The Journal of Animal & Plant Sciences, 28(2): 2018, Page: 533-538
ISSN: 1018-7081

DETERMINATION OF BIOACTIVE COMPOSITION OF SOME PEACH CULTIVARS

Ferhad Muradoğlu[1] and Onur Küçük[2]

[1]Department of Horticulture, Faculty of Agriculture and Natural Sciences, Abant İzzet Baysal University, Bolu, Turkey
[2]TAT food Industry company Karacabey/Bursa, Turkey.
Corresponding author's e-mail: muradogluf@ibu.edu.tr

ABSTRACT

Peach fruit, with high phenolic components, are a major source of antioxidant which play a vital role for human health. Phenolic compounds, thought to reduce the cancer disease, cardiovascular and coroner heart disease. Therefore we aimed to seek the bioactive composition of peach fruit of one peach genotypes and ten commercial cultivar which are commonly grown in Turkey. The organic acids contents, sugars, vitamin C and phenolic compounds in fruits of these cultivars were studied. According to results, 4 sugars, 5 organic acids, 11 phenolic compounds and Vitamin C were identified using HPLC. The results depicted significant differences in the composition of peach cultivars. Malic and citric acid were major organic acids and Sucrose was found as the most dominant sugar in all cultivars. Vitamin C contents of the cultivars varied between 149.62 and 347.02 mg/l. Rutine, catechin, and caffeic acid were the main phenolic compounds. Our data suggested that peach fruits have potential as good dietary source of sugar, organic acid and phenolic composition as a major source of antioxidant.

Key words: Organic acid, peach, phenolic, sugar, vitamin C.

INTRODUCTION

Peaches are important economic fruit that can be used both fresh and processed and it has a significant place in human nutrition. Peach fruits harbored many health benefits for human beings as they are rich source of antioxidant component because they are good sources of health benefits components. Many bioactive components such as sugars, phenolic compounds, carotenoids, organic acids and antioxidants like vitamins C and E as natural components of many fruits and vegetables, play important roles in maintaining fruit quality and determining their nutritive and medicinal value (Ashoor and Knox, 1984: Muradoğlu *et al.* 2011). Peach has been reported to have bioactive components such as sugars, antioxidant (Reig, 2013), organic acids (Bureau *et al.* 2013), carotenoids and flavonoids, vitamins and minerals (Versari *et al*. 2002; Gil *et al.* 2002; Colaric *et al.* 2004; Dragoudi and Tsipouridis 2007; Orazam *et al.* 2011). The phenolic compounds are known to be strong antioxidants (Chang *et al*. 2000) which are known to have protective role against cancer and aging (Halliwell and Gutteridge, 1989) atherosclerosis and coronary heart disease (Steinberg *et al*. 1989), body tissues against oxidative stress with ascorbic acid (Suzuki *et al.* 2005), high cholesterol, obesity and vision problem (Halliwell and Gutteridge, 1989; Dillard and German, 2000; Sloan, 2008). Plant tissues consist of many different antioxidant components. Pandey and Rizy (2009), mentioned that around 8,000 polyphenolic compounds were reported in different plants. All plant phenolic compounds arise from a common intermediate, phenylalanine, or a close precursor, shikimic acid. Nutritional, chemical composition and antioxidant activity of fruits was effected by many factors such as maturity, postharvest storage, fruits processed, climatic conditions, cultivars, rootstock, geographic location, soil types and properties (Award *et al.* 2000; Tomas-Barberan *et al.* 2001; Font i Forcada, *et al.* 2014). A research on the changes of individual sugars, organic acids and phenolic compounds of peach fruit grown in ecological conductions of Turkey previously have not been reported. However, limited study concerning physical properties and biochemical composition of peach have been performed up to now. This study was aimed to determine individual sugars, organic acids, phenolics and ascorbic acid content in important commercial varieties of peaches grown in Marmara region (Bursa province) of Turkey. The data generated in the present study will contribute to their biochemical and antioxidant capacity and promote their consuming, production and use for different products of peach fruit.

MATERIALS AND METHODS

Fruit materials: The study was conducted on 8 years old in a peach orchard at Mustafakemalpaşa, Bursa province. In the experiment 10 commercial cultivars (Cardinal, Cresthaven, Dixired, Early Red, Glohaven, R10, Redhaven, Royal, Şentürk, Takunya) and one peach genotype (wild peach) were used as plant material. Agronomic and plant protection measures were kept normal for the entire experiment for all peach cultivars. At harvest time, samples were randomly taken from four

different trees in same garden. Then the samples were placed into polyethylene bags and transported to laboratory. Fruit samples of each cultivar were first divided into part and then fruit juice was obtained from edible parts through a juice extractor and samples were kept at -20 °C until extraction.

Determination of sugar contents: Sugar analyses were performed according to Melgarejo *et al.* (2000) with some modifications. Briefly, 5 ml of peach juice were centrifuged at 12000 rpm; 2 min.; 4°C. Then the supernatant was filtered with SEP-PAK C_{18} cartridges and 20 µl of extract injected into HPLC with µbondapak-NH_2 column and refractive index (RI) detector. The mobile phase was used 85% acetonitrile.

Determination of organic acids: The analysis of organic acids was preformed according to the modified method as described by Bevilacqua and Califano, (1989). Firstly, 5 ml peach juice was placed inside the centrifuging tube and 10 ml 0.009 N H_2SO_4 was added to centrifuging tube, then the sample was homogenized using a homogenizer (Heidolph Silent Crusher M, Germany) and tubes prepared in this fashion were shaken for 1 h using a shaker (Heidolph Unimax 1010, Germany). After the samples were shaken, the prepared was centrifuged (15000 rpm) for 15 minutes at 4 °C. The supernatant was first filtered through 0.45 µm Millipore filter (Millipore Millex-HV Hydrophilic PVDF, Millipore, USA) and second filtered with SEP-PAK C_{18} cartridges, then the filtrated was collected in a vial. The extract in the vials were injected into HPLC (Agilent HPLC 1100 series G 1322 A, Germany) equipment with DAD (Agilent, USA) detector and Aminex HPX - 87 H, 300 mm x 7.8 mm clone (Bio-Rad Laboratories, Richmond, CA, USA) with 0.009 N H_2SO_4 used as a mobile phase.

Determination of phenolic compounds: For the phenolic acid analysis, 5 ml peach juice was centrifuged (1500 rpm) for 15 min and the supernatant was filtered through 0.45 µm membrane filter and the extracts were injected into HPLC, (Agilent 1100, USA) with equipment DAD (Agilent, USA) detector and ODS clone (250*4.6 mm, 4µm. HiChrom, USA). Methanol-Acetic acid and Water; 10:2:88 (solvent A), and 90:2:8 (solvent B) was used as mobile phase with 1ml/minute flow rate and 254-280 nm wavelength (Rodriguez-Delgado *et al.* 2001).

Statistical analysis: In this study, statistical analysis was conducted using the software SPSS 22.0. Separation of the means was determined according to Duncan's multiple range test implemented in SPSS 22.0 ($p \leq 0.05$).

RESULTS AND DISCUSSION

Sugar contents of peach fruits: Sugar accumulation especially the concentration of high level of fructose, is a very important physiological process that determines the dessert fruit quality. The composition of the peach cultivars is investigated in the present in Table 1. The most abundant sugars in peach cultivars were sucrose, glucose, fructose and maltose. Maltose content was detected on trace amount in all cultivars. Sucrose level was found as a dominant sugar in all cultivars. The content of sucrose varied from 29.65 g/100g (Glohaven) to 73.42 g/100g (R10). The second important sugar in peach cultivars was found as fructose that ranged from 6.31 g/100g (Early Red) to 14.11 g/100g (Peach seedling). Glucose contents varied between 6.32 g/100g (Royal Glory) to 12.84 g/100g (Redhaven). The maltose contents was determined the lowest the sugar among all cultivars varied from 1.09 g/100g (Cardinal) to 2.87 g/100g (R10). The results of the present study confirmed the earlier reports describing that sucrose is the major sugar in peach fruit, followed by fructose and glucose (Orazem *et al*. 2011; Font i Forcada, *et al.* 2014). Reig *et al.* (2013) investigated that sugar contents of 106 commercial peach cultivars grown in Spain and reported that peach cultivars harbored 67.35% sucrose , 10.26% glucose and 10.78% fructose. Our study showed 56.42-80.70% sucrose, 8.80-22.68% fructose, %7.52-20.17 glucose and %1.35- 3.15 maltose contents in the studied peach cultivars. In the study, fructose and glucose were found in approximately equivalent amount in several cultivars. The results of our study are in agreement with Genard and Souty, (1996) who reported that sucrose is the major sugar in peach. Also, fructose and glucose are present in equal concentration. The authors also reported that glucose and fructose can be inter-converted between each other, thus there could be reduction or enhancement in the concentration of both sugars

Organic acids contents of peach fruits: Organic acids are the main elements determining the taste of fruit and they give fruits tartness and slow bacterial spoilage. In peach cultivars, five organic acids were identified: malic acid, tartaric acid, citric acid, succinic acid and fumaric acid (Table 2). Malic and citric acid was found the most abundant organic acids in all cultivars, followed by succinic acid, tartaric acid and trace concentrations of fumaric acid. According to Versari *et al.* (2002) malic, citric, quinic and succinic acid were the plenty organic acid in peach juice of Redhaven, Suncrest and Maria Marta cultivars grown in Italy. In this study, Cardinal, Dixired, Early Red, Royal Glory and Şentürk cultivars had high malic acid contents with low citric acid contents, while Cresthaven, Glohaven, R10, Redhaven, Takunya and Peach seedling showed high citric acid contents. The contents level of malic acid ranged from 1.04 (Cresthaven) to 2.98 g/l (Şentürk). Takunya and R10 cultivars depicted highest citric acid concentration (3.08 mg/l) while the lowest citric acid also was found in 1.14 mg/l (Cardinal). Consist with these results Chapman and

Horvat (1990), reported that citric acid level decreases with the increase level of malic acid depending on maturity. Organic acid contents reported in the literature are 3.6-5.4 g kg^{-1} for malic, 2.5-3.7 g kg^{-1} for citric, 0.1-1.4 g kg^{-1} quinic and 0.3-0.4 g kg^{-1} succinic acid for three peach cultivars grown in Italy (Versari *et al.* 2002). Colaric *et al.* (2004) found that malic acid, citric acid, shikimic acid and fumaric acid varied between 3.82 and 7.09 g/kg, 1.71 and 5.64 g/kg, 1.27 and 3.27 mg/kg and 1.56 and 5.15 mg/kg respectively in peach cultivars.

Phenolic contents of peach fruits: Phenolic compounds are known to have strong antioxidant activity, increase the shelf life of food and inhibit the growth of pathogenic microorganisms, preventing the major chronic disease and effect the taste and color formation of fruits (Gil *et al.* 2002; Henriquez *et al.* 2010). The major phenolic compounds described in peach fruits are rutin, catechin, caffeic, chlorogenic, phlorodizin, procatechuic, siringic, quercetin, p-coumaric, gallic and ferrulic (Table 3, 4). In this study, rutin (20.55-192.01 mg/l) was found the most abundant phenolic compound in peach cultivars. Rutin contents was followed by catechin (11.21-101.85 mg/l) and caffeic (21.51-80.70 mg/l) content, unlike ferrulic (5.38-11.55 mg/l) content showed low phenolic content in all cultivars. The highest Rutin, chlorogenic, procatechuic and gallic contents were determined in Cresthaven among all in cultivars. Quercetin is important individual compound in peach varieties with the highest content determined in Redhaven cultivar. The main individual phenolic components were the highest caffeic, p-coumaric, and ferrulic contents in peach was determined peach seedling genotypes. Also the highest catechin, siringic and phlorodizin contents was determined in Takunya, Dixired and Glohaven cultivars respectively. According to Versari *et al.* (2002) the highest phenolic compound was catechin (20-34 mg kg^{-1}) followed by chlorogenic acid (2.9-13 mg kg^{-1}) and caffeic acid (0.5-1.8 mg kg^{-1}) in Redhaven, Suncrest and Maria Marta peach cultivars. Chang *et al.* (2000) reported both cholorogenic and neochlorogenic acid however the chlorogenic acid content was dominant. Their concentrations ranged from 23.9-470.5 mg/kg in chlorogenic and from 11.50-80.9 mg/kg in neochlorogenic acid in eight clingstone peach cultivars. Montevecchi *et al.* (2012) determined that catechin and chlorogenic acid in pulp and peel of white flesh peach ranged as 1160-2147 mg/kg in pulp and 1342-4578 in peel. Above mentioned studies showed that chlorogenic and catechin acid were the main phenolic compound in peach cultivars. Our results shows similarity with the above studies, but some results were determined higher or lower. These variabilities can be effect of genetic characterization, climatic conditions or extractions method (peel, flesh or whole fruit). Because, peach peel contain two or three times the concentration of total phenolic compounds compared to flesh and whole extracts.

Vitamin C contents of peach fruits: Vitamin C is one of the most important nutritional quality factor in fruits and vegetables. Besides it is a powerful reducing agent that prevent the formation of pigment and reduces tocopherol radicals. As seen from table 5, Vitamin C contents varied between from 149.62 mg/l to 347.02 mg/l, with Redhaven indicating highest (347.02 mg/l) contents followed by Cardinal (345.39 mg/l), Cresthaven (335.48 mg/l) and Early Red (316.17 mg/l). Also the lowest content was determined in R10 (149.62 mg/l) cultivars. Similar results were also reported in the peel and flesh tissue of peach cultivars by Gil *et al.* (2002) who reported that Vitamin C contents of 48-202 mg/kg in white-flesh and 31-181 mg/kg yellow-flesh peach cultivars from California region. By Font i Forcada *et al.* (2014) local Spanish and foreign peach cultivars as between 27.8 and 28.0 mg/100g, by Drogoudi and Tsipouridis, (2007) reported Vitamin C among peach cultivars between 5.3 and 7.3 mg/$100g^{-1}$. Montevecchi *et al*. (2012) determined vitamin C between 551 and 1518 mg/kg among 4 flesh peach cultivars grown at three different altitudes. Compared to above studies, results of vitamin C were found close in this study. According to Weston and Barth, (1997) and Lee and Kader, (2000) climatic conditions, cultivar, cultural practices, early and late harvest and rootstock has been a significant effect on the vitamin C contents of fruit and vegetables.

Biochemical compositions are significant for quality and evaluation the characterization of peach cultivars in respect of their nutritional value and potential use for different products. In the present study, organic acid, sugar, phenolic compounds and vitamin C contents of peach cultivars were determined. Data obtained from this study determined that Peach fruits have a respectable good source of nutrition components (Sugar organic acid) and antioxidant (phenolic component, Vitamin C) properties. Significant difference were found in biochemical composition of all peach cultivars. These variation might be attributed by several factor such as growth conditions, altitude, cultural and climatic conditions, harvest and genetic variation which major influences in their chemical composition and antioxidant activity of fruit. This study contributed to determine of biochemical profiles of some peach cultivars that could be interest of the consumers and the results generated in the present work could be as references for further studies in peach.

Table 1. Sugars contents in fruits of peach cultivars (g/100g).

Cultivars	Fructose	Glucose	Sucrose	Maltose
Cardinal	9.89^{e}	8.83^{cd}	61.29^{d}	1.09^{e}
Cresthaven	7.77^{g}	8.32^{cd}	54.34^{f}	2.08^{c}
Peach seedling	14.11^{a}	8.52^{cd}	50.42^{g}	2.08^{c}
Dixired	9.33^{f}	8.97^{cd}	64.67^{c}	2.59^{ab}
Early Red	6.31^{i}	6.55^{e}	38.61^{h}	1.25^{de}
Glohaven	11.12^{d}	10.65^{b}	29.65^{i}	1.13^{de}
R10	9.89^{e}	8.25^{cd}	73.42^{a}	2.87^{a}
Redhaven	13.36^{b}	12.84^{a}	38.27^{h}	1.52^{d}
Royal Glory	7.40^{h}	6.32^{e}	67.87^{b}	2.50^{ab}
Şentürk	7.37^{h}	8.04^{d}	57.71^{e}	2.38^{bc}
Takunya	12.41^{c}	9.32^{c}	31.67^{i}	1.33^{de}

*. Different letters in lines indicate significantly different values at $p \leq 0.05$.

Table 2. Organic acid contents in fruits of peach cultivars.

Cultivars	Malic (g/l)	Citric (g/l)	Succinic (g/l)	Tartaric (g/l)	Fumaric (mg/l)
Cardinal	2.42^{bc}	1.14^{c}	2.33^{ab}	0.63^{b}	13.30^{d}
Cresthaven	1.04^{e}	2.66^{ab}	0.99^{d}	0.86^{a}	3.82^{g}
Peach seedling	1.93^{cd}	2.34^{b}	2.01^{abc}	0.10^{g}	11.09^{e}
Dixired	1.69^{d}	1.33^{c}	1.65^{bcd}	0.60^{bc}	17.74^{c}
EarlyRed	1.92^{cd}	1.62^{c}	1.64^{bcd}	0.52^{d}	18.65^{c}
Glohaven	1.78^{d}	2.90^{a}	1.61^{bcd}	0.31^{e}	21.45^{b}
R10	1.42^{de}	3.08^{a}	1.28^{cd}	0.56^{cd}	10.04^{e}
Redhaven	2.58^{ab}	2.63^{ab}	2.33^{ab}	0.24^{f}	21.06^{b}
Royal Glory	2.43^{bc}	1.65^{c}	2.58^{a}	0.60^{bc}	33.71^{a}
Şentürk	2.98^{a}	2.56^{ab}	1.26^{cd}	0.27^{ef}	11.53^{de}
Takunya	1.72^{d}	3.08^{a}	1.07^{d}	0.58^{bc}	7.53^{f}

*. Different letters in lines indicate significantly different values at $p \leq 0.05$.

Table 3. Phenolic compounds in fruits of peach cultivars (mg/l).

Cultivars	Rutin	Catechin	Caffeic	Chlorogenic	Phlorodizin	Procatechuic
Cardinal	42.58^{e}	15.82^{g}	21.51^{f}	18.13^{g}	5.41^{g}	13.47^{e}
Cresthaven	192.01^{a}	36.16^{e}	60.43^{c}	56.16^{a}	42.39^{b}	57.76^{a}
Peach seedling	35.40^{f}	40.65^{d}	80.70^{a}	49.66^{b}	11.94^{e}	13.26^{ef}
Dixired	52.96^{d}	25.27^{f}	38.56^{d}	14.56^{h}	6.48^{g}	15.00^{e}
EarlyRed	20.55^{i}	54.55^{b}	22.72^{f}	22.33^{f}	40.57^{c}	18.24^{d}
Glohaven	151.53^{b}	56.07^{b}	21.88^{f}	28.48^{d}	69.49^{a}	23.32^{c}
Redhaven	22.60^{h}	11.21^{h}	21..70^{f}	33.03^{c}	10.92^{e}	37.92^{b}
Royal Glory	29.82^{g}	47.35^{c}	33.40^{e}	22.84^{f}	8.20^{f}	8.98^{g}
Şentürk	22.93^{h}	46.87^{c}	59.11^{c}	25.47^{e}	6.28^{g}	11.50^{f}
Takunya	107.97^{c}	101.85^{a}	69.66^{b}	50.01^{b}	33.57^{d}	22.74^{c}

*. Different letters in lines indicate significantly different values at $p \leq 0.05$.

Table 4. Phenolic compounds in fruits of peach cultivars (mg/l).

Cultivars	Siringic	Quercetin	P-Cumaric	Gallic	Ferrulic acid
Cardinal	30.09^{d}	25.68^{e}	16.32^{d}	5.17^{cd}	7.84^{c}
Cresthaven	20.37^{f}	40.50^{b}	11.97^{e}	12.16^{a}	7.92^{c}
Peach seedling	29.97^{d}	19.02^{g}	23.13^{a}	5.62^{cd}	11.55^{a}
Dixired	56.35^{a}	28.56^{d}	16.23^{d}	5.74^{cd}	5.65^{d}
EarlyRed	31.93^{d}	23.41^{f}	16.02^{d}	6.45^{c}	7.05^{c}
Glohaven	35.37^{c}	21.66^{f}	17.40^{c}	8.97^{b}	5.46^{d}

Redhaven	7.93^{g}	43.02^{a}	15.75^{d}	4.53^{d}	5.38^{d}
Royal Glory	31.03^{d}	31.16^{c}	16.48^{d}	4.70^{d}	7.56^{c}
Şentürk	38.25^{b}	22.74^{f}	17.64^{c}	5.40^{cd}	9.00^{b}
Takunya	23.95^{e}	27.27^{de}	18.87^{b}	9.13^{b}	7.69^{c}

*. Different letters in lines indicate significantly different values at $p \leq 0.05$.

Table 5. Vitamin C contents in fruits of peach cultivars (mg/l).

Cultivars	Vitamin C
Cardinal	345.39^{b}
Cresthaven	335.48^{c}
Peach seedling r	240.33^{e}
Dixired	230.20^{f}
Early Red	316.17^{d}
Glohaven	241.15^{e}
R10	149.62^{i}
Redhaven	347.02^{a}
Royal Glory	182.45^{i}
Şentürk	206.15^{h}
Takunya	222.43^{g}

*. Different letters in lines indicate significantly different values at $p \leq 0.05$.

Acknowledgments: This manuscript consist a part of M.sc thesis of Onur KÜÇÜK and the authors express their gratitude to Yuzuncu Yıl Universty, Scientific Research Projects Unit for their financial support. (Project No. 2013-FBE-YL039).

REFERENCES

Ashoor, S.H. and J.M. Knox (1984). Determination of organic acids in food by high-performance liquid chromatography. J. Chromatogr. 299:288-292.

Award, M.A., A. de Jager, and L.M. Van Westing (2000). Flavonoid and chlorogenic acid levels in apple fruit characterization of variation. Sci. Hortic. 83:249-263.

Bevilacqua, A.E. and A.N. Califano (1989). Determination of organic acids in dairy prod-ucts by high performance liquid chromatography. J. Food Sci. 54:1076–1079.

Bureau, S., B. Quilot-Turion., B. Signoret., C. Renaud., M. Maucourt., D. Bancel, and M.G.C. Renard (2013). Determination of the composition in sugars and organic acid in peach using mid infrared spectroscopy: comparison of prediction results according to data set and different references methods. Anal Chem. 85:11312-11318.

Chang, S., C. Tan., N.F. Frankel, and D.M. Barett (2000). Low-density lipoprotein antioxidant activitiy of phenoloic compounds and polyphenol oxidase activity in selected clingstone peach cultivars. J. Agric. Food Chem. 48:147-151.

Chapman, G.W. and R.J. Horvat (1990). Changes in nonvolatile acids, sugars, pectin and sugar composition of pectin during peach (Cv. Monroe) maturation. J. Agric. Food Chem. 38:383-387.

Colarıc, M., F. Stampar, and M, Hudına (2004). Contents of sugars and organic acids in the cultivars of peach (Prunus persica L.) and nectarine (Prunus persica var. nucipersica scheneid). Acta Agric Slov. 83:53-61.

Dillard, C.J. and J.B. German (2000). Phytochemicals: Nutraceuticals and human healthy. J. Sci. Food Agric. 80:1744-1756.

Drogoudi, P.D. and C. Tsipouridis (2007). Effect of cultivar and rootstock on the antioxidant content and physical characters of clingstone peach. Sci. Hortic. 115:34-39.

Font i Forcada, C., T.M. Gradziel., Y. Gogorcena, and M.A. Moreno (2014). Phenotypic diversty among local Spanish and foreign peach and nectarine (Prunus persica L. Batsch) accessions. Euphytica 197:261-277.

Genard, M. and M. Souty (1996). Modeling the peach sugar contents in relation to fruit growth. J. Amer. Soc. Hort. Sci. 121(6):1122-1131.

Gil, MI., FA. Tomas-Barberan., B, Hess-Pierce, and AA. Kader (2002). Antioxidant capacities, phenolic compounds, carotenoids, and vitamin C contents of nectarin, peach and plum cultivars from California. J. Agric. Food Chem. 50:4976-4982.

Halliwell, B. and J.M. Gutteridge (1989). Free radicals, aging and disease. In free radicals in biology and medicine 2nd ed. Oxford University Press:New York.

Henriquez, C., S. Almonacid., I, Chifelle., T, Valenzuela., M, Araya., L, Cabezas., R, Simpson, and H. Speisky (2010). Determination on antioxidant capacity, total phenolic content and mineral composition of different fruit disuse of five apple cultivars grown in Chile. Chil. J. Agric. Res. 70(4):523-536.

Lee, S.K. and A.A. Kader (2000). Preharvest and postharvest factors influencing vitamin c content of horticultural crops. Postharvest Boil. Tec. 20:207-220.

Melgarejo, P., D.M. Salazar, and F. Artes (2000). Organic acids and sugars composition of harvested pomegranate fruits. Eur. Food Res. Technol. 211:185–190.

Montevechi, G., G. Vasile Simone., F, Masino., C. Bignami, and A. Antonelli (2012). Physical and chemical characterization of Pescabivona, a Sicilian white flesh peach cultivars [Prunus persica (L.) Batsch]. Food Res. İnt. 45:123-131

Muradoğlu, F., M. Gündoğdu, and H. Yılmaz (2011). Determination of antioxidant capacities and chemical characteristics of pomegranate (Punıca granatum L.) grown in the Siirt district. Ital. J. Food Sci. 23:360-366.

Orazem, P., F. Stamper, and M. Hudina (2011). Quality analysis of "Redhaven" peach fruit grafted on 11 rootstocks of different genetic origin in a replant soil. Food Chem. 124:1691-1698.

Pandey, KB., SI. Rizy (2009). Plant polyphenols as dietary antioxidants in human health and disease. Oxid Med Cell Longey 2(5):270-278.

Reig, G., I. Iglesias., F. Gatius, and S. Alegre (2013). Antioxidant capacity, quality and anthocyanin and nutrient contents of several peach cultivars [Prunus persica (L.) Batsch] grown in Spain. J. Agric. Food Chem. 61:6344-6357.

Rodriguez-Delgado, M.A. S. Malovana., J.P. Perez., T. Borges, and F.J. Garcia-Montelongo (2001). Separation of phenolic compounds by high-performance liquid chromatography with absorbance and fluorimetric detection. J. Chromatogr. 912, 249–257.

Sloan, E. (2008). Top 10 functional food trends. Food Technol. 04.08:25-44.

Steinberg, D., S. Parthasarathy., T.E. Carew., J.C. Khoo, and J.L. Witztum (1989). Beyond cholesterol. Modification of low-density lipoproteins that increase its atherogenicity. N. Eng. J. Med. 320:915-924.

Suzuki, T., S. Someya., F, Hu, and M. Tanokura (2005). Comperative study of catechin compositions in five Japanese persimmons (Diospyros kaki). Food Chem. 93:149-152.

Tomas-Barberan, F. A., M. Gill., P. Cremin., A. L. Waterhouse., B. Hess-Pierce, and A. A. Kader (2001). HPLC-DAD-ESIMS analysis of phenolic compounds in nectarine, peach and plums. J. Agric. Food Chem. 49(10):4748-4760.

Versari, A., M. Castellari., G.P. Parpinello., C. Riponni, and S. Galassi (2002). Characterization of peach juices obtained from cultivars Redhaven, Suncrest and Maria Marta grown in Italy. Food Chem. 76:181-185.

Weston, L.A. and M. Barth (1997). Preharvest factor affecting postharvest quality of vegetables. Hort. Sciences. 32:812-816.