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ARTICLE

Comparative Study of Chemical and Biochemical Properties of Different Melon Cultivars: Standard, Hybrid, and Grafted Melons

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Chemical and biochemical properties of standard, hybrid, and grafted melons cultivated under the same agricultural conditions in adjacent fields in the Cumra region of Turkey were investigated and compared based on pH, Brix, antioxidant activity, total phenolics, ascorbic acid, individual phenolics, sugar, and organic acid values. Seventeen different phenolic constituents were quantified by reverse phase high-performance liquid chromatography (RP-HPLC). The highest phenolic acid variability and content were detected in the standard melon. Sugar and organic acid compositions of melon cultivars were tested by capillary electrophoresis, and significant differences in types and contents of individual sugars and organic acids were determined among the cultivars. Standard Cinikiz Cumra melons had the highest ascorbic acid, total phenolics, and total sugar contents. The fructose/glucose ratio increased three times in grafted melon as compared with standard melon. While sugar alcohol mannitol existed in the standard and hybrid cultivars, this constituent disappeared in the grafted types. Citric acid found in the standard cultivar was not detected in the hybrid and grafted types. Consequently, it was concluded that the nutritional value of melons changed by the application of hybridization, grafting, or standard (open pollinated) production methods. The standard melon was found to have the highest score in terms of taste, because of its highest sweetness and sourness. It was also found preferable because of its high antioxidant activity, total phenolic and ascorbic acid contents.

KEYWORDS: *Cucumis melo*; muskmelon; hybrid seed; grafted seedling; organic acid; sugars; phenolics; antioxidant

INTRODUCTION

Melons (*Cucumis melo* L.) and watermelons (*Citrillus lanatus* L.) are becoming the most highly produced fruits around the world and in Turkey. Many different melon cultivars have been produced worldwide such as cantaloupes, honeydews, casaba, Persian, Santa Claus, and Christmas melons. China is the world's largest melon producer with 13.7 million tons of yearly production, and it is followed by Turkey having 1.7 million tons/year production (*1*). The provinces where the highest melon cultivation is performed in Turkey are Ankara, Manisa, Diyarbakir, Balikesir, and Konya. In Konya, the production of melons is particularly intense in the region of Cumra. In the past couple of years, the farmers have put emphasis on fertile and high quality hybrid types. It has been observed that high yield has been reached by utilizing hybrid seeds in the production of Cumra melon. It is also denoted that melon production made with grafted seedlings also resulted in high yield.

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Compositional, nutritional, and functional properties are the significant parameters in determining food quality. For this reason, it is important to know in what ways the properties of products are changed in case of production by hybridization, grafting, and standard (open pollinated) methods. Although the history of genetically modified products is as not old as hybrid ones, there are many investigations on quality and other properties of genetically modified products. It was reported that quality, sensory attributes, shelf life, and many agronomic traits of melon fruit can be improved with some genetic manipulation (*2*). However, little or no comparative information is available on the chemical and biochemical properties of melons produced by standard, hybrid, and grafted methods. To the best of our knowledge, the closest research to this aim is the one reported by Lester and Saftner (*3*) on marketable quality and phytonutrient concentrations of a novel hybrid muskmelon and their parental lines.

The aim of this study is to compare standard, hybrid, and grafted Cumra melons produced under the same agricultural conditions in adjacent experimental fields and to determine the best one in regard to chemical and biochemical properties and

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biological activities. The results of the investigation allow the comparison of Cumra's melons cultivated by standard methods, hybrid seeds, and grafted seedlings in regard to quality, while providing important original data for the scientific literature. Furthermore, our findings contribute to the enhancement of melon farming and the utilization of melons in the food industry.

EXPERIMENTAL PROCEDURES

Chemicals. Standards (purity > 99.0%) were supplied as follows: ascorbic acid, gallic acid, protocathechuic acid, *p*-hydroxybenzoic acid, vanillic acid, caffeic acid, chlorogenic acid, syringic acid, epicatechin, *p*-coumaric acid, ferulic acid, benzoic acid, *o*-coumaric acid, *trans*-cinnamic acid, abscisic acid, catechin, rutin, quercetin, and propylparaben as internal standard (IS) from Sigma-Aldrich (St. Louis, MO) and Merck (Darmstadt, Germany); methanol, acetic acid, and acetonitrile from Merck (Darmstadt, Germany); 2,6-pyridinedicarboxylic acid, citric acid monohydrate, oxalic acid dihydrate, malic acid, *N*-cetyl-*N*,*N*,*N*-trimethylammonium bromide (CTAB), formic acid (d = 1.22 g/mL, 98%), Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid), TPTZ (2,4,6-tripyridyl-s-triazine), Folin−Ciocalteu's phenol reagent, and glycyl-glycine from Fluka Chemie GmbH (Switzerland); D(+)-glucose and D(−)-fructose, D-gluconic acid sodium salt, pyruvic acid, and fumaric acid from Sigma Chemical Co (Steinheim, Germany); maleic acid, D-tartaric acid, and succinic acid from Supelco (Bellefonte, PA); BHT (butylated hydroxytoluene) from Applichem (Darmstadt, Germany). Polytetrafluoroethylene (PTFE) membranes (porosity 0.2 μm) for the filtration of the extracts were obtained from Sartorius (Goettingen, Germany).

All the solutions were prepared with deionized water purified in an Elgacan C114 (Elga, England) filtration system.

Melons. Three types of melons, standard, hybrid and grafted, were analyzed in this study. Many factors affect the composition of plants including variety, state of ripening, soil type and condition, irrigation, fertilization, and weather (*4*, *5*). Several investigations have reported that, especially in the *Cucumis melo* fruit, physical and nutritional properties are highly linked with many factors such as moisture and agricultural conditions (*3*, *6*, *7*). For this reason, all the melon samples were produced under the same agricultural conditions, such as soil type, climate, and irrigation, in adjacent fields. Standard means open pollinated varieties that have more or less stabilized in their habitats from one generation to the next. On the other hand, a hybrid is formed by pollination of one specific variety of a class with the pollen of another genetically different variety of that class (*8*). Standard seeds are named "Cinikız" and hybrid seeds are named as "Edalı" in Cumra. Hybrid melon seeds were sent to the seedling firm (Yildiz Fide) in Antalya, Turkey, to be grafted onto squash (*Cucurbita moschata*). Then, the grafted melon seedlings were planted in the experimental field. Melons were harvested at a commercial stage of ripeness, like other melons cultivated in the Cumra region. The harvest time was at the end of August 2008, 65−70 days after pollination. For each cultivar, ten melons were collected and kept at a cool place (~18 °C) for 2−3 days until it was analyzed. For each melon type (standard, hybrid, or grafted), ten fruits were peeled and seeded. About 800 g of the edible mesocarp tissue was combined and homogenized using a blender for the chemical and antioxidant measurements. The homogenate was filtered through Whatman No.1 filter paper, and then the filtrate was centrifuged at 10000*g* for 15 min at 4 °C. The supernatant was then frozen at −20 °C. The analyses were conducted on defrozen supernatant samples, referred to as "samples" in Experimental Procedures.

Determination of Physicochemical Properties. Soluble solid, weight of total seeds, and acidity were immediately determined using an AOAC method (*9*). Soluble solid was determined as °Brix index, and the measurements were made using a manual refractometer ATAGO (Tokyo, Japan) with a working range of 0−32 °Brix.

Determination of Antioxidant Activity. The antioxidant activities of the samples were determined by FRAP assay. The antioxidant method is based on the measurement of the iron reducing capacities of the samples. The working FRAP reagent was prepared by mixing 25 mL of 0.3 mol/L acetate buffer at pH 3.6 with 2.5 mL of 10 mmol/L 2,4,6-tripyridyl-s-triazine (TPTZ) solution in 40 mmol/L HCl, and 2.5 mL of 20 mmol/L $FeCl_3 \cdot 6H_2O$ solution (*10*). One hundred microliters of the sample was mixed with 3 mL of freshly prepared FRAP reagent. The reaction mixture was then incubated at 37 °C for 4 min. After that, the absorbance was determined at 593 nm against a blank that was prepared using distilled water and incubated for 1 h instead of 4 min. A calibration curve was used, using an aqueous solution of ferrous sulfate $FeSO_4 \cdot 7H_2O$ concentrations in the range of 100−1000 μM (r^2 = 0.98). In order to make comparison, Trolox was also tested under the same conditions as a standard antioxidant compound. FRAP values were expressed in wet weight of the melon samples as millimoles of ferrous equivalent Fe(II) per gram of sample. UV−vis spectrophotometer (ATI-Unicam UV-2, Cambridge, U.K.) was used in all absorbance measurements.

Determination of Ascorbic Acid Content. Ascorbic acid content was determined spectrophotometrically as reported by Farajzadeh and Nagizadeh (*11*). According to this method, the purple color of Cu(II)−NH_3 complex solution decays in the presence of ascorbic acid, and the change of absorbance can be followed spectrophotometrically at 600 nm. Various concentrations of 5 mL of standard ascorbic acid solutions or sample solutions were mixed with 4 mL of Cu(II)−NH_3 complex solution, which was prepared by dissolving 2.50 g of $CuSO_4 \cdot 5H_2O$, 5.53 g of NH_4CI, and 7.5 mL of concentrated ammonia in about 50 mL, adjusting the pH to 9.2 by 1 mol/L NaOH, and diluting the solution to 100 mL with distilled water. The concentration of ascorbic acid was calculated as mg/100 g FW by using a standard graph.

Determination of Total Phenolics (TPs). Total phenolic contents were determined by the Folin−Ciocalteau procedure (*12*) using gallic acid as standard. Briefly, 20 μL of various concentrations of gallic acid and samples (20 μL), 400 μL of 0.5 N Folin−Ciocalteu reagent and 680 μL of distilled water was added, and the contents were vortexed. Following 3 min incubation, 400 μL of Na_2CO_3 (10%) solution was added, and after vortexing, the mixture was incubated for 2 h at 20 °C with intermittent shaking. The absorbance was measured at 760 nm at the end of the incubation period. The concentration of total phenolic compounds was calculated as mg of gallic acid equivalents (GAE) per g of 100 g FW, by using a standard graph for gallic acid in the concentration range between 0.015 and 0.5 mg/mL (r^2 = 0.9967).

Determination of Phenolic Compounds by HPLC. HPLC (Agilent 1000) analysis of phenolic compounds was performed on a reverse phase Zorbax Eclipse XDB-C18 column (4.6 × 150 mm, 5 μm particle size), using a gradient program with two solvent systems (A, 0.5% acetic acid in acetonitrile:water (1:1); B, 2% acetic acid in water at a constant solvent flow rate of 1.2 mL/min). Injection volume was 20 μL. The signals were detected at 280 nm by UV detection. After filtration and centrifugation of melon juice, pH was adjusted to 1.0 with HCl; then, solid phase extraction was applied by using Supelclean LC-18 SPE tubes (Bellefonte, PA) to separate phenolic compounds. The phenolic compounds adsorbed on the column were eluted with methanol. The solvents of the methanolic fractions were evaporated to dryness under reduced pressure in a rotary evaporator at 40 °C. The residue was redissolved in methanol for HPLC analysis.

Determination of Individual Sugars by CE. Capillary electrophoretic separations were performed with an Agilent capillary electrophoresis system equipped with a diode-array detector. The data processing was carried out with the Agilent ChemStation software. The fused silica capillary was 50 μm i.d. and obtained from Polymicro Technologies. The total length of the capillary was 64 cm, and the length to the detector was 56.5 cm. The new fused silica capillary was conditioned prior to use by rinsing with 1 mol/L NaOH for 30 min and with water for 10 min. The capillary was flushed with 0.1 mol/L NaOH and water for 2 min and with buffer solution for 10 min at the beginning of every working day. Between runs, the capillary was flushed for 2 min with running buffer solution.

Melon juice from melon samples was centrifuged at 2100 rpm for 5 min, and the supernatant was taken carefully by means of a Pasteur pipet. The dilution ratio with deionized water changed between 1:5 and 1:20 (v/v) for carbohydrate analysis. Diluted samples were injected to CE directly. A capillary electrophoretic method developed by our group (*13*) was used for the analysis of sugars in the melon samples. The method was based on using a dipeptide, glycylglycine, as the background electrolyte. This electrolyte, without any additive, improves the resolution of sugars as well as providing their indirect detection. For melon samples, optimal separation conditions were selected as 50 mmol/L glycylglycine at pH 12.42. Samples were injected at 50 mbar for 5 s from the anodic side, and the voltage was set at 25 kV. The signal wavelength was set at 350 nm with a reference at

207 nm. Glucose and fructose contents of melon samples were calculated from calibration curves drawn between 2 and 20 mmol/L for both sugar types with 0.994 and 0.997 regressions for glucose and fructose, respectively. Calibration curves of manitol and sucrose were drawn between 7.5 and 30 mmol/L (with 0.995 regression), and between 5 and 15 mmol/L (with 0.981 regression), respectively.

Determination of Individual Organic Acids by CE. Melon juice from melon samples was centrifuged at 2100 rpm for 5 min, and supernatant was taken carefully by means of a Pasteur pipet. The diluting ratio with deionized water changes between 1:10 and 1:100 (v/v) for organic acid analysis depending on melon type. A capillary electrophoresis method which recently was applied by us for the analysis of organic acids in pomegranate juices (*14*) was used here for the analysis of organic acids in melon samples. Analysis method was based on the indirect detection of organic acids using a chromophore, 2,6-pyridinedicarboxylic acid (PDC), in the separation electrolyte and obtaining fast coelectroosmotic migrations of organic acids by means of dynamic coating of capillary wall with a positively charged surfactant, *N*-cetyl-*N*,*N*,*N*-trimethylammonium bromide (CTAB). Optimal separation electrolyte was selected as 5 mmol/L PDC and 0.1 mmol/L CTAB at pH 5.26. Injections were done from the cathodic side at 50 mbar for 5 s. The running voltage was adjusted to 25 kV. The signal wavelength was set at 350 nm with a reference at 200 nm. Calibration curves were done with five different concentration levels of the standard samples. Regressions of calibration curves were between 0.997 and 0.999 for all the acids.

Sensory Analysis. Eight trained panelists evaluated melon samples in terms of taste, aroma and texture. Each melon cultivar was peeled, and seeds were removed. Each melon slice was presented to the panelists at room temperature in randomly numbered plastic dishes under artificial light. Panelists used potable water to clean their mouth. All panelists tested the samples in the same order. Panelists ranked their perceptions on a 1 to 5 scale, 5 being the most desirable and 1 being the worst.

Statistical Analysis. The results were presented as mean values and standard deviations (mean ± SD). Data and regression analyses were performed with Microsoft Office Excel 2003 (Microsoft Corporation, Redmond, WA). Data were tested using SPSS (version 9.0 for Windows 98, SPSS Inc.). Statistical analysis of the results was based on Kruskal–Wallis test and Pearson correlation analysis, a nonparametric test. The significance of the differences was statistically considered at the level of $p < 0.05$, or otherwise given.

RESULTS AND DISCUSSION

Physical Properties of Tested Melons. Table 1 shows the °Brix, total seed and pH values of standard, hybrid, and grafted melons cultivated in the Cumra region.

Antioxidant Capacities, Ascorbic Acid and Total Phenolic Contents of Melons. We selected the FRAP method to compare antioxidant capacities of cultivars. The FRAP assay is a simple and inexpensive method. Besides antioxidant capacity values, we determined ascorbic acid and total phenolic amounts of cultivars, which are both closely related to antioxidant powers of food products (*15*, *16*), FRAP values, ascorbic acid and total phenolic contents of three cultivars are given in **Table 2**. The FRAP value was significantly higher ($P < 0.05$) for the standard melon compared with the grafted type. Differences in FRAP values between the standard and hybrid melons were not significant.

Ascorbic acid, the most well-known antioxidant, is an important molecule in plant tissues and protects plants against oxidative damage resulting from the oxidant metabolites of photosynthesis and aerobic processes (*17*). We used a straightforward spectrophotometric method for the determination of ascorbic acid. Although not yielding absolute values due to the matrix effect and also due to storage at −20 °C, our approach is useful for the purposes of comparison. Although spectrophotometric methods are relatively less sensitive compared to chromatographic methods and the results might be affected from interfering substances, as well as from storage temperature, this simple method is well suited to the comparasion of ascorbic acid contents of the melon samples having the same interfering matrix and storage temperature. Moreover, the absolute values of ascorbic acid contents found were well matched with those in the literature. Lester and Saftner (*3*) reported that the ascorbic acid content of three different cultivar of muskmelon were approximately 34.7–44.7 mg/100 g. Obando-Ulloa et al. reported ascorbic acid contents of 29 near-isogenic lines as between 6 and 19.7 mg/100 g (*18*). As seen from **Table 2**, the highest value of ascorbic acid belongs to the standard melon and the following is for the grafted one. The hybrid melon has the lowest ascorbic acid content. The ascorbic acid level was significantly higher ($p < 0.05$) in standard melon compared to the ascorbic acid contents of the others.

Plant phenolics (TPs) are the largest class of plant secondary metabolites. They counteract reactive oxygen species in order to survive and prevent molecular damage and damage by microorganisms, insects, and herbivores (*19*). The phenolic content and composition of fruits and vegetables depend on genetic and environmental factors as well as postharvest processing conditions. As seen from **Table 2**, total phenolic contents of cultivars change between 92.54 and 115.2 mg/100 g melon (FW). TP level was significantly higher ($p < 0.05$) in standard melon compared to TPs of others.

HPLC Analysis of Phenolic Compounds. Figure 1 shows the chromatograms of standard phenolic acid mixtures (**A**), standard melon (**B**), grafted melon (**C**), and hybrid melon (**D**), respectively. Seventeen phenolic acids were analyzed, and fourteen compounds were determined. The amounts of the phenolic acids as mg/100 g FW are presented in **Table 3**. The amount of phenolic acids of aqueous extracts of the melons varied widely from 0.5 to 30 mg/100 g FW. The results showed that benzoic, abscisic, vanillic, and *trans*-cinnamic acids were detected in all samples in high amounts as the major phenolic component. *p*-Coumaric, ferulic and gallic acids were found in small amounts, but protocatechuic acid and cathecin were not found in any of them. *p*-Hydroxybenzoic acid, syringic acid, *o*-coumaric acid, and epicatechin were only found in standard melon sample but in very small concentrations. Quercetin was found only in grafted melon, and a high concentration of rutin was detected in grafted and hybrid types. The highest phenolic acid variability and content were detected in standard melon.

CE Analysis of Carbohydrates. Fruit sweetness is the major determinant of the fruit quality. The amount of major soluble

Table 1. Physical Parameters of the Tested Melons

parameter	standard ($n = 10$)	grafted ($n = 10$)	hybrid ($n = 10$)
pH	5.61 ± 0.04	5.91 ± 0.17	5.49 ± 0.05
°Brix	9.60 ± 0.14	8.30 ± 0.42	6.9 ± 1.27[a]
total seed (g/kg)	187 ± 12.72	157.93 ± 12.17[a]	170.09 ± 15.12

[a] Values are significantly different from those of standard ($p < 0.05$).

Table 2. Antioxidant Capacity, Ascorbic Acid and Total Polyphenol Contents of the Tested Melons

parameter	standard	grafted	hybrid
FRAP μM Trolox/kg FW[a]	493.8 ± 57.4	351.3 ± 32.9[b]	378.8 ± 46.6
ascorbic acid (mg/100 g FW)	22.47 ± 2.57	18.34 ± 2.02[b]	5.386 ± 1.54[b]
total polyphenol mg gallic acid/100 g FW melon	115.2 ± 5.10	92.54 ± 4.00[b]	96.00 ± 4.00[b]

[a] FW: fresh weight. [b] Values are significantly different from those of standard ($p < 0.05$).

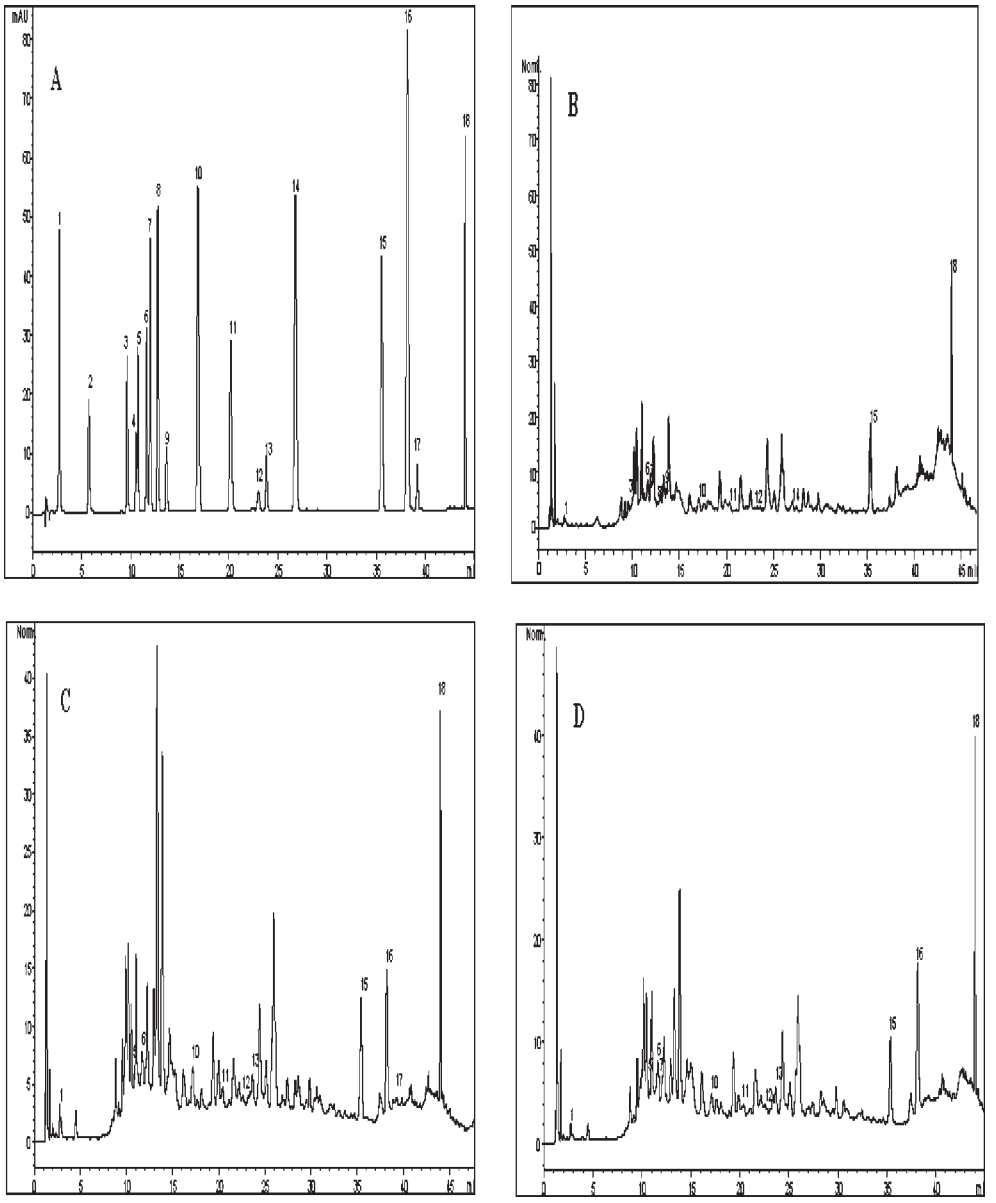

Figure 1. A high-performance liquid chromatography−UV−vis detection procedure for separating (**A**) standard phenolic compounds; (**B**) standard melon; (**C**) grafted melon; and (**D**) hybrid melon. All peaks were identified by comparison of retention time and UV spectra with commercial standards. Zorbax Eclipse XDB-C18 column (4.6 × 150 mm, 5 μm), gradient eluent acetic acid/acetonitrile/water, flow rate 1.2 mL/min. Peak identification: (1) gallic acid, (2) protocatechuic acid, (3) *p*-OH benzoic acid, (4) catechin, (5) chlorogenic acid, (6) vanillic acid, (7) caffeic acid, (8) syringic acid, (9) epicatechin, (10) *p*-coumaric acid, (11) ferulic acid, (12) benzoic acid, (13) rutin, (14) *o*-coumaric acid, (15) *cis*,*trans*-abscisic acid, (16) *trans*-cinnamic acid, (17) quercetin, and (18) propylparaben.

sugars, i.e., sucrose, glucose and fructose, determines the sweetness and marketing value of the fruits. Changes of sugar compositions during fruit development are related to changes of activity of sugar metabolizing enzymes (*2*). Sugar types and amounts were compared with a CE analysis. Electrophoregrams of the melon juices obtained from cultivars are given in **Figure 2**. The quantities of sugars calculated from electrophoregrams are given in **Table 4**. As seen from **Table 4**, carbohydrate types differ considerably between cultivars. As the main sugars are mannitol, sucrose, glucose, and fructose for standard type, mannitol was not detected in grafted melon and sucrose was not detected in hybrid melon. Fructose/glucose ratio (F/G) is a specific indicator for the type of fruit juices. F/G ratio increased (1.62) considerably (more than 3 times) in grafted melon compared with F/G ratios for standard (0.53) and hybrid (0.64) species. This decrease may be the result of high lactic acid production in hybrid melon with sugar utilization by lactic acid bacteria (*20*).

CE Analysis of Organic Acids. The main organic acid detected was citric acid for the standard type melon. Smaller amounts of succinic acid and lactic acid were also detected. However, while succinic and lactic acid were still detected, citric acid was not detected in grafted melon. For hybrid type melon, the only acid type was lactic acid with comparatively high amounts. The electrophoregrams of the juices are given in **Figure 3**, and quantitative amounts of the organic acids are given in **Table 4**. The predominance of the succinic acid over citric acid was reported for melons by Obando-Ulloa et al. (*18*). However, in this study, citric acid was found dominant for standard type melon.

Sensory Evaluation. Standard melon cultivar took the highest grades in terms of aroma, taste, and texture. According to statistical

Table 3. Phenolic Constituents of the Melon Types of Determined by Reverse Phase High-Performance Liquid Chromatography (mg Phenolic Compound/100 g)

compound	standard	grafted	hybrid
	Phenolic Acids		
gallic acid	1.74	2.23	1.34
protocatechuic acid	ND[a]	ND	ND
p-hydroxybenzoic acid	0.72	ND	ND
chlorogenic acid	0.90	2.29	1.60
vanillic acid	7.24	6.36	7.83
syringic acid	0.52	ND	ND
caffeic acid	2.04	1.37	1.47
p-coumaric acid	3.24	4.16	3.07
ferulic acid	3.69	3.72	2.91
benzoic acid	30.06	5.55	9.06
o-coumaric acid	1.22	ND	ND
abscisic acid	15.39	11.71	8.35
t-cinnamic acid	2.99	5.72	6.85
	Flavanoids		
quercetin	ND	2.26	ND
catechin	ND	ND	ND
epicatechin	3.71	ND	ND
rutin	ND	12.73	10.75

[a] ND: not detected.

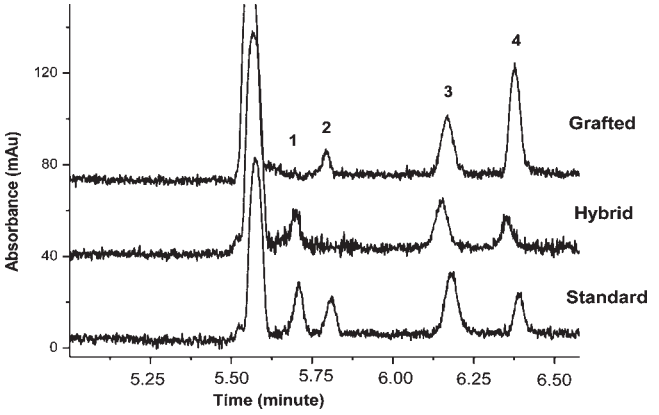

Figure 2. Electropherogram of 1/10 diluted melon juices; 50 mmol/L glycylglycine, pH 12.42; voltage 25 kV. Sugars: (1) mannitol, (2) sucrose, (3) glucose, (4) fructose.

analysis ($p < 0.05$), the differences in taste were found significant among melon cultivars (**Table 5**).

Although all three types of melon were cultivated in the same environmental conditions, the results of chemical studies on these cultivars show a considerable amount of differences in their chemical characteristics. Between the melon species investigated, the standard type had the highest sweet taste, due to its highest total sugar content. However, the fructose/glucose ratio increased approximately three times in grafted melon compared to the F/G ratio of standard melon. Fructose is recommended for diabetics due to low glycemic index compared to that of glucose. On the other hand, mannitol, which exists in standard and hybrid species, completely disappeared in the grafted type. This sugar alcohol is responsible for diuretic or laxative properties of melon fruit. Considerable variations in sugars between different melon cultivars have been reported before (*18*, *21*). Moreover, our results reveal that total phenolic contents and individual phenolic acid and small organic acid variability show differences between cultivars grown in adjacent fields. Thus, the results of this study show that

Table 4. Sugar and Organic Acid Contents of the Tested Melons

	standard	grafted	hybrid
	Sugars (g/L)		
mannitol	16.04 ± 0.37	ND[a]	15.50 ± 0.01
sucrose	16.53 ± 0.18	9.11 ± 0.15[b]	ND
glucose	20.14 ± 0.83	14.54 ± 0.02[b]	14.74 ± 0.03[b]
fructose	10.59 ± 0.40	23.50 ± 0.10[b]	9.47 ± 0.02
F/G ratio	0.53	1.62	0.64
total sugar	63.30	47.15[b]	39.71[b]
	Organic Acids (g/L)		
citric acid	3.04 ± 0.13	ND	ND
succinic acid	0.18 ± 0.01	1.11 ± 0.03[b]	ND
lactic acid	0.66 ± 0.03	0.90 ± 0.03	4.14 ± 0.79[b]

[a] Not detected. [b] Values are significantly different from those of standard ($p < 0.05$).

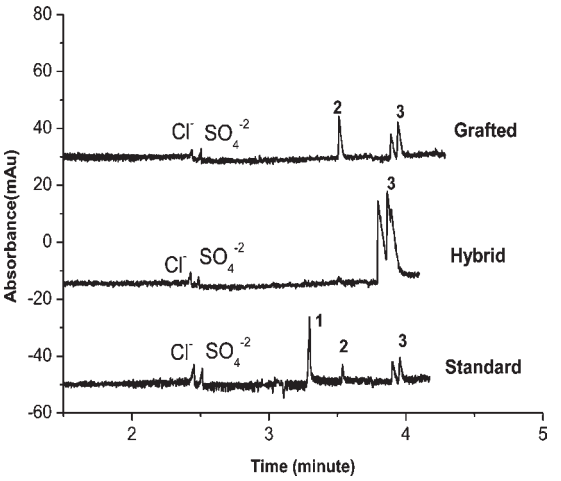

Figure 3. Electropherogram of 1/50 diluted melon juices. Separation electrolyte 5 mmol/L PDC, 0.1 mmol/L CTAB; pH 5.26; voltage −25 kV. Organic acids: (1) citric acid, (2) succinic acid, (3) lactic acid.

Table 5. Sensory Evaluation of the Tested Melons[a]

parameter	standard	grafted	hybrid
aroma	3.25 ± 1.06	2.75 ± 1.03	2.25 ± 1.38
taste	4.37 ± 1.18	2.62 ± 0.74[b]	2.37 ± 1.68[b]
texture	3.62 ± 0.91	2.75 ± 0.88	3.00 ± 1.06

[a] Values represent the mean of 10 melon fruits ± SD. [b] Values are significantly different from those of standard ($p < 0.05$).

nutritional value of melons can be changed by applying hybridization, grafting, or standard (open pollinated) production methods.

If we interpret the three cultivars studied in this work from the point of view of consumer preference, the first choice would be based on the sweetness of the melon. As can be seen from our results, the total sugar content of the standard type is considerably higher than that of the two other types. An important indicator for sweetness, the total solid amount (Brix), is significantly higher in the standard and grafted types as compared with the hybrid type. Moreover, in recent years, the antioxidant contents of the fruits have gained importance from the point of view of consumer health. In this respect, the ascorbic acid and total phenolic amount of the standard type is significantly higher than that of the two other types. Furthermore, the highest phenolic acid variability and content were detected in standard melon. Citric acid, which adds a sour taste to fruits, occurs in

important quantity in the standard type, but does not occur in the grafted and hybrid types. The sourness that citric acid provides on top of sweetness is probably the reason why test groups gave the highest taste score to the standard melon, by a considerable margin, as compared with the grafted and hybrid types. Because of all the reasons stated above, the standard cultivars will be those preferred by the consumer from the three cultivars.

ABBREVIATIONS USED

CE, capillary electrophoresis; FRAP, ferric-reducing/antioxidant power; FW, fresh weight; RP-HPLC, reverse phase high-performance liquid chromatography; IS, internal standard; CTAB, *N*-cetyl-*N*,*N*,*N*-trimethylammonium bromide; Trolox, 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid); TPTZ, 2,4,6-tripyridyl-s-triazine; BHT, butylated hydroxytoluene; PDC, 2,6-pyridinedicarboxylic acid; PTFE, polytetrafluoroethylene; GAE, gallic acid equivalents.

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LITERATURE CITED

(1) Taşkaya, B.; Keskin, G. K.-K. *Tarimsal Ekonomi Araştirma Enstitüsü* **2004**, *6*, 1303.
(2) Li, Z.; Yao, L.; Yang, Y.; Li, A. Transgenic approach to improve quality traits of melon fruit. *Sci. Hortic.* (*Amsterdam, Neth.*) **2006**, *108*, 268–277.
(3) Lester, G. E.; Saftner, R. A. Marketable quality and phytonutrient concentrations of a novel hybrid muskmelon intended for the fresh-cut industry and its parental lines: Whole-fruit comparisons at harvest and following long-term storage at 1 or 5 °C. *Postharvest Biol. Technol.* **2008**, *48*, 248–253.
(4) Hardisson, A.; Rubio, C.; Martin, M.; Alvarez, R.; Diaz, E. Mineral composition of the banana (*Musa acuminata*) from the island of Tenerife. *Food Chem.* **2001**, 153–161.
(5) Kolayli, S.; Küçük, M.; Duran, C.; Candan, F.; Dincer, B. Chemical and antioxidant properties of *Laurocerasusu officinalis* Roem.-(Cherry Laurel) fruit grown in the Black Sea region. *J. Agric. Food Chem.* **2003**, *51*, 7489–7494.
(6) Lester, G. E.; Shellie, K. C. Postharvest sensory and physiocochemical attributes of honey dew melon fruits. *HortScience* **1992**, *27*, 1012–1014.
(7) Lester, G. E.; Bruton, B. D. Relationship of netted muskmelon fruit water loss to postharvest storage life. *J. Am. Soc. Hortic. Sci.* **1986**, *111*, 727–731.
(8) Rindels, S. Let's talk about standards and hybrids. *Today's garden*; National Garden Bureau: Downers Grove, IL, 1993; pp 127−130.
(9) AOAC. *Official methods of analysis*, 15th ed.; Association of Official Analytical Chemists: Washington, DC, 1990.
(10) Benzie, I. F. F.; Strain, J. J. The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": The FRAP assay. *Anal. Biochem.* **1996**, *239*, 70–76.
(11) Farajzadeh, M. A.; Nagizadeh, S. A simple and reliable spectrophotometric method for the determination of ascorbic acid in pharmaceutical preparations. *J. Anal. Chem.* **2003**, *58* (10), 927–932.
(12) Singleton, V. L.; Rossi, J. L. Colorimetry of total phenolics with phosphomolybdic phosphotungstic acid reagents. *Am. J. Enol. Vitic.* **1965**, *16*, 144–158.
(13) Gürel, A.; Hızal, J.; Öztekin, N.; Erim, F. B. CE determination of carbohydrates using a dipeptide as separation electrolyte. *Chromatographia* **2006**, *64*, 321–324.
(14) Tezcan, F.; Gültekin-Özgüven, M.; Diken, T.; Özçelik, B.; Erim, F. B. Antioxidant activity and total phenolic, organic acid and sugar content in commercial pomegranate juices. *Food Chem.* **2009**, *115*, 873–877.
(15) Bernaldo, Q. R. A.; Arias, M. F.; Hernández, J. L. A screening method for the determination of ascorbic acid in fruit juices and soft drinks. *Food Chem.* **2009**, *116*, 509–512.
(16) Küçük, M.; Kolayli, S.; Karaoğlu, Ş.; Ulusoy, E.; Baltaci, C.; Candan, F. Biological activities and chemical composition of three honeys of different types from Anatolia. *Food Chem.* **2007**, *100*, 526–534.
(17) Smirnoff, N. The function and metabolism of ascorbic acid in plants. *Ann. Bot. London.* **1996**, *78*, 661–669.
(18) Obando-Ulloa, J. M.; Eduardo, I.; Monforte, A. J.; Trujillo, P. F. Identification of QTLs related to sugar and organic acid composition in melon using near-isogenic lines. *Sci. Hortic.* (*Amsterdam, Neth.*) **2009**, *121*, 425–433.
(19) Robards, K.; Prenzlere, P. D.; Tucker, G.; Swatsitang, P.; Glover, W. Phenolic compounds and their role in oxidative processes in fruits. *Food Chem.* **1999**, *66*, 401–436.
(20) Dalié, D. K. D.; Deschamps, A. M.; Richard-Forget, F. Lactic acid bacteria-potential for control of mould growth and mycotoxins. *Food Contam.* **2010**, *21*, 370–380.
(21) Lester, G. E. Antioxidant, sugar, mineral, and phytonutrient concentrations across edible fruit tissues of orange-fleshed honeydew melon (*Cucumis melo* L.). *J. Agric. Food Chem.* **2008**, *56*, 3694–3698.

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