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Antioxidant Capacity, Total Phenolics and Some Chemical Properties of Semi-Matured Apricot Cultivars Grown in Malatya, Turkey

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Abstract: In this study, antioxidant capacity and total phenolic content of 22 apricot cultivars which are produced in Malatya region were investigated. Antioxidant capacity was determined by 2-2-Diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging activity as IC_{50} value and total phenolic content (TPC) was measured using Folin-Ciocalteu method, expressed as mg GAE/ mg 100 g fresh weight. IC_{50} values and total phenolic contents of apricots ranged from 9.60 to 59.47 and from 58.4 to 309.5 mg GAE / 100 g fresh weight respectively. Reasonably well correlation was observed with IC_{50} and TPC (R^2= 0.777, p< 0.01). Water content,°Brix, pH, titratable acidity, total soluble solid/titratable acidity (TSS/TAc), color parameters (*L**, *h* and *C** values) of apricots were also determined.

Key words: Antioxidant capacity · IC_{50} value · Total phenolic content · Apricot varieties

INTRODUCTION

Oxygen-depend organisms are always at risk of free-radical damage. Free radicals from while oxygen metabolizes and may cause cellular damage, cancer, cardiovascular diseases, aging, cataract and some metabolic disorders such as erythropoietic protoporphyria, β- thalassemia, sickle cell anemia, favism hemolysis. To avoid such deleterious effects, biological systems have developed very efficient protective mechanisms; enzyme systems and natural/diet derived antioxidant nutrients. Enzyme systems are primary defense mechanisms against the free radical mediated cell damage and antioxidant nutrients are the secondary defense mechanisms and enzymatic defenses are supplemented by biochemical defenses. Vitamin E, vitamin C, vitamin A, β- carotene, antioxidant minerals (such as zinc, copper, iron, selenium) and phenolic compounds are some of the natural and diet derived antioxidant nutrients [1].

Fruits and vegetables are rich source of phytochemicals such as vitamins, minerals and phenolic compounds. Phenolic compounds are more important with antioxidant properties rather vitamin C, E and β- carotene. The antioxidant properties of phenolics is mainly due to their redox properties, which allow them to acts as reducing agents, hydrogen donors, singlet oxygen quenchers and metal chelators [2].

The apricot varieties include different levels of phenolic compounds, which have been reported by Akbulut and Artik [3] and Macheix *et al.* [4]. The hydroxycinnamic acids such as caffeic, β- coumaric and ferulic acids and their esters are the most common compounds in apricot fruits [5]. Chlorogenic acid (5'- caffeoylquinic acid) was dominant esters in apricots [6]. The other phenolic compounds determined in apricots are neochlorogenic acid (3'- coumaroylquinic), (+)-catechin and (-)-epicatechin [7]. Akbulut and Artik [3] have reported that (+)-catechin is the most common phenolics in the apricot cultivars which dry well in Turkey. Flavonols in apricots occurs mostly as glycosides and rutinosides of quercetin and of kaempferol and quercetin 3- rutinoside (rutin) was dominant [8]. Coumarins, aesculetin and scopoletin have also been identified and quantified in smaller level and they are characteristic for apricot fruits [9]. Phenolic compounds of apricot can change with cultivar, stage of maturity and geographical region [10]. Sunlight, soils and season can also make up differences and quantities on phenolic compounds of apricot [11,12,13,14].

The objective of this study was to determine the antioxidant capacity and total phenolic compounds of

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different semi-matured apricot varieties and to assess the correlation between antioxidant activity and total phenolic content.

MATERIAL AND METHODS

Standards and Chemicals: Sodium hydroxide, Folin-Ciocalteu's phenol reagent, sodium carbonate and methanol were obtained from Merck (Germany); gallic acid and 2, 2-diphenyl-1-picyrylhydrazyl (DPPH) were obtained from Fluka (USA).

Samples: Twenty-two apricot (*Prunus armeniaca L.*) cultivars were obtained from Malatya Fruit Research Institute in June. Fresh apricots were transported in laboratory and immediately frozen at -25°C until their analyses.

Determination of Moisture, Total Soluble Solids, pH and Titratable Acidity: The moisture of samples was determined by drying at 103±2°C until they reached constant weight [15]. Total soluble solid contents (TSS) were determined by extracting and mixing one drop of juice from each fruit into a refractometer (Atago HSR-500, Japan). The pH measurements were made using a digital pH meter (WTW GmbH, Weilheim, Germany) calibrated with pH=4 and 7 buffers. Titratable acidity (TAc) was measured by the titrimetric method [15]. Titratable acidity of apricots was expressed as % citric acid. TSS/TAc results were also calculated due to indicator of fruit maturity.

Fruit Skin Color Measurements: Six fruits of each variety were randomly selected and the measurements were done on the two opposite outer surfaces of fruits. After the colors of the fruit surfaces were determined for the L^* (lightness), a^* (green chromaticity) and b^* (yellow chromaticity) values using a colorimeter (Model CR-400; Konica Minolta, Inc., Osaka, Japan), Chroma (C^*) and hue (h) angle were calculated as described by McGuire [16]:

$$\text{Chroma } (C^*) = (a^{*2} + b^{*2})^{1/2}$$

$$\text{Hue angle } (h) = \tan^{-1} (b^*/a^*)$$

Extraction Procedure: The phenolics were extracted by using the homogenizer-assisted method with some modifications [17]. The mixture of 7 g fruits and 20 ml methanol was homogenized for 3 min at 20000 rpm using a homogenizer (IKA T25 D ULTRA-TURRAX, Germany) The homogenized mixture was kept in centrifuge tube with the headspace filled with nitrogen gas. After the tube stood for 18 h in the dark and then was centrifuged for 20 min under refrigerated conditions (+4°C). The supernatant was collected. The final volume of extract was 25 ml. Extraction was done 3 times. Phenolic extracts from fruits were stored at -18°C until analyses.

Determination of Total Phenolics: The methanol extracts of apricots were used for the determination of total phenolics. Total phenolic content was evaluated by colorimetric analyses using Folin-Ciocaltaue's phenol reagent [18]. The content of total phenolics was expressed as mg gallic acid equivalent (GAE)/ 100 g of fruits.

2-Diphenyl-2-picrylhydrazyl (DPPH) Free Radical Scavenging Activity: The free radical-scavenging activity against DPPH radical was evaluated according to the method of Leong *et al.* [19] and Miliouskas *et al.* [20] with minor modifications. According to principle of this method, in the presence of an antioxidant, the purple color intensity of 2, 2-diphenyl-2-picrylhydrazyl (DPPH) solution decays and the change of absorbance is followed spectrophotometrically at 517 nm. Briefly, a 0.15 mM solution of DPPH (2, 2-diphenyl-2-picrylhydrazyl) in methanol was prepared. Two milliliters of this solution was added to 1 ml of methanol extracts of fresh apricot fruits. The control was prepared by adding 2 ml of DPPH to 1 ml methanol. The content of the tubes were mixed and followed to stand for 30 min and absorbance was measured at 517 nm. The scavenging activity was expressed as IC_{50} (mg/ml). All analyses were done in quadruplicate. DPPH was used as a standard.

Statistical Analysis: All statistical analyses were performed using the SPSS of the Windows statistical package (Release 15.0).

RESULTS AND DISCUSSION

Total phenolic content ranged from 58.4 to 309.5 mg GAE / 100 g of fresh fruit in the methanol extract of the 23 varieties tested (Table 1). While the highest value was observed for the Karakabuk variety, the lowest value was observed for the Soganci variety as shown in Table 2. In different apricot cultivars, Akbulut and Artik [3] and Scalzo *et al.* [21] observed a range of total phenolic content of 769-1283 mg GAE / kg fresh weight and 214-266 mg GAE/ L, respectively. In this study, total phenolic contents of apricot fruits were much more than that of

Table 1: Some chemical properties of apricot varieties

Cultivars	Water content (%)	Brix	pH	Titratable acidity (% citric acid)	TSS/TAc
Alyanak	87.0±0.8	11.3±1.6	3.7±0.2	1.3±0.4	8.3±1.3
Çataloglu	85.8±0.8	15.3±2.0	4.7±0.8	0.3±0.3	47.4±2.3
Çekirge(52)	84.2±3.8	9.1±0.6	3.5±0.6	1.4±0.9	6.7±2.5
Erken Agerik	86.6±3.2	13.0±1.1	4.3±0.5	0.6±0.3	21.8±6.6
Ethem Bey	82.5±3.9	10.0±0.8	3.8±0.6	0.8±0.4	11.9±1.9
Hacihaliloglu	86.7±3.6	14.1±2.5	4.8±0.2	0.4±0.4	39.8±2.0
Hacikiz	85.8±3.1	14.0±0.3	5.0±0.6	0.2±0.2	68.3±4.3
Hasanbey	84.3±3.7	13.0±2.1	5.6±0.3	0.2±0.2	71.0±2.9
Ismailaga	87.9±4.8	11.9±1.3	4.8±0.7	0.3±0.4	39.3±2.8
Karacabey	85.9±3.5	12.0±2.1	3.6±0.3	1.4±0.8	8.7±1.0
Kurukabuk	81.6±1.4	11.0±1.0	3.8±0.2	1.0±0.2	10.9±1.5
Mahmudun Erigi	84.1±3.4	12.8±2.7	4.6±0.6	0.4±0.3	29.3±5.6
Rakowsky	87.0±2.5	12.0±1.6	3.6±0.1	1.4±0.1	8.4±0.8
Soganci	85.5±6.1	13.9±0.8	4.8±0.3	0.3±0.3	49.8±3.4
Stark Early Orange	82.7±5.6	9.2±2.7	3.9±0.7	0.8±0.4	12.0±5.1
Sam	86.5±4.3	11.0±1.0	3.6±0.4	1.4±0.6	8.1±0.4
Sekerpare	86.6±3.8	14.0±1.3	4.9±0.9	0.2±0.2	69.0±0.5
Tokaloglu(Konya Eregli)	84.5±2.3	11.0±0.3	4.0±0.8	0.9±0.6	12.5±2.4
Yegen (Eski Malatya)	85.4±4.4	12.1±1.6	4.1±0.7	0.8±0.3	15.3±1.7
Wilson delicious	88.2±3.2	10.2±1.7	3.7±0.6	1.1±0.8	9.1±1.8
Zerdali x1	80.5±2.4	12.2±2.3	3.8±0.7	1.2±0.4	10.3±3.4
Zerdali (Çolakli-Ispendere)	86.5±1.2	15.0±0.1	4.9±0.6	0.2±0.3	60.2±4.2
Min.	80.5±2.4	9.1±0.6	3.5±0.6	0.2±0.2	6.7±2.5
Max.	88.2±3.2	15.3±2.0	5.6±0.3	1.4±0.1	71.0±2.9
Means	85.26	12.32	4.4	0.81	28.47

Table 2: Total phenolic content and antioxidant capacity as IC_{50} value of apricots

Cultivars	Total phenolic content (mg GAE / 100 g)	IC_{50} value
Alyanak	161.6±52.4	31.53±2.40
Çataloglu	146.8±16.5	36.33±1.56
Çekirge(52)	193.2±45.6	28.16±1.67
Erken Agerik	141.6±10.5	33.20±2.87
Ethem Bey	197.9±11.6	23.73±2.59
Hacihaliloglu	140.5±17.4	51.59±2.47
Hacikiz	72.1±11.5	59.47±2.64
Hasanbey	294.7±36.9	15.17±2.91
Ismailaga	137.4±22.2	28.21±1.60
Karacabey	176.3±17.0	18.61±2.59
Kurukabuk	302.1±26.9	10.84±3.52
Mahmudun Erigi	208.4±22.7	24.66±4.10
Rakowsky	309.5±17.8	9.60±1.53
Soganci	58.4±6.2	46.72±2.90
Stark Early Orange	104.2±11.5	43.22±4.41
Şam	65.8±58.0	48.74±3,39
Şekerpare	116.8±44.5	42.80±2.18
Tokaloglu (Konya Eregli)	141.1±21.6	36.72±3.38
Wilson Delicious	299.5±33.8	11.61±6.19
Yegen (Eski Malatya)	144.2±30.9	20.72±0.57
Zerdali x1	184.7±53.9	31.74±2.11
Zerdali (Çolakli-Ispendere)	165.8±29.8	28.56±2.02
Min.	58.4±6.2	9.60±1.53
Max.	309.5±17.8	59.47±2.64
Means	171.0	31.00

Akbulut and Artik [3] and Scalzo *et al.* [21]. Higher phenolic values obtained from this study compared to reported studies may be related in the maturity levels of apricots. Similarly, Dragovic-Uzelac *et al.* [22] have reported that polyphenol amounts of apricots decreased with ripening. Although all apricots used in this study were grown in same location under similar horticultural practices, total phenolic contents showed variability due to their different varieties. The concentration required in order to decrease the initial DPPH concentration (IC_{50}) is a parameter widely used to measure the antioxidant activity. The lower IC_{50} values indicate the higher antioxidant activity [23]. The IC_{50} values of the apricots varieties ranged from 9.60 to 59.47. While Rakowsky variety had the highest antioxidant power among analyzed apricot varieties, Hacikiz variety had the lowest

Table 3: Color parameters of apricot varieties

Variety	*L**	*h**	*C**
Alyanak	44.98±5.85	53.67±5.95	23.54±2.67
Çataloglu	53.76±19.26	88.50±13.75	16,93±4.92
Çekirge(52)	46.09±18.61	67.36±1.38	22.10±3.43
Erken Agerik	49.40±20.04	70.77±2.81	18.21±4.22
Ethem Bey	42.57±4.88	53.74±3.05	22.88±3.66
Hacihaliloglu	57.51±8.87	86.44±10.54	17.93±3.87
Hacikiz	47.65±13.48	67.77±5.36	15.97±2.91
Hasanbey	48.68±13.85	85.79±5.17	16.31±2.32
Ismailaga	45.36±5.47	75.64±4.36	17.87±2.10
Karacabey	47.55±7.56	78.23±6.18	21.17±3.56
Kurukabuk	53.38±19.60	70.85±0.85	18.38±5.09
Mahmudun Erigi	47.42±11.25	74.17±4.64	22.23±1.76
Rakowsky	50.49±11.10	77.38±8.55	25.24±2.19
Soganci	48.87±4.92	84.95±5.63	17.58±4.80
Stark Early Orange	48.56±10.70	60.18±2.52	22.26±5.55
Şam	54.07±5.58	76.67±8.86	23.44±3.76
Şekerpare	49.05±17.23	79.34±13.39	18.96±3.06
Tokaloglu (Konya Eregli)	45.36±16.97	80.42±6.14	18.76±3.78
Wilson delicious	46.14±18.36	66.02±4.58	20.51±3.70
Yegen (Eski Malatya)	48.42±7.27	68.78±8.20	22.32±0.80
Zerdali x1	55.01±20.32	85.70±1.06	23.13±5.99
Zerdali (Çolakli-Ispendere)	48.62±10.61	86.24±2.15	18.91±5.19
Min.	42.57±4.88	53.67±5.95	15.97±2.91
Max.	57.51±8.87	88.50±13.75	25.24±2.19
Means	51.11	77.67	20.21

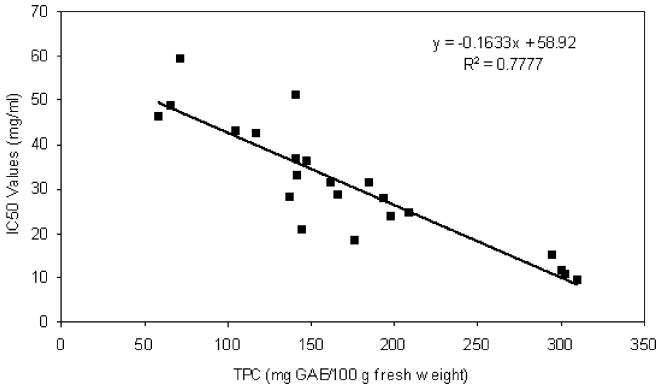

Fig. 1: The correlation between antioxidant activity (IC_{50}) and total phenolic content (TPC) of apricots

antioxidant power (Table 2). Total phenolic content were reasonably well correlated with the total antioxidant activity (R^2= 0.777, p< 0.01; Fig. 1). There was a negative and well correlation between IC_{50} values and total phenolic contents of apricots. Güçlü *et al*. [24] have reported a strong correlation (R^2 =0.93) between antioxidant capacity and total phenolic concentration of fresh, sun-and sulphited-dried apricots. Rupasinghe *et al*. [25] have also determined significantly important correlation (R^2= 0.96) between total phenolics and antioxidant capacity of 20 plum genotypes. Gil *et al*. [26] have obtained similar results in nectarine, peach and plum cultivars.

Poor correlations have been found between the antioxidant activities and *h* values (R^2=0.28, p<0.05); total phenolic contents and *h* values (R^2 =0.21, p<0.05). *L**, *h*, *C** values of apricots is shown in Table 3.

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REFERENCES

1. Despande, S.S., U.S. Despande and D. Salunkhe, 1996. Nutritional and health aspects of food antioxidants. Food Antioxidants. Madhavi, D.L., Deshpande, S.S., Salunkhe, D.K. (Ed.), Marcel Dekker, New York, pp: 361-469.
2. Rice-Evans, C.A., N.J. Miller and G. Paganga, 1997. Antioxidant properties of phenolic compounds. Trends Plant Sci., 2: 152-159.
3. Akbulut, M. and N. Artik, 2002. Kayisi ve zerdali meyvelerinin fenolik madde dagilimi ve prosesteki degisimi. Turkey 7th Food Congress, 22-24 May, Ankara.
4. Macheix, J.J., A. Fleuiret and J. Billot, 1990. Fruits phenolics. Boca Raton, FL: CRC Pres.
5. Hermann, K., 1976. Flavonols and compounds in fruits and vegetables. Ernaehrungs Unschau., 21: 177-181.
6. Radi, M., M. Mahrouz and A. Jaouad, 1997. Phenolic Content, Browning Susceptibility and arytenoids content of several apricot cultivars at maturity. Hort. Sci., 32: 1087-1091.
7. Arts, C.W., B. Van de Putte and P.C.H. Hollman, 2000. Catechin contents of foods commonly consumed in the Netherlands. 1. Fruits, vegetables, staple foods and processed foods. J. Agric. Food Chem., 48: 1746-1751.
8. Garcia-Viguera, C., P. Bridle, P. Ferreres and F.A. Tomas-Barberan, 1994. Influence of variety, maturity and processing on phenolic compounds of apricot nectars and jams. Z. Lebensm. Unters. Forsch., 199: 433-436.
9. Fernandez de Simon, B., J. Perez-Ilzabre and T. Hernandez, 1992. Importance of phenolic compounds for the characterization of fruit nectars. J. Agric. Food. Chem., 40: 1531-1535.
10. Dragovic-Uzelacü, V., B. Levaj, V. Mrkic, D. Bursac and M. Boras, 2007. The content of polyphenols and carotenoids in three apricot cultivars depending on stage of maturity and geographical region. Food Chem., 102: 966-975.
11. Spanos, G.A., R.E. Wrolstad and D.A. Heatherbell, 1990. Influence of processing and storage on the phenolic content of apple nectar. J. Agric. Food Chem., 38: 1572-1579.
12. Spanos, G.A. and R.E. Wrolstad, 1990. Influence of variety, maturity, processing and storage on the phenolic content of pear nectar. J. Agric. Food Chem., 38: 817-824.
13. Joshi, V.K., S.K. Chauhan and B.B. Lal, 1991. Extraction of nectars from peaches, plums and apricots by pectinolytic treatment. J. Food Sci. Techn., 28: 64-65.
14. Harris, R.S., 1997. Effect of agricultural practices on the content of foods. In: R.S. Harris and Karmas, Editors, Nutritional evaluation of food processing, The Avi Publishing Company Inc., Westport, CT 35-37.
15. AOAC., 1984. Officials methods of analyses (14th ed.) Arlington, VA, USA: Association of official analytical Chemist.
16. McGuire, R.G., 1992. Reporting of objective color measurement. Hort Sci., 27: 1254-1255.
17. Fang, N., S. Yu and R.L. Prior, 2002. LC/MS/MS characterization of phenolic constituents in dried plums. J. Agric. Food Chem., 50: 3579-3585.
18. Singleton, V.L. and J.A. Rossi, 1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungastic acid reagents. Am. J. Enol. Vitic., 16: 144-158.
19. Leong, L.P. and G. Shui, 2002. An investigation of antioxidant capacity of fruits in Singapore markets. Food Chem., 76: 69-75.
20. Miliauskas, G., P. R. Venskutonis and T.A. Van Beek, 2004. Screening of radical scavenging activity of some medicinal and aromatic plant extracts. Food Chem., 85: 231-237.
21. Scalzo, J., A. Politi, N. Pellegrini, B. Mezzetti and M. Battino, 2005. Plant genotype affects total antioxidant capacity and phenolic contents in fruits. Nutrition, 21: 207-213.
22. Dragovic-Uzalac, V., B. Levaj, V. Mrkic, D. Bursac and M. Boras, 2007. The content of polyphenols and carotenoids in three apricot cultivars depending on stage of maturity and geographical region. Food Chem., 102: 966-975.
23. Sanchez-Moreno, C., J.A. Larrauri and F.A. Saura-Calixto, 1998. A procedure to measure the antiradical efficiency of polyphenols. J. Sci. Food Agric., 76: 270-276.
24. Güçlü, K., M. Altun, M. Özyürek, E.S. Karademir and R. Apak, 2006. Antioxidant Capacity of fresh, sun- and sulphited-dried Malatya apricot (*Prunus armeniaca*) assayed by CUPRAC, ABTS/TEAC and folin methods. Int. J. Food Sci. Techn., 41: 76-85.
25. Rupasinghe, V.H.P., S. Jayasankar and W. Lay, 2006. Variation in total phenolics and antioxidant capacity among European plum genotypes. Sci. Hortic., 108: 243-246.
26. Gil, M.I., F.A.Tomas-Barberan, B. Hess-Pierce and A.A. Kader, 2002. Antioxidant capacities, phenolic compounds, carotenoids and Vitamin C contents of nectarine, peach and plum cultivars from California. J. Agric. Food Chem., 14: 4976-4982.