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THE EFFECT OF THE LENGHT OF STORAGE ON THE AMOUNT OF LYCOPENE IN THE FRUITS OF TOMATO (*LYCOPERSICON ESCULENTUM* L.)

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Abstract

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We focused on tomatoes for industrial processing due to its economical importance for its lycopene content. The objective of our research is to find the variation of lycopene content in tomato fruits depending upon the length of after harvest storage and thermic treatment, which is inevitable when being industrialy processed. From the point of view of nutritional qualities the most relevant contentual substance of tomatos are carotenoids, included lycopene.
At average for tree following experimental years we learnt significant differences regarding the content of lycopene and the length of storage of tomato fruits. Immediately after the harvest and proccesing tomato fruits contained, at average for tree years, 103.24 mg of lycopene. After 14 days the content of lycopene declined to 46.76 $mg.kg^{-1}$ of fresh mass. After 30 days the average value dropped to 29.26 $mg.kg^{-1}$. This fact comfirms that boiling respectively thermic treatment increases the content of lycopene in tomato fruits, particulary in our experiment to the value 83.33 $mg.kg^{-1}$. At varieties Ladislav, Peto 86, Prémium, Salus the content of lycopene has even risen in comparison with its content up to 48 hours after the harvest. Tomato (*Lycopersicon esculentum* L.) belongs to the most signifficant vegetable varieties either for its exploitation in processing industry as well as for its nutritional value with extraordinary beneficial effect for human organism.
Although the content of lycopene is genetically stable attribute, its content in our experiment ranged from 45.39 $mg.kg^{-1}$ (Prémium variety) to 77.98 $mg.kg^{-1}$ (Zámčan variety), which are significant differences.

tomato (*Lycopersicon esculentum* L.), lycopene, antioxidant, thermic treatment, storage lenght

Non-substitutable role of tomatos in human nutrition is given by theirs high biological and low energetical value, relatively high content of minerals, vitamins, antioxidants, fytochemical and other components, which positively influent physiological processes in human organism. According Velíšek (2002) the main pigment in tomatoes is lycopene (90 % of all carotenoids). ß-caroten is not so extended with amount about 6 $mg.kg^{-1}$. Some carotenoids as for example lycopene, astaxathin are more effective in singlet oxygen extinguishing than ß-caroten. Carotenoids react with free radicals, therefore they act as antioxidants. The simpliest prototype of carotens is acyclical polyunsaturated hydrocarbon lycopene. Another wide-spread carotenoids are hydroderivates of lycopene, e.g 3.4-dehydrolycopene and other compounds (neurosphoren, fytofluen, fytoen). From medicinal point of view lycopene is effective in prevention of mouth, larynx, prostate and colon cancer.

Lycopene has also important inhibitory effect on arterosclerosis, cancer and various inflammations, braces the liver and the heart functioning.

Tomatos and their products (juices, squash, ketchup, pastes, soups) are important sources of lycopene. Thermic treatment and presence of fats enhance biological availability of lycopene. This processes affect cell tissue and enables lycopene, present in tomatos in crude form, to extract from chromoplasts (Heber, 2000).

Carotenoids, especially lycopene, glutation, polyphenols and bioflavonoids along with vitamin E and C, act as very important antioxidants and anticarcinogen substances.

MATERIAL AND METHODICS

Field trial has been held at Research and Breeding Institute for Vegetable and Special Crops in 2002–2004. Experiment included examinated varietes of tomato (*Lycopersicon esculentum* L.) Prémium, Peto 86, Denár, Salus, Ladislav, Peto mac and Zámčan.

Seeds of tomato varieties were sowed into seeding boxes placed in heated greenhouses (21–25 °C) in mid April. When moved out, the temperature was reduced to 20 °C during the day and to 16 °C during the night. After first true leaf appearence, plants were planted into the packets (60 × 60 mm). Outgrown seedlings were planted in the experimental area (in the second decade of May) with spacing 60 × 40 cm. The experimental area was fertilized based on soil analysis. Deficient mineral nutrients were supplied to following levels: 120 kg $N.ha^{-1}$, 44 kg $P.ha^{-1}$ and 135 kg $K.ha^{-1}$ (in pure nutrients). The protection against pests and diseases was performed according to methodics for growing tomatos in field conditions (Valšíková a kol., 1996). Harvest of tomatos for lycopene content analysis was realized in the stage of botanical maturity (first week of September). Analysed fruits were deep red with consistent flesh, without yellow or green stains.

Lycopene content in the fruits of tomatoes was determined in the stage of botanical maturity in four terms. The first term was 48 hours (2 days) after harvest, the second 14 days after harvest, the third 30 days after harvest and the fourth term after thermic treatment (15 days after harvest).

Tomatoes were stored in air-conditioned boxes at the temperature +5 °C. Tree analysis for each variety were performed. Lycopene content was determined by method of spectrophotometry. The evaluation of obtained outcomes was realised using variation analysis (Tuckey test with significancy level $\alpha = 0{,}05$).

RESULTS AND DISCUSSION

Applicating variation analysis (Table I) on obtained results, we learnt significant differences within examinated varieties, after harvest storage period duration of fruits, experimental years and thermic treatment. No significant differences were experienced among repeatings.

The content of lycopene in tomato fruits fluctuated in the range from 45.39 $mg.kg^{-1}$ to 77.98 $mg.kg^{-1}$. The highest value of lycopene amount in fresh fruits was at variety Zámčan 77.98 $mg.kg^{-1}$. The lowest lycopene content was detected at variety Prémium (45.39 $mg.kg^{-1}$). Values of another varieties were following: Peto 86 with 61.28 $mg.kg^{-1}$, Denár 63.66 $mg.kg^{-1}$, Salus 66.54 $mg.kg^{-1}$, Ladislav 69.55 $mg.kg^{-1}$ and Peto mac 75.12 $mg.kg^{-1}$.

Significant differences in lycopene content among varieties at average for three years are presented in Table II. It results from obtained, that content of lycopene in tomato fruits is affected foremost by genotype and less significant by external environment, which is very stable attribute (Uher, 1995, Bystrická a kol., 2006).

Very important assignment of our research is fact, that lycopene content in the fruits of tomatos is depending on the lenght of after harvest storage and thermic treatment (boiling 100 °C). According Yeung et al. (2001) lycopene is liberating from the cell tissue by thermal treatment transformating into cisisomers. These processes lead to increase of pigment amount. Studies about biological availability of lycopene indicate, that lycopene is better absorbed in the presence of fat in food and that cis-isomers are better absorbed as trans-isomers. The content of lycopene respectively lycopene income from tomato juice increases after thermal treatment.

It results from obtained outcomes, at average for tree experimental years, that lycopene content decreases in dependance on extension of the lenght of storage. However, the content of lycopene increases after thermic treatment – boiling by 100 °C (Table III). After 48 hours since harvest, the value of lycopene content in tomato fruits (fresh mass) was 103.24 $mg.kg^{-1}$. The lycopene content after 14 days of storage decreased to 46.76 $mg.kg^{-1}$, what represents 45.29 % decline. 30 days after harvest, the content of lycopene reduced to 29.26 $mg.kg^{-1}$. After thermic treatment (boiling at 100 °C), tomato fruits contain 83.33 $mg.kg^{-1}$ of lycopene. These significant differences are presented in Table III and displayed in Figure 1.

We experienced significant differences of lycopene content also among experimental years (Table IV). The highest average amount of lycopene was 73.46 $mg.kg^{-1}$ in 2003. Less favourable results are from year 2004, with average value of lycopene content 64.99 $mg.kg^{-1}$. Least favourable year was 2002 due to high amount of rainfall and low temperatures in comparison with years 2003 and 2004.

CONCLUSION

The objective of our research was determination of lycopene content in the fruits of industrial tomatoes (*Lycopersicon esculentum* L.) in dependance on the lenght of storage and thermic treatment. Examinated varieties: Denár, Ladislav, Peto 86, Peto mac, Salus and Zámčan.

Field trial was held in period 2002–2004. Technology of cultivation met the requirements for growing examinated varieties of tomatos. Harvest of tomatos was in progress each year in the first decade of September. Obtained results were subject to variation analysis (Tuckey HSD test at $\alpha = 0{,}05$).

The result indicates significant effect of the lenght of storage and thermic treatment on lycopene content in tomato fruits, as well as significant differences within varieties and experimental years. There is a negative correlation between lycopene content and the lenght of storage and positive correlation between thermic treatment and lycopene content.

The lowest lycopene content was observed in variety Prémium (45.39 mg.kg^{-1}), the highest in variety Zámčan (77.98 mg.kg^{-1}). Table II shows more relevant data. The amount of lycopene depends on the lenght of storage and thermic treatment (at temperature of 100 °C), table III, Figure 1. After 48 hours since harvest, tomato fruits contained 103.24 mg.kg^{-1} of lycopene. After 14 days since harvest, content of lycopene was 46.76 mg.kg^{-1} in the fruits of tomatos. After 30 days since harvest, tomatos contained 29.26 mg.kg^{-1} of lycopene. After thermic treatment-boiling, the content of lycopene increased to 83.33 mg.kg^{-1}.

I: *Analysis of Variance for Lycopene [mg.kg^{-1}]*

Source of Variability	Sum of Squares	Degree of Freedom	Mean Squeres	F-ratio	P-value
Main Effects					
A: Variety	24 886,4	6	4 147,73	50,72	0,0000
B: Lenght of Storage	214 615,0	3	71 538,43	874,74	0,0000
C: Years	9 487,0	2	4 743,50	58,00	0,0000
D: Treatments	265,5	2	132,76	1,62	0,2044
Interactions					
A × B	67 433,7	18	3 746,32	45,81	0,0000
A × C	50 767,3	12	4 230,61	51,73	0,0000
A × D	1 075,1	12	89,59	1,10	0,3772
B × C	53 365,1	6	8 894,18	108,75	0,0000
B × D	814,9	6	135,81	1,66	0,1432
C × D	253,7	4	63,42	0,78	0,5447
A × B × C	39 948,7	36	1 106,91	13,53	0,0000
A × B × D	3 537,6	36	98,27	1,20	0,2510
A × C × D	2 289,2	24	95,38	1,17	0,3014
B × C × D	1 864,4	12	155,37	1,90	0,0485
Rezidual	5 888,4	72	81,78		
Total	476 392,0	251			

II: *The amount of Lycopene in tomato fruits per variety [mg.kg^{-1}]. (Tukey HSD, 95%).*

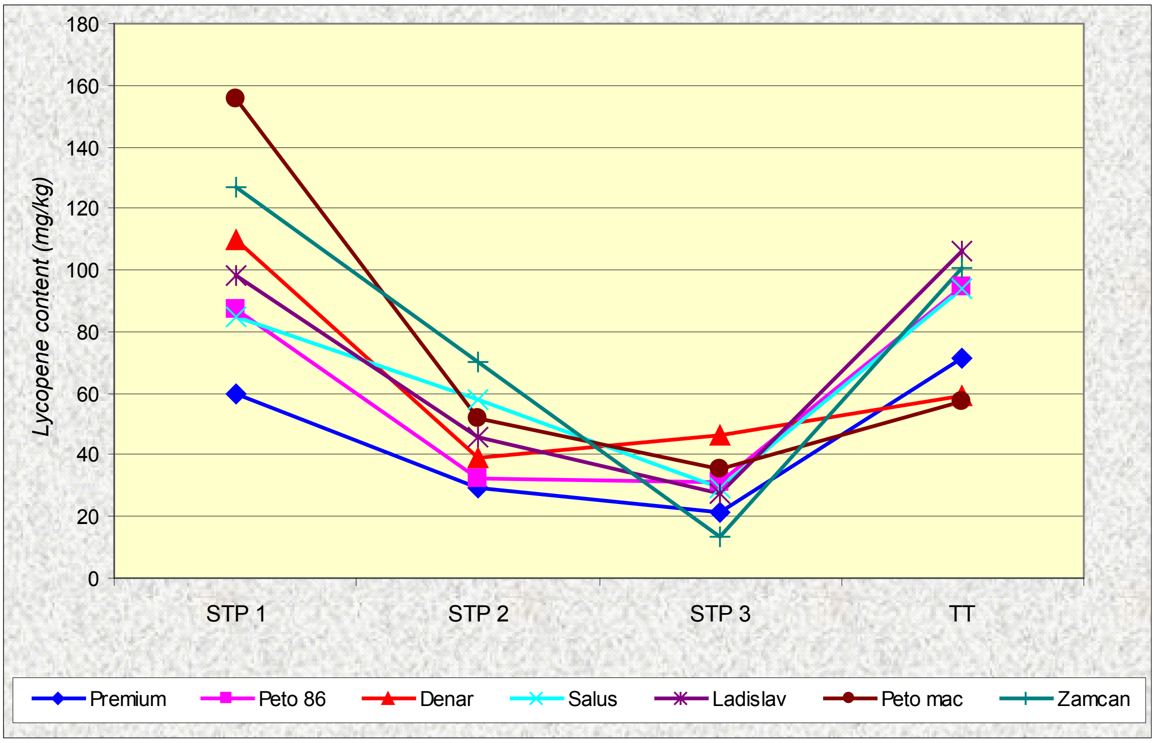
Variety	LS Mean	Homogeneous Groups				
Premium	45,39	a				
Peto 86	61,28		b			
Denar	63,00		b	c		
Salus	66,54		b	c		
Ladislav	69,55			c	d	
Peto mac	75,12				d	e
Zamcan	77,98					e

III: *The amuont of Lycopene in tomato fruits in dependence of storage length and thermic treatment [mg.kg^{-1}]. (Tekey HSD, 95%).*

Lenght of Storage	LS Mean	Homogeneous Groups			
after 48 hours since harvest	103,24	a			
after 14 days since harvest	46,76		b		
after 30 days since harvest	29,26			c	
after thermal treatment	83,33				d

IV: *The amount of Lycopene in tomato fruits in dependence of the zear of productio [mg.kg^{-1}]. (Tukey HSD, 95%).*

Years	LS Mean	Homogeneous Groups		
2002	58,48	a		
2003	64,99		b	
2004	73,46			c



1: *Lycopene content in tomato fruits in dependency on storage period after harvest and thermal treatment*
(STP 1) storage period – 48 hours after harvest, (STP 2) storage period – 14 days after harvest, (STP 3) storage period – 30 days after harvest, (TT) – after thermal treatment (15 days after harvest)

SÚHRN

Vplyv dĺžky skladovania na obsah lykopénu v plodoch rajčiaka jedlého (*Lycopersicon esculentum* L.)

Predmetom nášho výskumu bolo sledovanie obsahu lykopénu v plodoch priemyselných rajčiakov v závislosti od dĺžky skladovania a tepelnej úpravy. Sledovali sme nasledovné odrody: Denár, Ladislav, Peto 86, Peto mac, Salus a Zámčan.
Poľný pokus bol realizovaný v rokoch 2002–2004. Technológia pestovania zodpovedala požiadavkám pre pestovanie sledovaných vybraných odrôd rajčiakov. Zber plodov rajčiakov sa robil každoročne v prvej dekáde septembra. Získané výsledky boli vyhodnotené analýzou variancie (Tuckey HSD test at $\alpha = 0{,}05$).
Analýzou variancie (tabuľka I) sme zistili preukazné rozdiely v množstve lykopénu medzi vybranými odrodami, ďalej medzi dĺžkou skladovania a po tepelnej úprave plodov rajčiakov a medzi pokusnými rokmi (tabuľka IV). Na základe dosiahnutých výsledkov môžeme konštatovať negatívny vzájomný vzťah medzi obsahom lykopénu a dĺžkou skladovania a pozitívnu koreláciu medzi obsahom lykopénu a tepelnou úpravou.
Najnižší obsah lykopénu bol zistený pri odrody Prémium (45,39 mg.kg^{-1}) a najvyšší pri odrody Zámčan (77,98 mg.kg^{-1}). Dosiahnuté výsledky sú uvedené v tabuľke II. Množstvo lykopénu je závislé od dĺžky skladovania a tepelnej úpravy (pri teplote 100 °C), tabuľka III, obrázok 1. Po 48 hodinách od zberu, plody rajčiakov obsahovali 103,24 mg.kg^{-1} lykopénu. Po 14 dňoch od zberu bol zistený obsah lykopénu 46,76 mg.kg^{-1} v plodoch priemyselných rajčiakov. Po 30 dňoch od zberu rajčiaky obsahovali 29,26 mg.kg^{-1} lykopénu. Po tepelnej úprave – varení sa obsah lykopénu zvýšil na hodnotu 83,33 mg.kg^{-1}.

rajčiak (*Lycopersicon esculentum* L.), lykopén, antioxidant, tepelná úprava, dĺžka skladovania

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