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Selected Nutritional Parameters of Fruits of Several Indeterminate Tomato Cultivars

Wybrane parametry charakteryzujące wartość odżywczą owoców kilku wysoko rosnących odmian pomidora

Abstract. Fruits of nine Czech and Dutch indeterminate tomato cultivars were analysed for the content of selected nutritional compounds. Fresh fruits contained 6.4 % of dry matter, 5.6 °Bg of refractometric dry matter, 21 $g.kg^{-1}$ of glucose and fructose sum, 365 $mg.kg^{-1}$ of vitamin C, 144 $mg.kg^{-1}$ of total carotenoids, 2436 $mg.kg^{-1}$ of potassium, 152 $mg.kg^{-1}$ of calcium, 99 $mg.kg^{-1}$ of magnesium, and 28 $mg.kg^{-1}$ of sodium on average. Nutritional composition of tomato fruits was in most cases significantly dependent on cultivar and weather conditions during the cultivation period. A later fruit harvest had better nutritional quality. Cultivars ´Domino´ and ´Tipo´ as well as ´Tornádo´ and ´Toro´ showed a similar content of vitamin C and mineral elements. Fruits cv. ´Ultimo´ contained fewer mineral elements.

Key words: tomato, cultivar, vitamin C, carotenoids, mineral elements

INTRODUCTION

Tomato is a very popular vegetable species. Its fruits are rich in vitamins, carotenoids and sugars. They are also a good source of several organic acids. Processing tomatoes are checked for their refractometric dry matter value. An average content of selected nutritional substances in tomato fruits cited by different authors is shown in Table 1.

The effect of cultivar on refractometric dry matter was found by Valšíková and Viteková (1999). This parameter is positively correlated to the high sun radiation during summer (Islam and Khan, 2000). Mineral elements content is influenced by cultivar (Rosa et al., 2002) and also by the time of cultivation

Tabl. 1. Content of selected nutritional compounds in fresh tomato fruits according to different authors

Compounds	Value	Reference
Dry matter	5.5 %	USDA, 2004
Refractometric dry matter	4.2–5.2 %	Giorgi et al., 2000
Glucose	10–12 $g.kg^{-1}$	USDA, 2004
Fructose	14–18 $g.kg^{-1}$	USDA, 2004
Calcium	60–140 $mg.kg^{-1}$	Velíšek et al., 1999
Potassium	2370 $mg.kg^{-1}$	USDA, 2004
Magnesium	110–180 $mg.kg^{-1}$	Velíšek et al., 1999
Sodium	30–60 $mg.kg^{-1}$	Velíšek et al., 1999
Vitamin C	146–217 $mg.kg^{-1}$	Abushita et al., 2000
Carotenoids	8–133 $mg.kg^{-1}$	Lachman et al., 2000

(Gundersen et at., 2001). Vitamin C as one of the most important vitamins is a widely commented nutritional substance of tomatoes. The importance of cultivar on its highly variable content is discussed by Valšíková and Viteková (1999). Shi et al. (1999) state that the content of sugars increases simultaneously with fruit ripening. Similarly Yahia et al. (2001) found a tenfold higher vitamin C content in ripe fruits comparing to the green ones. Higher air temperatures and higher sun radiation during summer support an increase of vitamin C level in fruits (Peyvast, 2001). Tomatoes are an important source of carotenoids and among them the most important is lycopene (Vogel et al., 1996). Abushita et al. (2000) found cultivar differences in carotenoids content. Nitrates are considered as antinutritional substance. Tomatoes contain from 10 to 60 mg of nitrates in 1 kg of fresh fruits, which is quite low in comparison to other vegetables (Siomos and Dogras, 1999; Giorgi et al., 2000).

The aim of the present work was to evaluate the effect of cultivar, weather conditions and harvest time on the content of selected nutritional compound as well as nitrate level in fruits of nine indeterminate tomato cultivars cultivated in the field.

MATERIAL AND METHODS

Field experiments were carried out at the Faculty of Horticulture in Lednice (Czech Republic) on loamy-sandy soil. Table 2 shows climate conditions and agrochemical analysis of soil (Mehlich III method) before planting. Additional irrigation was used during the whole cultivation period in each year. The mean air temperature within all experimental years was 18.2 °C and the total mean length of sunshine was 225 hours. Climate data represent the period of May to September each year, according to the growing season.

Tabl. 2. Content of macroelements in soil, mean air temperature and sum of sunshine hours during growing period

Year	mg.kg^{-1}						Mean air temperature	Sum of sunshine
	N_{min}	P	K	Ca	Mg	pH	°C	hrs
1999		350	540	5238	376	7.4	18.3	220
2000	15.2	271	325	5500	359	7.4	18.2	231
2001	12.9	289	386	5412	388	7.4	17.6	213
2002	14.5	289	420	5064	390	7.3	18.5	234

Tomato seeds were seeded to the plastic trays in a greenhouse on April 1st 1999, March 28th 2000, April 4th 2001, and March 30th 2002. The volume of single cell was 45 cm^3. Transplants were planted in the field in the middle of May each year. The planting distance was 0.6 x 0.4 m. A single plot of 5 m^2 was used for each cultivar, all in three repetitions. Plots were randomly organised. The harvest dates were: September 24th 1999, August 1st and September 11th 2000, September 10th and October 3rd 2001, August 31st and September 23rd 2002. The investigated assortment of indeterminate tomato cultivars consisted of 6 Czech cultivars (Domino, Start, Stupické polní rané, Tipo, Tornádo, Toro) and 3 cultivars from the Netherlands (Calypso, Diadora, Ultimo).

Analytical methods. One sample consisted of 5 typical, ripe and size-developed fruits. Fresh fruit samples were immediately processed for the analysis of sensitive compounds by homogenization in stainless mixer Eta (Eta, Czech Republic). All chemicals were in HPLC grade and for sample preparation demineralised water was used.

Dry matter of fruits was determined after drying of samples in oven Sterimat 574.2 (BMT, Czech Republic) at 105°C till the samples reached constant weight. Refractometric dry matter was analysed by the handy refractometer RR 12 (PZO, Poland) in squeezed fruit sap.

Sugar content was determined as a sum of glucose and fructose by reflectometric method in the RQflex II (Merck, Germany) directly after sample homogenization and dilution of obtained fruit sap by distilled water. The content of potassium, calcium, sodium and magnesium was determined by capillary isotachophoresis at Ionosep 900.1 (Recman, Czech Republic). After digestion with sulphuric acid, samples were diluted and analysed during a 15 minutes' analysis. Leading electrolyte consisted of 7.5 mM sulphuric acid + 7 mM 18-crown-6 + 0.1 % hydroxypropyl methylcellulose and terminating electrolyte was prepared as solution of 10 mM bis-tris-propane and 5 mM acetic acid. Samples used for determination of vitamin C content were homogenized and purified by centri-

fuge Hettich EBA 12 (Hettich, Germany) and then injected directly to the HPLC system. Analysis of vitamin C (ascorbic acid) was done by reverse phase HPLC at 254 nm on column CGC Separon C18 150 x 4.6 mm (Tessek, Czech Republic) by chromatograph Ecom (Ecom, Czech Republic). Mobile phase consisted of tetrabutylammonium hydroxide, oxalic acid and water; the used flow was 0.5 ml per minute.

Content of total carotenoids was analysed by spectrometry at 440 nm wavelength in the spectrometer Jenway 6100 (Jenway, Great Britain). Samples for carotenoid analysis were extracted by the IKA extractor (IKA, Germany) during 8 extraction cycles (total time 160 minutes) in acetone. Elimination of light was assured with the use of dark lab glass and other lab equipment. Samples were purified by centrifugation before measurement.Nitrate content was determined by ion-selective electrode Crytur (Monokrystaly, CZ).

Statistical analysis was performed in statistical software Unistat 5.1 (Unistat, USA). Evaluation was made by analysis of variance and method of least significant difference (LSD) at 95% probability level. Hierarchic cluster analysis (method of distant measures, Euclidean distance) was used for evaluation of statistical difference of cultivars according to their nutritional parameters. Data are presented in Sun Ray Plot graph.

RESULTS

Data obtained in the years 1999 and 2002 from all analysis of nutritional substances are displayed in Table 3. Mean content of dry matter was 6.4 %. Effect of cultivar and year was significant, the same as positive effect of later harvest data. The higher value was shown by ´Start´ (7 %). Positive correlation to the refractometric dry matter was found.

Level of refractometric dry matter content was 5.6 °Bg in average. While the year effect was not detected, the cultivar was a highly significant factor. The highest value was found in cv. ´Domino´ and ´Start´(5.9 °Bg). Fruits from the later harvest data reached significantly higher content of refractometric dry matter.

Mean content of sugars (sum of fructose and glucose) was 21 $g.kg^{-1}$ f.m. The effect of cultivar was detected, the highest value was shown by ´Diadora´ and ´Tornado´ (24 $g.kg^{-1}$ f.m.).

Mean content of vitamin C was 365 $mg.kg^{-1}$ f.m. Cultivars were significantly different. The highest value was found in ´Tornádo´. The effect of year was also significant when the lowest values were detected in 1999 year. Later harvest resulted by the higher content of vitamin C.

Content of carotenoids was 144 mg.kg^{-1} f.m. and was influenced by cultivar (the highest value in ´Diadora´). Effect of year was not found in most cases. The harvest date did not influence carotenoids content at all. The level of present potassium was 2436 mg.kg^{-1} f.m. on average. The cultivar effect was detected, while the highest value was found in ´Tornádo´, the lowest in cv. ´Ultimo´. The significance of year and harvest date was not confirmed. The mean calcium content was 152 mg.kg^{-1} f.m. with a significant difference among cultivars. Cv. ´Tornádo´ reached the highest Ca content. The effect of year was confirmed, the highest calcium level was found in 2000. Difference in calcium content between harvest data was found; however, it was variable and no trend was possible
to observe. The content of magnesium was 99 mg.kg^{-1} f.m. on average. Cultivar significance was also confirmed and the same cv. (´Tornádo´) was the richest in this mineral. The year 2002 gave the lowest value of Mg. A later harvest date was significantly different and showed higher magnesium content. The mean content of sodium was 28 mg.kg^{-1} f.m. Two cultivars – ´Diadora´ and ´Tornádo´ showed the highest values and confirmed cultivar significance. In spite of magnesium content, here it was 2002 detected as the year with the

Tabl. 3. Mean content of analysed compounds in tomato fruits

Cultivar	Total dry matter	Rf dry matter	Sugars	Vitamin C	Carote-noids	K	Ca	Mg	Na	NO_3^-
	%	°Bg	g.kg^{-1}	mg.kg^{-1} of f.m.						
Calypso	6.1	5.7	22	314	116	2494	141	103	30	8.5
Diadora	6.5	5.8	23	337	200	2239	133	100	31	8.0
Domino	6.4	5.9	17	374	129	2510	154	98	30	8.5
Start	7.0	5.9	20	368	156	2516	158	99	23	7.6
Stupické	6.5	5.7	20	366	160	2399	163	103	26	8.2
Tipo	6.4	5.3	21	375	162	2522	154	100	28	8.0
Tornádo	6.1	5.2	23	390	114	2568	164	104	31	7.5
Toro	6.3	5.4	22	386	130	2505	162	91	28	7.1
Ultimo	6.2	5.2	21	376	126	2169	141	95	27	9.9
mean	6.4	5.6	21	365	144	2436	152	99	28	8.14
Cultivar effect	*	**	*	*	*	*	*	**	*	ns
Year effect	*	ns	ns	*	ns	ns	*	*	*	*
Harvest date effect	*	*	ns	*	ns	ns	*	*	ns	ns

Explanations: * – significant effect, ** – highly significant effect, ns – not significant

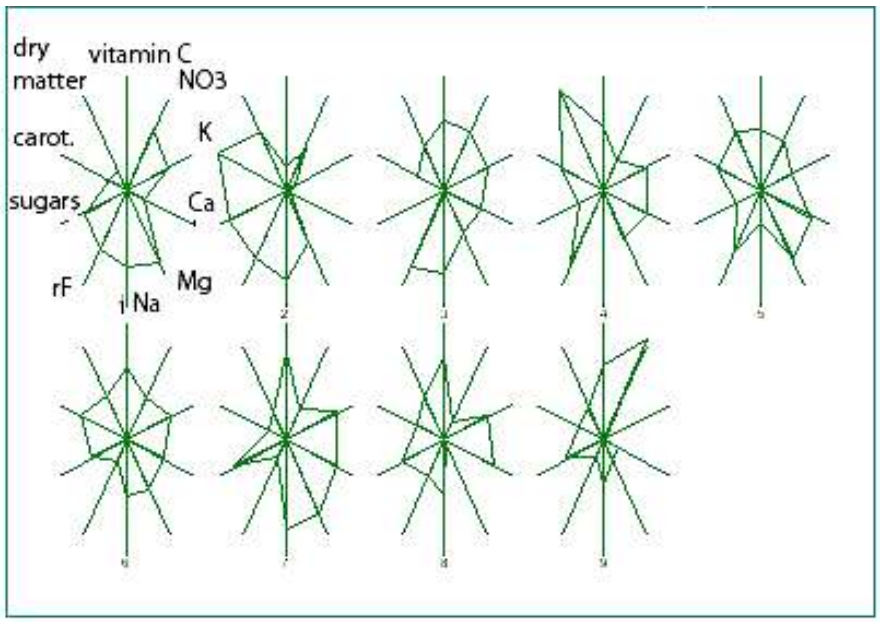

Fig. 1. Cluster analysis of tomato cultivars

Explanations (number of cultivars, from top left to the right bottom): 1 Calypso, 2 Diadora, 3 Domino, 4 Start, 5 Stupické polní rané, 6 Tipo, 7 Tornádo, 8 Toro, 9 Ultimo

highest sodium values. The effect of year was statistically confirmed, while the effect of harvest time was not found as influencing factor. The content of nitrates was very low, about 9 $mg.kg^{-1}$ f.m. The highest values in several samples were about 20 $mg.kg^{-1}$ f.m., but still with no potential risk in human diet.

Fig. 1 shows proportional expression of single compound content within the tested cultivars. Shapes of irregular curves characterize statistical differences of cultivars according to their nutritional value. Cultivars Domino and Tipo as well as cvs. Tornádo and Toro showed relatively the same content of most analyzed substances. Content of nutrients was not statistically significant. On the other hand, cluster analysis found cv. Ultimo as significantly different to the rest of the tested assortment.

DISCUSSION

The analysis of tomato fruits gave the total dry matter in interval 5–8 %, refractometric dry matter in the range of 4–9 °Bg and sum of glucose and fructose from 15 to 30 $g.kg^{-1}$. Similar results were obtained by Valšíková and Viteková

(1999). Level of vitamin C was in the range of 220 to 600 mg.kg^{-1}, comparable to the Abushita et al. (2000). Content of total carotenoids was 65–270 mg.kg^{-1}, some cultivars showed higher levels than those described by Lachman et al. (2000).

Potassium was detected in interval 1600–3200 mg.kg^{-1}, calcium from 60 to 260 mg, magnesium in range of 35–150 mg.kg^{-1}, and sodium from 10 to 80 mg.kg^{-1}. Such results correspond to the data of Velíšek et al. (1999) and USDA (2004). Magnesium content was partially lower if compared to the literature.

Cultivar importance in nutritional composition was confirmed in most cases. Such data are reported by many authors (Valšíková and Viteková, 1999; Rosa et al., 2002). A later harvest date showed better nutritional quality and such results correlate to the previously published data of Shi et al (1999) and Nurzyński et al. (2001).

CONCLUSIONS

The effect of cultivar on nutritional quality of tomato fruits was found in all analysed parameters. Harvest date and growing year was confirmed as a significant factor in some cases only. Cluster analysis of total evaluation of investigated assortment showed that cultivars ´Domino´ -´Tipo´ and ´Tornádo´ - ´Toro´ were similar by their high vitamin C and mineral elements content. Cultivar ´Ultimo´ gave a smaller content of mineral elements.

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STRESZCZENIE

W pracy przedstawiono wyniki analiz chemicznych dotyczących zawartości wybranych składników chemicznych w owocach pomidora dziewięciu odmian (czeskich i holenderskich). Świeże owoce zawierały średnio 6,4% suchej masy, 21 $g \cdot kg^{-1}$ cukrów prostych (glukozy i fruktozy), 365 $mg \cdot kg^{-1}$ witaminy C, 144 $mg \cdot kg^{-1}$ karotenoidów (suma), 2436 $mg \cdot kg^{-1}$ potasu, 152 $mg \cdot kg^{-1}$ wapnia, 99 $mg \cdot kg^{-1}$ magnezu oraz 28 $mg \cdot kg^{-1}$ sodu. Zawartość badanych składników w owocach pomidora zależała istotnie od odmiany i warunków pogodowych w okresie uprawy. Owoce zbierane w późniejszym terminie charakteryzowały się korzystniejszą zawartością badanych składników. Owoce odmiany 'Domino' i 'Tipo' oraz 'Tomado' i 'Toro' miały zbliżoną zawartość witaminy C i składników mineralnych. Natomiast owoce odmiany 'Ultimo', w porównaniu do innych odmian, zawierały mniej składników mineranych.