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Analytical Methods

Some compositional properties of main Malatya apricot (*Prunus armeniaca* L.) varieties

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Abstract

Malatya apricot (*Prunus armeniaca* L.) varieties are among the most important agricultural products of Turkey and protected as a geographical indication. In this research, it was aimed to determine some important analytical properties (dry matter, soluble solid content, a_w, ash, titratable acidity, pH, color, total phenolics, total carotenoids, β-carotene, sugars, organic acids, and mineral content) of Malatya apricots and to reveal the characteristic properties that differ these products from the similar ones. The apricot varieties, namely Hacıhaliloğlu, Hasanbey, Soğancı, Kabaaşı, Çataloğlu, Çöloğlu, and Hacıkız that are widely cultivated in Malatya region and other regions (Ereğli, İzmir, Iğdır, and Bursa) of Turkey were involved in the study. All analytical properties were found to be significantly different ($p < 0.05$) among different apricot varieties. The results have shown that dry matter and sugar content of Malatya apricot varieties are considerably higher than the other apricot varieties investigated in this study, as well as the data of other researches on apricots. All apricot varieties were found to be a good source of phenolic compounds (4233.70–8180.49 mg of gallic acid equiv/100 g of dry weight), carotenoids (14.83–91.89 mg of β-carotene equiv/100 g of dry weight), and β-carotene (5.74–48.69 mg/100 g of dry weight). Sucrose, glucose, and fructose were determined as the major sugars in all apricot varieties. In addition, sorbitol contents (16.91–26.84 mg/100 g of dry weight) of Malatya apricots were remarkably higher than the other apricot varieties. This was considered to be the one of the unique properties of Malatya apricots. Malic acid was the predominant organic acid in all Malatya apricot varieties. The results have also shown that the potassium content of Malatya apricots was significantly high and these apricots were important sources of Mg, Zn, and Se. This study has revealed that Malatya apricot contains functional food components with high nutritional value.

Keywords: Apricot; Dry matter; Color; Phenolics; Carotenoids; β-Carotene; Sugars; Sorbitol; Malic acid; Minerals

1. Introduction

Turkey is the leading apricot producer of the world. According to the FAO Statistical Database (FAO, 2005), in 2005, 390 000 tons of apricot were produced in Turkey contributing to ~13% of the total apricot production in the world. Malatya region, of eastern Turkey, is particularly important for cultivation, production, and processing of apricots, as around 50% of the fresh apricots and 90% of the dried apricots of the whole country are produced in this region. Moreover, the apricots grown in this region has a reputation for their characteristics and quality. The climate, structure and content of the soil, and the other environmental conditions in Malatya region enables the production of quality apricots with high dry matter and sugar content. The most cultivated apricot varieties in Malatya region are, Hacıhaliloğlu, Hasanbey, Soğancı, Kabaaşı, Çataloğlu, and Çöloğlu (Asma, 2000) and are protected as geographical indication in Turkey by Turkish Patent Institute (TPI, 2007) Geographical indications are signs indicating the origin of a product, which possesses a specific quality, reputation or other characteristics attributable to that place, area, region or country of origin.

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Foodstuffs, protected as geographical indications are mostly reputable and high quality products and thus, play an essential role for the economic development of the region they belong to (Josling, 2005; Dimara, Petrou, & Skuras, 2004). Hence, it is important to determine chemical and nutritional properties of such products and to find out unique characteristics thereof.

Sugars, organic acids, phenolic compounds and carotenoids, are being natural components of many fruits and vegetables, play important roles in maintaining fruit quality and determining their nutritive value (Ashoor & Knox, 1984). Therefore, food analysts have been interested in the amounts of the various chemical components and the changes occurring in the edible parts of fruits, because of their impact on the shelf life, technological and nutritive quality of the food product (Glew et al., 2003).

Epidemiological and clinical studies indicate that a diet rich in fruits and vegetable consumption can reduce the risk of several chronic diseases such as cancer, cardiovascular disease, coronary heart disease, and hypertension. Possible health effects of fruits and vegetables have been reviewed extensively (Hu et al., 2000; Ness & Powles, 1997; Steinmetz & Potter, 1996; Southon & Faulks, 2002). Available evidence provides support for the health benefits of a wide variety of fruits and vegetables, however, specific claims are most prolific for many of the colored-fleshed fruits and vegetables. Such foods are particularly rich in vitamin C, pro- and non pro-vitamin A carotenoids, folates, phenolics, and a range of bioactive (so-called) phytonutrients (Southon & Faulks, 2002).

Although, different apricot varieties have been investigated by many researchers in the world (Sass-Kiss, Kiss, Milotay, Kerek, & Toth-Markus, 2005; Dragovic-Uzelac, Pospisil, Levaj, & Delonga, 2005; Radi, Mahrouz, Jaouad, & Amiot, 2004; Dolenc-Sturm, Stampar, & Usenik, 1999; Katona, Sass, & Monar-Perl, 1999; Ruiz, Egea, Tomás-Barberán, & Gil, 2005), an extensive and comparative research as to the chemical compositions of Malatya apricots have not been investigated in detail. Therefore, this research was aimed to determine some important compositional properties (dry matter, soluble solid content, water activity, ash, titratable acidity, pH, color, total phenolics, total carotenoids, β-carotene, sugars, organic acids, and minerals) of apricots from Malatya region of Turkey. In addition, apricot varieties from other regions of Turkey (İzmir, Ereğli, Bursa and Iğdır regions) were also analyzed in order to provide a comparative study and delineate the different and unique characteristics of Malatya apricots.

2. Materials and methods

2.1. Fruit sample

Apricots varieties (Hacıhaliloğlu, Hasanbey, Soğancı, Kabaaşı, Çöloğlu, Çataloğlu, and Hacıkız) from Malatya region, and Tokaloğlu and Alyanak apricot varieties (from Ereğli and İzmir region, respectively) were harvested at commercial maturity stage from the Malatya Fruit Research Institute among the first and third weeks of July 2005. At least 100 apricot fruits were harvested from at least four different trees in same garden for each cultivar and then they were pooled. In addition, Iğdır and Bursa varieties were purchased from wholesale food market in Ankara. Samples were placed into polyethylene bags and stored at 4 °C until the analysis (analyzed with in five days). Three replicates of each variety were selected and analyzed.

2.2. Chemicals

All the reagents and solvents used were obtained from Merck (Darmstadt, Germany) and were of HPLC or analytical grade. Folin–Ciocalteu phenol reagent and gallic acid monohydrate were purchased from Sigma (St. Louis, MO, USA). Sources of reference compounds were citric acid, malic acid, ascorbic acid, sucrose, glucose, fructose, sorbitol, and β-carotene (Sigma, St. Louis, MO, USA). ICP (Inductively Coupled Plasma) multi element standard was purchased from Merck (Darmstadt, Germany).

2.3. Quality parameters

Dry matter content was determined according to the AOAC (1990). Soluble solid content, expressed as percentage (%), was determined in the juice of each sample using Bausch & Lomb Abbe-3 L refractometer (Tokyo, Japan) at 20 °C. Water activity of the samples was measured with an Aqualab CX-2 (Decagon Devices Inc., WA, USA) to an accuracy of ±0.003 at 25 °C (Lenz, 2003). Ash content of samples was determined at 550 °C (AOAC, 1990). Titratable acidity was determined by titrating 5 mL of juice with 0.05 M NaOH and results were expressed as percentage of citric acid (Turkish Standard, 2002). The pH values were measured by using a pH-meter (Mettler-Toledo MP220). Fruit weight (g) of apricot fruits were measured in 40 randomly selected apricot fruits for each apricot cultivar. Color values were measured from the surface (ground skin color) and in the flesh (after peeling) with Minolta Chroma Meter (CM-3600d, Minolta, Ramsey, NJ) (Ruiz et al., 2005). The measurements were displayed in L^*, a^*, and b^* values. C^* (chroma) and $h°$ (hue angle) were calculated by using the following equation:

$$C^* = \sqrt{a^{*2} + b^{*2}}$$
$$h^\circ = \arctan(b^*/a^*)$$

Color of the central region on both sides of ten apricots was measured for each treatment and average values were reported.

2.4. Measurement of total phenolics

Concentration of total phenolics was measured by using the Folin–Ciocalteu assay (Sponas & Wrolstad, 1990). At least ten apricot samples were homogenized with a high-speed homogenizer (Heidolph, Diax 900, Germany) for 2 min. The fruit puree (3 g) was diluted to 30 mL with deionized water and clarified by centrifugation at 10000*g* for 15 min. The extract was filtered through a 0.45 μm membrane filter. Filtrate (0.5 mL), 5 mL 0.2 N Folin–Ciocalteu reagent, and 4 mL of 7.5% sodium carbonate solution were added to a 25 mL volumetric flask and filled to volume by deionized water (Alper, 2001). The contents were allowed to stand for 5–8 min at 50 °C and the absorbance was measured at 765 nm using a UV-2101PC Spectrophotometer (Shimadzu, Kyoto, Japan). Total phenolics were quantified by calibration curve obtained from measuring the absorbance of a known concentration of gallic acid standard. The concentrations were expressed as milligrams of gallic acid equivalents (GAE) per 100 g of dry weight.

2.5. Measurement of total carotenoids

Total carotenoids were extracted according to the method of Rodriguez-Amaya (1999) with some modifications. Briefly, five grams of sample was extracted with 100 mL of methanol/petroleum ether (1:9, v/v) by using a high-speed homogenizer (Heidolph, Diax 900, Germany) and the mixture was transferred to a separating funnel. Petroleum ether layer was filtrated through sodium sulphate, transferred to volumetric flask, and to a volume of 100 mL with petroleum ether. Finally, the total carotenoid content was measured spectrophotometrically (2101PC Shimadzu Spectrophotometer, Kyoto, Japan) at 450 nm by using an extinction coefficient of 2500 and the results were expressed as β-carotene equivalents (milligrams per 100 g of dry weight) (Gross, 1987).

2.6. HPLC analysis

ThermoFinnigan HPLC system integrated with an auto sampler including temperature control for the column (SpectraSystem AS3000), a degasser system (SpectraSystem SCM1000), a quaternary gradient pump (SpectraSystem P4000), a photodiode-array detector (SpectraSystem UV6000LP), a refractive index detector (SpectraSystem RI-150), and a software package for system control and data acquisition (ChromQuest 4.0) were used for analyses.

β-Carotene analyses were performed according to the methods of Gokmen, Bahçeci, and Acar (2002) with some modifications. For the extraction, 5 g of sample was weighed into a homogenizer cup and homogenized with a Virtis homogenizer at medium speed for 2 min, with 30 mL of extraction solution (methanol:stabilized tetrahydrofuran, 1:1, v/v). The homogenates were centrifuged (5000*g*) for 15 min and the supernatant was collected into a 100 mL volumetric flask. The extraction process was repeated three times with 20 mL of extraction solution until no color appeared in the pellet. The extract was filtered through a 0.45 μm membrane filter and 20 μL of the extract was injected into the HPLC column. Separations were achieved on a Luna 5 μ C8 column (150 × 4.6 mm, Phenomenex) at 35 °C and based on isocratic elution. Elution was performed at a solvent flow rate of 1.0 mL/min and detection was done at 450 nm. The mobile phase consisted of 100% methanol (HPLC grade).

The fruit puree (10 g) was diluted to 50 mL with deionized water and clarified by centrifugation at 10000*g* for 15 min. The extract was filtered through a 0.45 μm membrane filter and filtrate was used for HPLC analysis of sugars (glucose, fructose, and sucrose), sorbitol, organic acids (malic acid, citric acid), and vitamin C.

Sugars and sorbitol were analyzed isocratically according to the method of Sturm, Koron, and Stampar (2003) with a Rezex RCM column (300 × 7.8 mm, Phenomenex) at 80 °C using an RI detector. Deionized water was used as the mobile phase, with an injection volume of 20 μL, and a flow rate of 0.6 mL/min. The concentrations were expressed as mg/100 g of dry weight.

Organic acids and vitamin C were analyzed isocratically according to the method of Poyrazoğlu, Gökmen, and Artık (2002) with Luna 5 μ C18 (250 × 4.6 mm, Phenomenex). HPLC elution was carried out at 35 °C temperature using 0.2 M KH_2PO_4 (pH 2.4 adjusted with H_3PO_4) as the mobile phase at a flow rate of 0.4 mL/min. The chromatograms were monitored at 210 nm and 245 nm for organic acids and vitamin C, respectively. The concentrations were expressed as mg/100 g of dry weight.

2.7. Mineral analysis

Approximately 0.8–1.0 g of the samples were accurately weighed into an acid washed teflon digestion tube and 10 mL ultra pure nitric acid (65% w/v) was added. The samples were incinerated in the microwave oven at 190 °C and the solution was diluted to 100 mL with deionized water (Anon, 2004). Calcium, potassium, and sodium content of the samples were determined by using Shimadzu A-660 model atomic absorption spectrophotometer (Turkish Standard, 1997). Magnesium, phosphor, iron, zinc manganese, nickel, and selenium content of the samples were determined by using the Thermo Elemental ICP-MS (Inductively Coupled Plasma-Mass Spectrophotometer, X7 series, Thermo Elemental, UK) (Creed, Brockhoff, & Martin, 1994). In order to provide a better comparison between the analytical compositions of different apricot varieties, results of the analyses were expressed as mass per dry matter.

2.8. Statistical analysis

Samples of fruits from individual varieties were considered as a source of variation. The results were statistically evaluated by one-way analysis of variance (ANOVA). Statistical differences with *P*-values under 0.05 were considered significant and means were compared by 95% Duncan multiple range test, using SPSS program, version 13.0.

3. Results and discussion

3.1. Quality parameters

All quality parameters of apricot varieties were found to be significantly different ($p < 0.05$). Dry matter content of the apricot varieties ranged from 11.83% to 25.81% (Table 1). Dry matter content is one of the most important parameters that shows the commercial value of the apricots. In general, apricot varieties with high dry matter content are preferred for drying processes while the ones with low dry matter content are consumed freshly. A considerable amount of the annual production of apricot in Malatya region is dried after sulphuration. Hacıhaliloğlu, Soğancı, Çöloğlu, and Kabaaşı varieties, which have relatively high dry matter content, are suitable for drying. These varieties are among the most cultivated apricot varieties in Malatya region. On the other hand, as apricots with low dry matter content are very sensitive to transportation and handling, they are not suitable for processing and drying. Early-ripened apricots from Bursa and Iğdır regions are preferably consumed as fresh fruit. As a result of the analyses, dry matter contents of Malatya apricots were determined to be considerably higher than the dry matter content of the apricot varieties from İzmir, Ereğli, Bursa and Iğdır regions. Water activities of the Malatya apricot varieties, ranged from 0.977 in Hacıhaliloğlı to 0.988 in Hasanbey, have lower values than that of other varieties. In addition, Malatya apricot varieties have significantly higher dry matter contents than the apricot varieties grown in different countries (Gebhard & Thomas, 2002; Forni, Sormani, Scalise, & Torreggiani, 1997; Rossello, Canellas, Santiesteban, & Mulet, 1993).

Ash contents of the apricot varieties varied from 0.50% to 0.89% and the differences between the varieties were found to be statistically significant ($p < 0.05$). The titratable acidity values were lower and pH values was higher in Malatya apricots. Especially, titratable acidity values of apricots from Bursa and Iğdır regions were significantly different from the other varieties ($p < 0.05$). It was determined that all Malatya apricot varieties have considerably higher pH values and soluble solid contents, as compared to the values obtained from the literature (Ruiz, Egea, Gil, & Tomás-Barberán, 2005). Average fruit weight of the apricots was between 21.16 and 38.24 g (Table 1). Among all Malatya apricot varieties, Hasanbey has the highest fruit weight value. It is commonly accepted that size of the fruit, affects consumer appeal and attractiveness; hence, because of its bigger size Hasanbey variety is mostly preferred for fresh consumption.

The Hunter color parameters L^*, a^*, and b^* have been widely used to describe the color properties of fruit and vegetable products. The color variables have been related to the types and quantities of some components present in foods (Sass-Kiss et al., 2005; Ameny & Wilson, 1997). Lightness factor, L^*, were ranged from 52.5 (Tokaloğlu) to 62.2 (Hacıkız) and from 51.8 (Kabaaşı) to 62.6 (Hacıhaliloğlu) for skins and fleshes, respectively (Table 2). The decrease of L^* value reflects the darkening of the apricot varieties by carotenoid accumulation (Ruiz et al., 2005). The a^* value, which represents the green–red spectrum with a range from −60 (green) to +60 (red), was higher in flesh than in the skin for most of the varieties. The b^* values, which represents the blue–yellow spectrum with a range from −60 (blue) to +60 (yellow), were found to be considerably lower than Spanish apricot varieties (Ruiz et al., 2005) for both skin and flesh. The C^* (chroma) values, which changes from 0 (dull) to 60 (vivid), in general, was higher in the flesh than in the skin for same variety. Hue angle (h^*) is expressed in degrees: 0° (red), 90° (yellow), 180° (green), and 270° (blue). The h^* values of all apricots ranged from 53.0 in Alyanak to 68.7 in Hacıkız varieties and from 46.8 in Soğancı to 71.1 in Hacıhaliloğlu varieties for skin and flesh, respectively (Table 2). In general, the values were closer to 90° (yellow) which may be due to carotene concentration.

Table 1
Quality parameters of apricot varieties[a]

Varieties	Dry matter (%)	Soluble solid content (%)	a_w	Ash (%)	Titratable acidity (% citric)	pH	Fruit weight (g)
Hacıhaliloğlu[b]	24.78 ± 0.44f	23.20 ± 0.38f	0.977 ± 0.001a	0.88 ± 0.025f	0.20 ± 0.033c	4.90 ± 0.07e	28.42 ± 1.74b
Hasanbey[b]	19.16 ± 1.54c	17.40 ± 1.34c	0.988 ± 0.001e	0.78 ± 0.019e	0.20 ± 0.006c	4.86 ± 0.07e	38.24 ± 2.96d
Soğancı[b]	25.81 ± 2.49f	23.65 ± 1.97f	0.986 ± 0.001d	0.71 ± 0.008c	0.23 ± 0.010d	4.77 ± 0.02d	27.41 ± 1.68b
Kabaaşı[b]	22.00 ± 0.27e	20.70 ± 0.26de	0.978 ± 0.001b	0.89 ± 0.008f	0.28 ± 0.017e	4.92 ± 0.02e	28.68 ± 1.88b
Çöloğlu[b]	23.53 ± 1.26ef	22.15 ± 1.68e	0.982 ± 0.001c	0.71 ± 0.005c	0.08 ± 0.005a	5.61 ± 0.01g	22.16 ± 2.45a
Çataloğlu[b]	21.50 ± 0.22d	19.50 ± 0.58d	0.981 ± 0.001c	0.74 ± 0.010d	0.10 ± 0.005b	5.51 ± 0.02f	22.17 ± 2.47a
Hacıkız[b]	16.86 ± 0.13b	15.90 ± 0.12b	0.982 ± 0.001c	0.50 ± 0.013a	0.08 ± 0.016a	5.62 ± 0.02g	23.38 ± 1.17a
Tokaloğlu	18.02 ± 0.78bc	17.00 ± 0.46bc	0.995 ± 0.001h	0.72 ± 0.013c	0.43 ± 0.013f	4.34 ± 0.01c	21.16 ± 1.28a
Alyanak	12.55 ± 0.12a	10.60 ± 0.23a	0.997 ± 0.001i	0.62 ± 0.014b	0.63 ± 0.018g	3.83 ± 0.01a	21.33 ± 1.14a
Iğdır	12.72 ± 0.31a	11.00 ± 0.05a	0.993 ± 0.001g	0.89 ± 0.008f	0.77 ± 0.008h	3.88 ± 0.02b	32.33 ± 1.47a
Bursa	11.83 ± 0.53a	10.20 ± 0.19a	0.990 ± 0.001f	0.73 ± 0.010c	1.00 ± 0.010i	3.84 ± 0.04ab	32.03 ± 0.56a

[a] Each value is the mean ± standard deviation of triplicate determinations. Means with different letters in the column for each apricot variety are significantly different ($p < 0.05$).
[b] Apricots varieties from Malatya region of Turkey.

Table 2
Color values of apricot varieties[a]

Varieties	L^*		a^*		b^*		C^*		$h°$	
	Skin	Flesh	Skin	Flesh	Skin	Flesh	Skin	Flesh	Skin	Flesh
Hacıhaliloğlu[b]	59.3 ± 4.59cd	62.6 ± 0.67d	13.3 ± 4.88ab	9.6 ± 1.84a	25.4 ± 2.89bcd	27.8 ± 1.09d	28.6 ± 0.46b	29.4 ± 1.49cd	62.5 ± 8.26bc	71.1 ± 2.98d
Hasanbey[b]	53.9 ± 4.46ab	52.2 ± 1.73ab	10.7 ± 1.83a	10.8 ± 2.10a	21.7 ± 3.59a	21.4 ± 0.43a	23.4 ± 3.74a	24.6 ± 1.29a	62.7 ± 3.64bc	63.3 ± 4.04bc
Soğancı[b]	55.6 ± 2.30abc	53.1 ± 2.57ab	12.5 ± 1.29ab	19.8 ± 1.43ef	24.3 ± 0.99abc	21.3 ± 3.05a	27.3 ± 1.25ab	29.1 ± 1.75cd	62.7 ± 2.20ac	46.8 ± 5.65a
Kabaaşı[b]	53.4 ± 1.99a	51.8 ± 2.34a	12.5 ± 2.54ab	11.9 ± 2.31ab	23.1 ± 0.78ab	21.6 ± 1.27a	26.3 ± 1.09ab	24.7 ± 2.18ab	61.5 ± 5.32abc	61.2 ± 3.45bc
Çöloğlu[b]	56.7 ± 5.52abc	60.7 ± 1.91cd	13.2 ± 5.37ab	14.1 ± 0.85bc	22.5 ± 6.36ab	27.5 ± 1.02cd	26.4 ± 7.66ab	30.9 ± 1.29de	60.0 ± 6.61abc	62.8 ± 0.58bc
Çataloğlu[b]	58.2 ± 3.74bcd	56.3 ± 1.49bc	16.2 ± 3.57bc	20.4 ± 0.80f	25.8 ± 2.88bcd	25.7 ± 0.91cd	30.5 ± 1.72bc	32.8 ± 1.09e	57.8 ± 7.99ab	51.6 ± 0.92a
Hacıkız[b]	62.2 ± 3.47d	56.4 ± 6.12bc	11.3 ± 3.16a	11.0 ± 2.42a	28.9 ± 2.06d	24.7 ± 3.99bc	31.0 ± 1.04bcd	27.0 ± 2.64bc	68.7 ± 6.69c	66.1 ± 8.17c
Tokaloğlu	52.5 ± 1.34a	55.1 ± 1.49bc	14.4 ± 0.78ab	15.5 ± 0.79cd	23.1 ± 0.97ab	24.7 ± 1.06bc	27.6 ± 1.10ab	28.8 ± 1.24c	58.1 ± 1.21ab	60.5 ± 0.87bc
Alyanak	55.0 ± 0.44abc	54.8 ± 2.61ab	21.1 ± 0.08d	24.4 ± 0.75g	28.0 ± 0.28cd	27.6 ± 1.37cd	35.1 ± 0.26d	36.8 ± 1.20f	53.0 ± 0.23a	48.5 ± 1.56a
Iğdır	53.6 ± 1.25a	54.7 ± 3.15ab	11.1 ± 1.79a	11.5 ± 0.40a	20.4 ± 2.89a	22.3 ± 1.82ab	23.4 ± 3.30a	25.0 ± 1.80ab	61.1 ± 2.04abc	62.7 ± 1.09bc
Bursa	60.1 ± 0.49cd	59.1 ± 0.70cd	19.9 ± 2.61cd	18.5 ± 2.73de	28.6 ± 0.80cd	27.8 ± 0.63cd	34.8 ± 2.12cd	33.4 ± 1.79e	55.2 ± 2.84ab	56.4 ± 3.89b

[a] Each value is the mean ± standard deviation of four determinations. Means with different letters in the column for each apricot variety are significantly different ($p < 0.05$).
[b] Apricots varieties from Malatya region of Turkey.

3.2. Total phenolics

Total phenolics content of apricot varieties was significantly different ($p < 0.05$). The mean total content of phenolics ranged from 4233.7 to 8180.5 mg of GAE/100 g dry weight in Tokaloğlu and Bursa varieties, respectively (Table 3). Among the Malatya apricot varieties, Hacıkız had the highest amount of total phenolics. It was reported that the amount of total phenolic compounds in Spanish apricot varieties ranged from 326 to 1600 mg/100 g of fresh weights (Ruiz et al., 2005). When dry matter content of Malatya varieties was not taken into account, the mean total content of phenolics ranged from 740.7 to 1335.2 mg of GAE/100 g fresh weights (data was not given in Table 3) in apricot varieties.

Four phenolic compound groups, procyanidins, hydroxycinnamic acid derivatives, flavonols, and anthocyanins have been identified in apricot varieties by Ruiz et al. (2005). They have been identified and quantified chlorogenic and neochlorogenic acids, procyanidins B1, B2, and B4, and some procyanidin trimers, quercetin 3-rutinoside, kaempferol 3-rhamnosyl-hexoside and quercetin 3-acetyl-hexoside, cyanidin 3-rutinoside, and 3-glucoside in different apricot varieties.

Total phenolic contents of various fresh fruits and their different cultivar have been reported (Moyer, Hummer, Finn, Frei, & Wrolstad, 2002; Gill, Tomás-Barberán, Hess-Pierce, & Kader, 2002). The ranges of total phenolic contents reported were as low as 9.1 mg/100 g of fresh weight in white-flesh nectarines (Gill et al., 2002) and as high as 1790 mg/100 g of fresh–frozen weight in one genotype of *Ribes* L. (black currants) (Moyer et al., 2002). In comparison to these data, Malatya apricot varieties may be considered as a good source of total phenolics.

3.3. Total carotenoids

It was reported that the main carotenoids in apricots are β-carotene, β-cryptoxanthin, γ-carotene, lycopene, and lutein (Sass-Kiss et al., 2005; Ruiz et al., 2005). Total carotenoid contents of the apricot varieties were found to be significantly different ($p < 0.05$) (Table 3). Total carotenoid contents in Bursa, Alyanak, and Tokaloğlu varieties were 91.89, 91.75, and 50.07 mg/100 g of dry weights (~10.87, 11.52, and 9.02 mg/100 g of fresh weights), respectively. Among the Malatya apricot varieties, Hasanbey and Kabaaşı have the highest total carotenoid contents (9.73 and 8.80 mg/100 g of fresh weights). Ruiz et al. (2005) have reported that the carotenoid content of Spanish apricot varieties varies from 1.36 to 38.52 mg/100 g of fresh weights. The carotenoid contents of some vegetables and fruits commonly consumed in the United Kingdom have been reported by Hart and Scott (1995). The total content of carotenoids in eight fruits ranged from 0.017 mg/100 g of fresh weight in strawberries to 2.263 mg/100 g of fresh weight in mandarins (Hart & Scott, 1995). In another research, total carotenoid content of fresh dates have been

Table 3
Total phenolics, total carotene, and β-carotene contents of apricot varieties[a]

Varieties	Total phenolics[c]	Total carotenoids[d]	β-Carotene[e]
Hacıhaliloğlu[b]	5341.29 ± 206.05b	21.87 ± 1.99ab	8.88 ± 0.62ab
Hasanbey[b]	5827.98 ± 401.84bc	50.78 ± 7.49d	22.02 ± 4.56e
Soğancı[b]	4965.99 ± 355.64bc	23.29 ± 7.04b	9.18 ± 2.97bc
Kabaaşı[b]	5822.03 ± 73.72bc	40.00 ± 2.85cd	26.18 ± 0.16f
Çöloğlu[b]	5674.25 ± 459.27bc	14.83 ± 1.47a	5.74 ± 0.50a
Çataloğlu[b]	6107.21 ± 209.41c	32.08 ± 7.14bc	17.53 ± 4.89d
Hacıkız[b]	6592.38 ± 59.83d	22.81 ± 0.99ab	13.05 ± 0.37c
Tokaloğlu	4233.70 ± 174.03a	50.07 ± 3.12d	21.59 ± 2.51e
Alyanak	6773.43 ± 78.70d	91.75 ± 8.16e	48.69 ± 0.44h
Iğdır	5823.76 ± 140.79bc	25.26 ± 0.58ab	13.44 ± 0.32c
Bursa	8180.49 ± 380.98e	91.89 ± 3.66e	42.18 ± 2.66g

[a] Each value is the mean ± standard deviation of four determinations. Means with different letters in the column for each apricot variety are significantly different ($p < 0.05$).
[b] Apricots varieties from Malatya region of Turkey.
[c] Total phenolics, expressed as milligrams of gallic acid equivalents (GAE) per 100 g of dry weight.
[d] Total carotenoids, expressed as milligrams of β-carotene equivalents per 100 g of dry weight.
[e] β-Carotene, expressed as milligrams per 100 g of dry weight.

found in the range of 1.39 to 3.03 mg/100 g of fresh weight (Al-Farsi, Alasalvar, Morris, Baron, & Shahidi, 2005). Thus, apricots can be considered a good source of carotenoids as compared to the above mentioned data on fruits.

3.4. β-Carotene

β-Carotene content of the apricot varieties was found significantly different ($p < 0.05$) (Table 3). The amount of β-carotene in Malatya apricot varieties was ranged from 5.74 mg/100 g of dry weight in Çöloğlu variety to 26.18 mg/100 g of dry weight in Kabaaşı variety. Alyanak variety from İzmir region has the highest β-carotene content (in dry weight). The percentage of β-carotene in total carotenoids varied from 39% to 65%. Similar findings have been reported by Ruiz et al. (2005) and Sass-Kiss et al. (2005).

It was reported that all of the carotenoid isomers might be of no antioxidative significance. The main precursors (provitamin) of vitamin A are β-carotene, β-cryptoxanthin and α-carotene (Müller, 1997). Vitamin A is an essential nutrient for human because it cannot be synthesized within the body. Thus, as being a good source of β-carotene, apricots can be considered as an important nutrient for human health.

3.5. Sugars and sorbitol

During the analyses, particular attention was paid to select the apricots, which have the same maturation stage. High levels of sugar attribute to advances in stages of fruit maturity (Glew et al., 2003). As a result of the analyses, the major sugars of apricot varieties are determined as sucrose, glucose, and fructose. Sugar content of the apricot varieties was found significantly different ($p < 0.05$). Sucrose was found as the predominant sugar present in all apricot varieties (Table 4). Sucrose content of apricot varieties changed from 22.96 to 56.83 mg/100 g of dry weights in Hacıhaliloğlu and Tokaloğlu varieties, respectively. Hacıkız variety has the highest glucose content (23.67 mg/100 g of dry weights). The highest fructose content was found in Çöloğlu and Çataloğlu varieties. The total sugar content ranged

Table 4
Sugar content of apricot varieties[a]

Varieties	Sucrose	Glucose	Fructose	Sorbitol	Total sugar[c]
Hacıhaliloğlu[b]	22.96 ± 0.89a	19.21 ± 0.63e	13.56 ± 0.64e	26.80 ± 1.27gh	82.53 ± 2.09bcd
Hasanbey[b]	35.96 ± 3.69cd	14.72 ± 0.76c	12.16 ± 0.67d	16.91 ± 1.49d	79.75 ± 3.81bc
Soğancı[b]	25.69 ± 3.16b	17.16 ± 2.44d	13.99 ± 1.52e	22.66 ± 3.93f	79.50 ± 9.90def
Kabaaşı[b]	39.00 ± 0.65de	18.64 ± 0.29e	13.05 ± 0.18e	19.14 ± 1.01de	89.82 ± 1.71efg
Çöloğlu[b]	34.89 ± 2.12c	18.95 ± 0.81e	15.68 ± 0.65f	24.35 ± 1.59f	93.88 ± 4.49g
Çataloğlu[b]	24.98 ± 2.29b	21.40 ± 0.72f	15.02 ± 0.36f	26.84 ± 1.83h	88.23 ± 2.48fg
Hacıkız[b]	30.07 ± 0.66b	23.67 ± 0.32g	11.03 ± 0.31c	19.87 ± 0.65e	84.64 ± 1.25cde
Tokaloğlu	56.83 ± 1.63g	11.38 ± 0.85b	7.77 ± 0.43b	5.05 ± 0.32bc	81.02 ± 2.49b
Alyanak	41.27 ± 1.31e	18.33 ± 0.16e	6.53 ± 0.17a	2.47 ± 0.24a	68.61 ± 1.61a
Iğdır	34.83 ± 0.60c	17.06 ± 0.29d	11.95 ± 0.24cd	6.37 ± 0.41c	70.20 ± 0.45a
Bursa	49.87 ± 0.76f	9.47 ± 0.52a	6.34 ± 0.28a	3.38 ± 0.41ab	69.06 ± 1.91a

[a] Sugar contents expressed as milligrams per 100 g of dry weight. Each value is the mean ± standard deviation of four determinations. Means with different letters in the column for each apricot variety are significantly different ($p < 0.05$).
[b] Apricots varieties from Malatya region of Turkey.
[c] The values show sum of sucrose, glucose, fructose and sorbitol content.

from 68.61 to 93.88 mg/100 g of dry weights in Alyanak and Çöloğlu varieties, respectively. Total sugar content of Alyanak, Iğdır and Bursa varieties in dry basis were lower than all the Malatya apricot varieties.

The sugar profile and ratios of specific sugars have been suggested as an indicator for determining the authenticity of juice samples. An average glucose:fructose ratio of 2.3 ranging from 1.6 to 3.1 has been reported for 11 Italian apricot varieties. It was concluded that the glucose:fructose ratio over 3.3 indicates that the apricot juice sample have been adulterated and that glucose is added to either mask the acidity of the juice or to return the glucose:fructose ratio to the baseline 2.3 value (Impembo, LoVoi, Fasanaro, & Castaldo, 1995).

It was also determined that the apricot varieties contain considerable amounts of sorbitol ranging from 2.47 to 26.80 mg/100 g of dry weights in Alyanak and Hacıhaliloğlu varieties, respectively (Table 4). The sorbitol content of Malatya varieties was significantly higher than the other varieties analyzed. The highest sorbitol content was found in Çataloğlu and Hacıhaliloğlu varieties (26.84 and 26.80 mg/100 g of dry weights, respectively). As compared to the data available in the literature, sorbitol content of Malatya apricots was considerably higher than the apricots grown in other counties (Katona et al., 1999; Forni et al., 1997). According to our knowledge, this is the first report showing the sorbitol content of Turkish apricots. It was reported that sorbitol as being one of alcohol sugars is more beneficial than other sugars with regard to diet control and dental health (reducing caloric intake) and it improves the taste and texture of fruits (Rapaille, Goosens, & Heume, 2003).

3.6. Organic acids and vitamin C

The organic acid content of apricot varieties are given in Table 5. Accordingly, organic acid content of the apricot varieties were found to be significantly different ($p < 0.05$). Malic acid was determined to be the predominant organic acid in all Malatya apricot varieties, ranging from 973.4 to 2341.1 mg/100 g of dry weights in Çataloğlu and Hasanbey varieties, respectively. However, the highest citric acid concentrations were determined as 7697.3 and 9997.1 mg/100 g of dry weights, in Iğdır and Bursa varieties, respectively. Malic acid concentrations in dry basis were also higher in Tokaloğlu, Alyanak, Iğdır, and Bursa varieties than all the analyzed Malatya apricot varieties. Differences between the contents of citric and malic acids were highest in Bursa and lowest in Alyanak varieties. Organic acid analysis clearly shows the differences between the Malatya apricot varieties and the other varieties. Higher sugar contents and lower organic acid concentrations characterized in Malatya apricots, provides the desired sweetness and taste in these apricots. It can also be seen from the Table 1 and Table 5, that the variations of titratable acidity and pH values in apricot varieties can be correlated with the organic acid concentrations. Impembo, LoVoi, Fasanaro and Castaldo (1995) have reported the main organic acids as citric acid (mean value 12.0 g/kg) and L-malic acid (mean value 7.7 g/kg) in apricot puree. Similar findings were observed in Iğdır and Bursa varieties.

Table 5
Organic acids of apricot varieties[a]

Varieties	Citric acid	Malic acid	Ascorbic acid
Hacıhaliloğlu[b]	776.2 ± 85.6c	1814.8 ± 84.0d	37.7 ± 1.7cd
Hasanbey[b]	739.7 ± 120.2c	2341.1 ± 285.0e	49.3 ± 2.3e
Soğancı[b]	725.7 ± 52.7c	1092.4 ± 205.7b	28.5 ± 0.7b
Kabaaşı[b]	923.1 ± 135.0d	1279.0 ± 33.1bc	41.6 ± 3.7cd
Çöloğlu[b]	431.8 ± 79.7a	1312.9 ± 98.5bc	20.6 ± 3.8a
Çataloğlu[b]	436.5 ± 42.2b	973.4 ± 63.7a	27.9 ± 1.0b
Hacıkız[b]	443.9 ± 10.3ab	1347.8 ± 34.1c	37.1 ± 2.3c
Tokaloğlu	2055.2 ± 34.6e	2656.2 ± 57.9e	45.8 ± 2.1de
Alyanak	3524.5 ± 138.0f	3888.9 ± 205.9g	38.3 ± 1.2cd
Iğdır	7697.3 ± 448.9g	3030.4 ± 41.1f	68.4 ± 0.7f
Bursa	9997.1 ± 458.5h	3930.0 ± 50.5g	96.8 ± 9.0g

[a] Organic acid contents expressed as milligrams per 100 g of dry weight. Each value is the mean ± standard deviation of four determinations. Means with different letters in the column for each apricot variety are significantly different ($p < 0.05$).
[b] Apricots varieties from Malatya region of Turkey.

The amount of sugars and organic acids and their ratios have been correlated with some of the sensory properties of peach and nectarine (Colaric, Veberic, Stampar, & Hudina, 2005). Sensory and chemical evaluations of apricot fruits showed that individual sugars and organic acids as well as their ratios could be crucial in determining the taste of the fruit (Dolenc-Sturm et al., 1999).

Ascorbic acid (vitamin C) content of apricot varieties was determined to be significantly different ($p < 0.05$) (Table 5), ranged from between 20.6 and 96.8 mg/100 g of dry weights. The Hasanbey variety had the highest vitamin C content (49.3 mg/100 g of dry weight) among the Malatya apricot varieties analyzed. Bursa and Iğdır apricot varieties have higher vitamin C content than the Malatya apricots with 68.4 and 96.8 mg/100 g of dry weights, respectively. In contrary, when fresh weight was taken into account, Malatya apricots have more vitamin C than the other apricots analyzed. There are no abundant comparative measures in the literature for ascorbic acid content of apricot varieties. However, Thompson and Trenerry (1995) have reported the ascorbic acid content of apricots as 10 mg/100 g of fresh weight. The ascorbic acid contents of Turkish apricot varieties, particularly Hacıhaliloğlu, Hasanbey, Kabaaşı, Tokaloğlu, Iğdır, and Bursa, agree with the reported data (Thompson & Trenerry, 1995).

3.7. Minerals

Significant varietal differences existed in mineral composition of Turkish apricot varieties ($p < 0.05$) (Table 6). Iron, Zn, Se, Mn, and Ni elements were present in small amounts and were considered as micro elements, while K, Na, Ca,

Table 6
Mineral compositions of apricot varieties[a]

Varieties	Potassium	Sodium	Calcium	Magnesium	Phosphor	Iron	Zinc	Selenium	Manganese	Nickel
Hacıhaliloğlu[b]	1849 ± 36c	10.9 ± 0.1ab	102.3 ± 9.0ab	134.7 ± 4.9bcd	107.0 ± 1.3d	2.98 ± 0.06a	1.38 ± 0.12a	0.150 ± 0.013a	1.41 ± 0.19ab	0.325 ± 0.019a
Hasanbey[b]	1811 ± 56bc	8.8 ± 2.3a	100.7 ± 0.6ab	152.2 ± 3.8cd	118.6 ± 2.3e	2.80 ± 0.43a	1.41 ± 0.11a	0.190 ± 0.031ab	1.59 ± 0.02abc	0.440 ± 0.033abc
Soğancı[b]	1879 ± 69c	8.9 ± 1.8a	110.0 ± 0.8ab	110.4 ± 10.4a	97.9 ± 4.5c	3.48 ± 1.58ab	1.90 ± 0.92ab	0.115 ± 0.024a	1.24 ± 0.11a	0.325 ± 0.013a
Kabaaşı[b]	1880 ± 75c	12.6[c] ± 2.9c	105.7 ± 8.3ab	131.0 ± 3.7abc	97.0 ± 3.1bc	2.34 ± 0.52a	2.63 ± 0.13cd	0.150 ± 0.043a	1.66 ± 0.08bc	0.430 ± 0.069abc
Çöloğlu[b]	1227 ± 57a	14.0 ± 1.4bc	87.0 ± 2.6a	120.4 ± 16.9ab	72.0 ± 2.8a	3.73 ± 0.32ab	1.61 ± 0.20abc	0.230 ± 0.078ab	1.71 ± 0.14bc	0.390 ± 0.069ab
Çataloğlu[b]	1377 ± 48a	13.9 ± 1.8bc	140.8 ± 4.0bc	131.7 ± 19.3abc	88.9 ± 7.4b	2.73 ± 0.32a	2.19 ± 0.51abc	0.145 ± 0.061a	1.58 ± 0.01abc	0.350 ± 0.103ab
Hacıkız[b]	1605 ± 63b	15.9 ± 7.3c	173.6 ± 20.06c	146.7 ± 3.0cd	104.6 ± 2.4cd	3.51 ± 0.17ab	2.02 ± 0.24abc	0185 ± 0.044ab	2.29 ± 0.04de	0.645 ± 0.021de
Tokaloğlu	1926 ± 74c	8.0 ± 0.4a	113.6 ± 1.4ab	148.8 ± 1.0cd	144.1 ± 3.1f	5.09 ± 1.35b	2.05 ± 0.13abc	0.250 ± 0.012ab	1.97 ± 0.23cd	0.510 ± 0.030bcd
Alyanak	2319 ± 84d	10.1 ± 1.5ab	240.5 ± 10.5d	160.4 ± 11.5d	157.2 ± 5.4g	7.74 ± 1.03c	2.54 ± 0.89bcd	0.335 ± 0.091bc	2.85 ± 0.13f	0.715 ± 0.163e
Iğdır	3219 ± 69e	17.8 ± 4.6d	233.7 ± 15.2d	222.0 ± 6.1e	237.9 ± 1.4i	7.94 ± 0.60c	4.24 ± 0.31ede	0.310 ± 0.058bc	2.67 ± 0.24ef	0.425 ± 0.052abc
Bursa	3455 ± 63f	11.7 ± 1.8b	230.2 ± 19.9d	284.4 ± 24.7f	177.6 ± 4.6h	11.3 ± 0.75d	3.38 ± 0.87	0.400 ± 0.132c	2.85 ± 0.35f	0.575 ± 0.063cde

[a] Mineral contents expressed as milligrams per 100 g of dry weight. Each value is the mean ± standard deviation of four determinations. Means with different letters in the column for each apricot variety are significantly different ($p < 0.05$).
[b] Apricots varieties from Malatya region of Turkey.

Mg, and P levels were considerably higher and were considered as macro elements. The mineral content of Malatya apricots in dry basis was lower than the Alyanak, Iğdır, and Bursa varieties, with some minor exceptions. However, when fresh weight is taken into account, it is evident that Malatya apricots contain more minerals. The sequences with regard to the content of macro and micro elements content in all cultivars are as K > Mg > Ca > P > Na and Fe > Zn > Mn > Ni > Se, respectively. In macro elements, potassium was the highest, ranging from 1227 to 3455 mg/100 g of dry weights and sodium was the lowest, ranging from 8 to 17.8 mg/100 g of dry weights. To the authors knowledge, there are no comparable data in the literature which show the detailed mineral content of Malatya apricots. Selenium content of the Malatya apricot varieties analyzed was found within the ranges of reported values (Munzuroglu, Karatas, & Geckil, 2003).

Dietary reference intakes (DRI) established by the US Food and Nutrition Board of the Institute of Medicine (IOM), National Academy of Sciences are 4700, 320–420, 700, 8–18, 8.1, 0.055, and 1.8–2.3 mg/days for K, Mg, P, Fe, Zn, Se, and Mn, respectively (Institute of Medicine, 2000a; Institute of Medicine, 2000b; Institute of Medicine, 2001; Institute of Medicine, 2004). The given DRI values are for female and male adults of ages 19–50 years. Since apricots can be considered as a good source of minerals, consumption of 3–4 fresh apricots per day may supply the daily requirement of K, Mg, Fe, Se, and Mn and half of P and Zn for an average adult.

The differences between some of the chemical compositions of (vitamins and minerals) apricot varieties or different cultural forms of a variety have been explained mainly by genetic and environmental variations. In addition to these, harvest of the fruit and ripening levels also affects the contents (Munzuroglu et al., 2003).

The results presented in this work suggest that Malatya apricots, serve as a good source of nutritive compounds such as phenolic compounds, carotenoids, sugars, organic acids, and minerals. Total phenolics, total carotenoids, sugar, and mineral contents of Malatya apricots were found to be significantly higher than most of the other apricot varieties. Sucrose was determined as the predominant sugar in all apricot varieties. Sorbitol, a beneficial sugar alcohol, was found in Malatya apricots at considerably high levels. As a result of this study, it can be stated that Malatya apricot which is protected as a geographical indication, contains functional food components with high nutritional value and has significantly different composition than the other apricot varieties analyzed as well as the the literature data.

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References

Al-Farsi, M., Alasalvar, C., Morris, A., Baron, M., & Shahidi, F. (2005). Comparison of antioxidant activity, Anthocyanins, carotenoids, and phenolics of three native fresh and sun-dried Date (*Phoenix dactylifera* L.) varieties grown in Oman. *Journal of Agricultural and Food Chemistry, 53*, 7592–7599.

Alper, N. (2001). Researches on Pomegranate juice production. Ph.D Thesis, Hacettepe University, Ankara, Turkey.

Ameny, M. A., & Wilson, P. W. (1997). Relationship between hunter color values and beta carotene contents in white-fleshed African sweet potatoes (*Ipomoea batatas* Lam). *Journal of the Science of Food and Agriculture, 73*, 301–306.

Anon (2004). CEM Operation Manual, Cem Corporation Matthews, North Carolina, US.

AOAC. (1990). Official Methods of Analysis, 15th ed., VA, USA: Association of Official Analytical Chemists, Arlington.

Ashoor, S. H., & Knox, J. M. (1984). Determination of organic acids in foods by high-performance liquid chromatography. *Journal of Chromatography, 299*, 288–292.

Asma, B. M. (2000). *Apricot growing*. Malatya, Turkey: Evin Publishing, in Turkish.

Creed, J. T., Brockhoff, C. A., & Martin, T. D. (1994). *Method 200.8 determination of trace elements in water and wastes by inductively coupled plasma-mass spectrometry revision 5.4*. Ohio: Environmental Monitoring systems Laboratory Office of Research and Development U.S Environmental Protection Agency.

Colaric, M., Veberic, R., Stampar, F., & Hudina, M. (2005). Evaluation of peach and nectarine fruit quality and correlations between sensory and chemical attributes. *Journal of the Science of Food and Agriculture, 85*, 2611–2616.

Dimara, E., Petrou, A., & Skuras, D. (2004). Agricultural policy for quality and producers' evaluations of quality marketing indicators: A Greek case study. *Food Policy, 29*, 485–506.

Dolenc-Sturm, K., Stampar, F., & Usenik, V. (1999). Evaluating of some quality parameters of different apricot cultivars using HPLC method. *Acta Alimentaria, 28*, 297–309.

Dragovic-Uzelac, V., Pospisil, J., Levaj, B., & Delonga, K. (2005). The study of phenolic profiles of raw apricots and apples and their purees by HPLC for the evaluation of apricot nectars and jams authenticity. *Food Chemistry, 91*, 372–383.

FAO. (2005). FAO statistical database, Available: http://apps.fao.org. (accessed on January 2007).

Forni, E., Sormani, A., Scalise, S., & Torreggiani, D. (1997). The influence of sugar composition on the color stability of osmodehydrofrozen intermediate moisture apricots. *Food Research International, 30*, 87–94.

Gebhard, S. E., & Thomas, R. G. (2002). *Nutritive Value of Foods*. Washington DC:US Government Printing Office: US Department of Agriculture Research Service.

Gill, M. I., Tomás-Barberán, F. A., Hess-Pierce, B., & Kader, A. A. (2002). Antioxidant capacities, phenolic compounds, carotenoids, and vitamin C contents of nectarine, peach, and plum cultivars from California. *Journal of Agricultural and Food Chemistry, 50*, 4976–4982.

Glew, R. H., Ayaz, F. A., Sanz, C., Vanderjagt, D. J., Huang, H. S., Chuang, L. T., et al. (2003). Changes in sugars, organic acids and amino acids in medlar (*Mespilus germanica* L.) during fruit development and maturation. *Food Chemistry, 83*, 363–369.

Gokmen, V., Bahçeci, S., & Acar, J. (2002). Liquid chromatographic method for the determination of chlorophylls, carotenoids, and their derivatives in fresh and processed vegetables. *The Journal of Liquid Chromatography & Related Technologies, 25*, 1201–1213.

Gross, J. (1987). Pigments in fruits. In J. Gross (Ed.), *Carotenoids* (pp. 87–186). London: Academic Press.

Hart, D. J., & Scott, K. J. (1995). Development and evaluation of an HPLC method for the analysis of carotenoids in foods, and the measurement of the carotenoid content of vegetables and fruits commonly consumed in the UK. *Food Chemistry, 54*, 101–111.

Hu, F. B., Stampfer, M. J., Manson, J. E., Grodstein, F., Colditz, G. A., Speizer, F. E., et al. (2000). Trends in the incidence of coronary heart disease and changes in diet and lifestyle in women. *The New England Journal of Medicine, 343*, 530–537.

Impembo, A., LoVoi, M., Fasanaro, G., & Castaldo, D. (1995). Chemical characterization of apricot puree. *Journal of Food Composition and Analysis, 8*, 78–85.

Institute of Medicine (IOM) (2000a). Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. Berlin: Springer.

Institute of Medicine (IOM) (2000b) Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. National Academy Press: Washington, DC. 2000. Washington, DC: National Academy Press.

Institute of Medicine (IOM) (2001). Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington, DC: National Academy Press.

Institute of Medicine (IOM) (2004). Dietary Reference Intakes: Water, Potassium, Sodium, Chloride, and Sulfate. Washington, DC: National Academy Press.

Josling, T. (2005). *What's in a name? The economics, law and politics of geographical indications for foods and beverages. In paper presented to the Institute for International Integration Studies*. Dublin: Trinity College, pp 28.

Katona, Z. F., Sass, P., & Monar-Perl, I. (1999). Simultaneous determination of sugars, sugar alcohols, acids and amino acids in apricots by gas chromotography–massspectrometry. *Journal of Chromatography A, 847*, 91–102.

Lenz, D. (2003). Osmotic dehydration of apple in glucose, fructose, sucrose solutions and corn syrup. Ph.D. Thesis, Hacettepe University, Ankara, Turkey.

Moyer, R. A., Hummer, K. E., Finn, C. E., Frei, B., & Wrolstad, R. E. (2002). Anthocyanins, phenolics, and antioxidant capacity in diverse small fruits: Vaccinium, Rubus,and Ribes. *Journal of Agricultural and Food Chemistry, 50*, 519–525.

Müller, H. (1997). Determination of the carotenoid content in selected vegetables and fruit by HPLC and photodiode array detection. *Zeitschrift fur Lebensmittel-Untersuchung und – Forschung A, 204*, 88–94.

Munzuroglu, O., Karatas, F., & Geckil, H. (2003). The vitamin and selenium contents of apricot fruit of different varieties cultivated in different geographical regions. *Food Chemistry, 83*, 205–212.

Ness, A. R., & Powles, J. W. (1997). Fruit and vegetables, and cardiovascular disease: A review. *International Journal of Epidemiology, 26*, 1–13.

Poyrazoğlu, E., Gökmen, V., & Artık, N. (2002). Organic acids and phenolic compounds in pomegranates (Punica granatum) grown in Turkey. *Journal of Food Composition and Analysis, 15*, 567–575.

Radi, M., Mahrouz, M., Jaouad, A., & Amiot, M. J. (2004). Characterization and identification of some phenolic compounds in Apricot fruit (*Prunus armeniaca* L.). *Sciences des Aliments, 24*, 173–183.

Rapaille, A., Goosens, J., & Heume, M. (2003). Sugar alcohols. In B. Caballero, L. C. Trugo, & P. M. Finglas (Eds.), *Encyclopaedia of Food Sciences and Nutrition* (pp. 5665–5671). Oxford, UK: Academic Press.

Rodriguez-Amaya, D. B. (1999). *A Guide to Carotenoid Analysis in Foods*. Washington: ILSI Pres.

Rossello, C., Canellas, J., Santiesteban, I., & Mulet, A. (1993). Simulation of the absorption process of sulphur dioxide in apricots. *Lebensmittel-Wissenschaft und-Technologie, 26*, 322–328.

Ruiz, D., Egea, J., Gil, M. I., & Tomás-Barberán, F. A. (2005). Characterization and quantitation of phenolic compounds in new apricot (Prunus armenica L.) varieties. *Journal of Agricultural and Food Chemistry, 53*, 9544–9552.

Ruiz, D., Egea, J., Tomás-Barberán, F. A., & Gil, M. I. (2005). Carotenoids from new apricot (*Prunus armeniaca* L.) varieties and their relationship with flesh and skin color. *Journal of Agricultural and Food Chemistry, 53*, 6368–6374.

Sass-Kiss, A., Kiss, J., Milotay, P., Kerek, M. M., & Toth-Markus, M. (2005). Differences in anthocyanin and carotenoid content of fruits and vegetables. *Food Research International, 38*, 1023–1029.

Southon, S., & Faulks, R. (2002). Health benefits of increased fruit and vegetable consumption. In W. Jongen (Ed.), *Fruit and vegetable processing: Improving quality* (pp. 2–19). Washington, DC: CRC Pres.

Sponas, G. A., & Wrolstad, R. E. (1990). Influence of processing and storage on the phenolic composition of Thompson seedless grape juice. *Journal of Agricultural and Food Chemistry, 38*, 1565–1571.

Steinmetz, K. A., & Potter, J. D. (1996). Vegetables, fruits and cancer prevention: A- review. *Journal of The American Dietetic Association, 96*, 1027–1037.

Sturm, K., Koron, D., & Stampar, F. (2003). The composition of fruit of different strawberry varieties depending on maturity state. *Food Chemistry, 83*, 417–422.

Thompson, C. O., & Trenerry, V. C. (1995). A rapid method for the determination of total L-ascorbic acid in fruits and vegetables by micellar electrokinetic capillary chromatography. *Food Chemistry, 53*, 43–50.

TPI. (2007). Turkish Patent Institute. Available: http://www.turkpatent.gov.tr (accessed on January 2007).

Turkish Standard (1997). Food staffs-determination of metals and other elements-atomic absorption spectrophotometric method (TS 3606).Turkish Standard Institute: Ankara, Turkey.

Turkish Standard (2002). Fruit and vegetable products-Determination of titratable acidity (TS 1125). Turkish Standard Institute: Ankara, Turkey.