.S. Senganais characterized with a rather large concentration of antocyanins (47.96mg/kg)with only Elsantashowing a greater content of antocyanins.

Pocahontastakes up as the sixth richest in antocyanins. With Elsanta, S. Sengana, Miranda, ErisandTethis filling in the spots from first to fifth place, respectively.The greatest statistically significant differences are there between Elsanta, S. Sengana, Miranda, Eris, Tethis, Pocahontasand Marmolada with Belrubi, Evita, Paros, Madlen, Idea, Honeoye, Onda, Camarosa, Chandler and Favette. Favette shows for the lowest values of antocyanins and has no established differences apart from those with the Chandler and Camarosa varieties. .

The mineral matters within a fruit if the strawberry varies from 0.52% (Onda) to 0.94% (Tethis) with the average being 0.74%. S. Senganawith 0.72%, takes the ninth place whereas Pocahontaswith 0.61% is at the fifteenth place.Higher values thanS. Senganaare noticed with Tethis, Paros, Honeoye, Idea, Evita, Camarosa, MirandaandBelrubi, and lower values than Pocahontashave been establish only with Chandler и Onda.Tethisshows no statistically significant differences whereas Paros, Honeoye, Idea и Evita. Paros, Honeoye, Ideaand Evitaare notices to have a higher concentration of mineral matters than Belrubi, S. Sengana, Marmolada, Elsanta, Madlen, Favette, Eris, Pocahontas, Chandlerand Onda.TheS. Senganastandard is noted to have significant differences with Erisand Pocahontas, and highly significant differences with Chandlerand Onda. Statistically, Pocahontasshows significantly higher values than Chandler and Onda.

According to the data on coefficients of variation, the characteristics under analysis vary only in the slightest percentage (Table 1). The lowest variation coefficient has been established with the total acid content (CV%=1.87), whereas the highest with the content of mineral matters (CV=7.31%).

The acquired results on the soluble dry matters are similar to those of the analyses conducted by Mratinić- Nenadović (1989) where the author claims that the content between varieties varies from од 8.5to 14.2%. Stanisavljević et al. (1997), noted a composition of soluble dry matters from 6.15to 9.50 %, Wozniak et al., (1997), from 9.46 to 9.57%, while Stančević, Stanisavljević (1986) and Stanisavljević et al.(1996) from 9.,5%, i.e.from6.3% до 10.1%. According to Nenadović - Mratinić et al.(2003, 2006)the

soluble dry matters content varies from 7.92 to 9.41%. Mratinić (1989) has established content of soluble dry matters with the S. Senganaraised in outdoor conditions with figure varying from 8.50 to 14.25 %. For Milivojević (2003), this variety showed numbers of 9.70%, while Blagojević (1999) analysed at 10.01%. In order to provide a proper choice of industrial strawberries with a high percentage of soluble dry matters fit to dry, Vittenet al. (2008), have established contents with 97 genotypes which ranged between 7.5% and 18.5%.

Кипријановски (2001) in the Skopje region analyses 8.1% dry matters with the Pocahontas variety. Gavrilović (1986) with the Belrub variety notes 9.50% in dry matters. The content of soluble dry matters with Elsanta (10.3%) and Marmolada (10.7%) are higher than those reached by Milivojević (2003) in the Belgrade region, of 8.30% i.e. 8.56%.

Wozniak et al. (1997), note a reductive sugars content of 5.5 to 5.8% and an amount of total sugars of 6.35% to 6.70 %. The values of Vitamin C range between 59% and 99.4% mg/kg. Growing strawberries in conditions of a drier and warmer climate is always accompanied by a larger content in sugars.

The average content of total acids, mineral matters and antocyanins are a match with the data acquired by Благојевић (1998) while the content of total sugars (7.97%) and antocyanins (43.58 mg/kg) is higher in contrast to his research. The author notes an average content of total acids from 0.38% to 0.84 %, a total sugars contents within the limits of 3.87% and 7.10% and antocyanins of 31.79 mg/kg. The author also notes an antocyanins content with the Belrubi (34.63 mg/kg) and S. Sengana (36.11 mg/kg) varieties. Stanisavljević et al. (1996), state the average values of total acids to be ranging from 0.64% to 1.00%, while the pH values moves from 3.30 to 3.72.

Our results on the chemical composition of the Marmolada variety are significantly higher than those reached by Milivojević (2003). The author has established a content of 5.68% in total and 4.48% in reductive sugars, 0.66% total acids, 51.08 mg% Vitamin C and 0.26% of mineral matters.

According to Wozniak et al. (1997), Elsanta has 6.70% in sugars and an elicitation index of 7.32. Voća et al. (2006), note a Vitamin C

content of 58.32 mg% in a non-soiled substratum to 68.58 mg% in high tunnels, within the Zagreb region. The fruit's pH values amounted to 3.70 onto an open field to 3.91 in a non-soiled substratum. Milivojević (2003), on the other hand, shows figures for this variety starting from 5.52 in total and 4.43% in reductive sugars, 0.71% in total acids, 13.18 mg% of Vitamin C and 0.24% of mineral matters. Our results concerning the Elsanta variety, show higher values in terms of the chemical composition covering all the parameters in contrast to the analysis by Milivojević (2003), an equal content of Vitamin C and pH values of the pulp which concerns a non-soiled substratum Voća et al. (2006) and elicitation index higher than the one reached by Wozniak et al. (1997).

The acquired data on the chemical composition of the S. Senganavariety are higher in contrast to all the parameters established by Milivojević (2003) – 7.35% in total and 6.11% in reductive sugars, 0.84% in total acids, 11.61 mg% of Vitamin C and 0.34 % in mineral matters, and those by Благојевић (1998) – 6.61% in total and 4.41% in reductive sugars, 0.80% in total acids, 2.87 pulp pH and 8.26 elicitation index.

Mratinić-Nenadović (1989), had been analyzing the chemical composition of the fruit with the S. Senganavariety both out and indoors and figures of 8.50% to 14.25% in soluble dry matter, 6.35% to 4.56% in total sugars, and 0.37% to 0.87% in total acids were established with the plants raised outdoors. The chemical composition of the plants raised indoors shows for higher values over the same parameters (soluble dry matters from 7.80 to 15.60%, total sugars from 4.25 to 8.46% and total acids from 0.62 to 0.97%).

During the analysis of the chemical composition of Honeoye, Wozniak et al. (1997) presented slightly lower values than those we have in terms of total sugars (6.78%) and total acids (0.71%).

Results on the total acids content (0.84%) and Vitamin C (72.49 mg%) with the Pocahontas variety are higher in contrast to those reached by Kiprijanovski (2001) who established 0.67% in total acids and 47.5 mg% in Vitamin C.

Nenadović - Mratinić et al. (2003) conducted an analysis over 7 varieties of strawberries with a different planting distance among which were the Favette, Evita, Erisand Madlen varieties.

The total sugars ranges between 6.31% and 8.00 %, inverted sugars from 5.53% to 6.34 %, total mineral matters of 0.21% to 0.28 % and Vitamin C from 14.0 to 18.5 mg%. From these figures a conclusion has been drawn that a greater distance planting (30x30 and 40x40cm) has a positive effect in raising the values of the tested chemical characteristics.

The data acquired on the chemical composition in soluble dry matters, total sugars, Vitamin C and mineral matters with the Favette and Madlen varieties, are higher than those reached by Nenadović - Mratinić et al. (2006) concerning the same varieties and are insignificantly lower in the values of total acids and reductive sugars. With Nenadović - Mratinić et al. (2006), Favette contains 7.92% soluble dry matter, 6.30% total sugars, 6.0% reductive sugars, 0.90% total acids, 18.8 mg% Vitamin C and 0.21% mineral matters. Madlen contains 9.90% soluble dry matters, 7.81% total sugars, 5.86% reductive sugars, 0.96% total acids, 15.2 mg% Vitamin C and 0.27% mineral matters.

The results reached in terms of soluble dry matters, total and reductive sugars, and total acids with the Evita and Eris varieties are lower than those reached in the research of Nenadović - Mratinić et al. (2006), over the same varieties, however are significantly higher in terms of Vitamin C and mineral matters. According to Nenadović - Mratinić et al. (2006), Evita contains 10.05% soluble dry matters, 8.80% total sugars, 6.60% reductive sugars, 0.98% total acids, 16.2 mg% Vitamin C and 0.30% mineral matters. Eris contains 9.30 % soluble dry matters, 8.14% total sugars, 6.96% reductive sugars, 0.68% total acids, 14.70 mg% Vitamin C and 0.28% mineral matters.

### Conclusions

With all the analyzed varieties a high content of the tested values within the chemical composition has been established.

The average content of soluble dry matters amounts to 10.0%, and varies from 8.5 (Eris) to 11.0% (Idea). The total and reductive sugars within the fruit of the plant range between 6.8 and 4.76% (Eris) and 8.80% and 6.16% (Idea), while the average amount to 7.97% and 5.58% respectively. The total acid concentration varies from 0.79% (Onda and Madlen) to 0.94% Evita or 0.85%. A pulp pH has been established between 3.5 (Tethis) to 4.2

(Chandler, Onda и Pocahontas) or a 3.9 pH on average. The average elicitation index for all the varieties amounts to 9.4, with Evita (8.1) with the lower, and the Paros, Madlen and Marmolada varieties with the highest index (10.4). The tested varieties of strawberries are characterized by a high content of Vitamin C which ranges somewhere between 72.49 (Pocahontas) and 113.73 mg% (Camarosa) with an average of 87.90 mg%. The strawberry poses a high source of anthocyanins with the average being 43.58 mg/kg and a variation of the figures between 37.06 (Favette) and 48.88 mg/kg (Elsanta). The mineral matters within the fruit show for numbers between 0.52 (Chandler и Onda) and 0.94 % (Tethis) with an average value amounting to 0.74% for all the analysed varieties.

Out of all the tested characteristics the lowest variation coefficient has been noted with the content of total acids (CV%=1.87) whereas the highest variation coefficient has been noted with the content of mineral matters (CV=7.31%). All of the analysed characteristics show only a slight variation.

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