Biologically active compounds in tomatoes from various fertilisation systems

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Abstract

The aim of this study was to investigate the effect of way of tomatoes cultivation on content of both health promoting and toxic components representing by carotenoids (lycopene, β-carotene), vitamin C and glycoalkaloids (α-tomatine, dehydrotomatine). The levels of biologically active compounds were shown to be strongly affected by the degree of maturity of fruit and varied among system with various fertilizers. Slurry, organic fertilizer with high fertilization efficiency, is good alternative to mineral fertilization. Lower content of toxic glycoalkaloids was found in tomatoes from organic and combined "low input" farming. The differences were variety depended in some extent.

Introduction

Higher quality standards, better taste and greater satisfaction represent consumers´ motives for the purchase of fruit and vegetables from organic or low input farming (Heaton, 2001). Generally, many plant crops are known for their richness in micronutrients and dietary fibre, thus their consumption has been distinctly recognized as being important factor for good health. It should be noted, however, that the influence of way of farming on the overall composition of organic crops as compared to conventional products has not been fully assessed until now (Williams, 2002; Worthington, 1998). This highlights how little we know about the impact of food on health, and the need for more and in particular better research (Brandt and Leifert, 2005).

Tomato (*Lycopersicon esculentum*), representing *Solanaceae* family, is one of the most popular vegetable crops. Alike many other plant commodities, tomato contains not only health promoting secondary metabolites but also natural toxins. The first group is represented by carotenoids, lycopene (10 -1000 mg/kg fresh weight) and β-carotene (up to 6 mg/kg), lycopene being one of the most important (Burri, 2002). The high intake of lycopene-containing vegetable is inversely associated with the incidence of certain types of cancer (Bramley, 2000). From natural toxins the dominating glycoalkaloid in tomatoes is α-tomatine, dehydrotomatine is only a minor component. At higher doses glycoalkaloids exhibit mainly two toxic actions in exposed mammals: membrane disruption activity affecting the digestive system and anticholinesterase activity on the central nervous system. Amount of glycoalkaloids in tomatoes depends on their size and ripeness. While the glycoalkaloids content in red tomatoes is in maximum 10 mg/kg in green ones their levels may be as high as 200 mg/kg (Friedman, 2002; ThemaNord599 1999).

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Presented project intends to study to what extent the cultivation conditions may influence the levels of health promoting as well as toxic secondary metabolites in selected food plants.

Materials and methods

Tomatoes were obtained from a green-house study performed in Czech University of Agriculture Prague in year 2005. Two different varieties of tomatoes were used for this experiment – variety Tornado (T) and Start (S) – hybrid F1. Plants were grown in containers (content 20 L) on peat-bark substrate. Number of plants in each experimental setup was 10. Red ripen tomatoes were used for all experiments. Variety Start from organic farming system was taken for analysis also 14 and 28 days before harvest (green and light-red tomatoes).

Four different fertilization regimes were employed in this experiment:

N - control farming (not fertilized with mineral and/or organic fertilizers)

O - organic farming (slurry in the amount 4 L were added into container, 2 L of slurry were added after 30 days of farming)

M - mineral farming (15 g of ammonium sulphate and 9 g of potash fertilizer were added into container, 7.5 g of ammonium sulphate were added after 30 days of farming)

C - combined farming (3 L of slurry, 7.5 g of ammonium sulphate and 4.5 g of potash fertilizer were added into container, 1.5 L of slurry and 3.75 g of ammonium sulphate were added after 30 days of farming)

Levels of carotenoids (β-carotene and lycopene) and vitamin C were analysed by HPLC method with diode array detection (DAD, 470 nm for carotenoids, and 251 nm for vitamin C), separation of sample components was curried out on analytical column LiChroCART, Lichrospher 100 RP-18. The limit of detection (LOD) was 1 mg/kg for lycopene, 0.05 mg/kg for β-carotene and 1 mg/kg for vitamin C.
The main tomato glycoalkaloids (α-tomatine and dehydrotomatine) were determined using LC/MS-MS (SRM mode) method. Analytical column HyPURITY AQUASTAR was used for separation. The limit of detection (LOD) was 0.01 mg/kg for α-tomatine and 0.02 mg/kg for dehydrotomatine.

Results and discussion

Vitamin C content ranged from 180 to 298 mg/kg, highest content was found in control samples (N), lowest in organic tomatoes (O) - Figure 1. Levels in ripe tomatoes depended on storage conditions.

Content of tomato glycoalkaloids α-tomatine (major tomato glycoalkaloid) and dehydrotomatine (minor one) ranged from 0.85 to 4.84 mg/kg and from <0.02 mg/kg to 0.24 mg/kg, respectively. The highest levels were found in tomatoes from mineral farming (M), lowest in organic tomatoes (O). Variety Start tended to contain slightly higher levels of these natural toxins (Figure 1).

Carotenoids content varied depending on the way of farming, variety and other parameters. Levels of β-carotene ranged from 5.4 to 9.8 mg/kg and levels of lycopene from 137 to 286 mg/kg. As shown in Figure 2, slightly higher content of lycopene was found in variety Tornado. No correlations between these two carotenoids levels were found.

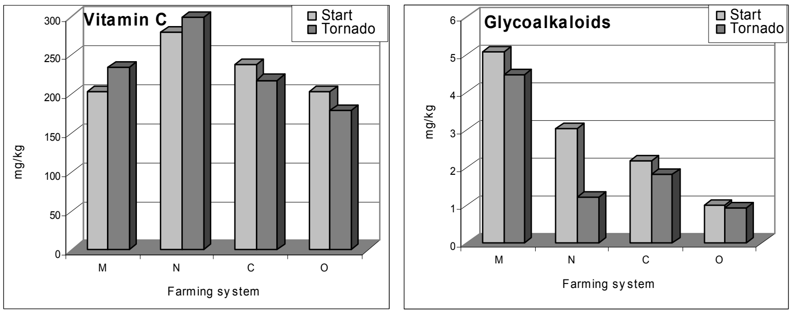

Figure 1: Content of vitamin C and glycoalkaloids (sum of α-tomatine and dehydrotomatine) in experimental tomatoes

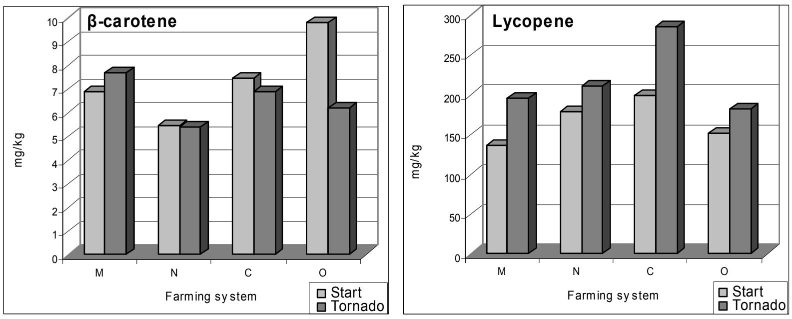

Figure 2: Content of carotenoids (β-carotene and lycopene) in experimental tomatoes

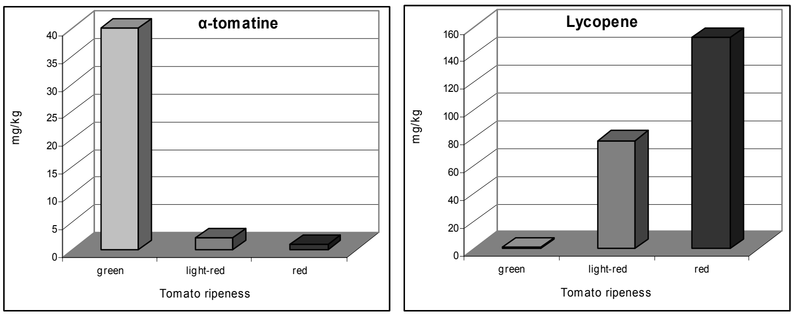

Figure 3: Content of α-tomatine and lycopene in tomatoes in different stages of maturity

Content of biologically active compounds in tomatoes is strongly influenced by degree of their maturity (see Figures 3). Rapid increase of major tomato carotenoids, lycopene and β-carotene, took place during ripening and, simultaneously, a significant decrease of glycoalkaloids, α-tomatine and dehydrotomatine, occurred. Lycopene content in ripen (red) tomatoes was 117 times higher as compared to green fruit, on the other hand α-tomatine levels in this unripe material were 43 time higher than in red fruits. Vitamin C content was highest in ripe tomatoes.

Conclusions

Based on experimental data, following conclusions can be drawn:

(i) Organic and "low input" combined farming resulted in lowest glycoalkaloids levels. Slightly higher levels of these natural toxins were determined in variety Start.

(ii) No relationships between the levels of biologically active compounds represented by vitamin C and carotenoids and the way of fertilization were observed, differences were found between the varieties. While Tornado was higher in lycopene, start contained slightly more β-carotene.

(iii) Considering the content of investigated health promoting and toxic biologically active secondary metabolites, slurry - organic fertilizer, was shown as good alternative to mineral fertilization.

(iv) Content of biologically active compounds in tomatoes was strongly influenced by their maturity, decrease of glycoalkaloids and increase of carotenoids occurs.

Further extensive, long-term investigations are necessary to obtain reliable information on the influence of farming system on the quality of products grown under various conditions. Described experiments are getting on also in year 2006, overall results will be evaluated.

Acknowledgments

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