Araştırma Makalesi

www.ziraat.selcuk.edu.tr/ojs
Selçuk Üniversitesi
Selçuk Tarım ve Gıda Bilimleri Dergisi
25 (3): (2011) 73-78
ISSN:1309-0550

Organik ve Konvansiyonel Olarak Yetiştirilen 'Camarosa' Çilek Çeşidinin Bazı Fizikokimyasal Özellikleri ve Antioksidan Kapasiteleri

Nilda ERSOY[1]

[1]*Selçuk Üniversitesi, Ziraat Fakültesi, Bahçe Bitkileri Bölümü, Konya/Türkiye*

(Geliş Tarihi: 06.06.2011, Kabul Tarihi:06.12.2011)

Özet

Organik ve konvansiyonel sistemlerde yetiştirilen Camarosa çilek çeşidinin meyve ağırlığı, meyve eni, meyve kalınlığı, meyve uzunluğu, meyve en/boy oranı, toplam kuru madde, titre edilebilir asitlilik ve antioksidan kapasiteleri gibi bazı fizikokimyasal özellikleri kıyaslanmıştır. Organik yetiştirme sistemi istatistiksel olarak toplam kuru madde ve toplam kuru madde/titre edilebilir asitlilik değerlerinin artışı bakımından daha etkili bulunmuştur. Organik olarak yetiştirilen çilekler konvansiyonel olarak yetiştirilenlere göre daha koyu renkli olmuşlardır. Ek olarak, organik olarak yetiştirilen Camarosa çilek çeşidinin meyvelerinin toplam antioksidan aktivitesi konvansiyonel olarak yetiştirilenleden daha yüksek değerlerde bulunmuştur.

Anahtar Kelimeler: *Fragaria x ananassa Duch., Camarosa, organik yetiştirme tekniği, konvansiyonel yetiştirme tekniği, fiziko-kimyasal özellikler, antioksidan aktiviteleri*

Some Physico-chemical Properties and Antioxidant Capacities of organically and conventionally cultivated strawberry 'Camarosa'

Abstract

The nutritional quality of strawberry fruits of the Camarosa cultivar cultivated in organic and conventional cropping systems was compared based on physico-chemical characterization of the fruits by analyses of fruit weight, fruit width, fruit thickness, fruit length, fruit width/fruit length, total soluble solids (TSS), titratable acidity (AT), TSS/AT and antioxidant capacities. The organic cropping system was statistically more effective in increasing contents of TSS and TSS/TA in the conventional growing system. The organic berries were darker red than conventional berries. In addition to, organically cultivated Camarosa strawberry fruit had more total antioxidant activity than conventionally grown one.

Key Words: *Fragaria x ananassa Duch., Camarosa, organic growing technique, conventional growing technique, physico-chemical properties, antioxidant activities*

Introduction

Although commercial strawberry (*Fragaria*X-*ananassa* Duch.) cultivation started towards the end of 1970 in Turkey, the country is currently one of the biggest strawberry producer in the world with 250,000 tons production annually (FAO, 2009). Recently some vegetable production areas of the Mediterranean region of Turkey have been converted to strawberry farms because of increased rentability of the Turkish strawberry production. The increased strawberry production in Turkey has initiated an increased interest to grow organic strawberries by farmers (Eşitken et al. 2010).

Several studies have shown that consumers have positive attitude towards organic food (Loureiro et al., 2001; Magnusson et al., 2001). Organic foods are associated with no concern, no risks and are seen as healthy (Tõnutare et al. 2009). In the past 10 years, so many review studies of the scientific literature comparing the nutrition of organic and conventional foods have been published. Many of these review studies (Reganold et al. 2010, Balcı & Demirsoy 2008, Polat & Çelik 2008, Abu-Zahra et al. 2006, Brandt & Molgaard 2001, Worthington 2001, Williams 2002, Magkos et al. 2003, Rembialkowska 2007, Benbrook et al. 2008, Lairon 2010) found some evidence of organic food being more nutritious, whereas a few review articles (Dangour et al. 2009, Doran & Parkin 1994) concluded that there were no consistent nutritional differences between organic and conventional foods.

The objective of the current study was to elucidate the effect of organic and conventional cultivation technology on some physico-chemical properties and antioxidant activities of strawberry 'Camarosa' fruits.

Materials and methods

Materials

Strawberry fruits from one-year-old plantations were hand-harvested on 1 June 2010 from organic and conventional orchards in Akcami-Bozyazı-Mersin-Turkey

[2]*Sorumlu Yazar:* nersoy@selcuk.edu.tr

(NL 36º 10′ 01.43″; EL 32º 55′ 44.72″, its elevation is 2174 feet). The organically grown strawberries were obtained from an orchard certified to be Organic Farm (Certificate No: TR-OT-006-GD-379; Grower No: 006-3303-01-1) by EKOTAR (Control and Certification Body, Origin: Turkey, Location: Mersin) in Turkey where brown ferric-phosphoric riched loamy soils dominate. Weather conditions in 2010 were favourable for strawberry growth and fruit ripening. No synthetic herbicides or insecticides were used. Four weeks before planting, aged composted farm manure was applied to the soil. 3 t/da. farm manure, 3 lt/da humic acid, 900 g/da B5A (liquid organic fertilizer) were used in the organic orchard during the growing season. The water management was done by drip irrigation. Weed control was performed by hand weeding. Black plastic mulch (tichness: 0.30 mm) were applied to conserve moisture and help control weeds. The conventionally grown strawberries were fertilised with 8 kg of active nitrogen/da, 4 kg of active phosphorus/da, and 4 kg of active potassium/da in the growing season. The conventional farms also had been managed conventionally for at least 5 years and included the use of inorganic and organic fertilizers, synthetic pesticides, and soil fumigation. Fruit samples were selected for uniform size, colour and absence of mechanical damage. Strawberries were placed in plastic trays and frozen immediately in liquid nitrogen, then stored at -80 °C until analysis.

Methods

Physico-chemical analysis

Sampling: Ten fruits of each treatment were used for all analysis.

Determination of fruit mass: Fruit weight was measured by an electronic balance with an accuracy of 0.01 g. Each measurement was replicated 10 times.

Determination of size: From the samples, 10 fruits were selected at random for determining the physical characteristics. For each fruit, three linear dimensions were measured, that is length, width and thickness, using a digital caliper.

Acidity: Titratable acidity (TA), expressed as % of citric acid, was determined in 10 ml of juice plus 50 ml of distilled water by titration to pH 8.1 with 0.1 N NaOH.

pH: The pH value was measured using a digital pH meter.

Total soluble solids: The total soluble solids (TSS), expressed as %, was determined in the juice of each sample using a portable refractometer at 21 °C.

Ratio (total soluble solids/titratable acidity): The ratio was calculated using the relation between the total soluble solids by titratable acidity.

Colour: Fruit color was evaluated by measuring Hunter L (brightness, 100 = white, 0 = black), a (+, red; -, green) and b (+, yellow; -, blue) parameters by means of a reflectance colorimeter (CR 300, Chromometer, Minolta, Japan). A white tile (No: 21733001) was used to standardize the instrument.

Free radical scavenging effect: The radical scavenging activity against the DPPH radical was evaluated according to the method of Serteser et al. (2008), with some minor modifications. The assay mixture contained 1.5 ml of 0.09 mg/ml DPPH (Sigma Chemical Co., St Louis, MO, USA) in methanol, 1 ml acetate buffer solution (100 mM, pH 5.5). The dilutions between 0.4 and 4 mg/ml were prepared with methanol. Then 3.9 ml DPPH solution prepared with $6x10^{-5}$ M methanol was added to each 0.1 ml dilution and shaken well. The mixture was prepared and incubated for 60 min at room temperature in the dark. The absorbance of the remaining DPPH was determined at 517 nm against a blank. The scavenging activity was expressed as the IC_{50} value (mg/ml). All analyses were carried out duplicate.

Linear regression equations of absorbance against concentrations were determined by measuring the absorbances of seven different concentrations of DPPH ($6x10^{-5}$ M) stock solution:

A (515 nm)=16,264 (C DPPH)-0.0192 (R^2=0,972)

The remaining DPPH concentrations against absorbance values of sample series of different concentrations were calculated and then the remaining DPPH percentage was calculated:

% Remaining DPPH=[DDPH] sample/[DPPH] control

Exponential regression equation was obtained between the rate of the remaining DPPH percentage and the DDPH amount of sample in vitro, and the sample concentrations of plants that decrease the initial DPPH concentrations by 50% (efficient concentration [EC_{50}]). The antiradical activity (AE) was calculated by dividing EC_{50} values into 1.

Fe^{2+} chelating activity: The modified methods of Lim and Murtijaya (2007) were used for determination of the Fe^{2+} chelating activities of samples. One millilitre of extracts with different concentrations between 6 and 45 mg/ml and 3.7 ml deionizer water were mixed. 0.1 ml of 2 mol $FeCl_2$ solution was added and shaken and kept at dark and room temperature for 70 min. Then, 0.2 ml of 5 mM ferrozin was added and shaken again, and the absorbance of the obtained Fe^{2+}-ferrozin complex after 10 min was measured at 562 nm. One millilitre of water was used instead of sample for the control. The equation is as follows (Yen and Duh 1999):

Chelating activity (%)=[1-(absorbance of sample/absorbance of control)]x100

H_2O_2 inhibition effect: The H_2O_2 inhibition effect of spice and plant extracts can be determined by spectrophotometer (Ruch et al. 1989). One millilitre (2.6 and 10 mg/ ml) of sample, 3.4 ml of 0.1 M phosphate buffer (pH 7.4) and 0.6 ml of 43 mM H2O2 were mixed and after 60 min the absorbance of mixture was measured at 230 nm. Control solutions without H_2O_2 were prepared for each sample concentration. To determine the H_2O_2 concentration that was not involved in the reaction, a linear repression equation was used. Phosphate buffer (3.4 ml) was added to 0.6 ml 10.15, 25.43 at 230 nm. Linear equation formulas were obtained by the graphic of Standard curve of absorbance vs. different concentrations of (+)- Catechin

A (230)=0.0132 x C (H_2O_2, mM)+0.0971 (R2=0.985)

(+)-Catechin was used as the reference antioxidant. The equation used is as follows:

H_2O_2 inhibition capacity (%)=[1-(H_2O_2 conc. of sample/H_2O_2 conc. of control)] x100

Statistical analyses

Statistical analysis was done using the JAMP. The experiment was performed in completely randomized blocks design, with three replications. Differences between means were analysed by ANOVA test ($p<0.05$) (Püskülcü & İkiz, 1989).

Results and Discussion

In this study, some physico-chemical properties in terms of fruit weight, fruit width, fruit length, fruit width/length, SSC, pH, titratable acidity, fruit color and antioxidant content in organically and conventionally cultivated strawberry ‘Camarosa’.

Table 1. Some physico-chemical properties of “Camarosa” strawberry fruit

	Camarosa Strawberry Variety		LSD Value
	Organic	**Conventional**	
Fruit weight (g)	16,634 a	18,584 a	2.726
Fruit width(mm)	33,096 b	36,210 a	2.488
Fruit thickness (mm)	28,525 b	31,344 a	2.139
Fruit length (cm)	34,304 a	33,405 a	1.300
Fruit width/length	0,965 b	1,084 a	0.097
SSC (%)	10,200 a	9,433 b	0.093
pH	4.133 a	4.200 a	0.093
TA (%)	0,9187 a	0,932 a	0,033
SSC/TA	11,104 a	10,127 b	0.337
Fruit Colour			
L	31,837 a	28,357 a	4.916
a	33,927 a	29,067 b	2.106
b	12,443 a	5,523 b	3.559

** Values in all the lines not connected by same letter are significantly different (P<0,05).*

According to the Table 1, fruit weight did not show statistically significant difference in growing system (organic or conventional). Fruit width and length values of conventionally grown fruits were higher than organically grown. Total soluble solids and TSS/TA ratio were statistically higher in organically grown fruits. Tõnutare et al. (2009) elucidate the effect of cultivation technology and plant age on fruit composition of strawberries (*Fragaria* x *ananassa* Duch.) ‘Polka’. Strawberry fruits from two- and three year-old plantations were harvested on two conventional and two organic farms in South Estonia in 2008. The results indicate that the strawberries cultivated under organic farming conditions had higher TSS (11.5%), compared to the conventionally grown strawberries (9.5 %). Strawberry TA ranged from 0.92 to 1.07%, and was affected by the cultivation technology. In this study, the results were obtained Tõnutare et al. (2009)'s is consistent with that obtained. Also, Gunnes et al.(2009) reported that investigations showed that the ratio SSC/TA is one of the predictors of the sweetness, sourness and flavour intensity of strawberry fruit (Tõnutare et al. 2009). Tõnutare et al. (2009) indicate that the conventionally -strawberry taste tends to be more acidic and less sweet compared to organically - strawberries. Similar results were obtained in my study. Schöpplein et al. (2002) found that the sensory popularity of strawberry cultivars correlated positively with fruity odour, sweet and aromatic taste, but negatively with watery taste. Abu-Zahra et al. (2006), carried out to determine the effect of four doses (1.5, 3.0, 4.5, and 6.0 kg/m^2) of fermented organic matter comparing with a conventional system on fruit quality of the strawberry cultivar in plastic house conditions during the 2004/2005 season at Abu-Ghannam's farm in Kreimeh in the northern Jordan Valley. They found that fruit titratable acidity (TA) percentage and size the conventionally produced fruits were higher than in the organically produced fruits and the organic treatments tended to produce fruits with higher total soluble solids (TSS) percentage, compared to the control and conventionally produced fruits. Results in my study were in parallel with Abu-Zahra et al. (2006)' s results. Balcı & Demirsoy (2008) carried out to determine yield and fruit quality of cvs. Sweet Charlie and Camarosa in conventional and organic growing systems in 2003-2005. Their study consisted of the following eight treatments: (1) Sweet Charlie using the conventional system mulched with a black plastic (SC-CL-BP), (2) Sweet Charlie using conventional system mulched with a floating sheet (SC-CL-FS), (3) Sweet Charlie using organic system mulched with a black plastic (SC-Or-BP), (4) Sweet Charlie using organic system mulched with a floating sheet (SC-Or-FS), (5) Camarosa using conventional system mulched with a black plastic (CAM-CL-BP), (6) Camarosa using conventional mulched with a floating sheet (CAM-CL-FS), (7) Camarosa using organic system mulched with a black plastic (CAM-Or-BP), (8) Camarosa using organic system mulched with a floating sheet (CAM-Or-FS). They found that the yield was higher in the conventional system than in the organic system in 2004, but no significant difference between the two was found in 2005. Soluble solid and vitamin C contents were higher in fruits grown using the organic system in both years. There was no difference between conventional and organic growing from the point of view of fruit weight and titreable acidity contents. At the end of their research, they recommended the organic strawberry growing because of the beneficial effects on the environment, human health and its higher price in market. The values obtained from Balcı & Demirsoy (2008) were similar my results. Polat & Çelik (2008) investigated that the effects of different organic applications on yield and some quality parameters of Camarosa and Fern strawberry cultivars at Ankara University Faculty of Agriculture Ayaş Horticultural Research Centre during 2002-2004 years. They obtained that the highest yield values from Green manure + farmyard manure+humic acid+foliar fertilizer application (Fern: 177,07 g/plant, Camarosa: 133,9 g/plant). As a result, they suggested the green manure+farmyard manure+humic acid + foliar fertilizer application to organic strawberry growers in Ankara ecological conditions. I support the results of Polat & Çelik (2008) in terms of high quality and high efficiency via organic farming practices.

L, a, b values of fruit color were different depending on the growing system. These values are organically grown fruits, 31.837, 33.927, 12. 443 respectively, and conventionally grown fruits, 28.357, 29.067 and 5.523 respectively. Reganold et al. (2010) determined that fruit firmness and external color intensity (C*) were similar between conventional and organic berries, but organic berries were darker red (significantly lower L* and h_{ab}) than conventional berries. Although their darker red color did not result in a preference for the appearance of organic over conventional 'Lanai' and 'San Juan' strawberries by consumer-sensory panels, these panels did prefer the appearance of organic 'Diamante' berries to their conventional counterparts. I also found that organically grown strawberries were more dark red than the conventionally grown ones.

Table 2. DPPH radical scavenging effects, Fe^{+2} chelating activity (%) and H_2O_2 inhibition activity (%) of fruit extracts

	Camarosa Strawberry Variety		LSD value
	Organic	**Conventional**	
EC_{50}	2,113	2,243	
AE	0,473 a	0,446 b	**0.019**
Fe Chelating Activity (%)	40,987 a	39,993 a	**1.500**
H_2O_2 Inhibition (%)	45,787 a	43,773 b	**0.914**

[a]Efficiency coefficient (EC_{50}) (mg sample/mg DPPH): sample amount needed to decrease the DPPH concentration at the beginning by 50 %, [b]Antiradical activity (AE): 1 / EC_{50}.
** Values in all the lines not connected by same letter are significantly different (P<0,05)*

The DPPH radical scavenging assay is commonly employed to evaluate the ability of antioxidant to scavenge free radicals. The use of the DPPH free radical is advantageous in evaluating antioxidant effectiveness because it is more stable than the hydroxyl and super oxide radicals (Layina-Pathirana et al., 2006). Radical scavenging activity, expressed as EC_{50}, ranged from 2.113 mg g^{-1} to 2.243 mg g^{-1}. The inverse relationship was found between Antiradical activity and EC_{50} values in the fruit grown by different growing system. Because of a lower EC_{50} value indicates greater antioxidant activity. Between two strawberry fruit types have different results. According to Table 2, higher antiradical activity was found organically grown fruit (0.473) than conventionally grown fruit (0.446) Because of different growing system, statistically significant differences were observed in terms of antiradical activity. According to the Table 2, the chelating activity was found to be statistically the same group. H_2O_2 inhibition activity method is used to eliminate $O2\bullet^{-}$, even though the superoxide radical anion ($O2\bullet^{-}$) does not initiate lipid oxidation directly.

Super reactive hydroxyl radical (.OH) may be formed from the Fenton Reaction ($Fe^{+2} + H_2O_2 \rightarrow Fe^{+3} + OH^{-} + .OH$) in the presence of metal ions. For this reason, H_2O_2 inhibition activity is an important method for the determination of antioxidant characteristics (Serteser et al. 2009a, Serteser et al. 2009 b, Serteser et al. 2008). In terms of H_2O_2 inhibition activity of fruit extracts were found statistically different. This value was obtained in organically grown fruit to be 45.787 %; conventionally grown fruit to be 43.773 %. Kovacevic et al. (2008) compared to conventional cultivation to organic cultivation, organic cultivation had effect on slightly higher levels of total phenolics, flavonoids and nonflavonoids in Elsanta and Marmolada strawberry cultivars. In spite of this, conventional strawberries showed higher antioxidant activity. Among fresh samples it is observed that cv. Elsanta contains higher amounts of total phenolics and flavonoids while cv. Marmolada contains higher amounts of nonflavonoids. According to my research, organically grown fruit has high antioxidant content than conventional. Therefore, the results obtained by Kovacevic et al. (2008) were in contrast with this research results. Reganold et al. (2010) investigated to strawberry (*Fragaria* x *ananassa* Duch.) varieties grown on the study farms included 'Diamante' and 'San Juan' in 2004 and 'Diamante', 'San Juan', and 'Lanai' in 2005. Strawberry fruit were collected from each of 13 pairs of organic and conventional strawberry farm fields in June and September 2004 and April, June, and September 2005. Organic strawberries had significantly higher total antioxidant activity (8.5% more), ascorbic acid (9.7% more), and total phenolics (10.5% more) than conventional berries, but significantly less phosphorus (13.6% less) and potassium (9.1% less). Specific polyphenols, such as quercetin and ellagic acid, showed mixed or no differences. Results in my study were in parallel with Reganold et al. (2010)' s results. Jin et al. (2011) investigated the effects of cultural systems and storage temperatures on antioxidant enzyme activities and nonenzyme antioxidant components in two cultivars ('Earliglow' and 'Allstar') of strawberries. They found that strawberries grown from organic culture exhibited generally higher activities in antioxidant enzymes. Moreover, the organic culture also produced fruits with higher level of antioxidant contents. In conclusion, they expressed that strawberries produced from organic culture contained significantly higher antioxidant capacities and flavonoid contents than those produced from conventional culture. Jin et al. (2011) emphasized that strawberries grown in organic culture had significantly higher ORAC, _OH and DPPH radicals scavenging capacities than those in conventional culture. Similar results were found in this research.

Conclusions

In conclusion, the data presented in this paper indicated that the cultural systems significantly affect the some physico-chemical properties and antioxidant capacity of strawberries. Strawberries produced from organic culture contained significantly higher level of total soluble solids and antioxidant capacities than those produced from conventional culture. Because of these findings organically grown strawberry fruits can be more delicious and healty.

References

Abu-Zahra T. R., Al-Ismail K., Shatat F., 2006. Effect of organic and conventional systems on fruit quality of strawberry (*Fragaria* x *ananassa* Duch.) grown under plastic house conditions in the Jordan valley. Proceedings of the 1st International Symposium on Fresh Food Quality Standards: Better Food by Quality and Assurance. Acta Horticulturae, 741: 159-171.

Balcı G. and Demirsoy H., 2008. Effect of Organic and Conventional Growing Systems with Different Mulching on Yield and Fruit Quality in Strawberry cvs. Sweet Charlie and Camarosa, *Biological Agriculture & Horticulture*, 26(2):121-129.

Benbrook C., Zhao X., Ya´n˜ez J., Davies N., Andrews P., 2008. New Evidence Confirms the Nutritional Superiority of Plant-Based Organic Foods. Boulder: The Organic Center, Available: www.organiccenter.org. Accessed on 2009 Oct 29.

Brandt K., Molgaard J. P., 2001. Organic agriculture: does it enhance or reduce the nutritional value of plant foods?, *J. Sci. Food Agr.*, 81: 924–931.

Dangour A. D., Dodhia S. K., Hayter A., Allen E., Lock K., 2009. Nutrional quality of organic foods: a systematic review, *Am. J. Clin. Nutr.*, 90: 680–685.

Doran J. W., Parkin T. B., 1994. Defining and assessing soil quality, *Soil Sci. Soc. Stet. Am.* pp. 3-21.

Eşitken A., Yıldız H. E., Ercişli S., Dönmez M. F., Turan M., Güneş A., 2010. Effects of plant growth promoting bacteria (PGPB) on yield, growth and nutrient contents of organically grown strawberry, *Scientia Horticulturae*, 124:62-66.

FAO, 2009. Statistical Database, http://www.fao.org

Jin P., Wang S. Y., Wanga C. Y., Zheng Y., 2011. Effect of cultural system and storage temperature on antioxidant capacity and phenolic compounds in strawberries, *Food Chemistry*,124:262-270.

Kovacevic D. B., Levaj B., Dragovic-Uzelac V., 2008. The Effect of Cultivar and Cultivation on Antioxidant Activity in Fresh and Processed Strawberries. Proceedings of the 2008 Joint Centrala European Congress, vol:2, Pages: 389-395.

Lairon D., 2010. Nutritional quality and safety of organic food, *A review. Agron. Sustain Dev* , 30: 33–41.

Layina-Pathirana C. M., Shahidi F., Alasalvar C., 2006. Antioxidant activity of cherry laurel fruit (*Laurocerasus officinalis* Roem.) and its concentrated juice, *Food Chem*., 99:121-128.

Lim Y. T. and Murtijaya J., 2007. Antioxidant properties of *Phyllanthus amarus* extracts as affected by different drying methods, *Lebensmittel Wissenschaft und Technologie,* 40:1664-1669.

Loureiro M. L., McCluskey J. J., Mittelhammer R. C., 2001. Assessing consumer preferences for organic, eco-labelled, and regular apples, *Journal of Agricultural and Resource Economics*, 26(2):404–416.

Magkos F., Arvaniti F., Zampelas A., 2003. Organic food: Nutritious food or food for thought? A review of the evidence, *Int. J. Food Sci. Nutr*., 54: 357–371.

Magnusson M. K., Arvola A., Koivisto Hursti U. K., Åberg L., Sjöden P. O., 2001. Attitudes towards organic foods among Swedish consumers, *British Food Journal*, 103:209-226.

Polat M. and Celik M., 2008. Organic Strawberry Growing in Ankara (Ayas), *Journal of Agricultural Sciences*, 14(3): 203-209.

Püskülcü H. and İkiz F., 1989. Introduction to Statistic. Bilgehan Press, p333, Bornova, Izmir, Turkey.

Reganold J. P., Andrews P. K., Reeve J. R., Carpenter-Boggs L., Schadt C. W., Alldredge J. R., Ross C. F., Davies N. M., Zhou J. Z., 2010. Fruit and Soil Quality of Organic and Conventional Strawberry Agroecosystems, *Plos One*, 5(9), Article Number: e12346.

Rembialkowska E., 2007. Quality of plant products from organic agriculture, *J. Sci. Food Agric.*, 87: 2757–2762.

Ruch R. J., Cheng S. J., Klaunig J. E., 1989. Prevention of cytotoxicity and inhibition of intracellular communication by antioxidant catechins isolated from Chinese green tea, *Carcinogenesis*, 10:1003-1008.

Schöpplein E., Krüger E., Rechner A., Hoberg E., 2002. Analytical and sensory qualities of strawberry cultivars, *Acta Hort.,* 567:805-808.

Serteser A., Kargıoğlu M., Gök V., Bağcı Y., Özcan M. M., Arslan D., 2008. Determination of antioxidant effects of some plant species wild growing in Turkey, *International Journal of Food Sciences and Nutrition*, 1-9, First article.

Serteser A., Kargıoğlu M., Gök V., Bağcı Y., Özcan M. M., Arslan D., 2009a. Antioxidant properties of some plants growing wild in Turkey, *Grasas Y Aceites*, 60(2):147-154.

Serteser A., Kargıoğlu M., Gök V., Bağcı Y., Özcan M. M., 2009b. Antioxidant Activity of *Ribes multiflorum* Kit.ex Roem. & Schult (blackcurrant) Extract, *Jeobp*, 12(5):635-639.

Tõnutare T., Moor U., Mölder K., Põldma P., 2009. Fruit composition of organically and conventionally cultivated strawberry 'Polka', *Agronomy Research 7* (Special issue II), 755-760.

Williams C. M., 2002. Nutritional quality of organic food: shades of grey or shades of green?, *Proc. Nutrition Soc.,* 61: 19-24.

Worthington V., 2001. Nutritional quality of organic versus conventional fruits, vegetables, and grains, *J. Altern. Complem. Med*., 7:161-173.

Yen G. C., Wu J. Y., 1999. Antioxidant and radical scavenging properties of extracts from Ganoderma tsugae, *Food Chem*., 65:375-379.