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Do Consumers Fully Benefit from the Richness of Dietary Contribution to Human Health offered by Tomato?

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Do Consumers fully Benefit from the Richness of Dietary Contribution to Human Health offered by Tomato

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Abstract

Tomatoes are one of the most popular and consumed vegetables, occupying second place after potatoes. Fresh tomato fruits contain intermediate levels of essential for human heath micronutrients as lycopene, β-carotene and lutein. The importance of these carotenoids is associated with a decreased risk of cardiovascular diseases, premature aging, cancer and cataracts.

The present study was designed to get an idea to what extent the consumers take advantage from the tomato fruits richness and their contribution to human health. The content of the three carotenoids – lycopene, β-carotene and lutein in nine tomato genotypes with different fruit color: red, pink, orange and yellow were analyzed by High Performance Liquid Chromatography (HPLC).

The results demonstrated a great nutritional potential, which tomato cultivars with different fruit color posses in relation to the carotenoid content. It is important to underline that limiting their consumption to red and pink tomatoes only, consumers did not fully profit from the nutritive and flavor potential offered by tomatoes.

Keywords: Tomato nutritive quality, lycopene, β- carotene, lutein content, High Performance Liquid Chromatography (HPLC)

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Introduction

A typical tomato fruit contains intermediate levels of lycopene, β-carotene, ascorbic acid, sugars, but because of the volume of fresh tomatoes and tomato products that are consumed, tomatoes make important contribution to the dietary intake. The two most valuable carotenoids in tomato fruits are lycopene and β-carotene. Therefore, nutritive quality of tomato fruits and tomato products can be well characterized by the monitoring of the content of these compounds. It is well known that a healthy diet is an essential element in the prevention of chronic diseases, to health improvement and control of body weight. Many studies have shown a strong correlation between consumption of tomatoes and tomato products and reducing the risk of developing certain types of cancer, neurodegenerative, cardiovascular diseases and age-related macular degeneration (Rao and Agarwal, 2000; Giovannucci, 2002; Giovannucci et al., 2002; Sesso et al., 2003; Stahl and Sies, 2005). Carotenoids are a family of pigmented compounds that are synthesized by plants and microorganisms. There are several hundred carotenoid pigments, however, only about 40-50 are present in a typical human diet (Marshall B.Ketchum University-MBKU, 2014). The major sources of these compounds are the fruits and vegetables with different flesh color due to variable carotenoid content and composition (Guzman et al., 2010).

Lycopene is a carotenoid pigment presented in red fruits and vegetables like watermelon, pink grapefruit, red cabbage and red sweet pepper. According to data of Clinton (1998) at least 85% of our dietary lycopene comes from tomato fruit and tomato-based products. Lycopene is considered to be the most effective natural antioxidant. It is reported that it is twice more effective than β-carotene and ten times more effective than ά-tocopherol (Di Mascio et al., 1989). According to Ronen et al. (1999) the major carotenoids that accumulate in ripe red tomato fruits except lycopene, which presented ~ 90% from the total carotenoid content, are β-carotene from 5 to 10% and lutein from 1 to 5%. A trace amounts, less than 1%, correspond to the other carotenoids.

The β-carotene has pro-vitamin A activity. In the human body one molecule of β-carotene converts into two molecules of vitamin A (retinol) (Basu and Imrhan, 2007; Rao and Rao, 2007; Singh and Goyal, 2008). β-carotene boosts immunity, enhances the skins health and mucous membranes, and plays an significant role for vision health. Lutein is becoming increasingly important in preventive medicine due to its role in maintaining the good vision and in detain of the age-related maculopathy development (Giorio et al., 2013). Lutein is found in all dark-green leafy vegetables and in fruits and vegetables with red, orange or yellow pigments, such as tomatoes.

The aim of the present study was to determine and compare the content of lycopene, β-carotene and lutein between Bulgarian tomato cultivars with different fruit color.

Material and Methods

Plants were grown on the open field condition using standard production practices.

The experiment included nine Bulgarian tomato varieties, divided in four groups:

i. Reyana F1 and Ideal- indeterminate, red tomato varieties for fresh consumption;
ii. Berika and Trapezitsa - determinate, red tomato varieties for processing;
iii. Rosalina-Rossa F1 and Volsko Surce - indeterminate, pink tomato varieties for fresh consumption;
iv. Paco orange and Carobeta - determinate, orange tomato varieties for processing and one indeterminate, yellow variety for fresh consumption– Zlatista.

Tomato fruits were harvested randomly and samples were prepared by cutting ¼ of 10 fully ripe fruits. Samples were frozen immediately and lyophilized in Dryer Rotational vacuum concentrator (CHRIST). Dry samples (0.02 mg) were subject of the extraction following the protocol of George et al. (2011) with some modifications. Briefly, the samples were extracted with 5ml acetone included 0.1 % butylhydroxytoluene (BHT), incubated for 1h at room temperature with shaking and centrifuged for 5 min at 2500 rpm. The supernatant was filtrated by anhydrous Na2SO4. The pellet was extracted two more times. Both phases were separated with n-Hexane: water (1:1). The phases containing carotenoids was collected and evaporated by CentriVap concentrator (LABConco). Samples were analyzed by HPLC system in the Institute of microbiology (Bulgarian Academy of Sciences). HPLC separation was achieved using a reversed phase C18 column Discovery® with a gradient system with acetonitrile : methanol (8:2) and MTBE (methyl tert-butyl ether) with flow rate 1.0 mL/min for 15 min. (Georgieva et al. 2013).

Statistics

Each sample was extracted three times, and two consecutive column injections for each analysis were performed. The obtained data was subjected to one-way ANOVA analysis of variance for comparison of means, and significant differences were calculated according to the Fisher LSD (Least Significant Difference) test at the 5% level using a statistical software package (Statigraphics Plus, version 5.1 for Windows). Data was reported as means ± standard deviation.

Results and Discussion

When we say 'tomato' most of the people imagine a nice red, round tomato fruit, popular with the high content of lycopene. Employing the genes such as B, hp, ogc in the breeding programs, made it possible to develop tomato varieties with a high content of β-caroten and lycopene. The objectives of this study were to identify and quantify carotenoid compounds in tomato cultivars with red, pink, yellow and orange fruit color. Three major carotenoids were monitored: lycopene, β-carotene and lutein.

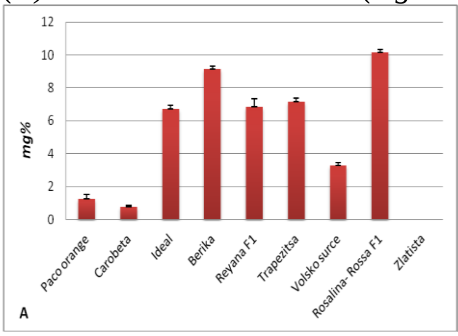
Among all analized tomato cultivars the lycopene content varied between 0.75 mg% in the orange cultivar Carobeta to 10.16 mg% in the pink cultivar Rosalina- Rossa F1. The lycopene content in the red tomato cultivars ranged between 6.74 mg% in cv. Ideal to 9.12 mg% in cv. Berika (Table 1, Figure 1A). The red cultivars for processing showed higher lycopene content in comparison with those for fresh consumption. Values between 6.12 and 10.19 mg% of lycopene content were reported by Garcia and Barrett (2006) for red tomato cultivars for canning, grown in California.

Table 1. *Content of Carotenoids in Fresh, Lyophilised Red, Pink, Orange and Yellow Tomatoes (mg/100g f.w.) (Values are Mean ± Standard Deviation of Three Determinations)*

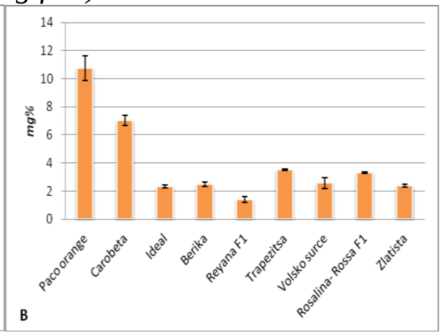
Genotype	lycopene	β-carotene	lutein
Orange fruits			
Paco orange	1.24±0.28b	10.75±0.88e	0.71±0.03d
Carobeta	0.75±0.09a	7.03±0.38d	0.52±0.02c
Red fruits			
Ideal	6.74±0.22d	2.34±0.09b	0.47±0.03b
Berika	9.12±0.19e	2.49±0.16b	0.51±0.02bc
Reyana F1	6.86±0.48d	1.41±0.22a	0.35±0.02a
Trapezitsa	7.15±0.23d	3.51±0.05c	0. 48±0.02b
Pink fruits			
Volsko surce	3.29±0.15c	2.58±0.39b	0.67±0.03d
Rosalina- Rossa F1	10.16±0.18f	3.32±0.06c	0.79±0.02e
Yellow fruits			
Zlatista	nd	2.38±0.11b	0.70±0.02d
LSD	0.44	0.62	0.04

Source: Authors' estimations.
Note: Different letters indicate significant differences assessed by the Fisher LSD test ($P \leq 0.05$) after performing ANOVA multifactor analysis.

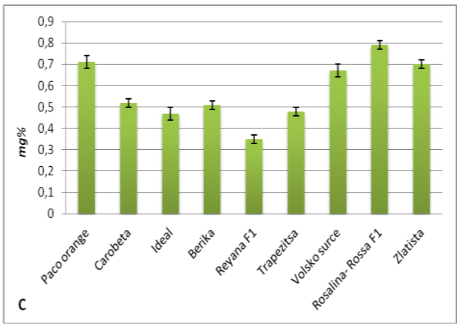
Figure 1. *Content of Carotenoids - Lycopene (A), β-carotene (B) and Lutein (C) in Fresh Tomato Fruits (mg/100g f.w.)*



A) lycopene



B) β-carotene



C) lutein

Source: Authors' estimations.

It was surprising that the highest lycopene content was obtained in the pink cultivar Rosalina-Rossa F1 in comparison with the other pink cultivar Volsko source (3.29 mg%) and the red cultivars analyzed (Table 1, Figure1A). These results could be explained with the genetic improvement methods used. The lowest value of lycopene was detected in the orange colored varieties. In the yellow cultivar cv. Zlatista lycopene was not found.

As a precursor of vitamin A the β - carotene has a significant role for human growth and development. Vitamin A deficiency is still a public health problem in more than half of all countries, especially in Africa and South-East Asia and is one of the most serious nutritive disorders in children and pregnant women (van Lieshout M. et al., 2003). The analysis of β-carotene content in Bulgarian tomato cultivars varied in the following range: from 1.41mg % in the red cultivar Reyana F1 to 10.75 mg% in the orange cultivar Paco orange. Both orange varieties analized in the present study were genetically selected as high β-carotene tomato cultivars by introduction of the dominant gene B (Vulcova et al. 1997). The estimated content of β-carotene was 7.03 mg% in cv. Carobeta and 10.75 mg% in cv. Paco orange respectively (Table 1, Figure 1B). In comparison, with cherry tomato lines, homozygous to gene B (Stommel 2005), cv. Paco orange showed two times higer value of β-carotene content. There were significant differences among red genotypes with respect to the levels of β-carotene. In cultivar Trapezitsa the content of this compound was

3.51 mg% in comparison with cv. Reyana F1 - 1.41 mg% respectively. The red phenotype Trapezitsa and pink hybride Rosalina- Rossa showed equal content of β-carotene (Table 1, Figure 1B). The favorite pink cultivar Volsko source (like Cuore de Bue) as well as the yellow fruited variety Zlatista were characterized with low nutritive value concerning β-carotene content (Table 1, Figure 1B).

The obtained data presented on in Table 1 and Figure 1C showed that there were significant differences in lutein content between the tomato fruits with red, pink, orange and yellow color: the values varied from 0.35 mg% in the red cultivar Reyana F1 to 0.79 mg% in the pink cultivar Rosalina Rossa F1. The lutein content estimated in the other pink cultivar Volsko surce was 0.67 mg%. No significant differences between the yellow tomato cultivar Zlatista and orange fruit genotype Paco orange concerning the lutein content were detected (Table 1). Similar to the lycopene content, Rosalina-Rossa has the highest lutein value in its carotenoide profile in comparison with the other cultivars tested. UCLA (University of California, Los Angeles) laboratory tests showed that lutein reduces the cell growth of prostate cancer by 25%, while lycopene reduces the cell growth by 20%. When lutein and lycopene were combined, prostate cancer cell growth was reduced by 32%. These results indicate that both nutrients together can provide better help for the protection against prostate cancer than either nutrient alone (http://www.rejuvenation-science.com/n_antioxidants_prostate-cancer.html). According to Dr. David Heber, “Lutein and lycopene in combination appear to have additive or synergistic effects against prostate cancer,” (http://www.rejuvenation-science.com/n_antioxidants_prostate-cancer.html).

Conclusion

In the present study for the firs time carotenoide profile of the whole range of tomato fruit with different colours was analysed. The results confirmed that carotenoid content as well as the ratio between lycopene and β-carotene in tomato fruits are genotype dependent.

Quantitative analyses of fresh tomatoes showed that the presence of lycopene was in wide range. Our data confirms that red tomatoes are a major source of lycopene. The great capacity of the pink varieties to produce lycopene was demonstrated.

The ability of the orange tomato varieties to become a considerable source of β-carotene was shown. The content of this carotene in both ornage cultivars is thee to five times higer in comparison with the red and yellow genotypes. The results reveal that orange and yellow tomatoes were characterised with high lutein content. Significant value of this carotenoid was detected in the pink genotype too.

The presented data demonstrates the rich nutritive potential of the Bulgarian tomato cultivars with different fruit color .

We recommend to the consumers to include in their daily diet fresh tomato and tomato products by red, pink, orange and yellow fruits in order to fully benefit from the nutritive capacity of this vegetable.

References

Basu, A., and Imrhan, V. 2007. Tomatoes versus lycopene in oxidative stress and carcinogenesis: conclusions from clinical trials. Eur. J. Clin. Nutr. 61, 295–303.

Clinton, S. K. 1998. Lycopene: chemistry, biology, and implications for human health and disease. Nutrition Rev. 56, 35–51.

Di Mascio, P., Kaisler, S., and Sies, H. 1989. Lycopene as the most effi cient biological carotenoid singlet oxygen quencher. Archives of biochemistry and biophysics. 47, 9, 532–538. ISSN 0003-9861.

Garcia, E., and Barrett, D. 2006. Assessing lycopene content in California processing tomatoes. Journal of Food Processing and Preservation. 30, 56–70.

Georgieva, L., Marchev, A., Ivanov, I., Ganeva, D., Bojinov, B., and Pavlov, A. 2013. Improved HPLC Methods for determination of carotenoids and tocopherols in different varieties of tomatoes. Scientific works Volume LX „Food science, engineering and technologies – 2013“ 18-19 October 2013, Plovdiv

George, S., Tourniaire, F., Gautier, H., Goupy, P., Rock, E., and Caris-Veyrat, C. 2011. Changes in the contents of carotenoids, phenolic compounds and vitamin C during technical processing and lyophilisation of red and yellow tomatoes. Food Chemistry. 124, 4, 1603-1611.

Giorio, G., Yildirim, Y., Stigliani, A.L., and D'Ambrosio, C. 2013. Elevation of lutein content in tomato: A biochemical tug-of-war between lycopene cyclases.Metabolic Engineering. 20, 167–176.

Giovannucci, E., 2002. A review of epidimiologic studies of tomatoes, lycopene, and prostate cancer. Experimental biology and medicine. 110, 10, 852–859. ISSN 1535-3699.

Giovannucci, E., Rimm, E., Liu, Y., Stampfer, M., and Willett, W. 2002. A prospective study of tomato products, lycopene, and prostate cancer risk. Journal of national cancer institute. 94, 5, 391–398. ISSN 1460-2105.

Guzman, I., Hamby, S., Romero, J., Bosland, P.W., and O'Connell, M. 2010. Variability of Carotenoid Biosynthesis in Orange Colored Capsicum spp. Plant Sci. 179(1-2), 49–59.

Rao, A.V., and Agarwal, S. 2000. Role of antioxidant lycopene in cancer and heart disease.J.Am.Coll.Nutr. 2000 Oct;19, 5, 563-569.

Rao, A.V., and Rao, L.G. 2007. Carotenoids and human health. Pharmacol Res. 55, 207–216.

Ronen G., Cohen M., Zamir D., and Hirschberg J. 1999. Regulation of carotenoid biosynthesis during tomato fruit development: expression of the gene for lycopene epsilon-cyclase is down-regulated during ripening and is elevated in the mutant Delta. Plant Journal. 17, 341–351.

Sesso, H. D., Liu, S., Gaziano, J. M., and Buring, J. E. 2003. Dietary lycopene, tomato-based food products and cardiovascular disease in women. Journal of Nutrition, 133, 7, 2336–2341. ISSN 1541-6100.

Singh, P., and Goyal, G.K. 2008. Dietary lycopene: its properties and anticarcinogenic effects. Compr. Rev. Food Sci. Food Saf. 7, 255–270.

Stahl, W., and Sies, H., 2005. Bioactivity and protective effects of natural carotenoids. Biochimica et Biophysica Acta - Molecular Basis of Disease, 1740, 2, 101–107. ISSN 0006-3002. http://dx.doi. org/10.1016/j.bbadis.2004.12.006.

Stommel, J.R. 2005. USDA 02L1058 and 02L1059: cherry tomato Breeding Lines with High Fruit β –Carotene Content. Hort. Science 40, 5, 1569-1570.

van Lieshout, M., West, C.E., and van Breemen, R.B. 2003. Isotopic tracer techniques for studying the bioavailability and bioefficacy of dietary carotenoids, particularly β-carotene, in humans: a review. Am J Clin Nutr 77, 12-28.
Vulkova, Z., Chalukova, M., and Baralieva, D. 1997. The hybrid Lycopersicon esculentum x Lycopersicon pinpinellifolium f. Galapgos, source of high beta carotene and licopene content in the friuts. Reoprt of the Tomato Genet. Cooperative. 47, pp. 45.

Web References

MBKUniversity, 2014. Carotenoids and Macular Nutrients. (http://apps.ketchum.edu/ceonline/courseview.asp?selclassid=13&selID=113&selOrderID=5
Lutein and Lycopene Can Help Prevent Prostate Cancer (http://www.rejuvenation-science.com/n_antioxidants_prostate-cancer.html