Relationship between carotenoid content and fruits colour of 'cherry' tomato (*Solanum lycopersicum* L. var. *cerasiforme*)

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INTRODUCTION

It is proved that daily intake of fresh and processed tomato fruits decrease risk of chronic diseases, like cardiovascular diseases and cancer. Lycopene and other carotenoids protect health because of antioxidant activity. Tomato fruits are the main source of lycopene, and important source of β-carotene, the precursor of vitamin A (Burns et al., 2003). Physical, chemical and sensory traits of tomato fruit can be modified by environmental factors. Many studies indicate that the key factor for plant growth, yield, fruits quality and their storage ability may be the growing medium used in greenhouse cultivation. Nowadays, the most popular growing medium in a modern soilless vegetable cultivation is a rockwool. However, rockwool is not suitable for recycling, so a new environmental friendly growing medium is needed to protect environment. Good alternative for the rockwool may be a coconut fibre. It is a biodegradable material of good physical and chemical traits. After completing the growing season, coconut fiber slabs can be composting and then use as organic soil fertilizer.

Carotenoids are natural pigments, providing orange, yellow, red and purple colours throughout the natural world. These pigments are produced by all higher plants, along with some bacteria and algae. They are derived from the terpenoid family and are biosynthetically related to other secondary metabolites such as tocopherols and ubiquinones (Burns et al.., 2003). In plant cells the lycopene molecule is an intermediate compound in the biosynthesis of β-carotene. More than 600 carotenoids have been isolated so far. Red color is initiated by lycopene, which is the most abundant carotenoids in ripe tomatoes. The most important isomers of lycopene are cis- and trans-lycopene. The trans configuration represents 95.4 % of the lycopene in fresh tomatoes. During processing a large part of trans-lycopene transforms into cis-lycopene. Lycopene production is inhibited when environmental temperature is above 32°C. During the ripening period, lycopene content of tomatoes increases sharply from the pink stage onwards, but no sufficient attempts have been made so far to assess the changes of the other antioxidants, presented in the fruit (Helyes et al., 2006). According to Helyes et al. (2002) the lycopene content of sixteen different tomato varieties in Hungary ranged between 39.3 and 171.0 mg kg^{-1}. The highest concentration of lycopene was detected in cherry tomato (77.4 mg kg^{-1} f.w.) while Daniela F1 and Delfine F1 with 59.2 and 69.6 mg kg^{-1} respectively, were significantly lower.

The aim of this study was to find relationship between colour parameters of 'cherry' tomato fruit and carotenoid content in relation to growing medium and postharvest treatment with 1-MCP.

MATERIAL AND METHODS

The study was carried out in 2012 in the greenhouse and laboratories of the Department of Vegetable and Medicinal Plants of Warsaw University of Life Sciences. Tomato seeds were sown in December; seedlings were planted to the experimental greenhouse in January. Cultivars 'Dasher F1' and 'Pareso F1' were used in the experiment. The growing mediums used were standard mineral wool slabs and coconut fibre slabs, as an environmentally friendly alternative. The fruits were harvested in June at 3rd and 5th stage of maturity according to USDA classification and stored for three and fourth weeks with different concentration of 1-MCP. The factors for the experiment were: growing medium, 1-MCP concentration and stage of fruit maturity. There were determined for the fruits carotenoid content by HPLC method and fruit colour in CIE Lab system. Regression models for different carotenoid compounds were calculated, using L*, a*, b* colour parameters and chroma.

The obtained extracts were filtered with ProFill HPLC Syringe Filter blue, Regenerated Cellulose (RC) membrane, diameter 25 mm, pore size 0.20 µm and subjected to HPLC. The analyses were performed using Shimadzu Prominence Liquid Chromatograph equipped with two LC-20AD pumps, SIL-20AC HT auto sampler, CTO-10AS VP oven, photodiode array detector SPD-M20A and LCsolution software. A modern C-18 reversed-phase column with core-shell technology (Phenomenex Kinetex® 2.6 µm, C18, 100A, 100×4.60 mm i.d.) was used as solid phase. The following conditions were applied: isocratic elution of Methanol (Chromasolv® for HPLC, Sigma-Aldrich) with 9 µM of Triethylamine (Sigma-Aldrich), flow rate 1.4 ml×min-1, injection volume: 20 µl, oven temperature 30 °C, total time of analysis 10 min, UV-spectra were recorded between 190 and 800 nm. Peak identification was confirmed by comparison of retention time and spectral data with adequate parameters of standards purchased from ChromaDex (α-carotene, β-carotene) and Sigma Life Science (RedivivoTM – lycopene). For quantitation of investigated compounds the five-point calibration curve method was used. Methanol stock standard solutions were prepared according to the ChromaDex's Tech Tip 0003: Reference Standard Recovery and Dilution. The solutions (0.5, 1.0, 2.0, 5.0 and 10 µl) were applied on a column in triplicate. The peak table and spectra library (190-800 nm) of individual compounds were created. Detection wave applied: 445 nm (α-carotene), 450 nm (β-carotene) and 470 nm (lycopene). The content of the determined compounds was calculated in mg×100g-1 dry matter.

The results were analysed with one-way ANOVA and Tukey's HSD test at α=0.95 using Statgraphics Plus for Windows v. 4.1 software.

RESULTS

Table 1. Content of lycopene in dependen on growing medium, postharvest treatment with 1-MCP and stage of fruit maturity

	Storage duration	0 days	21 days					28 days				
			concentration of 1-MCP					concentration of 1-MCP				
Growing medium	Stage of maturity	Fresh fruits	Control	0.5 1-MCP	1.0 1-MCP	Mean for growing medium	Mean for stage of maturity	Control	0.5 1-MCP	1.0 1-MCP	Mean for growing medium	Mean for stage of maturity
Coconut fibre	3rd stage	1.39	6.50	8.13	5.10	25.55	3rd stage	8.67	9.40	6.03	29.32	3rd stage
	5th stage	42.01	48.93	42.40	42.23		5.35	52.33	53.83	45.67		7.97
Mineral wool	3rd stage	2.46	4.73	4.04	3.60	28.11*	5th stage	7.80	8.03	7.87	31.83*	5th stage
	5th stage	42.52	65.33	47.10	43.83		48.31*	67.60	54.57	45.13		53.19*
	Mean	22.10	31.37 a	25.42 b	23.69 b			34.10 a	31.46 a	26.18 b		

Note: Means marked with different letters differ significantly at α = 0.05

Table 2. Content of β-carotene in dependen on growing medium, postharvest treatment with 1-MCP and stage of fruit maturity

	Storage duration	0 days	21 days					28 days				
			concentration of 1-MCP					concentration of 1-MCP				
Growing medium	Stage of maturity	Fresh fruits	Control	0.5 1-MCP	1.0 1-MCP	Mean for growing medium	Mean for stage of maturity	Control	0.5 1-MCP	1.0 1-MCP	Mean for growing medium	Mean for stage of maturity
Coconut fibre	3rd stage	1.31	3.55	3.35	2.62	4.98 ns	3rd stage	6.45	5.87	5.10	10.79*	3rd stage
	5th stage	3.27	6.94	6.61	6.82		3.15	16.13	16.50	14.70		5.73
Mineral wool	3rd stage	1.17	3.61	3.08	2.66	4.94 ns	5th stage	5.83	6.03	5.07	10.29	5th stage
	5th stage	3.34	7.31	6.50	6.47		6.78*	17.03	15.10	12.67		15.36*
	Mean	2.26	5.35 a	4.89 b	4.64 b			11.36 a	10.88 ab	9.38 b		

Note: Means marked with different letters differ significantly at α = 0.05

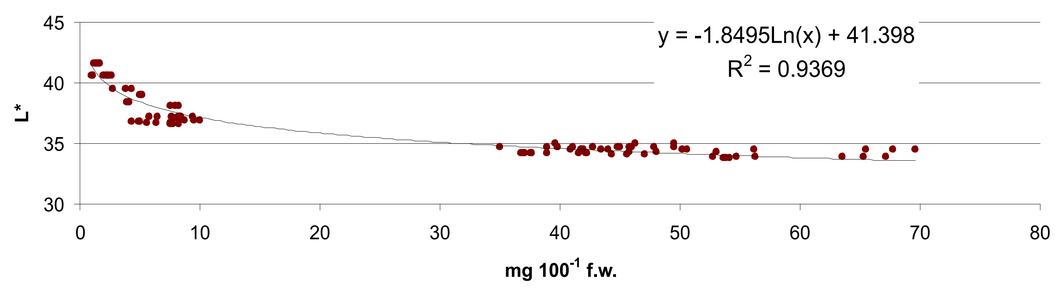

Figure 1. Experimentally found lycopene content in 'cherry' tomato fruits and L* values for the fruits in relation to calculated regression function

Table 3. Relationship between CIE parameters of fruits and lycopene content in 'cherry' tomato fruits

Storage duration	Colour parameter	Regression models	Correlation coefficient r
0 days	L*	y = -2.0346Ln(x) + 41.993	0.98
	a*	y = 0.9437Ln(x) + 20.544	0.92
	b*	y = -2.5605Ln(x) + 30.183	0.96
21 days	L*	y = -1.5954Ln(x) + 40.56	0.89
	a*	y = 0.3967Ln(x) + 25.295	0.07
	b*	y = -2.6204Ln(x) + 28.047	0.82
28 days	L*	y = -1.501Ln(x) + 40.275	0.90
	a*	y = 0.459Ln(x) + 26.772	0.11
	b*	y = -2.4273Ln(x) + 28.073	0.70

Table 4. Relationship between CIE parameters of fruits and β-carotene content in 'cherry' tomato fruits

Storage duration	Colour parameter	Regression models	Correlation coefficient r
0 days	L*	y = -6.8406Ln(x) + 42.538	0.95
	a*	y = 3.2081Ln(x) + 20.266	0.91
	b*	y = -8.5589Ln(x) + 30.835	0.93
21 days	L*	y = -4.7066Ln(x) + 43.352	0.95
	a*	y = 1.0202Ln(x) + 24.83	0.06
	b*	y = -7.6476Ln(x) + 32.505	0.86
28 days	L*	y = -2.916Ln(x) + 42.265	0.93
	a*	y = 0.9692Ln(x) + 25.991	0.14
	b*	y = -4.8093Ln(x) + 31.5	0.78

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CONCLUSIONS

1. **Brightness of the fruits (component L*) is strongly correlated with the content of lycopene and β-carotene in the fruits – fruits with the higher content of these compounds are darker. This can be seen directly after harvesting and after three and four weeks of storage.**
2. **The correlation between the a* parameter and the content of lycopene and β-carotene can be seen only in fresh fruit – before storage. After three and four weeks of storage the value of a* is gradually compensated for in all combinations. Despite this the fruits obtained from plants grown on a mineral wool slabs and collected as red characterized by the highest value of the a* parameter (red) after 4 weeks of storage.**
3. **The value of the component b* is strongly negatively correlated with the content of lycopene and b-carotene in the fruit. This is particularly evident in the fruit directly after harvesting.**

LITERATURE

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