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THE EFFECT OF VARIETIES AND DEGREE OF RIPENESS TO VITAMIN C CONTENT IN TOMATO FRUITS

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Nine selected varieties of tomatoes were grown in field experiments in order to follow up changes in the content of vitamin C, depending on the degree of the fruit ripeness. Vitamin C content of green fruit ranged from 6.74 mg (Denár) to 10.23 mg (Salus). The mean value for the varieties in the green state was 8.66 mg.100 g^{-1}. The value of vitamin C in the semi-mature tomatoes ranged from 11.34 mg (Denár) to 14.95 mg (Darinka). The mean value for all varieties was 12.89 mg. 100 g^{-1}. The lowest content of vitamin C was found in consumer (red) ripening tomato varieties Šejk (16.03 mg), Denár (16.32 mg) and Zámčan (16.80 mg) and the highest content of vitamin C in varieties Salus (19.43 mg) and Darinka (19.26 mg). The mean value for the nine varieties was 17.70 mg.100 g^{-1}. In the botanical (overripe) maturity, we recorded the highest vitamin C content in the variety Salus (21.51 mg. 100 g^{-1}). The highest increase in vitamin C was also recorded at the variety Darinka, where we registered the content of 21.32 mg.100 g^{-1}. The lowest vitamin C content in botanical ripeness was observed in the variety Zámčan (19.44 mg.100 g^{-1}). The average amount of vitamin C marked 20.26 g mg.100^{-1}. The results can be concluded that the level of vitamin C is increasing by the gradual ripening of the fruits.

Keywords: tomatoes; maturity stages; vitamin C

Tomato is one of the most frequent and most popular vegetables in the world (Dorais, Ehret, Papadopoulos, 2008). According to FAOSTAT statistics, the largest producers of tomatoes in the world are China, India, USA, and Turkey (FAOSTAT, 2014). The fruits of tomatoes are tasty, easily digestible; they are widely used in gastronomy and in the canning industry (Toor and Savage, 2004). As for their composition, tomatoes are valuable kinds of vegetables, like bell peppers. They contain precious minerals, vitamins and other bioactive components and antioxidants which help to prevent against many civilization diseases (Valšíková and Paulen 2013). In Slovakia, tomatoes are grown on the area of about 500 ha of arable land, where about 20,000 tons are produced annually. The total area of tomatoes (including gardens), occupies 2800 ha and produces the annual average of 50,000 tons. With this production, tomatoes are in second place after cabbage (Meravá et al., 2015; Rozborilová et al., 2016).

Material and methods

The field experiment was established in the botanical garden of the Slovak University of Agriculture in Nitra. For testing purposes, we used nine varieties of tomatoes (Table 1).

The results of soil analysis (2013–2014):

1. N_{an} = 13.3–14 mg.kg^{-1} soil,
2. P = 120.5–118 mg.kg^{-1} soil,
3. K = 525–235 mg.kg^{-1} soil,
4. Ca = 4,976–5,100 mg.kg^{-1} soil,
5. Mg = 576–548 g.kg^{-1} soil,
6. S = 45–50 mg.kg^{-1} of soil,
7. humus content = 3.75–3.65%,
8. pH / KCl = 6.96–7.00.

The first fertilization during the vegetation period was performed in both years in mid-June. The LAD 27% in the amount of 200 g on the area 30 m^2 was applied to soil. The NPK was applied at 200 g per trial plot of 30 m^2 in mid-July.

Sowing was carried out on March 13, 2013 and March 17, 2014 into seeding trays in lines. Transplanting was done on April 16, 2013 and April 15, 2014 into rooting containers with the plants space of 40 × 40 × 80 mm. Growing transplants have not been chemically treated, but were fertilized by Harmavit with foliar sprays in the end of April. Ready transplants were planted into outside beds on May 16, 2013 and May 14, 2014.

Parameters of experiments:

- spacing of planting: 0.30 × 0.60 m,
- number of plants per a variety: 12,
- number of repetitions: 3,
- area per a variety: 2.52 m^2,
- area of all varieties: 24 m^2.

Harvesting and analysis of fruits

Dates of fruits harvesting: August 2, 2013 and August 5, 2014 in green maturity, August 14, 2013 and August 18,

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Table 1 Origins and properties of tomato varieties

Variety	Origin	Fruit shape	Suitability
Darinka F1	Czechia, Semo a. s.	round	manual harvesting, consumption
Denár	Czechia, Semo a. s.	pear-shaped to square	manual and mechanized harvesting, processing
Diana	Czechia, Semo a. s.	round	manual harvesting, consumption
Kecskeméti	Hungary	flat-round	manual harvesting, consumption
Oranže	Czechia, Semo a. s.	flat-spherical	manual harvesting, consumption
Paulína	Czechia, Semo a. s.	round	manual and mechanized harvesting, consumption, processing
Salus	Czechia, Semo a. s.	oval or square	manual and mechanized harvesting, consumption, processing
Šejk	Czechia, Semo a. s.	oval or square, intense red	manual and mechanized harvesting, processing
Zámčan	Slovak Republic, Lestra s. r. o.	rectangular	mechanized harvesting, processing

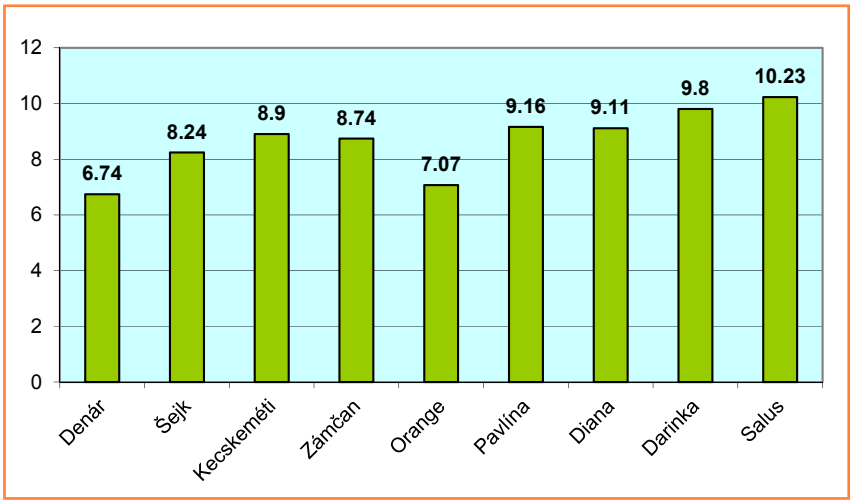

Figure 1 Mean content of vitamin C in green mature tomatoes in mg. 100 g^{-1}

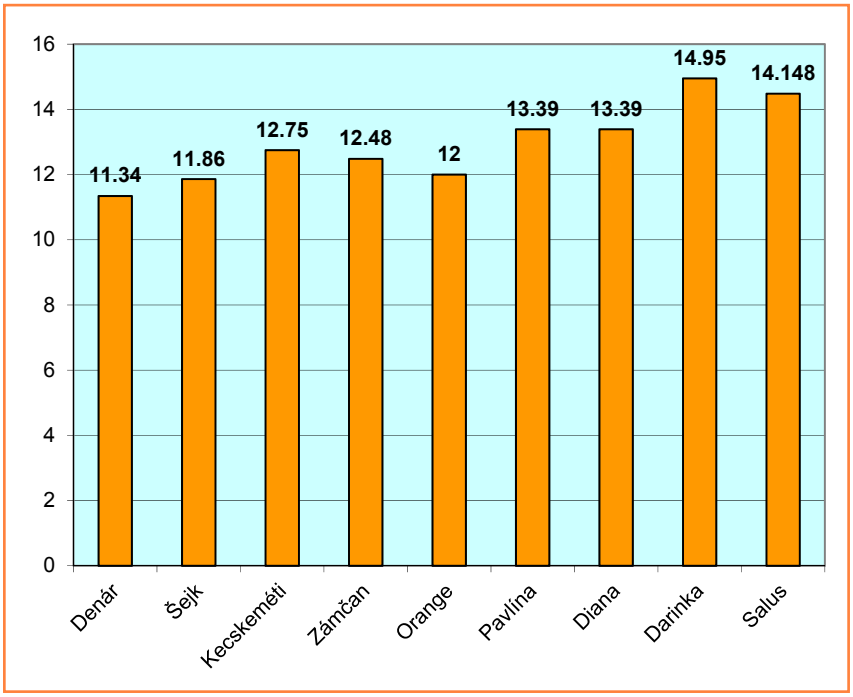

Figure 2 Mean content of vitamin C in semi-mature tomatoes in mg. 100 g^{-1}

2014 in semi-mature stage, August 22, 2013 and August 28, 2014 in consumer (red) maturity, September 9, 2013 and September 16, 2014 in botanical (overripe) maturity. The analysis of fresh tomato fruits was carried out in the laboratory at the Department of Vegetables Production of the Slovak University of Agriculture in Nitra. For determination of vitamin C content, the HPLC method with liquid chromatograph and UV detector was used (Stan et al., 2014).

Statistical evaluation

To establish the evidential differences in vitamin C, we used the program Statgraphics Centurion XVII (Stat Point Inc. USA). The results were evaluated by the analysis of variance (ANOVA) and the mean values were tested by the Tukey HSD test at the significance level of 95%.

Results and discussion

Evaluation of the vitamin C content in green mature tomatoes

The samples were harvested in green fruit stage for determining the amount of vitamin C per 100 g of fresh material. The content of vitamin C in the varieties ranged from 6.74 mg (Denár) to 10.23 mg (Salus). The mean value of all varieties was 8.66 mg.100 g^{-1}. There was no significant difference between replicates. The mean value of the vitamin C content for the two monitored years is shown in Figure 1.

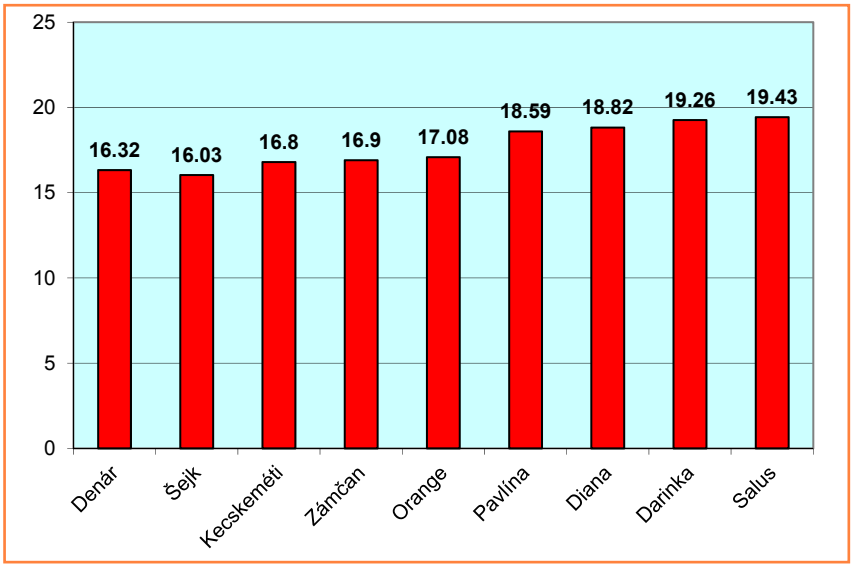

Figure 3 Mean content of vitamin C in consumer (red) maturity in mg. 100 g^{-1}

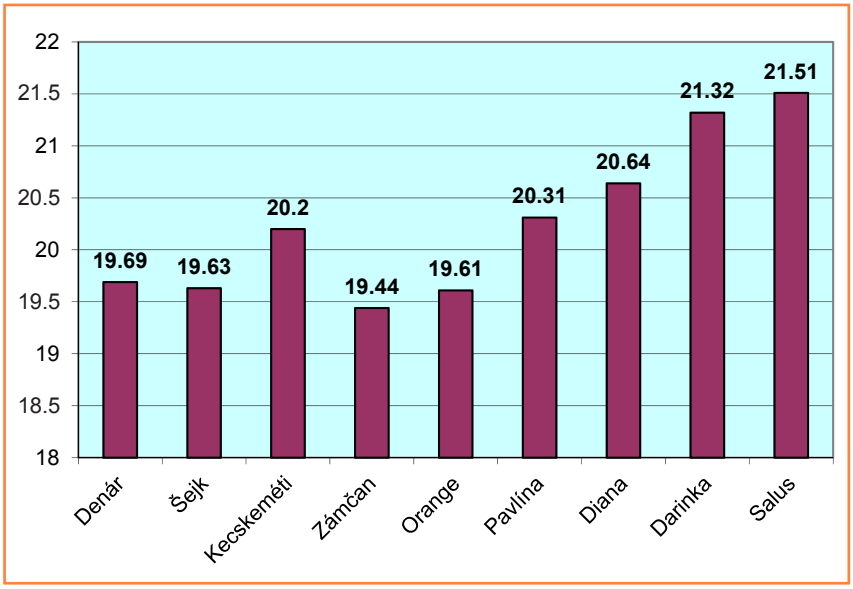

Figure 4 Mean content of vitamin C in botanical (red) maturity in mg.100 g^{-1}

Evaluation of the vitamin C content tomatoes in semi-mature tomatoes

Semi-mature tomatoes are not suitable for consumption yet. The value of vitamin C ranged from 11.34 mg (Denár) to 14.95 mg (Darinka). The mean value of all varieties in the two years marked 12.89 mg.100 g^{-1} (Figure 2). Compared to the values of green fruits, there was an increase in the amount of vitamin C.

Evaluation of the vitamin C content in tomatoes of consumer (red) maturity

The fruits were ripe and red-coloured, except of the variety Orange, which matures into orange colour. We found out that the lowest content of vitamin C was recorded in the varieties Šejk (16.03 mg) and Denár (16.32 mg). The highest content of vitamin C (19.43 mg) was marked by the varieties Salus and Darinka with 19.26 mg.100 g^{-1} (Figure 3). The mean value of all varieties for the two years was 17.70 mg.

Evaluation of the vitamin C content in botanically mature (overripe) tomatoes

The botanical (overripe) maturity of tomato fruits was reached in mid-September. The fruits were mostly already softened but in good health with no signs of damage. We recorded the highest vitamin C content of 21.51 mg.100 g^{-1} at the variety Salus (Fig. 4), which is about 10.71% more than in the consumer (red) maturity and by 48.54% more than in the semi-mature

Table 2 Mean content of vitamin C in differently ripened tomatoes in mg.100 g^{-1}

Varieties	Green fruits	Semi-red fruits	Red fruits	Overripe fruits
Denár	6.74	11.34	16.32	19.69
Šejk	8.24	11.86	16.03	19.63
Kecskeméti	8.90	12,75	16.80	20.20
Zámčan	8.74	12.48	16.90	19.44
Orange	7.07	12.00	17.08	19.61
Paulína	9.16	13.39	18.59	20.31
Diana	9.11	13.39	18.82	20.64
Darinka	9.80	14.95	19.26	21.32
Salus	10.23	14.48	19.43	21.51
Average	8.66	12.89	17.70	20.26

fruits. We found 110.26% increase of the vitamin C content in the variety Salus compared to the situation in green maturity.

High increase of vitamin C was recorded also at the variety Darinka, where we recorded the content of 21.32 mg.100 g^{-1}. It is by about 10.69% more than in the consumer (red) maturity and by 42.61% more than at the semi-maturity and by 117.55% more than at harvest in the green maturity.

The lowest level of vitamin C in botanical ripeness was found in the variety Zámčan (19.44 mg.100^{-1}), which is by 15.03% more than in the consumer (red) maturity and by 55.76% more than in the semi-maturity. At this variety was in the botanical (overripe) maturity more vitamin C about 122.42% compared to the result of the harvesting in the green maturity. The average amount of vitamin C marked 20.26 g $mg.100^{-1}$. The average value of vitamin C in different ripened tomato varieties and in two years is shown in Table 2. Fig. 5 shows differences in the vitamin C content by tomato fruit maturity.

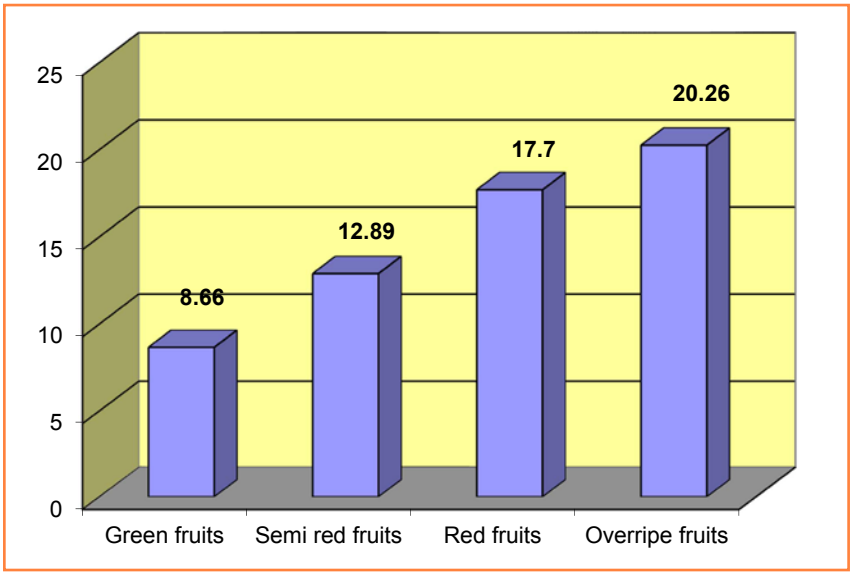

Figure 5 Mean content of vitamin C in differently ripened tomato fruits in mg.100 g^{-1}

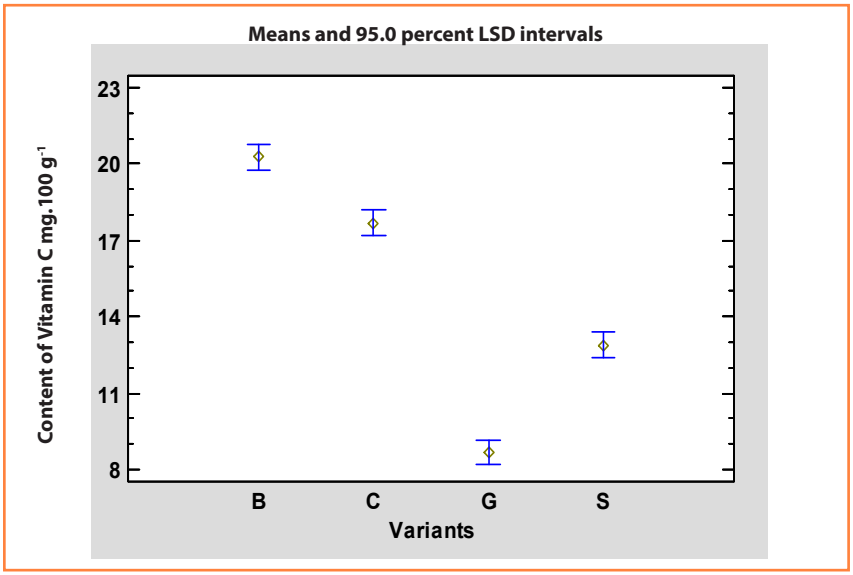

Figure 6 Tests for the vitamin C content in mg.100 g^{-1} by variants

Table 3 Multiple range tests for the vitamin C content in mg.100 g^{-1} by years
Method: 95.0 percent LSD

Years	Count	LS Mean	LS Sigma	Homogeneous Groups
2013	108	13.0842	0.463313	X
2014	108	16.6718	0.463313	X

From the results we can conclude that the levels of vitamin C increase with the gradual ripening of fruits, which is confirmed by works of other authors such as Kader (1999) and Rahman et al. (2016). Valšíková et al. (1996) report that the average content of vitamin C in tomato ripe fruits is in the range 20–80 mg. Similar values are shown by Kopec (1998), namely 20–50 mg. Uher et al. (2009) give lower values, 22.4 g of $mg.100^{-1}$. Similar results are indicated by Kopec (2010). We are closer to these values in the botanical maturity as our measured values ranged from 19.44 to 21.51 mg.100 g^{-1}. Jedlička (2012) argues that tomato is a good source of vitamin C as 100 g of tomatoes provide 21% (13 g) of the recommended daily allowance (RDA). That results are in compliance with our results, as during the transition of maturity we obtained the values ranging from 11.6 to 15.8 mg. In our experiment, it was found out that the amount of vitamin C in the consumer maturity fruit was 17.70 mg and 20.26 mg at the botanical maturity.

The statistical analysis showed probative difference in vitamin C content between the two monitored years and four variants of different maturity (Table 3, Figure 6). Insignificant differences were found between varieties and repetitions.

Conclusions

The paper examined the comparison of the vitamin C contents in different varieties and demonstrated the amount of this vitamin in various ripeness variants of tomatoes. The results confirmed that the maturation of fruits significantly increase the amount of vitamin C. The significant difference in the content of vitamin C has not been established between varieties and repetitions. The production of vitamin C is affected by fruit maturity, seasons, soil and agricultural engineering.

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