Article

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Physical Characters and Antioxidant, Sugar, and Mineral Nutrient Contents in Fruit from 29 Apricot (*Prunus armeniaca* L.) Cultivars and Hybrids

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Fruit physical and chemical characters of 29 apricot cultivars of Greek and American origin and their hybrids were evaluated using correlation and principal component analysis. A remarkable variation was observed in the total phenol content (0.3−7.4 mg gallic acid equivalent g^{-1} FW) and total antioxidant capacity (0.026−1.858 mg ascorbic acid equivalent g^{-1} FW), with the American origin cultivars Robada and NJA_2 and the new cultivar Nike exhibiting the greatest values. The cultivar Tomcot and hybrid 467/99 had the highest content of total carotene (37.8 μg β-carotene equivalent g^{-1} FW), which was up to four times greater as compared with the rest of studied genotypes. The dominant sugar in fruit tissue was sucrose, followed second by glucose and third by sorbitol and fructose-inositol. The new cultivars Nike, Niobe, and Neraida contained relatively higher contents of sucrose and total sugars, while Ninfa and P. Tirynthos contained relatively higher contents of K, Ca, and Mg. Correlation analysis suggested that late-harvesting cultivars/hybrids had greater fruit developmental times ($r = 0.817$) and contained higher sugar ($r = 0.704$) and less Mg contents ($r = -0.742$) in fruit tissue. The total antioxidant capacity was better correlated with the total phenol content ($r = 0.954$) as compared with the total carotenoid content ($r = 0.482$). Weak correlations were found between the fruit skin color and the antioxidant contents in flesh tissue. Multivariate analysis allowed the grouping of variables, with more important variables being the harvest date, fruit developmental time, skin Chroma, sorbitol, and total sugar, K and Mg contents. Plotting the genotypes in a dendrogram revealed cases of homonymy between parents and hybrids, although independent segregation of the measured traits after hybridization was also found.

KEYWORDS: Apricot; fruit weight; fruit color; fruit maturation time; cultivars and hybrids; mineral nutrients; *Prunus armeniaca* L.; sugars; total antioxidant capacity; total carotenoids; total phenolics

INTRODUCTION

The apricot (*Prunus armeniaca* L.) fruit is highly appreciated by consumers and is one of the most important fruit species grown in the world. The greatest percentage of the world's apricot production comes from the countries around the Mediterranean Sea, that is, Turkey, Spain, Italy, France, and Greece. The apricot cultivars that are cultivated show good adaptability to local climatic conditions. However, most breeding programs aim to produce new cultivars with better traits such as good flesh taste, aroma, and firmness, high sugar content, big size and attractive fruit color, extensive harvesting period, and resistance to Sharka disease, as all local European cultivars are susceptible (*1*−*4*). Lately, there is a considerable interest in determining the variation that may exist in the content of antioxidant compounds and other nutritional properties of fruit from different genotypes within species (*5*−*7*). This would provide a way of allowing breeders to select and breed genotypes with higher levels of nutritional compounds and also increasing the dietary intake by the consumers.

Fruits are known to have a clear role to combat degenerating diseases due to their high content in antioxidant compounds such as carotenoids and polyphenols (*8, 9*). The apricot fruit is an important source of provitamin A carotenoids since 250 g of fresh or 30 g of dried fruit provides 100% of the recommended daily allowance (*10*). The major carotenoid compound found in apricots is β-carotene, constituting 60−70% of the total carotenoid level (*7, 11, 12*). The major phenolic compounds in apricot are chlorogenic and neochlorogenic acids, (+)-catechin, (−)-epicatechin, and rutin (or quercetin-3-rutinoside) (*12*). Although these phenolic compounds are know to be strong antioxidants (*9*), Scalzo and colleagues (*13*) found that the

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Table 1. Parentage, Harvest Date, Days after Anthesis (Fruit Developmental Time), and Mean (±SE) Fruit Weight of the Apricot Genotypes Assayed[a]

genotype	parentage	harvest date	days after anthesis	fruit weight (g)
309/99	Orangered × K-104-98	May 29	80	38.5 ± 3.0
312/99	Orangered × K-104-98	June 1	88	36.6 ± 1.1
467/99	Harlayne open pollination	June 18	95	44.9 ± 1.1
704/99	Sunglo open pollination	June 20	93	57.4 ± 7.2
A 600/91	Bebecou × Veecot	June 15	92	55.8 ± 1.5
A 614/91	Bebecou × Veecot	June 26	98	76.2 ± 1.3
A 615/91	Bebecou × Veecot	June 26	97	69.3 ± 1.9
Aurora	NJA53	May 29	80	64.7 ± 2.6
Bebecou	Chance seedling	June 22	99	105.3 ± 3.9
Danae	Veecot × P. Tirynthos	June 13	95	70.4 ± 1.9
EOT - 30	S. Early Orange × P. Tirynthos	June 13	95	63.6 ± 1.8
Goldrich	Sunglo × Perfection	June 20	97	74.7 ± 3.0
Harcot	[(Geneva × Naramata) × Morden 604] × (Phelps × Perfection)	June 20	90	71.7 ± 3.0
K 104−98	Orangered × NJA_2	May 29	70	52.0 ± 2.7
Nefele	Koliopoulou × Veecot	June 25	111	79.4 ± 1.5
Neraida	Bebecou × NJA_2	June 13	89	55.0 ± 2.4
Nereis	Bebecou × Lito [S. Early Orange × P. Tirynthos]	June 26	102	88.7 ± 5.4
Nike	S. Early Orange × P. Tirynthos	June 13	89	48.2 ± 1.9
Ninfa	Ouardi × P. Tirynthos	May 30	67	51.4 ± 1.9
Niobe	S. Early Orange × Bebecou	June 13	96	72.3 ± 4.1
NJA_2	Morden 604 open pollination	June 6	81	52.8 ± 3.4
Nostos	Veecot × Bebecou	June 26	109	91.3 ± 3.5
Orangered	Lasgerdi Mashhad × NJA_2	June 10	79	60.0 ± 3.2
P 252−1	B_{51-77} open pollination	May 25	76	71.5 ± 4.0
Proimo Tirynthos	Chance seedling	June 5	101	50.7 ± 2.5
Robada	Orangered × K113−40	June 8	95	92.8 ± 4.7
Sadunska	unknown	May 29	80	71.6 ± 3.1
Soledane	unknown	June 6	83	51.9 ± 1.4
Tomcot	Rival × PA63-265	June 8	86	70.9 ± 3.1

[a] The LSD for mean fruit weight was 8.69.

Table 2. Correlation Coefficients of Fruit Physical and Chemical Characters of Apricots[a]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. harvest date	1																				
2. fruit development time	**0.817**	1																			
3. fruit fresh weight	0.500	0.509	1																		
4. skin, *L**	NS	NS	NS	1																	
5. skin, *a**	NS	NS	NS	NS	1																
6. skin, *b**	0.607	0.478	NS	NS	NS	1															
7. total phenolics	NS	NS	NS	−0.550	NS	−0.435	1														
8. antioxidant capac.	NS	NS	NS	−0.532	NS	−0.466	**0.954**	1													
9. total carotenoids	NS	NS	NS	−0.582	NS	NS	0.533	0.482	1												
10. K	−0.669	−0.592	−0.478	NS	NS	NS	NS	NS	NS	1											
11. Ca	−0.432	NS	NS	0.535	NS	NS	NS	NS	NS	**0.750**	1										
12. Mg	−**0.742**	−0.522	−0.468	NS	NS	v0.542	NS	NS	NS	**0.725**	0.623	1									
13. sucrose	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1								
14. glucose	NS	NS	NS	NS	NS	NS	NS	NS	NS	−0.496	−0.453	NS	NS	1							
15. fructose + inositol	NS	NS	NS	NS	NS	NS	NS	NS	NS	−0.494	NS	NS	NS	**0.782**	1						
16. sorbitol	0.660	0.640	0.475	NS	NS	0.435	NS	NS	NS	−0.531	−0.482	−**0.714**	NS	NS	NS	1					
17. total sugars	**0.704**	0.636	NS	NS	NS	NS	NS	NS	NS	−0.660	−0.455	−0.576	**0.725**	0.436	NS	0.442	1				
18. SSC	0.414	NS	NS	−0.529	NS	NS	NS	NS	NS	−0.524	−0.426	−0.589	NS	NS	NS	0.640	NS	1			
19. total acids	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1		
20. pH	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.411	NS	NS	NS	NS	NS	NS	NS	NS	−**0.791**	1	

[a] NS, not significant; absolute linear correlations ≥|0.70| are marked in bold.

antioxidant capacity in apricot fruit was not correlated with its phenolic content. Moreover, phenolic compounds are known to be responsible for the induction of enzymatic browning in the presence of oxygen and the enzyme polyphenol oxidase (*12*).

The consumer preference for apricots is greatly influenced by its sugar content, constituting an important compositional property (*14*). Moreover, information on the content of individual sugars in fruits can help dieticians to plan diets for diabetics. It has been reported that fructose is 1.8 times sweeter than sucrose, while glucose is less sweet than sucrose (*15*). Furthermore, the sugar profile and ratio of specific sugars are considered as useful tools in authenticization of juice samples. The glucose/fructose ratio should range from 1.6 to 3.1 in apricot juice, and ratios greater than 3.3 indicate adulteration in the juice samples (*16*). Nevertheless, apricots from the Central Asia germplasm have been found to have a glucose/fructose ratio higher than 3.3 (*4*).

Multivariate analysis is a useful tool for germplasm description and characterization and has been used to determine the relationships among cultivars/hybrids and to study correlations among variables in apricot (*17*−*21*) and other species (*22*). However, a few studies included nutritional properties of the apricot fruit in multivariate or correlation analyses (*5, 11, 19*). In apricots, Ruiz et al. (*11*) found a high positive correlation between the carotenoid content and the skin and flesh color. Information on the associations that may exist among fruit physical and chemical characters may be beneficial for consumers interested in a healthier product.

Table 3. Mean Values (±SE) of Total Antioxidant Capacity (Ascorbate Equivalent Antioxidant Capacity, AEAC) (mg Ascorbic Acid g^{-1} FW), Total Phenolic (mg Gallic Acid g^{-1} FW), Total Carotenoid (μg β-Carotene g^{-1} FW), Potassium (%), Calcium (%), and Magnesium (%) Contents in Fruit from Different Apricot Cultivars/Hybrids

	AEAC	total phenolics	total carotenoids	K	Ca	Mg
309/99	0.174 ± 0.047	0.676 ± 0.006	28.1 ± 1.69	1.705 ± 0.005	0.100 ± 0.010	0.065 ± 0.005
312/99	0.409 ± 0.014	0.943 ± 0.021	17.4 ± 0.33			
467/99	0.249 ± 0.004	1.699 ± 0.033	37.8 ± 0.51	1.613 ± 0.024	0.083 ± 0.003	0.050 ± 0.000
704/99	0.113 ± 0.002	0.990 ± 0.014	21.6 ± 1.21	1.327 ± 0.018	0.093 ± 0.013	0.040 ± 0.000
A 600/91	0.125 ± 0.123	0.538 ± 0.047	20.5 ± 0.84			
A 614/91	0.085 ± 0.039	0.336 ± 0.020	21.5 ± 0.71	1.595 ± 0.105	0.100 ± 0.020	0.050 ± 0.000
A 615/91	0.026 ± 0.056	0.801 ± 0.002	18.1 ± 0.14	1.470 ± 0.001	0.110 ± 0.010	0.050 ± 0.000
Aurora	0.170 ± 0.087	0.492 ± 0.012	17.8 ± 0.29	1.760 ± 0.026	0.125 ± 0.022	0.075 ± 0.003
Bebecou	0.109 ± 0.051	1.003 ± 0.005	9.5 ± 0.43	1.440 ± 0.038	0.090 ± 0.001	0.040 ± 0.000
Danae	0.079 ± 0.011	1.171 ± 0.031	28.1 ± 0.12	1.440 ± 0.010	0.120 ± 0.011	0.060 ± 0.000
EOT-30	0.682 ± 0.056	2.932 ± 0.144	26.8 ± 0.09	1.560 ± 0.001	0.140 ± 0.006	0.063 ± 0.003
Goldrich	0.387 ± 0.035	2.087 ± 0.089	26.6 ± 0.08	1.500 ± 0.044	0.093 ± 0.003	0.057 ± 0.003
Harcot	0.728 ± 0.005	2.204 ± 0.015	26.0 ± 0.08	1.445 ± 0.025	0.105 ± 0.015	0.050 ± 0.000
K 104-98	0.474 ± 0.094	0.949 ± 0.033	33.9 ± 0.63	1.805 ± 0.036	0.118 ± 0.009	0.068 ± 0.003
Nefele	0.049 ± 0.037	0.969 ± 0.025	22.3 ± 0.71			
Neraida	0.095 ± 0.004	1.119 ± 0.047	17.8 ± 0.42	1.655 ± 0.075	0.105 ± 0.015	0.065 ± 0.005
Nereis	0.083 ± 0.062	0.303 ± 0.004	10.4 ± 0.31	1.425 ± 0.025	0.100 ± 0.001	0.050 ± 0.000
Nike	1.858 ± 0.058	7.422 ± 0.068	31.0 ± 1.92	1.455 ± 0.035	0.065 ± 0.005	0.045 ± 0.005
Ninfa	0.142 ± 0.012	0.484 ± 0.022	11.9 ± 0.85	2.087 ± 0.182	0.260 ± 0.022	0.070 ± 0.004
Niobe	0.100 ± 0.072	1.057 ± 0.087	20.0 ± 0.14	1.505 ± 0.075	0.100 ± 0.010	0.055 ± 0.005
NJA_2	1.068 ± 0.039	4.399 ± 0.337	27.1 ± 0.60	1.723 ± 0.058	0.088 ± 0.003	0.050 ± 0.000
Nostos	0.027 ± 0.009	0.378 ± 0.009	16.6 ± 0.83	1.410 ± 0.010	0.060 ± 0.001	0.040 ± 0.000
Orangered	0.552 ± 0.311	3.563 ± 0.136	28.8 ± 0.20	1.435 ± 0.055	0.065 ± 0.005	0.050 ± 0.000
P 251- 1	0.572 ± 0.440	0.859 ± 0.036	19.3 ± 0.95			
P. Tirynthos	0.128 ± 0.013	1.049 ± 0.021	22.7 ± 0.24	1.817 ± 0.031	0.212 ± 0.019	0.070 ± 0.000
Robada	1.396 ± 0.019	5.596 ± 0.066	32.5 ± 0.91			
Sadunska	0.226 ± 0.114	0.857 ± 0.049	18.9 ± 1.09	1.565 ± 0.035	0.110 ± 0.001	0.060 ± 0.000
Soledane	0.114 ± 0.048	0.654 ± 0.016	22.5 ± 1.01	1.450 ± 0.014	0.090 ± 0.011	0.063 ± 0.003
Tomcot	0.372 ± 0.067	2.046 ± 0.169	37.8 ± 1.99	1.545 ± 0.165	0.130 ± 0.020	0.050 ± 0.010
LSD	0.605	0.309	2.460	0.022	0.043	0.009

Table 4. Mean (±SE) Values of Color Parameters L^*, a^*, and b^*, Hue, and Chroma in Skin of 29 Apricot Genotypes

	L^*	a^*	b^*	hue	chroma
309/99	58.0 ± 1.1	20.4 ± 0.7	36.9 ± 1.3	60.9 ± 0.6	42.2 ± 1.3
312/99	64.3 ± 0.5	7.4 ± 0.6	42.3 ± 0.5	80.1 ± 0.7	43.0 ± 0.5
467/99	57.9 ± 0.3	22.8 ± 0.5	47.7 ± 0.1	64.4 ± 0.9	52.8 ± 0.8
704/99	56.4 ± 0.8	26.0 ± 0.5	42.1 ± 1.6	58.3 ± 1.1	49.5 ± 1.4
A 600/91	62.2 ± 1.0	16.6 ± 0.8	65.7 ± 0.9	75.8 ± 1.0	67.8 ± 0.9
A 614/91	64.1 ± 0.8	15.4 ± 0.7	52.1 ± 0.7	73.5 ± 0.9	54.3 ± 0.5
A 615/91	63.6 ± 1.0	15.8 ± 0.4	51.3 ± 0.2	72.9 ± 0.4	53.6 ± 0.3
Aurora	56.0 ± 0.7	9.8 ± 0.5	28.0 ± 0.6	70.6 ± 0.9	29.7 ± 0.6
Bebecou	63.1 ± 0.2	7.8 ± 0.8	50.1 ± 0.2	81.1 ± 0.1	50.7 ± 0.2
Danae	64.0 ± 1.5	19.0 ± 2.3	35.7 ± 1.5	62.0 ± 3.7	42.1 ± 0.6
EOT-30	57.0 ± 1.2	17.5 ± 1.5	27.4 ± 1.3	57.4 ± 3.4	33.6 ± 0.6
Goldrich	58.3 ± 0.2	14.3 ± 0.9	44.1 ± 0.6	72.0 ± 1.2	46.4 ± 0.4
Harcot	59.9 ± 0.8	13.8 ± 0.6	43.7 ± 1.4	72.5 ± 1.2	45.8 ± 0.1
K 104-98	60.5 ± 0.4	23.0 ± 0.4	34.9 ± 0.4	56.6 ± 0.7	41.9 ± 0.3
Nefele	59.3 ± 0.8	16.4 ± 1.0	59.2 ± 0.9	74.5 ± 0.8	61.4 ± 0.5
Neraida	62.1 ± 1.5	24.2 ± 1.4	38.6 ± 1.6	57.4 ± 2.6	46.4 ± 0.7
Nereis	65.2 ± 2.5	11.1 ± 2.5	47.9 ± 2.8	77.0 ± 4.7	49.2 ± 2.0
Nike	55.3 ± 2.1	24.5 ± 2.3	28.1 ± 2.5	48.2 ± 4.9	40.0 ± 0.7
Ninfa	68.7 ± 0.7	12.9 ± 0.7	37.7 ± 0.8	71.1 ± 1.0	40.0 ± 0.8
Niobe	63.6 ± 1.8	19.3 ± 2.5	33.3 ± 1.6	60.5 ± 4.0	40.5 ± 1.0
NJA_2	61.4 ± 0.6	15.4 ± 1.0	35.4 ± 0.6	66.7 ± 1.3	38.7 ± 0.8
Nostos	60.5 ± 1.4	11.5 ± 1.6	45.0 ± 1.7	75.6 ± 2.4	46.4 ± 1.3
Orangered	55.8 ± 1.5	24.9 ± 1.3	30.9 ± 1.9	50.4 ± 3.3	40.8 ± 0.6
P 252- 1	57.4 ± 1.3	20.8 ± 1.7	34.8 ± 1.6	58.9 ± 3.1	41.6 ± 0.6
Proimo Tirynthos	64.8 ± 1.3	20.3 ± 1.5	33.4 ± 1.2	58.6 ± 2.7	39.9 ± 0.5
Robada	54.6 ± 1.6	25.8 ± 1.3	31.3 ± 2.0	49.8 ± 3.0	41.6 ± 1.1
Sadunska	61.6 ± 0.9	13.9 ± 1.3	36.1 ± 0.6	69.4 ± 1.7	39.0 ± 0.8
Soledane	62.2 ± 0.9	18.9 ± 1.3	34.9 ± 0.9	61.6 ± 2.1	40.2 ± 0.7
Tomcot	58.3 ± 0.6	20.0 ± 0.4	44.4 ± 0.7	65.7 ± 0.7	48.7 ± 0.5
LSD	6.1	7.1	6.7	13.4	3.8

The aims of this study were to (i) identify the variation in the content of bioactive compounds and individual sugars in apricot cultivars and hybrids, (ii) find possible relationships that may exist among physical and chemical characters in the apricot fruit, (iii) assess the overall degree of polymorphism in the characters studied, and (iv) detect similarities among the phenotypic characters and their genetic relations. The studied apricot cultivars are of Greek and American origin, and the hybrids have resulted from a breeding program aimed at developing, by controlled hybridization, cultivars with resistance to Sharka disease. Of the resulting hybrids are now the cultivars named Danae, Neraida, Niobe, Nike, Nereis, Nostos, and Nefele, which apart from being resistant to Sharka disease are also self-compatible and have good agronomical characteristics (*23, 24*).

MATERIALS AND METHODS

Fruit was harvested at commercial maturity from 29 apricot cultivars and hybrids maintained in a collection orchard in Skydra (40°76′E longitude, 22°17′N latitude), which belongs to the Pomology Institute (Naoussa, Greece). The parentages, harvest dates, and fruit developmental times of the apricot genotypes assayed are shown in **Table 1**. Four trees per cultivar/hybrid with a natural fruit set were used, and 9−10 fruits were collected from each experimental tree. Fruit sampling was made between 09:00 h and 10:00 h to minimize possible diurnal changes in carbohydrate concentrations (*25*). Upon harvest, the fruit weight was measured, and the skin fruit color parameters L^*, a^*, and b^* were measured on the surface (ground skin color), using a Minolta Chromatometer (Minolta, Ramsey, NJ). The hue angle [H^0 = arctangent (b^*/a^*)] and chroma $(a^{*2} + b^{*2})^{1/2}$ parameters were calculated. Soluble solid content (SSC) and total acidity (TA) were determined in juice extracted using a food processor in three replicates of four apricots. SSC was determined using a digital refractometer (model PR-1, Atago, Japan) and expressed as %, and TA was analyzed in juices by titration with 0.1 N NaOH and expressed as malic acid content (g 100 mL^{-1}).

For the antioxidant content analyses, nine fruits per apricot genotype were immediately frozen at −20 °C. For sugar analyses, the fruit flesh from another nine fruits was cut into pieces, immediately frozen at

Table 5. Mean Values (±SE) of Individual and Total Soluble Sugars (% DW), SSC (%), and Total Acid (% Malic Acid) Contents and pH in Fruit from Different Apricot Cultivars/Hybrids

	sucrose	glucose	fructose-inositol	sorbitol	total sugars	SSC	total acids	pH
309/99	28.4 ± 0.73	11.4 ± 0.04	4.2 ± 0.06	0.7 ± 0.08	44.6 ± 0.82	10.5 ± 0.50	0.84 ± 0.010	4.05 ± 0.005
312/99								
467/99	37.8 ± 1.18	8.7 ± 0.74	2.8 ± 0.17	5.9 ± 0.60	54.8 ± 1.28	14.3 ± 0.33	1.25 ± 0.110	3.69 ± 0.062
704/99	37.5 ± 0.97	11.3 ± 1.27	4.6 ± 0.28	3.6 ± 0.30	57.0 ± 1.96	14.7 ± 0.44	1.05 ± 0.061	3.69 ± 0.020
A 600/91								
A 614/91	34.6 ± 4.52	11.2 ± 1.54	4.6 ± 0.46	4.6 ± 0.99	54.9 ± 4.60	11.1 ± 0.10	1.58 ± 0.049	3.68 ± 0.010
A 615/91	43.0 ± 1.08	8.8 ± 2.29	1.8 ± 0.19	3.9 ± 0.14	57.5 ± 3.70	11.9 ± 0.10	2.19 ± 0.076	3.53 ± 0.015
Aurora	37.3 ± 1.05	8.3 ± 0.45	1.2 ± 0.10	0.8 ± 0.14	47.6 ± 1.36	12.4 ± 0.24	2.10 ± 0.027	3.49 ± 0.039
Bebecou	36.6 ± 0.73	10.9 ± 0.79	3.6 ± 0.30	4.3 ± 0.23	55.3 ± 1.43	11.7 ± 0.35	1.50 ± 0.035	3.69 ± 0.045
Danae	34.7 ± 1.18	15.1 ± 0.81	5.8 ± 0.47	0.6 ± 0.09	56.2 ± 2.37	11.7 ± 0.15	2.42 ± 0.064	3.53 ± 0.005
EOT-30	35.9 ± 0.59	11.2 ± 0.64	2.8 ± 0.04	4.6 ± 0.32	54.3 ± 1.22	12.5 ± 0.33	2.61 ± 0.021	3.43 ± 0.006
Goldrich	35.8 ± 0.77	10.2 ± 0.73	2.7 ± 0.38	3.6 ± 0.14	52.3 ± 0.40	11.7 ± 0.24	2.97 ± 0.055	3.14 ± 0.032
Harcot	38.1 ± 2.73	11.8 ± 2.55	4.0 ± 0.54	2.3 ± 0.44	56.2 ± 0.08	13.6 ± 0.40	1.81 ± 0.059	3.30 ± 0.005
K 104-98	33.6 ± 0.51	9.4 ± 0.20	2.8 ± 0.20	0.3 ± 0.08	46.0 ± 0.36	11.2 ± 1.12	1.18 ± 0.029	3.87 ± 0.046
Nefele								
Neraida	40.3 ± 2.69	13.4 ± 0.03	3.3 ± 0.15	2.6 ± 0.54	59.5 ± 1.98	10.6 ± 0.40	2.06 ± 0.035	3.50 ± 0.015
Nereis	34.1 ± 0.85	11.8 ± 0.50	4.2 ± 0.07	3.9 ± 0.17	54.1 ± 0.60	12.3 ± 0.75	2.02 ± 0.108	3.42 ± 0.000
Nike	47.1 ± 0.69	10.1 ± 0.66	1.9 ± 0.12	3.0 ± 0.18	62.2 ± 0.04	12.0 ± 1.00	2.03 ± 0.086	3.68 ± 0.025
Ninfa	36.7 ± 2.56	5.33 ± 0.49	0.6 ± 0.04	0.5 ± 0.10	43.1 ± 2.48	10.3 ± 0.32	1.08 ± 0.039	4.01 ± 0.036
Niobe	44.9 ± 1.42	10.5 ± 0.37	2.2 ± 0.24	4.0 ± 0.03	61.5 ± 2.01	11.0 ± 0.20	2.45 ± 0.108	3.44 ± 0.010
NJA_2	30.1 ± 1.06	12.5 ± 0.46	3.3 ± 0.15	2.9 ± 0.49	48.7 ± 0.55	10.5 ± 0.17	1.81 ± 0.053	3.39 ± 0.010
Nostos	35.2 ± 0.01	8.3 ± 0.35	2.2 ± 0.06	8.2 ± 0.00	53.9 ± 0.41	14.3 ± 0.50	1.92 ± 0.062	3.57 ± 0.005
Orangered	34.5 ± 0.88	11.0 ± 0.09	2.1 ± 0.31	4.6 ± 0.98	52.2 ± 0.12	12.5 ± 0.01	0.90 ± 0.071	4.12 ± 0.030
P 252-1								
P. Tirynthos	38.7 ± 0.69	8.0 ± 0.31	1.1 ± 0.06	2.0 ± 0.38	49.8 ± 0.77	8.8 ± 0.27	1.64 ± 0.033	3.89 ± 0.035
Robada								
Sadunska	32.7 ± 2.13	7.4 ± 0.17	3.1 ± 0.22	3.9 ± 0.78	46.9 ± 0.01	12.5 ± 0.50	1.85 ± 0.149	3.72 ± 0.001
Soledane	32.9 ± 0.60	11.3 ± 0.40	3.0 ± 0.22	1.8 ± 0.29	48.9 ± 0.59	9.6 ± 0.22	2.27 ± 0.037	3.24 ± 0.009
Tomcot	34.1 ± 0.83	11.5 ± 0.64	3.1 ± 0.23	4.3 ± 0.90	52.9 ± 1.54	14.0 ± 1.0	2.75 ± 0.232	3.60 ± 0.001
LSD	4.33	2.33	0.67	1.27	4.64	1.09	0.197	0.101

Table 6. Apricot Characters with Factor Loadings and Explained Cumulated Proportion of Variation

characters	component 1 (31.2)	component 2 (19.6)	component 3 (10.3)
harvest date	0.927	0.077	0.100
fruit developmental time	0.800	0.103	0.267
fruit fresh weight	0.683	0.402	0.172
skin, *L**	−0.043	0.771	0.221
skin, *a**	0.057	0.036	−0.091
skin, *b**	0.677	0.521	−0.251
skin, hue	0.413	0.733	0.038
skin, chroma	0.700	0.277	−0.304
total phenolics	−0.029	−0.858	0.166
antioxidant capacity	−0.123	−0.803	0.141
total carotenoids	−0.155	−0.674	−0.323
K	−0.820	0.330	0.083
Ca	−0.608	0.487	0.285
Mg	−0.823	0.215	0.189
sucrose	0.224	−0.256	0.714
glucose	0.373	−0.348	−0.286
fructose + inositol	0.446	−0.021	−0.579
sorbitol	0.718	−0.068	0.037
total sugars	0.711	−0.386	0.353
total soluble solids	0.549	−0.257	−0.241
total acids	0.313	−0.123	0.611
pH	−0.464	0.069	−0.423

−20 °C, and, after 24 h, were lyophilized, homogenized using a pestle and mortar, and stored at −20 °C. Sugar and mineral analyses were obtained from 24 of the 29 apricot cultivars and hybrids assayed.

Total Antioxidant Capacity and Total Phenolics Assays. Frozen samples (about 1 g) from the flesh of three replicate fruits were homogenized in 8 mL of 80% MeOH/H_2O (v/v) using a mortar and pestle. The extract was centrifuged at 10000*g* for 10 min, and the supernatant was recovered.

The total antioxidant capacity was measured using the stable 1,1-diphenyl-2-picryl hydrazyl (DPPH) free radical (*26*), which has an intense violet color but turns colorless as unpaired electrons are sequestered by antioxidants. Reaction mixtures containing 50 μL of extract, 2300 μL of 106.5 μM DPPH in MeOH, and 650 μL of H_2O were vortexed and then held at room temperature in darkness for 4 h. The absorbance of the reaction mixtures was measured at 517 nm, and the ascorbate equivalent antioxidant capacity (mM) was extrapolated from a standard curve prepared using 0−2.7 mM ascorbate. Total soluble phenolics were determined with the Folin−Ciocalteu reagent, and results were expressed as mg gallic acid equivalents 100 g^{-1} FW. Analyses were made in triplicate.

Total Carotenoid Assay. Total carotenoids were assayed using the procedure described by Kuti (*27*). Frozen samples (about 1 g) from the flesh of three replicate fruits were homogenized in 1/1/2 ethanol/acetone/*n*-hexane solution using a pestle and mortar. After it was well-shaken, the extract was allowed to stand for about 30 min, and the absorbance of the upper layer of hexane was measured in a spectophotometer at 450 nm. The total carotenoid content was calculated using an extinction coefficient of β-carotene, $E^{1\%} = 2592$.

Sugar Analysis Using High-Performance Liquid Chromatography (HPLC). Freeze-dried samples (40−50 mg) were put into a centrifuge tube and washed with 5 mL of petroleum ether (40−60°), and the sugars were extracted with 80% ethanol according to Vemmos (*28*). HPLC-grade water (5.0 mL) was added to the residue in a centrifuge tube to dissolve the sugars. Charcoal (10−12 mg) was added to decolorize the solution and mixed well, and the mixture was centrifuged at 3000 rpm for 5 min. The supernatant was removed for HPLC analysis. The sample was past through a 25 mm diameter and 0.22 μm pore filter. A sample of 20 μL was injected onto a 250 mm × 4 mm HC-75 Ca^{2+} (Hamilton) column at 80 °C. The mobile phase HPLC-grade water was supplied by an isocratic pump (Hewlett-Packard 1050) at 0.8 or 1.0 mL min^{-1}. After they left the column, separated sugars were detected using a refractive index detector (Hewlett-Packard HP 1047A). Fructose and inositol coeluted despite every effort at their separation; therefore, they were measured together.

Mineral Analysis. Dry fruit material (0.5−0.8 g) was heated at 600 °C in a muffle furnace for 4−5 h. The ash obtained was dissolved in

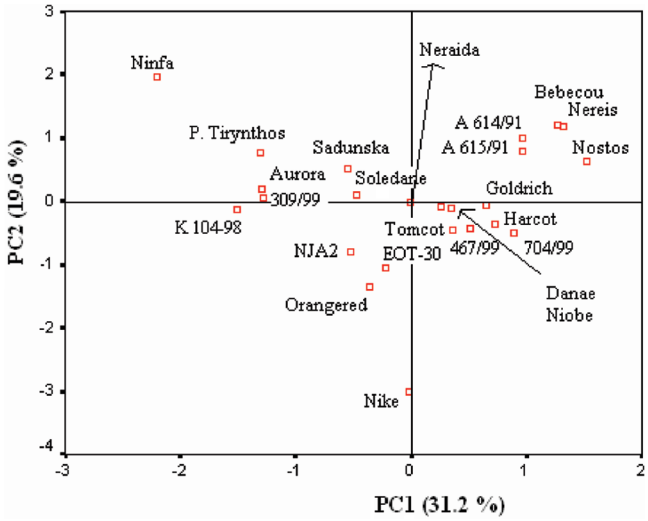

Figure 1. Segregation of 24 apricot cultivars and hybrids according to their quality characteristics determined by PCA.

1−2 mL of 1 M HCl and made up to 50 mL with distilled water. Ca and Mg were measured using atomic absorption spectrometry (Varian A-300), and K was determined using a flame photometer (410 Corning).

Statistical Analyses. Data were subject to one-way analysis of variance (ANOVA), and least significant difference (LSD) values were calculated in cases where significance at $P \leq 0.05$ variance was found among cultivars/hybrids. Correlation analysis was performed. Principal component analysis (PCA) was applied to mean values of the measured traits, and single linkage cluster analysis was performed using the method of squared Euclidean distance on six factors produced after PCA analysis (uncorrelated factor scores). PCA and cluster analysis were made for the 24 out of 29 apricot genotypes for which data from all measured traits were available. Statistical analyses were performed using SPSS 13.0 (SPSS Inc., Chicago, IL).

RESULTS AND DISCUSSION

Considerable variation was found in all measured traits among the 29 apricot cultivars and hybrids (**Tables 1**−**6**). The earliest harvesting cultivars were Aurora, Sadunska, and Ninfa (May 25), and the latest harvesting cultivars were Nostos, Nereis, Nefele, and Bebecou (June 26) (**Table 1**). Significant positive correlations were found between harvest date and days after anthesis ($r = 0.817$), suggesting that the late harvesting cultivars/hybrids usually had a relatively greater fruit developmental time (97−111 days) (**Tables 1** and **2**). The harvest date was positively correlated with total sugars ($r = 0.704$), while negative correlation was found between harvest date and Mg content in fruit tissue ($r = -0.742$), suggesting that late-maturing genotypes also contained higher sugar and less Mg contents in fruit tissue.

The heaviest fruit was produced by the cultivars Bebecou (105.3 g) and Nostos (91.3 g), whereas the lightest fruit was produced by the hybrid 309/99 (38.5 g) (**Table 1**). A weak positive correlation was found between fruit weight and harvest date ($r = 0.500$) (**Tables 1** and **2**). Previously, it was found that small fruit was usually produced by early season cultivars in apricot (*21* but not by *18*) and peach (*29, 30*) trees due to their shorter maturation time. Lopez and DeJong (*31*) recently found that in peach trees the fruit development rate and final fruit weight were governed by exposure to heat in the first 30 days after bloom, which may also be the case in apricots affecting differently the fruit weight in cultivars/hybrids depending on their blooming date and exposure to heat.

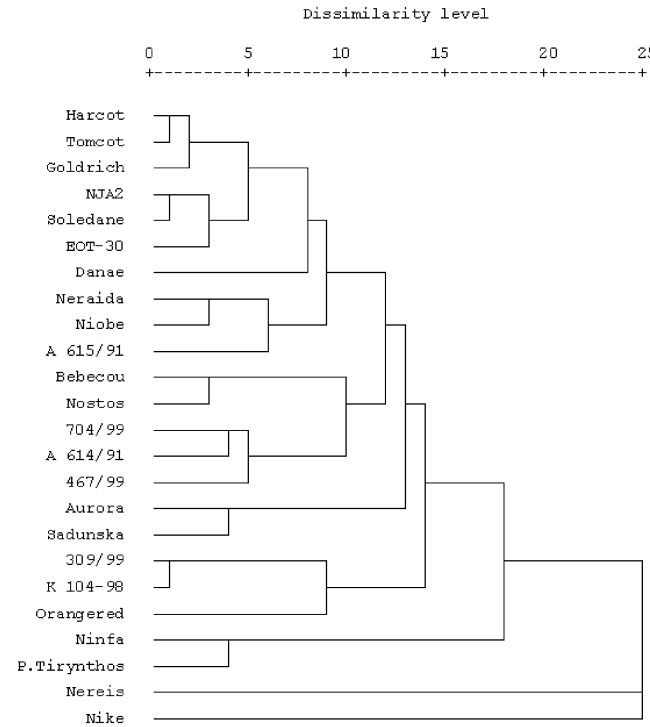

Figure 2. Cluster dendrogram of 24 apricot cultivars and hybrids.

Considerable variation was found in the content of antioxidant compounds in fruit from different apricot cultivars and hybrids (**Table 3**). Mean values of total antioxidant capacity ranged between 0.026 and 1.858 mg ascorbic acid equivalent g^{-1} FW, and the total phenol content ranged between 0.303 and 7.422 mg gallic acid equivalent g^{-1} FW. Although mean values of total phenols in flesh tissue were comparable with results reported by Ruiz et al. (*5*) (0.202−1.202 mg g^{-1} FW) for 37 apricot varieties and hybrids, maximum values of total phenolics were greater in the present genotypes. Relatively high total antioxidant capacities and phenol contents were found in the American origin cultivars Robada and NJA_2 and the new cultivar Nike, whereas low values were detected in the cultivar Nostos. Cultivars Bebecou and P. Tirynthos had a relatively low total phenol content, which coincides with results reported by Radi et al. (*12*) showing that these cultivars were less susceptible to browning due to low initial percentages of flavan-3-ols.

The highest total carotene content (37.8 μg β-carotene equivalent g^{-1} FW) was found in cultivar Tomcot and hybrid 467/99, which was up to four times greater as compared with the rest of studied genotypes (**Table 3**). Mean values of total carotenoids were similar to those reported by Sass-Kiss et al. (*7*) (20−57 μg g^{-1} FW) for 11 apricot cultivars and by Ruiz et al. (*11*) (15−165 μg g^{-1} FW of edible portion) for 37 apricot varieties and hybrids.

The total antioxidant capacity was better correlated with total phenol content ($r = 0.954$) as compared with total carotenoid content ($r = 0.482$), suggesting that phenols have a more significant contribution to the total antioxidant capacity in apricots (**Table 2**). This is not coincident with results of the only relevant study on apricot fruit by Scalzo and colleagues (*13*) where the antioxidant capacity was not correlated with the total phenol content. A weak positive correlation was found between the total phenol and the carotenoid contents ($r = 0.533$).

The cultivars Nike and Orangered and the hybrid K 104-98 had the most orange-colored skin (highest a^* and lowest L^* and hue values), whereas Bebecou had the most white-colored skin (lowest a^* and highest L^* and hue values) (**Table 4**). The

carotenoid content in apricot fruit has been shown to correlate well with the skin and flesh color, with apricots with orange-colored flesh containing higher levels of carotenoids than those of white-colored flesh (*11*). However, in the present study, weak correlations were found between the skin color and the antioxidant parameters, the skin L^* value and total phenol content ($r = -0.550$), the antioxidant capacity ($r = -0.532$), and the total carotenoid content ($r = -0.582$) (**Table 2**), which may be due to the less diverse phenotypic group of genotypes studied.

K, Ca, and Mg are considered as major minerals of the apricot fruit. In the present study, the highest content was found for K (mean values ranged between 1.327 and 2.087%), followed by Ca (0.060−0.260%), and then by Mg (0.040−0.075%) in the different apricot genotypes (**Table 3**). Mean values were in the range of those reported for apricot cultivars from Turkey by Haciseferogullari et al. (*32*) and Akin et al. (*33*), although values were lower for K and Mg, respectively. In the present study, the cultivars P. Tirynthos and Ninfa contained relatively higher K, Ca, and Mg contents as compared with the rest of studied cultivars and hybrids.

The dominant sugar in all cultivars and hybrids was sucrose, followed second by glucose and third by sorbitol and fructose-inositol (**Table 5**). This is in accordance with results from other studies (*16, 34, 35*); nevertheless, Femenia et al. (*36*) found glucose as the dominant sugar in apricot. Other sugars such as xylose, mannose, maltose (*34*), and raffinose (*4*) were also found present in apricot fruit in varying concentrations. In the studied apricot genotypes, the sucrose level was greatest in Niobe, Neraida, Nike, and A 615/91, glucose in Danae and Neraida, and sorbitol in Nostos and 467/99. The highest total sugar content (59.5−62.2% DW) was found in the new cultivars Niobe, Neraida, and Nike, whereas the lowest content was found in Aurora, Sadunska, Ninfa, 309/99, and K 104-98 (43.1−47.7% DW). Similar mean values of soluble sugars were also reported for cultivar Harcot (*34*) and other apricot cultivars (*16, 35*). The widely cultivated Greek cultivars Bebecou and P. Tirynthos are very sensitive to Sharka; therefore, their cultivation is diminished. Considering that Neraida and Niobe had higher and Nereis, Nostos and Danae had similar contents of sucrose and total sugars as compared with Bebecou and P. Tirynthos, it is suggested that the new cultivars should be considered as important genetic material for new plantations.

The total soluble sugar content was positively correlated with the total SSC (refractometer index) ($r = 0.640$, $P < 0.001$). Strong correlations between total soluble solids and total sugar content were reported by Gurrieri et al. (*19*) and Ledbetter et al. (*4*), suggesting that the refractometer index can be effectively used for the determination of fruit maturity and date of harvest in apricots. Mean values of total acid content ranged between 0.80 and 2.83% and were negatively correlated with the pH ($r = -0.791$).

PCA and Grouping of Genotypes. PCA was applied to mean values of measured traits to study which parameters contributed most to the total data variation (**Table 6**). The PCA carried out produced six components accounting for 31.2, 19.6, 10.3, 10.0, 7.0, and 7.8% of variance, respectively. The most important variables integrated in the first component were harvest date, fruit developmental time, chroma, sorbitol, and total sugar contents, while negative correlations had the K and Mg contents. The second component was positively correlated with the L^* and hue parameters and negatively with the antioxidant capacity and total phenol content. The third component was positively correlated with the sucrose and negatively with the fructose-inositol content.

The similarity among cultivars and hybrids was examined when each sample was plotted using the first and second PC components, which retained 50.8% of the total variance (**Figure 1**). Positive values for PC1 indicate genotypes with late harvest date, longer fruit developmental time, high chroma, and sorbitol and total sugar contents (Nostos, Nereis, and Bebecou), whereas negative values indicate genotypes with high K and Mg contents (Ninfa, K-104-98, P. Tirynthos, Aurora, and 309/99). The highest PC2 values correspond to genotypes with light-colored skin (high L^* and hue values) (Ninfa), while the group of genotypes with negative PC2 values indicate genotypes with high total phenol contents and antioxidant capacities (Nike).

Moreover, all PC components were plotted in a dendrogram (**Figure 2**). High homonymy was found between the parent cultivar Bebecou and its hybrids Nostos and A 614/91, between the parent K 104-98 and its hybrid 309/99, and between the parent P. Tirynthos and its hybrid Ninfa (**Table 1** and **Figure 2**). High dissimilarity in all measured traits was found in the cultivars Nike and Nereis. Dissimilarity in measured traits was found between parents Bebecou and NJA_2 and its hybrid Neraida, suggesting an independent segregation of the measured traits after hybridization. Similar results were reported by Ledbetter et al. (*4*) for the heritage of sugar levels in an apricot breeding program.

LITERATURE CITED

(1) Audergon, J. M. Variety and breeding. *Acta Hortic.* **1993**, *384*, 35–45.

(2) Bassil, D.; Bellinil, E.; Guerrierol, R.; Monastral, F.; Pennonel, F. Apricot breeding in Italy. *Acta Hortic.* **1993**, *384*, 47–54.

(3) Karayiannis, I.; Thomidis, T.; Tsaftaris, A. Inheritance of resistance to Plum pox virus in apricot (*Prunus armeniaca* L.). *Tree Genet. Genomes* **2008**, *4*, 143–148.

(4) Ledbetter, C.; Peterson, S.; Jenner, J. Modification of sugar profiles in California adapted apricots (*Prunus armeniaca* L.) through breeding with Central Asian germplasm. *Euphytica* **2006**, *148*, 251–259.

(5) Ruiz, D.; Egea, J.; Gil, M. I.; Tomás-Barberan, F. A. Characterization and quantitation of phenolic compounds in new apricot (*Prunus armeniaca* L.) varieties. *J. Agric. Food Chem.* **2005a**, *53*, 9544–9552.

(6) Drogoudi, P.; Tsipouridis, C.; Michailidis, Z. Physical and chemical characteristics of pomegranates. *HortScience* **2005**, *40*, 1200–1203.

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

(8) Le Marchand, L.; Murphy, S. P.; Hankin, J. H.; Wilkens, L. R.; Kolonel, L. N. Intake of flavonoids and lung cancer. *J. Natl. Cancer Inst.* **2000**, *92*, 154–160.

(9) Rice-Evans, C.; Miller, N.; Paganga, G. Antioxidant properties of phenolic compounds. *Trends Plant Sci.* **1997**, *2*, 152–159.

(10) Bolin, H. R.; Stafford, A. E. Effect of processing and storage on provitamin A and vitamin C in apricots. *J. Food Sci.* **1974**, *39*, 1034–1036.

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

(12) Radi, M.; Mahrouz, M.; Jaouad, A.; Tacchini, M.; Aubet, S.; Hugues, M.; Amiot, M. J. Phenolic composition, browning susceptibility, and carotenoid content of several apricot cultivars at maturity. *HortScience* **1997**, *32*, 1087–1091.

(13) Scalzo, J.; Politi, A.; Pellegrini, N.; Mezzetti, B.; Battino, M. Plant genotype affects total antioxidant capacity and phenolic contents in fruit. *Nutrition* **2005**, *21*, 207–213.

(14) Moreau-Rio, M.; Roty, C. L'abricot: Perceptions et attentes des consommateurs français. *Ctifl-Infos* **1998**, *141*, 16–21.

(15) Doty, T. E. Fructose sweetness: a new dimension. *Cereal Foods World* **1976**, *21*, 62–63.
(16) Voi, A.; Impermbo, M.; Fasanaro, G.; Castaldo, D. Chemical characterization of apricot puree. *J. Food Compos. Anal.* **1995**, *8*, 78–85.
(17) Asma, B. M.; Ozturk, K. Analysis of morphological, pomological and yield characteristics of some apricot germplasm in Turkey. *Genet. Resour. Crop Evol.* **2005**, *52*, 305–313.
(18) Badenes, M. L.; Martínez-Calvo, J.; Llácer, G. Analysis of apricot germplasm from the European ecogeographical group. *Euphytica* **1998**, *102*, 93–99.
(19) Gurrieri, F.; Audergon, J.-M.; Albagnac, G.; Reich, M. Soluble sugars and carboxylic acids in ripe apricot fruit as parameters for distinguishing different cultivars. *Euphytica* **2001**, *117*, 183–189.
(20) Pérez-González, S. Associations among morphological and phenological characters representing apricot germplasm in central Mexico. *J. Am. Soc. Hortic. Sci.* **1992**, *117*, 486–490.
(21) Ruiz, D.; Egea, J. Phenotypic diversity and relationships of fruit quality traits in apricot (*Prunus armeniaca* L.) germplasm. *Euphytica* **2008**, *163*, 143–158.
(22) Iezzoni, A. F.; Pritts, M. P. Applications of principal component analysis to horticultural research. *HortScience* **1991**, *26*, 334–338.
(23) Karayiannis, I.; Mainou, A.; Styianidis, D.; Thomidis, T.; Karayiannis, N. I.; Tsaftaris, A. Resistant to sharka disease (PPV) apricot hybrids of high quality, selected in Greece. *Acta Hortic.* **2006**, *701*, 337–340.
(24) Karayiannis, N. I.; Karayiannis, I. Evaluation of apricot hybrids resistant to PPV for their suitability for canning. *Acta Hortic.* **2006**, *701*, 553–557.
(25) Chong, C.; Taper, C. D. Daily variations of sorbitol and related carbohydrates in Malus leaves. *Can. J. Bot.* **1971**, *49*, 173–177.
(26) Blios, M. S. Antioxidant determination by the use of stable free radicals. *Nature* **1958**, *181*, 1199–1200.
(27) Kuti, J. O. Antioxidant compounds from four *Opuntia* cactus pear fruit varieties. *Food Chem.* **2004**, *85*, 527–533.
(28) Vemmos, S. N. Carbohydrate content of inflorescent buds of defruited and fruiting pistachio (*Pistacia vera* L.) branches in relation to biennial bearing. *J. Hortic. Sci. Biotechnol.* **1999**, *74*, 94–100.
(29) Reginato, G. H.; Garcia De Cortazar, V.; Robinson, T. L. Predicted crop value for nectarines and cling peaches of different harvest season as a function of crop load. *HortScience* **2007**, *42*, 239–245.
(30) Drogoudi, P. D.; Tsipouridis, C. Gr. Effects of cultivar and rootstock on the antioxidant content and physical characters of clingstone peaches. *Sci. Hortic.* **2007**, *115*, 34–39.
(31) Lopez, G.; DeJong, T. M. Spring temperatures have a major effect on early stages of peach fruit growth. *J. Hortic. Sci. Biotechol.* **2007**, *82*, 507–512.
(32) Haciseferogullari, H.; Gezer, I.; Özcan, M. M.; Muratasma, B. Post harvest chemical and physical-mechanical properties of some apricot varieties cultivated in Turkey. *J. Food Eng.* **2007**, *79*, 364–373.
(33) Akin, E. B.; Karabulut, I.; Topcu, A. Some compositional properties of main Malatya apricot (*Prunus armeniaca* L.) varieties. *Food Chem.* **2008**, *107*, 939–948.
(34) Bassi, D.; Selli, R. Evaluation of fruit quality in peach and apricot. *Adv. Hort Sci.* **1990**, *4*, 107–112.
(35) Radi, M.; Mahrouz, M.; Jaouad, A.; Amioti, M. J. Influence of mineral fertilization (NPK) on the quality of apricot fruit (cv. Canino). The effect of the mode of nitrogen supply. *Agronomie* **2003**, *23*, 737–745.
(36) Femenia, A.; Sanchez, E. S.; Simal, S.; Rossello, C. Development and ripening-related effects on the cell wall of apricot (*Prunus armeniaca*) fruit. *J. Sci. Food Agric.* **1998**, *77*, 487–493.

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