Indian Journal of Agricultural Sciences **83** (6): 651–5, June 2013/Article

Micronutrient composition and quality characteristics of tomato (*Lycopersicon esculentum*) from conventional and organic production

Z S ILIC[1], N KAPOULAS[2] and L MILENKOVIC[3]

Faculty of Agriculture, Priština-Lešak, Lešak 38219, Serbia

Revised: 9 September 2012; Revised accepted: 4 March 2013

ABSTRACT

Three tomato (*Lycopersicon esculentum* Mill) varieties (Robin-F_1, Amati-F_1 and Elpida-F_1) were grown in the greenhouse condition (Northeastern Greece) using organic and conventional cultivation methods. The objective of this study was to investigate whether there were any differences in the micronutrient contents of lycopene, carotenoids, citric acids content and mineral content (K, Ca, Na, Mg, Fe, Zn, Mn, Cu) in organic and conventional tomatoes. Tomato fruit from conventional greenhouse production contained on average higher levels of total soluble solid (TSS) and lycopene, whereas tomatoes grown organically contained on average more carotenoids. We found significantly greater concentrations of P, K, Ca and Mg in organic tomatoes but in conventionally grown tomato we found greater content of Zn, Fe and Cu. This study confirms that the most important variable in the micronutrient content of tomatoes is cultivar. Elpida cultivar had the highest content of TSS (5.08 %), lycopene (3.75 mg/100g f.w.) and citric acid (0.48%) of the three different varieties grown under same conditions. Also, the taste index in organic Elpida (1.10) was much more pleasant because the ratio of total soluble solid and total acid more favourable than the tomatoes from conventional production.

Key words: Tomato, Production, Organic, Conventional, Micronutrients, Quality

Increased interest in organic tomato production imposed the need to evaluate the quality and nutritional value of organic tomato. The absence of proven differences in nutritional properties between organic and conventional products may be attributed at least in part to methodological issues. Valid comparison of nutritional quality would, for example, require that the same cultivars are grown at the same location, in the same soil and with the same amounts of nutrients.

Kelly and Bateman (2010) found significantly greater concentrations of minerals in organic tomatoes. Borguini and Torres (2006) and Toor *et al.* (2006) showed that tomatoes coming from organic cultivation procedures presented higher vitamin C content than the fruit by conventional cultivation. Heeb (2005) concluded that organic production methods by definition did not guarantee a higher quality product. Research results on the effects of organic and conventional production on fruit quality are sometimes contradictory. In terms of quality, some studies report better taste, higher vitamin C contents and higher levels of other quality related compounds for organically grown products (Caris-Veyrat *et al.* 2004), whereas several other studies have found the opposite or no differences in quality characteristics between organically and conventionally grown vegetables (Kapoulas *et al.* 2011). The factors influencing tomato quality are complex and interrelated, and additional studies are necessary to consolidate the knowledge about the real interdependences. The aims of this paper were to determine the content of several major chemical compounds in different tomato cultivars which contribute to the nutritive quality of the tomato and to evaluate the change of the chemical composition according to the cultivation method.

MATERIALS AND METHODS

Three tomato varieties (Robin F_1, Amati F_1 and Elpida F_1) have been tested in greenhouse production (plastic tunnels 3.5m high, covered with termolux 180 µm) during 2008-2010, located in the Sapes, Northeastern Greece, using two different growing systems: organic and conventional. Greenhouse technology and horticultural practices differ little. The main variations concerned pest control, fertilization and fertility of soil, which was of much better quality in the organic production. In conventional cultivation mineral

[1]Full Professor (e mail: zoran.ilic63@gmail.com), [3]Assistant Professor (e mail: lidijamilenkovic@gmail.com); [2]Project Manager (e mail: nikos.kapoulas@gmail.com), Regional Develop Agency of Rodopi, Komotini 69100, Greece

Table 1 Chemical analysis of soil in conventional and organic production

Production system	Soil depth (cm)	pH		$CaCO_3$ (%)	Humus (%)	N total (%)	P_2O_5 (%)	K_2O (%)
		KCl	H_2O					
Conventional	0-20	6.46	7.70	2.10	1.28	0.08	25.20	15.68
	20-40	5.89	6.87	3.36	1.38	0.09	15.79	26.99
	40-60	5.42	6.50	2.52	0.95	0.06	7.89	26.54
Organic	0-20	6.00	6.46	2.94	6.73	0.44	179.35	37.36
	20-40	5.99	6.62	2.10	1.96	0.13	51.62	62.21
	40-60	5.72	6.71	3.36	1.39	0.09	22.04	37.81

fertilizers and chemical plant protection were applied.

The differences between production systems were the fertilizers used (organic: goat manure 3 tonnes/ha; conventional: mineral fertilizer NPK (12:12:17), nitrophos blue special + 2MgO +8S +Trace elements – 400 kg/ha), the number of phytosanitary (solarization) treatments (larger in organic system), the pesticide types applied (preventive in the organic systems and preventive or healing with variable period of effectiveness in the conventional one). It was an early-medium production; planting was done between 15 April and 20 April at a density of 2.64 plants/m^2 (Table 1).

At the pink stage of ripening determined by visual inspection, samples were collected for quality analyses (colour, firmness, total soluble solids, total sugar, total acidity content of vitamin C, content of carotenoids and lycopene). For sensory evaluation fruits were evaluated by trained descriptive panelists on the day of harvest (red stage). Tomato samples (20 fruits) were collected each year from June till August and were taken from the third to sixth floral branches. All analyses were carried out in the Technological Faculty of Novi Sad and the Analytical Laboratory of Biolab Epirus (Tzimas S. Bioepirus Ltd), Ioannina – Greece. Determination of total soluble solids (TSS) was carried out by a refractometer. The results were reported as ^{o}Brix at 20 ^{o}C. The titrable acidity (TA) was measured with 5 ml aliquots of juice that were titrated at pH 8.1 with 0.1 N NaOH (required to neutralize the acids of tomatoes in phenolphthalein presence) and the results were expressed as citric acid percentages.

Pigment extraction from tomato fruits, preparation of extracts for analysis and calibration plots of standard components was determined according to method by Cvetkovic and Markovic (2008).

Approximately 0.5 g of freeze-dried sample was weighed into porcelain crucibles that had previously been heated for 3 hr at 550^{o} C and was converted to white ash at this same temperature over 12–18 hr. Each ashed sample was dissolved in 20 mL of 3 m HCl, and K, Ca, Na, Mg, Fe, Zn, Mn and Cu were determined by atomic absorption spectrophotometry.

Besides, a taste index and the maturity were calculated using the equation proposed by Navez *et al.* (1999) and Nielsen (2003) starting from the Brix degree and acidity values which were determined in a previous paper (Hernandez *et al.* 2007).

$$\text{Taste index} = \frac{\text{Brix degree}}{20 \times \text{Acidity}} + \text{Acidity}$$

$$\text{Maturity} = \frac{\text{Brix degree}}{\text{Acidity}}$$

All chemicals and reagents were of analytical grade and were purchased from Sigma Chemical Co. (St Louis, MQ, USA), Aldrich Chemical Co. (Steinheim, Germany) and Alfa Aesar (Karlsruhe, Germany).

All statistical analyses were performed using SAS procedure (SAS Institute, Cary, NC) for analyses of variance. Means were compared by Tukey's multiple range test.

RESULTS AND DISCUSSION

Red colour is initiated by lycopene, which is the most abundant carotenoid in ripe tomatoes and constitute up to 90% of the total carotenoids present. The results showed that the lycopene content in organic tomatoes was higher than in conventional tomatoes. The average content of this pigment in the organic fruit was 2.92 mg/100 g f.w., while for conventional tomatoes it was 2.84 mg/100 g f.w. (Fig 1). Different tomato cultivars obtained different lycopene levels. Elpida in organic production contained more lycopene in fruit than the other two cultivars (3.75 mg/100 g f.w.). Lycopene content changes significantly during maturation and accumulates mainly in the deep red stage (Helyes *et al.* 2006). Differences in sunlight and temperature between the years might be a cause for the contradictory observations. Tomatoes from organic cultivation contained more carotenoids compared to conventional cultivation. The cultivar Amati contained the lowest level of carotenoids in fruit in both cultivation systems. These differences were statistically significant (P=005). Organically grown Robin produced the highest level of carotenoids in fruit (4.03 mg/100g) comparing to the other two cultivars (Fig 2.). Studies on carotene and lycopene contents in organic tomatoes, have reported different results including higher levels (Caris-Veyrat *et al.* 2004) or lower levels (Rossi *et al.* 2008) compared with conventional methods. No consistent effect of the farming system on the content of bioactive antioxidant compounds (Juroszek *et al.* 2009, Kapoulas *et al.* 2011) were also reported.

Growing method and cultivar had significant influence on K, Ca, Na or Mg contents (Table 2). The main factor

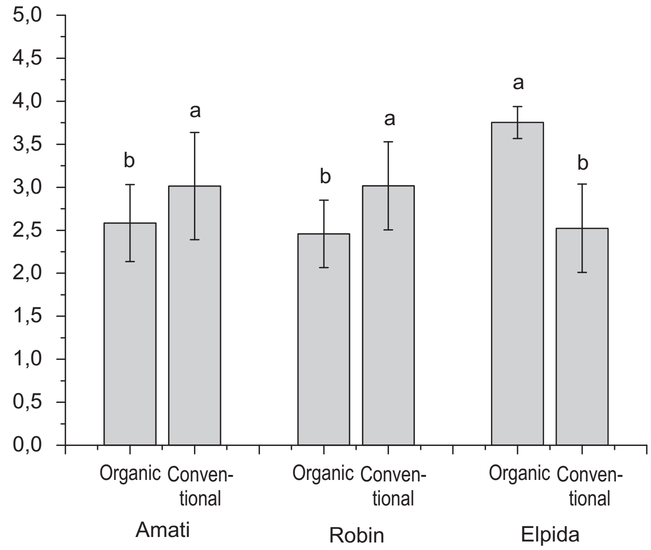

Fig 1 Lycopene content (mg/100 g f.w.) in organic and conventional tomato cultivars

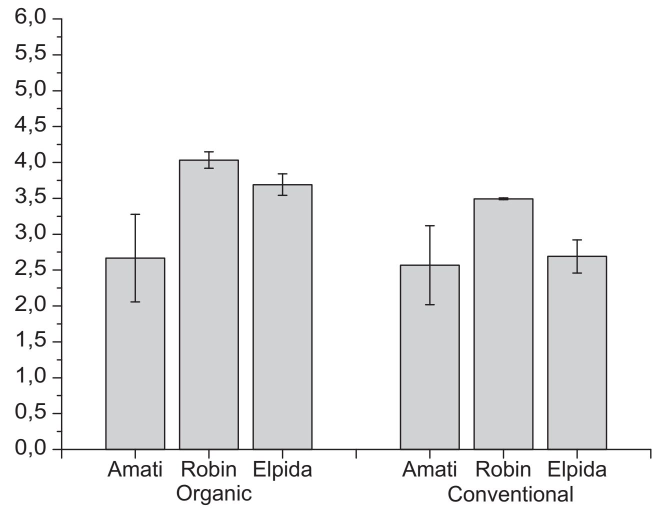

Fig 2 Carotenoid content (mg/100 g f.w.) in organic and conventional tomato cultivars

influencing tomato micronutrient content was cultivar (Ordonez-Santos *et al.* 2011). Our results showed that the potassium content in organic tomatoes (153.05-164.31 mg/100g) was higher than in conventional tomatoes (126.79-142.54 mg/100g). Organically grown Elpida produced the highest level of potassium in fruit (164.31 mg/100 g) comparing to the other two cultivars. Potassium concentrations were similar to those (191.42–236.54 mg 100/g) reported by Hernandez Suarez *et al.* (2007).

Our results showed that the calcium content in organic tomato (8.08-9.00 mg/100g) was higher than in conventional tomatoes (7.84-8.58 mg/100g). Calcium concentrations reported by Ordonez-Santos *et al.* (2011) were higher (15.97–23.13 mg/100g) than those found in our studies. Kelly and Bateman (2010) found significantly greater concentrations of Ca and Mg in organic tomatoes. Magnesium concentrations in organic (17.36-22.22 mg/100g) and conventional tomato (18.75-19.16 mg/100g) were higher than those found by Ordonez-Santos *et al.* (2011) (10.30–11.88 mg/100g), Loiudi Gundersen *et al.* (2001), but similar to those of Hernandez Suarez *et al.* (2007).

The ranges of measured iron concentration in this study 0.51-0.64 in organic and 0.69-0.72 mg 100/g in conventional tomato respectively. Iron concentration reported by Ordonez-Santos *et al.* (2011) were higher 0.54–1.37 mg/100g. We observed no significant influence of growing method, which in the case of iron is in keeping with the findings of Rodrýguez *et al.* (2001). On the contrary, Kelly and Bateman (2010) found significantly greater concentrations of these minerals in organic tomatoes.

Copper concentration (0.11-0.13 mg/100g) in conventional tomatoes was higher than in organic tomato (0.5-0.7 mg/100g). The ranges of measured copper concentrations (0.05–0.11 mg/100g) in study by Ordonez-Santos *et al.* (2011), were higher than those reported by Gundersen *et al.* (2001) and Hernandez Suarez *et al.* (2007).

There were no significant differences in zinc concentrations between organic (0.16-0-18 mg 100/g) and conventional tomatoes (0.18-0.19 mg/100g). Zinc concentrations (0.14–0.33 mg/100 g) reported by Ordonez-

Table 2 Mineral contents of conventionally and organically grown Elpida, Robin and Amati tomatoes

	Moisture (%)	Total N	P	K	Ca	Mg	B	Mn	Zn	Fe	Cu
					(mg/100g fresh weight)						
					Conventional production						
Elpida	93.19	191.80	33.74	126.79	7.84	18.75	0.02	0.08	0.19	0.69	0.11
Robin	94.28	214.32	29.18	137.59	8.58	19.16	0.03	0.09	0.18	0.73	0.10
Amati	93.62	223.41	27.10	142.54	8.29	18.81	0.03	0.08	0.19	0.82	0.13
					Organic production						
Elpida	93.27	218.77	43.43	164.31	8.08	22.22	0.03	0.08	0.17	0.64	0.07
Robin	92.86	248.73	46.75	159.17	8.92	22.13	0.03	0.08	0.16	0.59	0.05
Amati	93.57	193.02	45.34	153.05	9.00	17.36	0.03	0.07	0.18	0.51	0.05

Table 3 Total acidity and TSS (total soluble solid) content of three tomato cultivars from organic and conventional production system

	Organic production		Conventional production	
	Total acidity (%)	TSS (Brix°)	Total acidity (%)	TSS (Brix°)
Amati	0.41± 0.01c	4.83± 0.4b	0.48± 0.02 a	4.95± 0.5a
Robin	0.44± 0.01b	4.76± 0.5b	0.47± 0.02a	4.85± 0.6a
Elpida	0.47± 0.01a	5.08± 0.5a	0.48± 0.01a	4.59± 0.5b

Santos *et al.* (2011) were higher than those reported by Gundersen *et al*. (2001) and Hernandez Suarez *et al.* (2007). Like Rodrýguez *et al.* (2001), we found growing method to have no influence on zinc content. On the contrary, Kelly and Bateman (2010) found significantly greater concentrations of Zn in organic tomatoes.

There were insignificant differences of manganese content between conventional (0.08-0.09 mg/100g) and organic tomato (0.07-0.08 mg/100g). Manganese concentrations (0.05–0.13 mg/100g) found by Ordonez-Santos *et al*. (2011) were similar to those reported by Gundersen *et al.* (2001) and lower than those measured by Hernandez Suarez *et al.* (2007) and were significantly influenced by both cultivar and growing method. Rodrýguez *et al.* (2001) found Mn levels to be unaffected by growing method. Like Rodriguez *et al.* (2001), we found growing method to have no influence on zinc content (Table 2); on the contrary, Kelly and Bateman (2010) found significantly greater concentrations of Zn in conventional tomatoes. On the other hand, in the present study, one possible hypothesis that may explain the insignificant differences in the majority of the minerals could be that the tomato plants of the two cultivation methods managed to have similar soil conditions and irrigation. Previous studies support such a claim. Hernandez Suarez *et al.* (2007) report significant differences in the concentration of Na, Ca, Mg and Zn in tomato grown in two different production regions of the island of Tenerife (Spain). Some mineral contents in the tomato fruit must be influenced by the region of production, which is mainly influenced by the mineral contents of the cropping soils and of the water for irrigation (Hernandez Suarez *et al.* 2007).

Greenhouse vegetable production offers advantages compared to production at the open field with regard to quality assurance principally, because the plants are not exposed directly to the rapid changes of climate conditions. An important role for this purpose is also the cultivar selection by using tomato hybrid varieties with a high yield potential and a good fruit quality. The results of the chemical analysis are presented in Table 3. Organic tomatoes contained on average at all cultivars 4.73°B and at conventional 4.79 of TSS-total soluble solids in fruit. Results obtained showed that the accumulation of TSS (total soluble solid) at different organic and conventional (in average at all cultivars) cultivation system did not show any statistically significant difference. Elpida tomato fruit in organic production system contained the highest level of TSS. Irrespective of the cultivation method used, Elpida in average also contained the highest level of TSS (5.08°Brix) in comparison to the rest of examined tomato cultivars. In relation to product quality, Borret *et al.* (2007) reported on higher content of total soluble solids (TSS), higher titrable acidity and firmness in organic tomatoes when compared with conventional ones.

The organic acid in a tomato fruit consist of mainly citric and malic acid with a range of 0.3 to 0.6%. The obtained results showed that conventional tomatoes contained more organic acids in comparison to those cultivated by organic methods, in all periods of analysis, being approximately about 0.48%. At the same time, it should be noted that Elpida tomatoes were richer in organic acids in comparison to other examined cultivars, independently from the used cultivation system (Table 3). As with the sugars, the organic acids are crucial to the flavour of the fruits. The average contents Brix degree and acidity were 4.6 and 0.50 g/100 g of citric acid, respectively (Hernandez *et al.* 2008). The taste index is calculated using the values of Brix degree and acidity, applying the equation performed by Navez *et al.* (1999). The Elpida cultivar from organic production system had a mean value (1.1) of the taste index higher ($P < 0.05$) than those values determined for the organic Robin (0.98) and Amati (1.0) cultivars (Table 4). No significant differences were found between the cultivars in the mean taste index obtained for conventional cultivated tomatoes. When using these data, the mean values of the taste index in all the tomatoes belonging to all the cultivars considered were higher than 0.85, which indicates that the tomato cultivars analyzed are tasty. If the value of the taste index is lower than 0.7, the tomato is considered as having little taste (Navez *et al.* 1999).

Another parameter related with the taste index is maturity index which is usually a better predictor of an acid's flavour impact than Brix degree or acidity alone. Acidity tends to decrease with the maturity of the fruits while the sugar content increases.

Table 4 Index of maturity and taste index in fruit of three tomato cultivars from organic and conventional production system

	Amati F1		Robin F1		Elpida F1	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Index of maturity	11.7a	10.3b	10.8b	10.3b	10.8b	9.6b
Taste index	1.00b	1.00b	0.98b	0.98b	1.10a	0.96b

We found significantly greater maturity index in organic Amati fruit (11.7) and significantly lower maturity index in conventional Elpida fruit (9.6) obtained for conventional and organically cultivated tomatoes. Maturity index in our study (in all cultivars in both production system) were higher than those found by maturity index reported by Hernandez *et al.* (2007) was 9.4 and therefore, it can be deduced that the maturity levels of the analyzed tomatoes were adequate for consumption. This ratio can also be affected by climate, cultivar and horticultural practices (Nielsen 2003). There are many factors such as cultivar, cultivation method and region of cultivation that influence the chemical composition of tomatoes. The cultivar is a more influential factor than cultivation methods in the differentiation of the tomato samples according to the chemical characteristics. Elpida from organic production had greater concentration of carotenoid and K, Ca, Mg, B content and the best taste index.

ACKNOWLEDGEMENTS

This study is part of the TR-31027 project entitled "Organic agriculture -Improvement of production using fertilizers, bio-products and biological methods" financially supported by the Ministry of Science and Technological Development, Republic of Serbia.

REFERENCES

Barrett D M, Weakley C, Diaz J V and Watnik M. 2007. Qualitative and nutritional differences in processing tomatoes grown under commercial organic and conventional production systems. *Journal of Food Science* **72:** C441451.

Borguini R G and Torres E A F S. 2006. Organic food: nutritional quality and food safety. *Seguranc¸ a Alimentar e Nutricional* **13**: 64–75.

Caris-Veyrat C, Amiot M J, Tyssandier V, Grasselly D, Buret M, Mikoljozak M, Guilland J C, Bouteloup-Demange C and Borel P. 2004. Influence of organic versus conventional agricultural practice on the antioxidant microconstituent content of tomatoes and derived purees; consequences on antioxidant plasma status in humans. *Journal of Agricultural and Food Chemistry* **52**: 6 503–9.

Cvetkovic D and Markovic D. 2008. UV-induced changes in antioxidant capacities of selected carotenoids toward lecithin in aqueous solution. *Radiation Physics and Chemistry* **77**: 34–41.

Heeb A. 2005. 'Organic or mineral fertilization effects on tomato plant growth and fruit quality'. Doctoral thesis, Faculty of Natural Resources and Agricultural Sciences. Swedish University of Agricultural Sciences. Uppsala

Hernandez Suarez M, Rodrýguez Rodrýguez E M and Dýaz Romero C. 2007. Mineral and trace element concentrations in cultivars of tomatoes. *Food Chemistry* **104**: 489-99.

Hernández Suárez M, Rodríguez Rodríguez E M and Díaz Romero C. 2008. Chemical composition of tomato (*Lycopersicon esculentum*) from Tenerife, the Canary Islands. *Food Chemistry* **106**: 1 046–56.

Helyes L, Dimény J, Pék Z and Lugasi A. 2006. Effect of maturity stage on content, color and quality of tomato (*Lycopersicon lycopersicum* (L.) Karsten) fruit. *Inernational Journal of Horticultural Science* **12**: 41–4.

Juroszek P, Lumpkin H M, Yan R, Ledesma D R and Ma C. 2009. Fruit quality and bioactive compounds with antioxidant activity of tomatoes grown on-farm: comparison of organic and conventional management systems. *Journal of Agricultural and Food Chemistry* **57**: 1 188–94.

Kapoulas N, Ilic S Z, Trajkovic R, Milenkovic L and Đurovka M. 2011. Effect of organic and conventional growing systems on nutritional value and antioxidant activity of tomatoes. *African Journal of Biotechnology* **10** (71): 15 938–45.

Kelly S D and Bateman A S. 2010. Comparison of mineral concentrations in commercially grown organic and conventional crops – tomatoes (*Lycopersicon esculentum*) and lettuces (*Lactuca sativa*). *Food Chemistry* **119**: 738–45.

Navez B, Letard M, Graselly D and Jost M. 1999. Les criteres de qualite de la tomate. *Infos-Ctifl*, **155**: 41–7.

Nielsen S. 2003. *Food Analysis*, 3rd Ed. Kluwer Academic, New York.

Ordonez-Santos L E, Vazquez-Oderiz M L and Romero-Rodrýguez M A. 2011. Micronutrient contents in organic and conventional tomatoes (*Solanum lycopersicum L.). International Journal of Food Science and Technology* **46**: 1 561–8.

Rodrýguez A, Ballesteros A, Ciruelos A, Barreiros J M and Latorre A. 2001. Sensory evaluation of fresh tomato from conventional, integrated, and organic production. *Acta Horticulturae* **542**: 277– 82.

Rossi F, Godani F, Bertuzzi T, Trevisan M, Ferrari F and Gatti S. 2008. Health-promoting substances and heavy metal content in tomatoes grown with different farming techniques. *European Journal of Nutrition* **47**: 266–72.

Toor R K, Savage G P and Heeb A. 2006. Influence of different types of fertilisers on the major antioxidant components of tomatoes. *Journal of Food Composition and Analysis* **19**: 20–7.