Comparison of the Nutritive Quality of Tomato Fruits from Organic and Conventional Production in Poland

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Abstract

Organic horticulture is generally accepted as friendly to the environment, good for crop quality and also for the consumer's health. Recent research data has shown that organic crops under organic farming practices contained more bioactive substances such as flavones, vitamin C, carotenoids; they also contain less pesticides residues, nitrates and nitrites. Five tomato cultivars: four large – fruit (Rumba, Juhas, Kmicic, Gigant) and one cherry cultivar (Koralik) were selected for study. The organic tomato fruits contained more dry matter, total and reducing sugars, vitamin C, total flavones and beta-carotene, but less lycopene in comparison to conventionally grown tomatoes.

Introduction

Organic plants products are recognized by some consumers as safer and better in taste than conventional ones. Unfortunately organic cultivation has a markedly negative effect on the yield (Hamouz et al. 2005); moreover, organic fruits show more visible defects in comparison to conventional ones. This can make them less attractive for the consumers (Conclin and Tomson 1993).

Considerable research has shown that organic plants contain more bioactive substances such as antioxidants. Toor et al. (2006) reported that the mean total phenolic and ascorbic acid content of tomatoes grown organically was higher than the tomatoes grown using mineral fertilization. However knowledge about the nutritive value and antioxidant status of organic crops is still incomplete. There is very limited information about the content of carotenoids (lycopene, alpha- and beta-carotene, lutein) and their interrelationship with vitamins (other than vitamin C) and secondary plants metabolites such as polyphenols (flavonoids, anthocyanins), which are of great health importance. Plants flavonoids, and especially these belonging the flavones group (quercitine, kaempferol and mercitine) have been reported to prevent some kinds of cancer. The consumption of raw fruit and vegetables has a protective effect in humans for some forms of cancer, especially when plants contain flavonoids together with vitamin C, β – carotene and lycopene (Crozier et al. 1997). Lycopene is a pigment mainly responsible for a distinctive red color of ripe tomato (Riso et al. 1999, Shi 2000). The amount of this carotenoid in raw tomatoes depends on the variety, stage of maturity and

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the environmental conditions during cultivation (Shi 2000). There is good epidemiological data on the relationship between risk of cancer and dietary intake of tomato fruits and products. Giovanucci et al. (1995) found that an intake of lycopene was correlated with a diminished risk of prostate cancer. Nagasawa et al. (1995) showed that a prolonged dietary intake of lycopene had a preventative effect of breast tumour growth. The potent singlet oxygen quenching ability of lycopene is twice a high as that β-carotene and 10 times higher than that of α-tocopherol. Among the different tomato cultivars, cherry tomatoes (*Lycopersicon esculentum* var. *cerasiforme*) are well known, for their good taste and flavour, and although the yield of cherry tomato is only half that compared to standard large tomatoes, it is worth cultivating this new variety, especially in organic systems, due to their higher nutrient value (Hobson and Kilby 1985, Hallmann, 2003).

Materials and Methods

Five tomato cultivars: four large – fruit (Rumba, Juhas, Kmicic, Gigant) and one cherry cultivar (Koralik) were selected for study. Tomatoes were cultivated in certified organic and conventional farms in the Mazovia region of Poland. At this stage of study, only one of the pairs of the farms (organic – conventional) has been used as it was the Pilot Study. The next stage will involve an increased number of the farms. The organic farm was separated from the conventional farm by a distance of 60 km. The geographical situation of organic farm was 51°42' N and 20°44' E. The tomato plants were cultivated in a light loamy, sandy soil. In the organic system, all recommended standards for fertilization, plant protection and rotation were applied. The fertilizers used were horse manure (applied at 30 t/ha) and compost (applied at 30 t/ha). For plant protection we used the biological insecticide Biobit 3.2 WP, the biofungicide Biosept 33 SL and the pesticide Miedzian 50 WP, which are permitted for use in organic farming. In the crop rotation, legume plants and white mustard were used as compost for fertilization. The geographical situation of conventional farm was 52°09'N and 21°03'E with a heavy clay soil. In the conventional cultivation, the mineral fertilizers used were ammonium phosphate (applied at a rate of 350 kg/ha), ammonium nitrate (applied at a rate of 200 kg/ha), potassium sulphate (applied at a rate of 450 kg/ha), lime (applied at a rate of 1100 kg/ha). The chemical plant protection products we used were fungicides Bravo 500 SC and Amistar 250 S.C. Samples of fully ripe tomatoes were harvested in the same week of fruiting for chemical analysis. Dry matter content was determined by the scale method described in PN-90/A-75101/03, total and reducing sugars content by the Luff – Shoorl's method described in PN-90 A-75101/07, total acidity content as titratable acidity (PN-90 A-75101/04), vitamin C content by Tillman's method (PN-90 A - 75101/11), carotenoids (lycopene and beta-carotene) have been determined by liquid column chromatography method. For carotenoid analysis, the whole tomato fruits (peel and flesh) were used according to the method described by Saniawski and Czapski (1983). Flavonoid content was determined by Christ – Müller's method, described by Strzelecka, et al. (1978). This experiment did not compare tomato yield, only quality parameters. All analyses were replicated six times and the results were statistically calculated using Statgraphics 5.1 program, specifically Tukey's test at $\alpha = 0.05$.

Results

The results of all the chemical analyses are presented in a Table 1. The results showed a statistically significant difference in the content of dry matter in tomato fruits (table 1).

Tab. 1. Chemical composition of organic and conventional tomatoes

	cultivar	dry matter	total sugars	reducing sugars	total acidity
organic	Rumba	6.17 ± 0.78	8.54 ± 0.14	5.76 ± 0.34	0.45 ± 0.00
	Juhas	6.43 ± 0.31	8.26 ± 0.00	5.52 ± 0.34	0.61 ± 0.01
	Kmicic	5.97 ± 0.14	7.97 ± 0.27	6.36 ± 0.17	0.50 ± 0.02
	Gigant	7.64 ± 0.58	8.35 ± 0.14	8.04 ± 0.51	0.42 ± 0.02
	Koralik	13.09 ± 6.96	9.94 ± 0.20	9.48 ± 0.17	0.78 ± 0.04
mean		**7.86**	**8.61**	**7.03**	**0.55**
conventional	Rumba	4.85 ± 0.78	3.17 ± 0.00	2.40 ± 0.34	0.45 ± 0.00
	Juhas	4.96 ± 0.07	3.22 ± 0.34	3.00 ± 0.85	0.47 ± 0.00
	Kmicic	5.12 ± 0.05	3.72 ± 0.14	2.04 ± 0.85	0.55 ± 0.02
	Gigant	5.00 ± 0.12	4.37 ± 0.34	1.08 ± 0.03	0.49 ± 0.01
	Koralik	5.42 ± 4.23	9.41 ± 0.27	6.00 ± 0.34	0.86 ± 0.02
mean		**5.07**	**4.78**	**2.90**	**0.56**
$HSD_{/0.05/\ method}$		2.55	1.03	0.44	0.01
$HSD_{/0.05/\ culltivar}$		1.45	2.38	1.02	0.08
$HSD_{/0.05/\ method\ x\ cultivar.}$		2.60	0.22	0.47	0.02

Organic tomatoes contained on average 7.86 g·100 g^{-1}f.m, and conventional 5.07 g·100 g^{-1}f.m. of dry matter in fruits. From among the cultivars, cherry tomato contained the highest level of dry matter in comparison to the other varieties tested.

Organic tomato fruits contained twice the amount of total sugars in comparison to the conventional tomatoes. In particular cherry tomatoes from organic cultivation contained more total sugars in comparison to other cultivars examined (table 1). The organic tomatoes also contained higher levels of reducing sugars whereas the conventional tomatoes had higher total acidity in comparison to those cultivated organically, but this difference was very small. The cherry tomatoes had higher total acidity in comparison to other examined cultivars, apart from the used cultivation system (table 1) and contained higher level of vitamin C (fig.1). It was also found that the cherry

cultivar Koralik contained more vitamin C in fruits in comparison to all the tomato cultivars examined under both farming systems.
The analyses also showed that the lycopene content in organic tomatoes was lower in comparison to conventional ones (Figure 2).

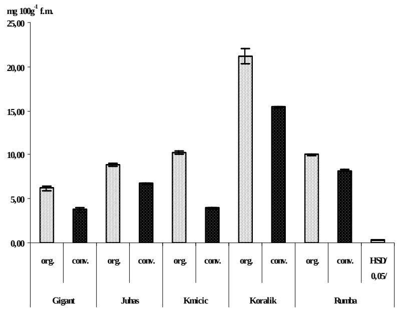

Figure.1 Vitamin C content in tomato fruits from organic and conventional cultivation

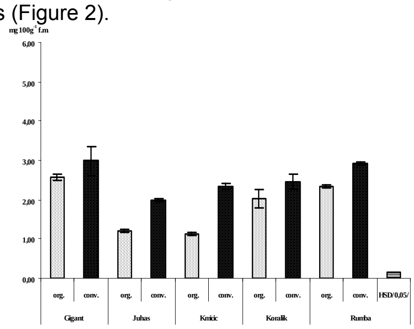

Figure.2 Lycopene content in tomato fruits from organic and conventional cultivation

The large fruit tomato Gigant had the highest level of lycopene among all the other cultivars. Tomatoes under organic cultivation contained more β- carotene in comparison to those grown under conventional management. These differences were statistically significant (Figure 3). Furthermore organic tomatoes contained more flavonoids than conventional ones (Figure 4).

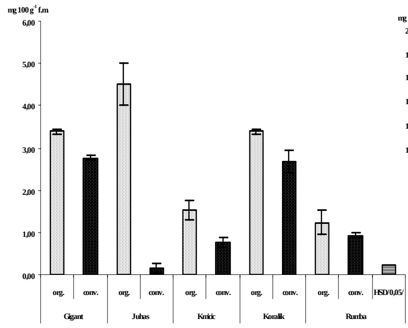

Figure. 3 β-carotene content in tomato fruits from organic and conventional cultivation

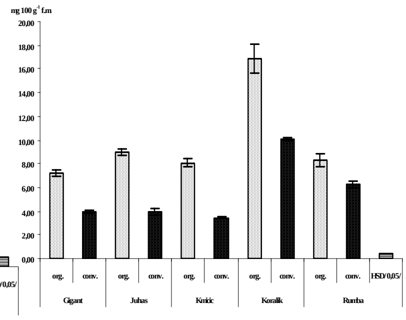

Figure. 4 Quercitine content in tomato fruits from organic and conventional cultivation

Overall cherry tomatoes contained twice the amount of flavonoids than the large tomato cultivars, irrespective of the cultivation system.

Discussion

There are only a few research studies comparing the nutritional value of organic and conventional tomatoes. Pither and Hall (1990) found a higher

content of vitamin C, vitamin A and potassium in organic tomatoes. In Sweden, Lundegårdh et al. (2000) carried out an experiment over three years on the effect of cultivation methods on tomato quality. The results showed that organically produced tomatoes contained a higher level of vitamin C, lycopene and chlorine than conventionally cultivated ones. Furthermore, Toor et al. (2006) found higher levels of vitamin C in organically produced tomatoes. In this paper a clearly higher content of flavonoids and β-carotene has been found in organic tomatoes. These results are similar to those previously presented by the author (Rembialkowska et al. 2003), and to the results of Toor et al. (2006) who found a slightly higher content of the phenols, and a significantly higher total soluble antioxidant activity in organically cultivated tomatoes compared to conventionally grown tomatoes.
As described above, there is evidence that some organic vegetables, in this case tomatoes, contain more antioxidants than conventional ones. Both the research data presented here and the cited results appear to confirm the above theories. But not everything is clear. Heeb (2005) in her Doctoral thesis found different levels of the nutritional compounds she investigated in every year of her studies on tomatoes. Heeb concluded that organic production methods by definition did not guarantee a higher quality product. In order to obtain uniform higher quality standards it is necessary to understand the processes influencing the chemical composition of vegetables - in this case tomatoes. The factors influencing tomato quality are complex and interrelated, and additional studies are necessary to consolidate the knowledge about the real interdependences.

Conclusions

In our study, organic tomatoes contained more dry matter, total and reducing sugars, vitamin C, β-carotene and flavonoids in comparison to the conventional ones. Conventional tomatoes were richer in lycopene and organic acids. The cherry cultivar Koralik contained significantly more nutrients than the other tomato cultivars. In most respects the results obtained support the GDBH theory as the organic production system, with its lower nitrogen availability in soil, appears to have an impact on the levels of several bioactive compounds in tomato fruit. Organic cherry and standard tomatoes can be recommended as part of a healthy diet including plant products which have been shown to be of value in cancer prevention.

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