African Journal of Biotechnology Vol. 9(46), pp. 7909-7914, 15 November, 2010
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.830
ISSN 1684–5315 © 2010 Academic Journals

Full Length Research Paper

Organic and conventional production systems, microbial fertilization and plant activators affect tomato quality during storage

Husnu Unlu[1]*, Halime Ozdamar Unlu[1], Yasar Karakurt[1] and Huseyin Padem[2]

[1]Horticultural Sciences Department, Agricultural Faculty, Suleyman Demirel University, Isparta, Turkey.
[2]International Burch University, Francuske revolucije bb. Ilidza, Bosnia and Herzegovina.

Accepted 12 October, 2010

A common belief among consumers is the superior quality of organically grown tomato fruits over their conventionally grown counterparts. The present study was performed to evaluate the quality characteristics of tomatoes grown using organic and conventional production systems and to determine the effects of microbial fertilization and plant activators on the tomato fruit quality during storage. Results indicated that firmness, soluble solids, color L and H* values decreased significantly in all treatments during storage. However, total soluble and reducing sugars and color C* value significantly increased in both organically and conventionally grown fruit during storage. Application of plant activator and microbial fertilizer and their combination significantly affected the trend of changes in quality parameters but these effects were cultivar dependent rather than growing system. The data suggest that organically produced fruit maintain their quality during storage for a period comparable to that of conventionally grown fruit. Although certain quality parameters remain higher either in organically or in conventionally grown fruit during storage, these effects seem to be cultivar dependent.

Key words: Microbial fertilization, organic production, plant activator, quality, storage.

INTRODUCTION

Consumers generally choose organically produced fruits since it is believed that these fruits are healthier, have higher nutritional value and better quality than conventionally grown fruit. It is also believed that organic production enhances overall soil health, agricultural sustainability and environmental quality. Therefore, alternative production systems including organic systems are being investigated as choices to enhance the use of a more sustainable and environmentally friendly cultivation method. However, previous research results remain inconclusive (Zhao et al., 2007).

Tomato fruits are grown both conventionally and organically. Several studies compared organically- and conventionally-grown tomatoes in terms of yield and nutritional quality. However, all have reported inconsistent differences between organically and conventionally grown fruit. One of the studies reporting the effects of different types of fertilizers on the antioxidant components of tomato, demonstrated that the mean plant shoot biomass was significantly higher in plants grown with mineral nutrients (Toor et al., 2006), but total phenolics and ascorbic acid content of organically grown tomatoes was significantly higher. Additionally, the authors reported no significant differences for yield, dry matter content or soluble solids between mineral and organically grown plants. On the other hand, they suggested that organic fertilization can significantly enhance tomato fruit taste by increasing the titratable acidity of the fruits. In contrast to these findings, Zhao et al. (2007) showed that the conventionally produced tomato was rated as having significantly stronger flavor than the organically produced tomato but the overall liking was the same for both

*Corresponding author. E-mail: hunlu@ziraat.sdu.edu.tr.

Notations: C*, Color chroma; L, color brightness; H*, color hue.

organic and conventional samples (Zhao et al., 2007). In another study, Barret et al. (2007) indicated that tomato juice from organically grown tomatoes contained significantly higher soluble solids and titratable acidity, but lower red coloration, ascorbic acid and total phenolics than the juice from conventionally grown fruit. Therefore, it seems that further research comparing organically and conventionally grown fruit is required to reach a conclusive result regarding the fact that organic or conventional food systems are superior with respect to safety or nutritional composition (Brandt and Molgaard, 2001). Although there are some studies reporting the benefits of organic production systems in terms of agricultural sustainability and environmental quality with maintaining similar yields and fruit quality (Poudel et al., 2002; Gunnarsson, 2003), the studies determining the behavior of organically and conventionally produced fruit after harvest are rather limited.

The objectives of the present study are to determine the effects of microbial fertilizer and plant activator on tomato quality and to evaluate the physico-chemical properties of organically and conventionally grown tomatoes during postharvest storage.

MATERIALS AND METHODS

Two commercial tomato cultivars, Yeni Talya and Zorro, were used in the present study as plant materials. The seedlings of these cultivars were obtained from a commercial supplier (Fiser Fidecilik, Antalya, Turkey). The study was performed in the Research Farm of Faculty of Agriculture, Suleyman Demirel University, Isparta, Turkey in 2007 and 2008 crop seasons. The experiment was set up as a randomized complete block design with 4 replications and 20 plants per replication. Seedlings were transplanted to the field on May 15 with 100 x 40 cm row spacing and regular cultural practices were applied uniformly throughout the experimental area. A commercial microbial fertilizer (Natural Bioplasma), a plant activator (ISR 2000) and their combination along with one conventional fertilizer treatment and the control (no conventional and organic fertilizers applied) were employed in the study. Natural Bioplasma (Denge Tarım, Antalya, Turkey) contained *Chlorella* algae cells (2 x 10^7 algae/ml), N, P, K, S, B, Mn, Ca, Mg, Fe, trace amounts of Mo, Co, Cu, Pb, Zn, Cr, Ni, Cd, Hg, vitamines biotin, A, B1, B2, C, E and amino acids (lysine, methionine, cystine, tryto-phane, histidine, isoleucine, leucine, phenylalanine, valine and arginine) and ISR 2000 (Improcrop) contained *Lactobacillus acidophilus* (855.81 g/l), yeast extract (140.97 g/l), plant extract (111 g/l) and benzoic acid (2.22 g/l) were applied to the plants twice during the experimental period. Natural Bioplasma solution (1 L/da) was applied twice to the soil of the experimental area during the vegetation period. ISR 2000 (90 ml/da) was sprayed twice to both plants and the soil of the experimental area during the vegetation period. For the plants grown conventionally, 50 kg/da 15.15.15 composite fertilizer was applied to the experimental area prior to planting. Additionally, 20 kg potassium nitrate, 20 kg ammo-nium nitrate, 10 kg calcium nitrate and 10 kg micronutrients were applied to the plants via drip irrigation during the vegetation period per decare.

Fruits harvested at green maturity stage were immediately transported to the laboratory, surface sterilized with chlorinated water and then stored at 13°C until they decayed. Twenty fruits from each treatment were removed from storage every 5 days and their firmness, total soluble solids content, color L, a, b values, and total and reducing sugars contents were measured. Moreover, to determine the fruit weight loss during storage, the weights of 10 marked fruits were recorded every 5 days using a digital balance.

Firmness was measured on 20 fruits from each sample with a pocket penetrometer (Model 0603, Eijkelkamp Agrisearch Equipment, Giesbeck, Netherlands) equipped with a 0.6 mm probe. Measurements were performed on the opposite cheeks of each fruit. The maximum force (N) required to reach the bioyield point was recorded. Three samples from 20 fruit of each treatment and the control were utilized for the determination of total soluble solids. A piece of mesocarp tissue (1 g) from each of the 20 fruits was grinded. Total soluble solids were measured using a hand-held digital refractometer (Model WYT-1, Quanzhou Zhoungyou Optical Instrument Co. Ltd. China) and the results were expressed in % Brix.

The color L, a and b values were determined on 20 fruits at two different locations in the equatorial zone using a Minolta CR-300 colorimeter. The results were expressed as L, hue (H) and chroma (C) values.

Total soluble and reducing sugar contents

Total soluble and reducing sugars were extracted as described (Karakurt et al., 2009). Total soluble sugars were determined using 0.5 ml of the extracts as described in Dubois et al. (1956) and reducing sugar content was determined as described by Karakurt et al. (2009). Aqueous solutions of 40, 80, 120, 160 and 200 µg/ml glucose were used as standard.

Statistical analysis

The data from 2007 and 2008 were combined and analyzed using Costat statistical program according to a randomized complete block design (Costat, 2007) and the means were separated with Duncan's multiple range test at the 5% level of significance.

RESULTS AND DISCUSSION

Conventionally and organically grown tomatoes showed significant changes in fruit quality during 35 days of storage. The weight loss changed was dependent on the cultivar rather than growing system and ranged from 4.11 to 9.88% after 35 days of storage (Table 1). Fertilization of plants with microbial fertilizer and plant activator also affected weight loss in both cultivars. After 35 days of storage, the highest weight loss was observed in Yeni Talya fruit treated with ISR 2000 (9.88%) and the lowest weight loss was obtained in Zorro fruit treated with Natural Bioplasma and ISR 2000 combination (4.11%). The difference between organically and conventionally grown fruit in terms of the change in weight loss during storage was minimal in both cultivars.

The changes in soluble solids contents of both cultivars were minimal in response to treatments (Table 2). Soluble solids contents of conventionally and organically grown fruits and ISR 2000 applied fruit of both cultivars did not change significantly during 30 days of storage.

Table 1. Weight loss (%) of tomatoes during storage.

Cultivar	Treatment	Storage time (day)							
		0	5	10	15	20	25	30	35
Yeni Talya	Natural Bioplasma	0	1.14	1.14	2.27	3.41	3.41	5.68	
	ISR 2000	0	1.23	3.70	4.94	6.17	7.41	8.64	9.88
	N.Bioplasma + ISR 2000	0	1.02	2.04	3.06	4.08	4.08	5.10	
	Organically	0	1.10	2.25	3.41	3.45	4.60	5.81	7.06
	Conventional	0	1.82	1.85	3.70	5.66	5.77	7.69	7.84
Zorro	Natural Bioplasma	0	1.04	2.08	3.13	4.17	5.21	5.21	9.21
	ISR 2000	0	1.32	1.32	2.63	3.95	3.95	5.26	
	N.Bioplasma+ISR 2000	0	1.35	1.35	1.35	2.70	2.70	2.70	4.11
	Organically	0	0.91	2.75	3.74	3.77	4.72	5.71	6.73
	Conventional	0	1.03	1.04	2.08	2.11	3.19	4.30	5.43

Table 2. Brix values (%) of tomatoes during storage.

Cultivar	Treatment	Storage time (day)						
		0	5	10	15	20	25	30
Yeni Talya	Natural Bioplasma	4.17	4.33	4.17	4.00	4.00	3.67	4.00
	ISR 2000	4.00	4.17	4.33	4.17	4.17	3.83	3.83
	N.Bioplasma+ISR 2000	4.00	4.17	4.17	4.17	3.83	4.00	4.00
	Organically	4.00	3.83	3.83	4.17	4.17	4.17	4.17
	Conventional	4.33	4.17	4.33	4.33	4.50	4.33	4.33
Zorro	Natural Bioplasma	4.00 bc	4.50 a	4.50 a	4.17 b	4.00 bc	4.00 bc	3.83 c
	ISR 2000	4.17	4.17	4.50	4.17	4.67	4.00	4.17
	N.Bioplasma+ISR 2000	4.00	4.17	4.17	4.17	4.33	4.00	3.83
	Organically	4.17	4.33	4.33	4.17	3.83	4.17	4.17
	Conventional	4.33	4.33	4.00	4.33	4.33	4.17	3.67

Means within each row followed by the same letters are not significantly different at 5% level of significance.

However, in Natural Bioplasma applied fruits, soluble solids content increased significantly during first 10 days of storage and then decreased towards the end of storage. Soluble solids are important not only in terms of their contribution to flavor, but also, in terms of their relationship to processing requirements (Taiwo et al., 2007; Bender et al., 2008). Unlike our results, Pieper and Barett (2008) reported a higher level of total soluble solids in organically produced tomatoes possibly due to factors including cultivar differences and differences in maturity at harvest (Taiwo et al., 2007; Pieper and Barett, 2008).

A significant decrease in firmness was observed in all treatments of both cultivars with time in storage (Table 3). Decrease was not dependent on cultivation system, microbial fertilization or plant activator. After 30 days of storage, the firmness values of organically and conventionally grown fruits declined from 4.66 to 3.92 N in Yeni Talya from 5.27 to 4.04 in Zorro, respectively. The effects of Natural Bioplasma and ISR 2000 on the changes in firmness during storage were cultivar dependent and did not show any trend with storage.

Significant changes were also observed in color composition of tomatoes during storage and in response to growing system and pre-harvest applications. Table 4a shows the color L (brightness) values of tomatoes. L value demonstrated significant reduction during storage suggesting the loss of brightness in all treatments in both cultivars. A comparable level of decline in L value was also observed in both conventionally and organically produced fruit. Application of Natural Bioplasma and ISR 2000 did not significantly affect the trend of changes in brightness. Confirming our findings, Pieper and Barret (2008) observed no significant difference in L value between conventionally and organically cultivated tomatoes. Significant changes were also observed in color chroma (C*) value of all treatments (Table 4b). C* value increased in comparable levels in both conventionally and organically produced fruits. Application of Natural Bioplasma and ISR 2000 or their combination did not change the trend in C* value as compared to that in organically or conventionally produced fruit. The increase in C* value indicates an increase in red coloration possibly due to an increase in lycopene content (Caris-

Table 3. Firmness values (N) of tomatoes during storage.

Cultivar	Treatment	Storage time (day)						
		0	5	10	15	20	25	30
Yeni Talya	Natural Bioplasma	12.37 a	11.88 a	7.35 b	6.13 c	5.27 c	4.29 d	4.17 d
	ISR 2000	13.97 a	13.60 a	12.13 b	9.07 c	5.15 d	4.90 d	3.43 e
	N.Bioplasma+ISR 2000	14.58 a	13.84 ab	12.62 b	6.25 c	5.27 cd	4.78 cd	4.41 d
	Organically	12.50 a	12.25 a	10.54 b	8.58 c	6.00 d	5.02 c	4.66 e
	Conventional	11.27 a	11.27 a	9.07 b	6.86 c	4.90 d	4.66 d	3.92 d
Zorro	Natural Bioplasma	13.84 a	12.99 ab	12.01 b	7.35 c	5.64 d	5.64 d	5.64 d
	ISR 2000	12.62 a	11.76 b	11.52 b	7.60 c	4.53 d	4.41 d	4.29 d
	N.Bioplasma+ISR 2000	15.44 a	14.58 a	11.88 b	7.60 c	6.62 c	5.27 d	4.78 d
	Organically	14.58 a	14.46 a	13.60 a	10.05 b	7.11 c	6.62 c	5.27 d
	Conventional	12.01 a	11.52 a	8.82 b	6.98 c	5.76 d	4.29 e	4.04 e

Means within each row followed by the same letters are not significantly different at 5% level of significance.

Table 4a. Colour L* values of tomatoes during storage.

Cultivar	Treatment	Storage time (day)						
		0	5	10	15	20	25	30
Yeni Talya	Natural Bioplasma	66.01 a	66.43 a	54.50 b	49.23 c	45.96 d	44.59 d	42.01 e
	ISR 2000	66.53 a	64.26 b	62.23 c	53.77 d	44.33 e	44.19 e	41.05 f
	N.Bioplasma+ISR 2000	66.45 a	65.97 a	64.57 a	48.74 b	46.94 b	42.02 c	40.90 c
	Organically	67.96 a	64.53 b	62.81 c	52.02 d	44.26 e	44.13 e	42.95 e
	Conventional	64.45 a	63.36 a	63.93 a	58.48 b	45.98 c	45.77 c	43.32 d
Zorro	Natural Bioplasma	66.42 a	64.58 b	61.86 c	50.79 d	44.39 e	43.44 ef	42.96 f
	ISR 2000	65.30 a	64.21 a	63.63 a	51.95 b	44.27 c	42.99 c	42.48 c
	N.Bioplasma+ISR 2000	64.39 a	62.43 b	61.12 c	53.34 d	47.62 e	43.16 f	42.85 f
	Organically	64.48 a	63.05 ab	61.39 ab	59.52 b	50.35 c	47.82 cd	44.37 d
	Conventional	63.15 a	62.94 a	60.06 a	55.35 b	48.44 c	43.41 d	41.55 d

Means within each row followed by the same letters are not significantly different at 5 % level of significance.

Table 4b. Colour C* values of tomatoes during storage.

Cultivar	Treatment	Storage time (day)						
		0	5	10	15	20	25	30
Yeni Talya	Natural Bioplasma	28.98 c	28.86 c	30.39 c	37.87 b	39.98 a	37.92 b	38.17 b
	ISR 2000	32.08 b	30.72 b	26.73 c	31.09 b	40.38 a	40.63 a	40.24 a
	N.Bioplasma+ISR 2000	29.36 c	28.57 c	26.39 c	36.58 b	40.10 a	39.98 a	38.24 ab
	Organically	30.25 c	29.61 c	29.61 c	34.29 b	38.74 a	40.26 a	40.37 a
	Conventional	35.94 cd	34.71 d	30.39 e	36.44 cd	38.12 bc	40.95 ab	41.50 a
Zorro	Natural Bioplasma	30.71 c	29.53 cd	27.93 d	36.35 b	41.80 a	40.31 a	40.95 a
	ISR 2000	30.28 bc	29.15 cd	26.55 d	33.33 b	39.03 a	39.13 a	38.24 a
	N.Bioplasma+ISR 2000	31.88 bc	29.91 bc	28.49 c	32.81 b	38.12 a	40.32 a	40.58 a
	Organically	32.80 c	31.83 cd	30.78 cd	29.06 d	37.32 b	40.05 ab	40.39 a
	Conventional	34.41 b	32.49 bc	31.21 c	34.23 b	40.11 a	39.42 a	40.06 a

Means within each row followed by the same letters are not significantly different at 5 % level of significance.

Veyrat et al., 2004). Likewise, significant variations were also determined in color hue (H*) value (Table 4c). In all treatments of both cultivars, H* value increased until day 15 of storage and then showed significant reductions

Table 4c. Colour H* values of tomatoes during storage.

Cultivar	Treatment	Storage time (day)						
		0	5	10	15	20	25	30
Yeni Talya	Natural Bioplasma	-72.60 e	-72.50 e	59.54 a	42.52 b	37.15 c	32.47 d	30.28 d
	ISR 2000	-72.29 c	-75.04 cd	-75.29 d	51.93 a	37.08 b	37.91 b	35.51 b
	N.Bioplasma+ISR 2000	-73.63 d	-75.52 d	-80.59 e	42.47 a	38.03 b	36.08 b	30.72 c
	Organically	-75.85 c	-75.67 c	-75.94 c	46.63 a	37.33 b	35.54 b	35.25 b
	Conventional	-68.88 d	-71.91 de	-74.25 e	50.56 a	43.34 b	39.81 bc	38.61 c
Zorro	Natural Bioplasma	-74.80 e	-73.99 e	-77.92 f	48.22 a	40.52 b	37.91 c	34.20 d
	ISR 2000	-73.45 d	-73.68 d	-72.04 d	48.63 a	39.67 b	36.42 c	33.80 c
	N.Bioplasma+ISR 2000	-72.39 d	-73.58 d	-76.03 d	51.50 a	42.64 b	38.57 bc	34.47 c
	Organically	-71.22 e	-73.89 e	-77.74 f	76.73 a	47.04 b	38.82 c	35.64 d
	Conventional	-70.60 d	-73.39 e	-75.90 f	58.63 a	42.80 b	38.63 c	37.30 c

Means within each row followed by the same letters are not significantly different at 5 % level of significance.

Table 5. Total sugar (mg/g) content of tomatoes during storage.

Cultivar	Treatment	Storage time (day)						
		0	5	10	15	20	25	30
Yeni Talya	Natural Bioplasma	18.23 e	26.43 d	29.83 cd	34.73 bc	31.04 cd	39.28 b	44.30 a
	ISR 2000	18.76 d	25.92 c	27.40 c	33.44 b	39.28 ab	45.51 a	42.17 a
	N.Bioplasma+ISR 2000	20.96 d	23.70 cd	25.58 cd	28.86 c	43.51 a	37.15 b	35.32 b
	Organically	22.50 d	27.84 cd	32.10 bc	36.57 ab	38.20 ab	41.03 a	43.40 a
	Conventional	22.70 c	30.29 b	31.76 b	32.04 b	35.20 b	35.88 b	48.72 a
Zorro	Natural Bioplasma	20.56 c	19.26 c	28.71 b	33.66 b	35.28 b	44.44 a	42.61 a
	ISR 2000	22.70 e	26.70 de	31.43 cde	35.28 bcd	36.75 bc	46.76 a	43.39 ab
	N.Bioplasma+ISR 2000	19.73 d	23.37 d	27.27 cd	25.26 cd	35.65 bc	41.84 b	52.16 a
	Organically	21.70 e	28.79 cde	27.64 de	31.71 bcd	35.94 abc	43.06 a	39.28 ab
	Conventional	24.76 c	30.33 bc	37.52 abc	41.60 ab	42.39 ab	45.28 a	49.06 a

Means within each row followed by the same letters are not significantly different at 5% level of significance.

during the rest of the storage period, suggesting a significant proportional decrease in yellowness. The decrease in H* value was similar in organically and conventionally-produced fruit. Application of Natural Bioplasma and ISR 2000 did not significantly affect the trend of changes in H* value. A decrease in yellowness during ripening of tomato fruit was also reported by Kaur et al. (2006).

Tomato fruit quality is significantly affected by sugar content of the fruit (Granges, 2002; Pieper and Barret, 2008). Total and reducing sugar contents of tomatoes were significantly affected by storage (Tables 5 and 6). Total soluble and reducing sugars increased significantly during 30 days of storage period in all treatments in both cultivars. In both cultivars, total soluble sugars showed higher increase in conventionally grown fruit as compared to organically grown fruit. Natural Bioplasma and ISR 2000 and their combination enhanced soluble sugar accumulation during storage. The change in reducing sugar content was affected by storage. While reducing sugars content showed a higher increase in organically grown Yeni Talya fruit, in Zorro, it demonstrated a higher increase in conventionally grown fruit during storage. Moreover, Natural Bioplasma and Natural Bioplasma and ISR 2000 combination enhanced reducing sugar accumulation in Zorro but the same effect was not observed for Yeni Talya.

In conclusion, the data suggest that organically produced fruit maintain their quality for a period comparable to those of fruit grown using conventional fertilizers during storage. Although certain quality parameters remain higher in conventionally grown fruit during storage, these effect seems to be cultivar dependent since the same effect was not observed for both cultivars evaluated in this study. On the other hand, the applications of plant activators and microbial fertilizers improved the quality characteristics of tomato fruit during storage as compared to conventionally grown fruit. In a similar paper, we have observed a significant improvement in firmness and soluble sugar content of tomatoes in organically grown fruit. It can also be suggested that conventionally grown fruit are

Table 6. Reducing sugar (mg/g) content of tomatoes during storage.

Cultivar	Treatment	Storage time (day)						
		0	5	10	15	20	25	30
Yeni Talya	Natural Bioplasma	9.50 e	12.50 d	15.00 cd	16.50 c	19.50 b	23.21 a	22.12 a
	ISR 2000	7.87 e	11.87 d	14.57 cd	16.03 bc	18.87 ab	22.20 a	20.12 a
	N.Bioplasma+ISR 2000	8.33 d	12.53 cd	15.04 bc	16.54 bc	19.88 ab	22.49 a	23.33 a
	Organically	9.44 e	12.02 d	14.42 c	15.86 c	19.02 b	25.15 a	26.11 a
	Conventional	9.12 e	13.28 d	15.93 cd	18.28 bc	20.86 ab	23.79 a	21.61 a
Zorro	Natural Bioplasma	8.81 e	10.22 de	12.26 cd	13.49 c	20.74 b	25.08 a	25.48 a
	ISR 2000	9.16 c	11.33 c	15.26 b	16.79 b	20.67 a	23.32 a	22.04 a
	N.Bioplasma+ISR 2000	9.92 c	13.73 c	12.10 c	15.10 bc	18.11 bc	22.59 ab	26.89 a
	Organically	7.77 e	12.60 d	15.12 c	16.63 c	25.72 a	24.11 ab	22.78 b
	Conventional	8.04 d	13.30 c	15.96 bc	19.83 ab	18.22 bc	20.53 ab	24.83 a

Means within each row followed by the same letters are not significantly different at 5% level of significance.

in a more advanced maturity stage and reach full maturity faster than organically produced fruit since at the day of harvest, conventionally grown fruit showed less firmness, higher coloration and sugar contents as compared to organically produced fruit.

REFERENCES

Barret DM, Weakley C, Diaz JV, Watnik M (2007). Qualitative and Nutritional Differences in Processing Tomatoes Grown Under Commercial Organic and Conventional Production Systems. J. Food Sci. 72: 441-450.

Bender I, Raudseping M, Vabrit S (2008). Effect of Organic Mulches on The Growth of Tomato Plants and Quality of Fruits in Organic Cultivation. Proceedings of the International Symposium on Growing Media, Acta Horticulturae. 779: 341-346.

Brandt K, Molgaard JP (2001). Organic Agriculture: Does It Enhance or Reduce The Nutritional Value of Plant Foods? J. Sci. Food Agric. 81: 924-931.

Caris-Veyrat C, Amiot MJ, Tyssandier V, Grasselly D, Buret M, Mikolajczak M, Guiiland JC, Demange CB, 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. J. Agric. Food Chem. 52: 6503-6509.

Costat (2007). Costat for windows. Version 6311.

Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F (1956). Colorimetric Method for Determination of Sugars and Related Substances. Anal. Chem. 28: 350-356.

Granges A (2002). Variations Annuelles de la Qualit´e Organoleptique de la Tomate: Appreciation de Consommateurs. Revue Suisse de Viticulture, Arboriculture, Horticulture. 34: 219-222.

Gunnarsson S (2003). Optimisation of N release-Influence of Plant Material Chemical Composition on C and N Mineralisation. PhD. Thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Kaur D, Sharma R, Wani AA, Gill BS, Sogi DS (2006). Physicochemical Changes in Seven Tomato (*Lycopersicon esculentum*) Cultivars During Ripening. Int. J. Food Properties, 9: 747-757.

Karakurt Y, Unlu H, Unlu-Ozdamar H, Padem H (2009). The Influence of Foliar and Soil Fertilization of Humic Acid on Yield and Quality of Pepper. Acta Agriculturae Scandinavica, Section B-Soil Plant Sci. 59: 233-237.

Pieper JR, Barrett DM (2008). Effects of Organic and Conventional Production Systems on Quality and Nutritional Parameters of Processing Tomatoes. J. Sci. Food Agric. 89: 177-194.

Poudel DD, Horwath WR, Lanini WT, Temple SR, van Bruggen AHC (2002). Comparison of Soil N Availability and Leaching Potential, Crop Yield and Weeds in Organic, Low-Input and Conventional Farming Systems in Northern California. Agric. Ecosyst. Environ. 90: 125-137.

Taiwo LB, Adediran JA, Sonubi OA (2007). Yield and Quality of Tomato Grown with Organic and Synthetic Fertilizers. Int. J. Vegetable Sci. 13(2): 5-19.

Toor RK, Savage GP, Heeb A (2006). Influence of different types of fertilizers on the major antioxidant components of tomatoes. J. Food Composition Anal. 19: 20-27.

Zhao X, Chambers E, Matta Z, Loughin TM, Carey EE (2007). Consumer Sensory Analysis of Organically and Conventionally Grown Vegetables. J. Food Sci. 72: 87-91.