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EFFECT OF SOIL SUBSTRATE ON THE CHEMICAL COMPOSITION OF FRUIT OF SOME TOMATO CULTIVARS GROWN IN AN UNHEATED PLASTIC TUNNEL

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Abstract

The effect of cultivar and soil substrate on the chemical composition of tomato fruit was studied in an experiment conducted over the years 2004-2006 in an unheated plastic tunnel. The experimental materials comprised eight tomato cultivars: Atut F_1, Baron F_1, Bekas F_1, Carmello F_1, Gracja F_1, Ognik F_1, Słonka F_1, Terra F_1, as well as two types of soil: peat substrate purchas and hotbed soil. Tomato fruit was assayed for the content of: dry matter, L-ascorbic acid, total sugars, simple sugars, organic acids and nitrates. The levels of dry matter and L-ascorbic acid in tomato fruit were found to be significantly dependent on both the cultivar and the cultivar-substrate interaction. Cultivar Atut F_1 had the lowest water content of fruit, while cv. Terra F_1 was the richest source of L-ascorbic acid. The fruit of tomato cultivars grown in hotbed soil accumulated more dry matter. Hotbed soil, compared to peat substrate, had a more beneficial influence on the concentrations of sugars and nitrates in tomato fruit. The average $N\text{-}NO_3$ content of the fruit of the investigated tomato cultivars was below the maximum permissible level, whose exceedance would pose a hazard to human health. The fruit of all tomato cultivars accumulated more nitrates when grown in peat substrate. The lowest nitrate content was recorded in cv. Bekas F_1.

Key words: tomato, cultivar, soil substrate, chemical composition.

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WPŁYW PODŁOŻA NA SKŁAD CHEMICZNY OWOCÓW KILKU ODMIAN POMIDORA UPRAWIANEGO W TUNELU FOLIOWYM NIEOGRZEWANYM

Abstrakt

Badania wpływu odmiany i podłoża zastosowanego w uprawie pomidora na skład chemiczny owoców przeprowadzono w nieogrzewanym tunelu foliowym w latach 2004-2006. Materiał do badań stanowiło osiem odmian pomidora: Atut F_1, Baron F_1, Bekas F_1, Carmello F_1, Gracja F_1, Ognik F_1, Słonka F_1, Terra F_1 oraz dwa podłoża: torfowe i ziemia inspektowa. Owoce pomidora poddano analizie chemicznej na zawartość: suchej masy, kwasu L-askorbinowego, cukrów ogółem i prostych, kwasów organicznych oraz azotanów. Poziom zawartości suchej masy i kwasu L-askorbinowego w owocach pomidora istotnie zależał od uprawianej odmiany oraz jej współdziałania ze stosowanym podłożem. Najmniej wody w owocach zawierała odmiana Atut F_1, a najwięcej kwasu L-askorbinowego – odmiana Terra F_1. Owoce z uprawy roślin w ziemi inspektowej nagromadziły więcej suchej masy. Podłoże z ziemi inspektowej, w porównaniu z torfem wysokim, miało również korzystny wpływ na zawartość cukrów i azotanów w owocach pomidora. Średnia zawartość $N\text{-}NO_3$ w owocach badanych odmian pomidora była mniejsza od dopuszczalnego poziomu uznanego za szkodliwy dla zdrowia ludzkiego. Podłoże torfowe miało jednak wpływ na zwiększone gromadzenie azotanów w owocach wszystkich odmian. Najmniejszą ich zawartość odnotowano w owocach odmiany Bekas F_1.

Słowa kluczowe: pomidor, odmiana, podłoże, skład chemiczny.

INTRODUCTION

The increasing economic significance of tomato fruit is a consequence of their high biological value, specific taste and flavor as well as a wide range of uses and applications. Tomatoes are consumed throughout the year, both raw (approx. 50%) and canned or processed, in the form of juice, paste and concentrate (Statistical Yearbook 2005).

The chemical composition of tomatoes grown under protective structures may be controlled by selecting the appropriate substrate type and cultivars marked by a high nutritive value of fruit (MARTYNIAK-PRZYBYSZEWSKA 2000, KOBRYŃ et al. 2007, WINIARSKA, KOŁOTA 2007).

The objective of this study was to compare the chemical composition of fruit of eight tomato cultivars grown in two types of soil substrate in an unheated plastic tunnel.

MATERIALS AND METHODS

A two-factorial experiment was performed in an unheated plastic tunnel at the Experimental Garden of the University of Warmia and Mazury in Olsztyn, during the years 2004-2006, in a randomized complete block design, in three replications. The first experimental factor was eight tomato cultivars: Atut F_1, Baron F_1, Bekas F_1, Carmello F_1, Gracja F_1, Ognik F_1, Słonka F_1 and Terra F_1, and the second experimental factor was two types of soil: peat substrate and hotbed soil.

Seedlings were grown in a hothouse. Seeds were sown each year in the middle of March. Seedlings were planted in pots (10 cm in diameter), filled with peat substrate or hotbed soil. The chemical composition of peat substrate, saturated with mineral nutrients, was as follows: N-NO_3 – 100, P – 80, K – 215, Ca – 1240, Mg – 121 mg·dm^{-3}; pH in H_2O – 5.9, salt concentration – 1.5 g·dm^{-3}. Hotbed soil was a mixture of organic and mineral components: N-NO_3 – 200, P – 390, K – 185, Ca – 2330, Mg – 284 mg·dm^{-3}; pH in H_2O – 6.9, salt concentration – 1.9 mg·dm^{-3}. In the first week of May seedlings were planted in an unheated plastic tunnel, at the 100x50 cm spacing, 5 plants per replication. Tomato plants were allowed to develop one stem and six clusters. Cultivation was carried out in accordance with the recommendations for tomatoes grown under protection.

Fruit were harvested from the third week of July to the middle of September. A total of around 15 harvests were conducted each year. Fifteen ripe tomato fruit were picked per treatment to determine the content of: dry matter – by drying the collected plant material at 105°C to constant weight, L-ascorbic acid – by the Tillmans method modified by Pijanowski, sugars – by the Luff-Schoorl method, organic acids – expressed as malic acid equivalents, as described by Pieterburgski, and nitrates – with the use of salicylic acid.

The results were verified statistically by analysis of variance. The significance of differences between mean values was estimated with the use of Tukey's confidence intervals at a significance level of 5%.

RESULTS AND DISCUSSION

The biological value of fresh tomato fruit is dependent on weather conditions during the growing season, and on agronomic factors (MARTYNIAK-PRZYBYSZEWSKA, 2000, KOŁOTA, WINIARSKA 2005). According to HALMANN, KOBRYŃ (2002) and NURZYŃSKI (2002), the most suitable organic substrates for growing tomatoes under protection include: low-moor peat mixed with pine bark, coconut fiber and straw. The present experiment revealed that the chemical composition of the edible parts of tomato plants is affected by cultivar, substrate type and their interaction (Table 1).

The dry matter content of tomato fruit ranged from 4.44% to 6.28%, and it was significantly dependent on both the cultivar and the cultivar-substrate interaction. The results are similar to those reported by ROŻEK (2001), MARTYNIAK-PRZYBYSZEWSKA (2000) and WINIARSKA and KOŁOTA (2007).

Table 1

Chemical composition of tomato fruit – means of the years 2004-2006

Cultivar	Substrate	Dry matter (%)	L-ascorbic acid ($mg \cdot 100 g^{-1}$)	Sugar total ($g \cdot 100 g^{-1}$)	Sugar mono-saccharides ($g \cdot 100 g^{-1}$)	Organic acids
Atut F_1	peat substrate	6.23	9.42	2.03	1.98	0.40
	hotbed soil	6.19	14.36	2.45	2.24	0.47
	average	6.21	11.89	2.24	2.11	0.44
Baron F_1	peat substrate	5.20	14.81	2.45	0.97	0.54
	hotbed soil	5.75	14.81	1.20	0.97	0.27
	average	5.39	14.81	1.83	0.97	0.40
Bekas F_1	peat substrate	5.00	17.95	1.20	0.48	0.34
	hotbed soil	5.75	13.46	3.30	2.24	0.60
	average	5.38	15.71	2.25	1.36	0.57
Carmello F_1	peat substrate	4.44	14.36	1.22	1.20	0.60
	hotbed soil	5.42	9.87	2.45	1.98	0.54
	average	4.93	12.12	1.84	1.59	0.47
Gracja F_1	peat substrate	5.95	11.22	1.47	0.80	0.54
	hotbed soil	5.58	14.36	1.72	1.62	0.47
	average	5.77	12.79	1.60	1.21	0.50
Ognik F_1	peat substrate	5.19	13.46	2.03	1.72	0.34
	hotbed soil	6.28	11.67	3.30	1.47	0.54
	average	5.75	12.57	2.67	1.60	0.44
Słonka F_1	peat substrate	6.16	17.95	1.62	1.22	0.40
	hotbed soil	4.72	11.67	3.30	2.24	0.27
	average	5.44	14.91	2.46	1.73	0.34
Terra F_1	peat substrate	6.02	15.71	1.72	1.62	0.40
	hotbed soil	5.94	18.85	2.24	1.20	0.40
	average	5.98	17.28	1.98	1.41	0.40
Average	peat substrate	5.52	14.36	1.72	1.25	0.45
	hotbed soil	5.68	13.63	2.50	1.75	0.44
$LSD_{0.05}$ cultivar		0.75	3.05	n.s.	n.s.	n.s.
substrate		n.s.	n.s.	0.44	0.37	n.s.
interaction		0.89	1.99	0.90	0.84	n.s.

Fruit of cv. Ognik F_1 grown in hotbed soil had the highest dry matter content, while fruit of cv. Carmello F_1 grown in peat substrate – the lowest (4.44%).

L-ascorbic acid concentration in tomato fruit was also affected by cultivar and cultivar-substrate interaction, and it varied from 9.42 to 18.85 mg per 100 g of edible parts. These values are similar to those reported by KUNACHOWICZ et al. (2006), and the fact that particular tomato cultivars differ with respect to L-ascorbic acid content has been previously demonstrated by KOBRYŃ et al. (2007) and WINIARSKA and KOŁOTA (2007). Fruit of cv. Terra F_1 contained the largest quantities of L-ascorbic acid, and fruit of Atut F_1 – the smallest. An analysis of the interactions between experimental factors indicated that L-ascorbic acid concentration in the edible parts of tomato plants decreased significantly in cv. Atut F_1 grown in peat substrate, and it reached the highest level in cv. Terra F_1 grown in hotbed soil.

The content of total and simple sugars in the edible parts of tomato plants was significantly affected by substrate type and substrate-cultivar interaction. In both cases the concentration of the above compounds in tomato fruit was higher in plants grown in hotbed soil and lower in those grown in peat substrate, with the difference reaching 0.78 $g \cdot 100\ g^{-1}$ for total sugars and 0.50 $g \cdot 100\ g^{-1}$ for simple sugars. An increase in the sugar content of tomato fruit was noted in cv. Ognik F_1, Bekas F_1 and Słonka F_1, grown in hotbed soil.

The average organic acid content of tomato fruit, expressed as malic acid equivalents, ranged from 0.27 to 0.60 $g \cdot 100\ g^{-1}$, but these differences were statistically non-significant. Comparable amounts of organic acids were reported by MARTYNIAK-PRZYBYSZEWSKA (2000) and ROŻEK (2001).

The average nitrate content of fruit of the investigated tomato cultivars was below the maximum permissible level, whose exceedance would pose a hazard to human health (250 mg $N\text{-}NO_3 \cdot kg^{-1}$ fresh weight) (Journal of Laws No. 2 of 2005, item 9). Nitrate accumulation was influenced by tomato cultivar and substrate type, and it varied from 52.6 to 193.5 mg $N\text{-}NO_3 \cdot kg^{-1}$ fresh weight (Figure 1). Among the analyzed tomato cultivars, the lowest $N\text{-}NO_3$ content was recorded in cv. Bekas F_1, while the highest – in cv. Gracja F_1. A particularly small quantity of the above compounds was observed in cv. Baron F_1 grown in hotbed soil, whereas cv. Słonka F_1 grown in peat substrate was characterized by the highest nitrate concentration. The effect of cultivar and substrate on nitrate levels in the edible parts of vegetables has been previously described by ROŻEK (2000).

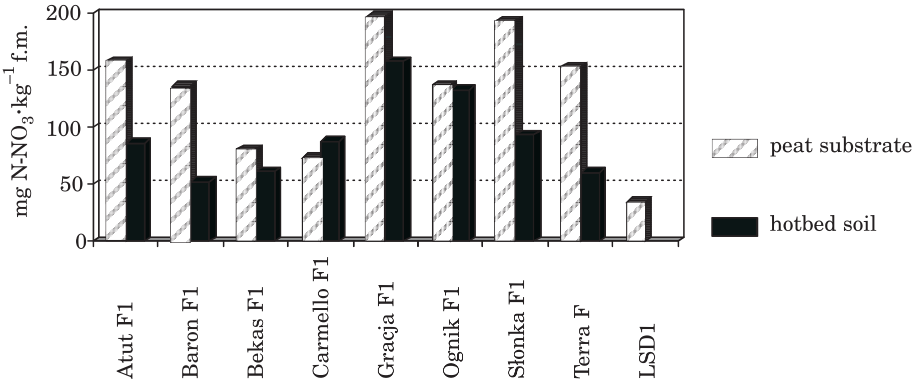

Fig. 1. Effect of cultivar and soil substrate on the nitrate content of tomato fruit

CONCLUSIONS

1. The content of dry matter and L-ascorbic acid in the edible parts of tomato plants was significantly affected by cultivar. The highest concentrations of dry matter and vitamin C were recorded in cv. Atut F_1 and Terra F_1 respectively.

2. Hotbed soil, compared to peat substrate, contributed to a significant increase in sugar concentrations and to a significant decrease in nitrate levels in tomato fruit.

3. Substrate-cultivar interaction was found to exert a statistically significant effect on the content of dry matter, L-ascorbic acid, total sugars and simple sugars in the edible parts of tomato plants. Fruit of cv. Ognik F_1 grown in hotbed soil had the highest content of dry matter and total sugars, in comparison with the other treatments.

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