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Determination of Some Physicochemical and Sensorial Differences between Organic and Conventional Growing Sweet Red Pepper (*Capsicum annuum* L.)

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Abstract In this study, the quality of sweet red pepper (SRP) from organic and conventional farming was investigated in two-year study. Organic and conventional SRP samples were analyzed for pomological, physicochemical and quality parameters. Production system (PS) was significant for average weight and average length of SRP. Total dry matter (TDM), soluble solids (SS), ash, pH, titratable acidity (TA), electrical conductivity (EC) were not affected by the PS. Surface color values of organic SRP were higher than conventional in 2005 and 2006, except a values in 2005. Firmness values were statistically significant in 2005. Interior and exterior color of conventional SRP were more redness values than organical SRP in 2005, but values were not different in 2006. And also, fruit firmness and taste values of conventional SRP were higher than organic SRP in 2005 and 2006, and differences were statistically significant ($p<0.05$).

Keywords Sweet red pepper, organic, conventional, firmness, color

Introduction

Turkey is one of the leading countries about pepper (*Capsicum annuum* L.) production in the worldwide. Turkey's total pepper (Chili) production was 2.457.822 MT and was ranked 3rd in the world. Peppers have a special role in Turkish cuisine and are consumed either fresh, canned or dried [1,2].

Organic farming has attracted an increasing attention over the last three decades, because it is perceived as a solution to the problems currently besetting the agricultural sectors of industrialized countries [3]. The demand for organically grown produce is increasing because of the commercial opportunities offered by such products, increasing consumer awareness of the relationship between foods and health and environmental concerrns [4]. There is considerable latent interest among farmers in switching over to organic farming in Turkey. Parallel to its worldwide increasing popularity, activities in the field of organic farming have been increasingly carried out in Turkey since 1985 and there is a steady progress since then. Almost all of the crops produced by the organic agriculture methods are exported to European Union (EU) countries and have a significant contribution to the nation's agricultural exports in general. Besides, organic agriculture system brings an extra opportunity to Turkish farmers and exporters who use traditional means of production [3].

Previously published studies on organic *versus* conventional production have often been carried out on only one growing location during one season. Several recent studies point to significant variation between geographical locations and years [5].

The aim of this study was to compare some physicochemical and sensorial properties of SRP produced in certified organic and conventional production systems over the two-year period.

2. Materials and Methods

2.1. Materials

All commodities used in these studies were grown under controlled conditions and supplied by Ege University Agricultural Research Field Station. Organic pepper production area between 2001 and 2004 years were subjected to transition period, this field has been certificated to organic farmland by ETKO firm in 2005.

Organic SRP seeds were supplied from Ege University Agricultural Research Field Station, which were, produced previous year organic sweet red peppers. Organic pepper seedling were grown under certified field in Ege University Agricultural Research Field Station. Organic plot was near the conventional plot, with similar environmental conditions. The soil had adequate physicochemical parameters for SRP. Sowing was carried out on 15 April 2005 and 2006. Seedlings were planted at a 70x30 cm distance in the same farm. Irrigation was applied using a drip method. Before planting 3 tons, well-burnt manure was applied per decare in the two years. A mixture of fresh animal manure and irrigation water was made during the second anchor. When the first fruits reached normal size, water-soluble certified organic manure pellets (40 kg/100 L water) were applied. At the stage of spraying, copper preparation (organically certified), two times potassium soap, two times wetable sulphur, two times white fly spray and one times green worm spray were applied to seedlings in the seedbed.

Conventional pepper seeds were obtained from Altin Tohumculuk A.Ş. Seedlings were grown in the Ege University Agricultural Faculty Horticultural Sciences Department's Seedbed. Sowing was carried out on 15 April 2005-2006. Seedlings were planted at a 70x30 cm distance in the same farm. Irrigation was applied using a drip method. Before planting 30 kg of 15 % nitrogen, 15 % phosphorus and 15 % potassium were applied to plot per decare every two years. 20 kg per decare ammonium sulphate (26 %) was applied to field following 2-nd anchor and 10 kg per decare potassium sulphate was applied to field in full fruit. For underground pests in the seedbed, some applications were operated in the spraying stage, which were two times for aphids, white fly and green caterpillar. Pesticides were applied for weeds at a one time.

Pepper fruits were hand harvested on August 21, 2005, and August 24, 2006.Organic and conventional sweet red pepper production systems had the same cultivars, same sowing and transplanting dates and same harvest date. The soils in both fields are classified as sandy clay loam.

2.2. Chemicals

Sodium hydroxide, sulphuric acid, hydrochloric acid, ethanol, selenium powder were purchased from JT Baker. Other reagents used in this study were all of analytical reagent grade.

2.3. Sweet Red Pepper Harvest and Sampling

SRP samples were hand harvested on August 21, 2005, and August 24, 2006. Pomological properties (fresh fruit weight, length and average diameter), color values (L, a and b values), sensorial attributes (outer color, inner color, hardness and taste) and hardness were performed in the whole pepper fruits. The ripe SRP were cut into small pieces with stainless steel knife and successively homogenized in a kitchen type blender for other analyses. Some part of sample was quickly used for TDM, SS, ash, pH, TA, EC, nitrogen content analysis.

2.4. Analytical Determinations

TDM was determined using a vacuum dryer (Gallenkamp, 3300). SS content was determined in pepper juice using a digital refractometer (RFM 330 Bellingham+Stanley Limited, England) and expressed in °Brix.

2.5. Pepper Quality Analysis

2.5.1. Pomological Properties

Fruit fresh weight (to the nearest 0.01 g) was determined after transporting harvested fruit to the laboratory. Fruit diameter and length were determined by measuring the longest diameter and length with digital vernier calliper [6].

2.5.2. TDM, SS, Ash, pH, TA, EC, Nitrogen Content

TDM of SRP was analyzed according to the Association of Analytical Chemists (AOAC, 1990) [7] vacuum oven method. Triplicate TDM measurements were made on approximately 3 g samples. SS content was determined in pepper juice using a digital refractometer (RFM 330 Bellingham+Stanley Limited, England) and expressed in °Brix. Approximately 5 g of homogenized pepper fruit was burnt for pre-burning at 280-300 °C and then pepper residues were burnt in muffle at 550±25 °C for 16 h and the residue weighted to determine the ash content. pH value was measured using a pH meter (WTW Inolab, Germany) for the supernatant. TA was determined by titration 0.01 N NaOH to reach pH 8.1of supernatants and presented as citric acid equivalent (%, w/v). The EC was measured by conductometer in homogenized SRP samples at room temperature. The nitrogen content estimated by the Kjeldahl method [7].

2.5.3. Color Values

Color values such as L (white to black or light to dark), a (green to red), and b (yellow to blue) measurements in homogenized pepper were taken with Minolta Chroma Meter in 2005 and Hunter colorimeter in 2006. L, a and b values were determined by averaging the results of three independent readings per sample [6].

2.5.4. Texture Measurements

The texture of the peppers was measured using an Instron (Model 1140 Food Testing System) with a 7 mm diameter hole, and the following parameters: 5 kg force load cell, 2 mm diameter Magness Taylor Probe, 200 mm min^{-1} test speed and 50 mm min^{-1} paper speed. The property "firmness" (hardness), the maximum force applied to puncture the pepper tissue, was measured as an indicator of texture, which is very similar to the one performed by mastication that takes part during eating. The measurements were done on both sides of the pepper tissue that is, from the skin and the flesh sides. Rupture of the skin from the flesh side required a lower force when compared with the same action from the skin side. An average value of firmness from 10 puncture with two replicates measurements were calculated for each experimental condition.

2.5.5. Sensory Evaluation

Eight judges, aged 25-35 years (4 females and 4 males, all members of Ege University Food Engineering Department) were trained in quality evaluation of SRP. Two paired-comparison tests were used to determine that trained judges could detect differences in interior and exterior color redness, firmness of samples and taste. Samples were sliced by knife and were put in plastic dishes and labeled with three-digit random number codes. Two sessions were presented to panelist and it has been reached 16 numbers for each panel.

2.5.6. Statistical Analysis

All data were analyzed using TARIST statistical software. Analysis of variance (ANOVA) was carried out using two factor, randomized split-plot design with three replicates in each treatment; where significant F-values were obtained, differences between individual means were tested using the LSD (Least Significant Difference) test, with a significance level of $p<0.01$-0.05. All statistical comparisons were performed using TARIST statistical package programmer version 4, serial number A1001 [8].

3. Results and Discussion

The results showed that organically and conventionally produced sweet red peppers are comparable in their pomological properties, physicochemical and chemical properties, some nutrient contents, textural parameter and sensorial preference test.

3.1. Pomological properties

Pomological properties of the SRP grown under the organic and conventional production systems are presented in Table 1. The results showed that average fruit weights were 26.5% and 5% higher in conventional SRP in 2005 and

2006 year, respectively. Interactive effects between year and cropping system (Y x CS) were significant for average fruit weight ($p<0.01$).

Table 1: Average weight, length and radius of organic and conventional growing SRP in 2005 and 2006 year

Production system	Year	Average weight (g)	Average length (mm)	Average radius (mm)
Organic	2005	83.71 ± 11.10	120.18 ± 5.55	58.43 ± 3.42
	2006	73.59 ± 9.38	125.53 ± 6.97	54.48 ± 2.87
	Average	78.65 ± 18.12	122.86±13.67	56.45 ± 5.41
Conventional	2005	105.89 ±	134.88±12.02	61.25 ± 3.16
	2006	77.27 ± 14.86	123.97 ± 5.21	54.92 ± 4.23
	Average	91.58 ± 17.38	129.45 ± 9.37	58.09 ± 4.33
Year's average	2005	94.80 ± 13.75	127.53±12.02	59.84 ± 3.16
	2006	75.43 ± 12.35	124.75 ± 6.10	54.70 ± 3.56
Year	LSD	36.26	1.852	33.146
	Significant degree	**	NS	**
Production system	LSD	16.158	10.323	3.328
	Significant degree	**	**	NS
Year*Production system	LSD	8.265	15.784	1.792
	Significant degree	**	**	NS

** Least significant difference (LSD) at P<0.01.

NS: not significant

This differences were most likely due to using fertilizer type. According to Heaton (2001) [9] excessive fertilisation stimulates rapid growth that increases the yield crops partly by simply swelling them with a higher water content. Riahi et al. (2009) [4] reported that mean tomatoes fresh fruit weight was not affected by the organic and conventional production system whatever the cultivar.

Average fruit lengths were statistically significant ($p<0.01$) according to PS, interactive effects between Y and PS. Average fruit length in organic and conventional production system were found as 120.18 mm, 125.53 mm in 2005 and 134.88 mm, 123.97 mm in 2006, respectively. Lumpkin (2005) [10] reported that tomatoes grown in conventional production system had much smaller than those grown with organic production system.

Y factor was significant for an average fruit radius ($p<0.01$). Average fruit radius were 59.84 mm in 2005 and 54.7 mm in 2006, respectively. Pérez et al. (2007) [11] found that organic mandarin had higher radius than that of conventional.

3.2. Physicohemical Properties

The physicochemical properties of both SRP are analyzed and, there were no significant differences according to statistical analyzes between production methods. Results for the some physicochemical properties and nutrients of the SRP grown under the conventional and organic production systems are presented in Table 2. Some of the features seen in the Table 2 were affected Y, PS and Y x PS interaction, some of them were not affected. TDM, TA and EC were not affected by the Y, PS and interaction between Y and PS ($p>0.01$). However, SS, pH and nitrogen content value were significantly affected by one or two of the factor such as year, production system and interaction between year and production system ($P<0.01$-0.05). Y was significant for SS ($p<0.01$), ash ($p<0.05$), pH ($p<0.05$) and N ($p<0.05$). While the PS was not significant for TDM, SS, pH, TA and EC, interactive effects between Y and PS was significant only for SS ($p<0.05$). The TDM of conventional SRP had greater than organic SRP in 2005 year,

whereas greater in organic SRP than that of conventional in 2006. TDM contents measured in both organic and conventional SRP were higher than values previously reported by del Amor (2007) [12]; however, Martínez et al. (2007) [13] were similar to levels reported in fresh Arnoia peppers. There was no significant effect of PS on the TDM content of organic and conventional growing SRP.

Table 2: The physichochemical properties of organic and conventional growing SRP in 2005 and 2006 year

Production system	Year	TDM (%)	SS (°Brix)	Ash (%)	pH	TA (%)	EC (x10^{-2}) 1/ Ù	Nitrogen (%)
Organic	2005	10.11±0.87	7.90±0.18	0.68±0.05	4.87±0.31	0.24±0.01	0.0145 ± 0.00	0.3±0.05
	2006	9.37±0.67	8.00±0.27	0.51±0.09	5.16±0.07	0.26±0.02	0.013 ± 0.00	0.21±0.01
	Average	9.74 ± 0.86	7.95 ± 0.23	0.59 ± 0.11	5.02 ± 0.26	0.25 ± 0.02	0.0138 ±	0.25±0.06
Conventional	2005	9.18±1.32	7.7±0.33	0.75±0.14	4.81±0.08	0.23±0.03	0.015 ± 0.00	0.30±0.06
	2006	9.83±0.10	8.95±0.51	0.64±0.13	5.09±0.08	0.25±0.03	0.0128 ± 0.00	0.26±0.02
	Average	9.51 ± 0.99	8.33 ± 0.76	0.69 ± 0.14	4.95 ± 0.16	0.24 ± 0.03	0.0139 ±	0.28±0.05
Year's average	2005	9.65±1.29	7.80±0.30	0.71±0.10	4.84±0.24	0.23±0.02	0.01 ± 0.00	0.30±0.06
	2006	9.60±0.57	8.48±0.67	0.57±0.12	5.13±0.09	0.25±0.03	0.01 ± 0.00	0.23±0.04
Year	LSD	0.011	11.685	6.958	8.761	1.547	3.15	8.298
	Significant level	NS	**	*	*	NS	NS	*
Production system	LSD	0.22	3.607	3.636	0.456	0.032	0.014	1.725
	Significant level	NS	NS	NS	NS	NS	NS	NS
Year*Production system	LSD	1.952	8.479	0.251	0.03	0.789	0.126	1.633
	Significant level	NS	*	NS	NS	NS	NS	NS

* Least significant difference (LSD) at P<0.05.

** Least significant difference (LSD) at P<0.01.

NS: not significant

Levels of SS were higher in organic SRP than that of conventional in 2005, whereas higher in conventional SRP than that of organic in 2006, which is consistent with the results of the Chassy et al. (2006) [14] in organic and conventional California Wonder and Excalibur varieties of bell peppers.

For the 2005 experiment, organic SRP had a higher ash content (10.11 %) than that of conventional (9.18 %); for 2006 experiment, conventional SRP (9.83 %) had a higher ash content than that of organic (9.37 %). No significant effects of Y, PS and Y x PS interaction were observed in either year for these traits. Kumpulainen (2001) [15] found higher levels of ash content in conventional growing potatoes and carrots than that of organic. Bourn and Prescott (2002) [16] reported equal levels of ash content in organic and conventional growing strawberry. Levels of pH were higher in organic SRP as compared to their conventional counterparts in 2005 and 2006. There was only significant effects of year (p<0.05). del Amor (2007) [12] showed that higher pH values of organic SRP treatment but these differences were not significant with respect to the conventional treatment. The determined content of TA in organic and conventional SRP were higher than the results indicated in literature [13]. The results showed that TA was not affected by the Y, PS and Y x PS interaction. Concerning EC, an effect of Y, PS and Y x PS interaction were not observed. Similar results were obtained by del Amor (2007) [12] with organic and mineral fertilization of sweet pepper. Analysis of nitrogen content in the samples revealed statistically relationship between nitrogen content and Y, but no relationship between nitrogen content and PS. The results showed that nitrogen contents were equal in

2005, but higher in conventional SRP in 2006. Kumpulainen (2001) [15] reported higher levels of N in conventional growing potatoes than organic growing. He is reported that it is depended on N fertilization in conventional farming system.

Color parameters are presented in Table 3 and Table 4. Table 3 shows the results for L, a and b values in SRP measured with Minolta in 2005 year. Analyses of surface color results showed that statistical difference of L, a and b values in 2005 year but no differences in 2006 year. L, a and b values appeared to be highly affected by PS. Values of L, a and b were higher in organic fruits. The impact of PS was statistically significant for L, a and b values in 2005 year. L, a and b values for of SRP were higher in organic fruit than conventional. In the study of Barrett et al., (2007) [17] the only color values to significantly differ between organic and conventional tomatoes were also the b values. However, in our study L, a and b values were always higher in organic SRP.

Table 3: Surface color of organic and conventional growing SRP in 2005

Production system	L	a	b
Organic	36.53 ± 0.56	27.21 ± 0.97	17.63 ± 1.30
Conventional	31.66 ± 1.43	25.57 ± 0.53	14.52 ± 0.68
Average	34.09 ± 2.79	26.39 ± 1.13	16.07 ± 1.92
LSD	40.308	8.759	17.980
Significant level	**	*	**

* Least significant difference (LSD) at P<0.05.

** Least significant difference (LSD) at P<0.01.

Table 4 shows the results for L, a and b values in SRP measured with Hunter Lab in 2006 year. L, a and b values were not affected by production system. Juroszek et al. (2009) [18] found that no significant differences between organic and conventionally produced tomatoes color values across two years. In contrast, Crecente-Campo et al. (2012) [19] reported cultivation system affected on all of the surface color parameters of strawberry.

Table 4: Surface color of organic and conventional growing of SRP in 2006

Production system	L	a	b
Organic	28.39 ± 2.57	36.29 ± 1.29	20.30 ± 2.58
Conventional	26.68 ± 1.85	36.48 ± 3.06	19.37 ± 3.83
Average	27.53 ±2 .26	36.38 ± 2.18	19.83 ± 3.06
LSD	1.170	0.013	0.161
Significant level	NS	NS	NS

NS: not significant

Fruit firmness results are presented in Table 5. Fruit firmness showed higher values in the organic treatment and differences were statistically significant (p<0.05) according to the PS. The results also showed that SRP firmness values were not significantly affected by the Y and Y x PS interaction (p>0.01). del Amor (2007) [12] found higher firmness values in organic sweet pepper than conventionally produced but these differences were not statistically significant. Fruit firmness could be affected from other constituents such as pectin, cellulosic matter, lignin etc.

Table 5: Fruit firmness of organic and conventional growing SRP in 2005 and 2006 year

Production system	Year	Firmness (kg)
Organic	2005	2.67 ± 0.44
	2006	1.95 ± 0.26
	Mean	2.49 ± 0.43
Conventional	2005	2.30 ± 0.32
	2006	1.91 ± 0.28
	Mean	1.93 ± 0.27
Year's average	2005	2.31 ± 0.51

Year	2006	2.11 ± 0.36
	LSD	1.139
	Significant level	NS
Production system	LSD	8.349
	Significant level	*
Year*Production system	LSD	0.738
	Significant level	NS

* Least significant difference (LSD) at P<0.05.
NS: not significant

Results from the sensory evaluation are presented in Table 6. The results for inside and outside surface color, firmness and taste of SRP were tested with trained panelists. In 2005 year, conventionally produced SRP were rated superior to organically produced SRP in all the attributes evaluated and differences were statistically significant ($p<0.05$).

Table 6: Inside and outside color, firmness and taste results of sensorial test

Production Year	**Inner color**		**Outer color**		**Firmness**		**Taste**	
	Differences	**More red**	**Differences**	**More red**	**Differences**	**More harder**	**Differences**	**More delicious**
2005 I. harvest	*	Con	*	Con	*	Con	*	Con
2005 II. harvest	*	Con	*	Con	*	Con	*	Con
2006 I. harvest	NS	-	NS	-	*	Con	*	Con
2006 II. harvest	NS	-	NS	-	*	Con	*	Con

* Least significant difference (LSD) at P<0.05.
NS: not significant
Con: Conventional SRP

In 2006 year, PS was not statistically significant for inner and outer surface color of SRP, while the firmness and taste differences between organically and conventionally produced SRP were statistically differences ($p<0.05$). Firmness and taste scores of conventionally produced SRP were higher than organically produced SRP. A consistent trend for both years was that the conventionally growing system produced SRP with high pepper-taste, while the organically growing system produced peppers with weak pepper taste. A study by Burton (2006) [20], found that conventionally produced apple, tomatoes, carrot and orange juice as organically produced were scored higher for taste by a consumer sensory panel.

4. Conclusion

To conclude on the basis of two-year results, organic and conventional farming had a no effect except fruit firmness (texture analyze results), L, a and b surface color value (in 2005 year) on the quality parameters of SRP. According to sensorial parameters, conventional farming had a positive effect on inner color, outer color, firmness and taste of SRP.

Year to year variations were determined as significant in this study. Changing measured parameters according to PS and Y could be depend on soils level of Carbon level (lignin content or C-to-N ratio), the differences in manure

(well burnt) quality year to year and soil microbial biomass values which can be affect relatively robus towards short-term.

Results of this study showed that some selected parameters affected from PS or Y factor, that's why new study design can be establish to determine relationship between farming system input and synthesized nutritional parameters in fruit.

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