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Characterization and Quantitation of Phenolic Compounds in New Apricot (*Prunus armeniaca* L.) Varieties

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Thirty-seven apricot varieties, including four new releases (Rojo Pasión, Murciana, Selene, and Dorada) obtained from different crosses between apricot varieties and three traditional Spanish cultivars (Currot, Mauricio, and Búlida), were separated according to flesh color into four groups: white, yellow, light orange, and orange (mean hue angles in flesh were 88.1, 85.0, 77.6, and 72.4, respectively). Four phenolic compound groups, procyanidins, hydroxycinnamic acid derivatives, flavonols, and anthocyanins, were identified by HPLC-MS/MS and individually quantified using HPLC-DAD. 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, were detected and quantified in the skin and flesh of the different cultivars. The total phenolics content, quantified as the addition of the individual compounds quantified by HPLC, ranged between 32.6 and 160.0 mg 100 g^{-1} of edible tissue. No correlation between the flesh color and the phenolic content of the different cultivars was observed.

KEYWORDS: Anthocyanins; flavonols; flavan-3-ols; HPLC-MS; hydroxycinnamic acid derivatives; polyphenols

INTRODUCTION

In the past few years there has been a renewed interest in evaluating the phenolic content and profile of fruits due to its possible beneficial effects on health (*1*, *2*). A wide range of phenolic compounds are present in fruits (*3*), and their chemical characteristics such as the type of glycosylation, esterification, or polymerization have a great influence on their bioavailability and metabolism (*4*−*7*). Therefore, it is essential to know in detail the type of compounds present in different cultivars of a given fruit. Epidemiological studies support the beneficial effects of flavonoid consumption to decrease the risk of cardiovascular diseases (*8*−*10*) and cancer (*11*).

The phenolic content of stone fruit cultivars grown in California (plums and white and yellow fresh peaches and nectarines) has been recently studied (*12*), and its correlation with the in vitro antioxidant capacity has been demonstrated (*13*). These studies show large differences in the phenolic contents of the studied cultivars and the occurrence of neochlorogenic and chlorogenic acids, proanthocyanidin dimers and trimers, several quercetin and kaempferol glycosides, and cyanidin 3-glucoside as the main pigments (*12*). In apricot cultivar Canino a similar phenolic compound pattern has been recently reported (*14*), although the individual phenolics were not quantified. In addition, the occurrence of quercetin and kaempferol rutinosides in apricot has been also reported (*15*, *16*).

A new group of apricot releases has been obtained from different crosses between apricot cultivars from the apricot breeding program at the research institute CEBAS (CSIC). This includes varieties with different flesh pigmentation intensities: white, yellow, light orange, and orange, as well as different peel colors. Four of them have been registered as new cultivars (*17*−*20*).

The aim of the present work was the characterization and quantitation of the phenolic compound profiles of the different new apricot varieties and the evaluation of the possible correlation between peel and flesh color and the content of phenolic compounds. The high number of evaluated varieties from different genetic origins and with a large phenotypic variability could provide valuable information about phenolic content in the apricot species.

MATERIALS AND METHODS

Plant Material. The plant material assayed included 30 apricot varieties and 4 new releases (Rojo Pasión, Murciana, Selene, and Dorada) obtained from different crosses between apricot cultivars from the apricot breeding program carried out at the research institute CEBAS-CSIC (Murcia, Spain). In addition, 3 traditional Spanish

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cultivars (Currot, Mauricio, and Búlida) have been included as a reference. All of them were cultivated in the same experimental orchard (southeastern Spain, 37° N latitude, 1° W longitude, and 450 m altitude) according to habitual apricot orchard management. All varieties used were harvested between May 9 and June 27 (2003) at the commercial maturity stage on the basis of their skin color (fully colored). Immediately after harvest, fruits were transported in an air-conditioned car to the laboratory (55 km), where they were carefully selected to ensure that fruits were free of defects. For each variety, the ripening stage was based on the assessment of fruit firmness and surface color in all fruits. Three replicates of 10 fruits for each variety were selected. Fruits were peeled and two wedges cut vertically from each side of the fruit. The flesh and peel were frozen separately in liquid nitrogen and kept at −80 °C until analyzed. The frozen fruit was ground to a fine powder in liquid nitrogen before sampling to ensure uniformity, and three replicates of 10 fruits each were analyzed.

Quality Indices. Skin and flesh color, firmness, titratable acidity (TA), pH, and soluble solids content (SSC) were evaluated as quality indices. Color values on the surface (ground skin color) and after peeling in the flesh were measured with a Minolta Chroma Meter (CR-300, Minolta, Ramsey, NJ) tristimulus color analyzer calibrated to a white porcelain reference plate. The color space coordinates L^*, a^*, and b^*, hue angle [H° = arctangent (b^*/a^*)], and chroma ($a^{*2} + b^{*2})^{1/2}$ were determined around the equatorial region in three different positions (with an average of nine times for each apricot). Fruit firmness was evaluated by a compression test using a Lloyd instrument (model LR10K, Fareham Hants, U.K.) equipped with two (12 × 18 cm) flat plates. The maximum force required to deform the fruit 5 mm at a speed of 25 mm/min, with the slice lying on the bottom plate, was recorded. TA was determined by titrating 5 mL of juice with 0.1 mol L^{-1} NaOH to pH 8.1 by an automatic titration system (*21*). The pH values were measured using a pH-meter, and SSC was determined with an Atago N1 hand-held refractometer (Tokyo, Japan). The fruit characteristics from the evaluated apricot varieties are shown in a previous work (*22*). The fruit firmness ranged from 24.2 to 60.1 N, the soluble solids between 10.4 and 17.0%, the titratable acidity between 0.9 and 2.44 g of malic acid/100 mL of juice, and the pH between 3.17 and 3.87 as reported previously (*22*). In addition, the color values (L^*, a^*, b^*, H°, and C^*) have already been described (*22*). In the case of orange flesh cultivars, H° values ranged between 79.49 and 67.75, light orange cultivars ranged from 79.79 to 74.97, yellow cultivars ranged between 90.93 and 81.48, and the white flesh cultivars ranged between 93.45 and 84.19.

Extraction of Phenolic Compounds. Five grams of frozen fruit material was homogenized with an Ultra Turrax (Ika, Staufen, Germany) with 10 mL of extraction solution (methanol/water 8:2 v/v contaning 2 mM NaF to inactivate polyphenol oxidases and prevent phenolic degradation due to browning) for 2 min on ice, and the homogenates were kept in ice until centrifuged (11500*g*, 15 min, 2−5 °C). The supernatant was recovered carefully to prevent contamination with the pellet. A 1-mL portion of this extract was filtered through a 0.45-μm Osmonics/MSI cameo nylon filter (Fisher Scientific, Los Angeles, CA) and directly analyzed by HPLC after a period not exceeding 24 h. The results were expressed as milligrams per 100 g of fresh weight.

HPLC-DAD Analyses. Samples of 40 μL of extracts were analyzed using an HPLC system (Merck Hitachi, Tokyo, Japan) equipped with a model L-7100 pump and a model L-7455 photodiode array UV−vis detector. The samples were injected by a model L7200 autosampler. Separations were achieved on a 250 × 4 mm i.d., 5-μm reversed-phased LiChrocart C_{18} column (Merck, Darmstadt, Germany) with water/formic acid (95:5 v/v) (A) and methanol (B) as the mobile phases. The gradient program started with 10% B in A to reach 15% B in A at 5 min, 30% B at 20 min, 50% B at 35 min, 70% B at 42 min, and 90% B at 45 min. After separation, the column was washed for 5 min with 90% B before returning to the initial conditions. The flow rate was 1 mL/min, and chromatograms were recorded at 280, 320, 360, and 510 nm. The UV spectra of the different compounds were recorded with a diode array detector.

HPLC-MS/MS Analyses. The mobile phase consisted of two solvents: water/formic acid (1%) (A) and methanol (B). The gradient program, elution conditions, column, and DAD detection were the same as those described above. The HPLC analyses were carried out in an Agilent HPLC 1100 series equipped with a diode array detector and a mass detector in series (Agilent Technologies, Waldbronn, Germany). The HPLC consisted of a binary pump (model G1312A), an autosampler (model G1313A), a degasser (model G1322A), and a photodiode array detector (model G1315B). The HPLC system was controlled by ChemStation software (Agilent v. 08.03). The mass detector was an ion trap spectrometer (model G2445A) equipped with an electrospray ionization (ESI) system (capillary voltage, 4 kV; dry temperature, 350 °C). Mass scan (MS) and MS-MS daughter spectra were measured from *m*/*z* 150 900. Collision-induced fragmentation experiments were performed in the ion trap using helium as the collision gas, and the collision energy was set at 50%. Mass spectrometry data were acquired in the alternative positive/negative ionization mode.

Identification and Quantitation of Phenolic Compounds. The phenolic compounds in apricot were identified by their UV spectra, recorded with a diode array detector, molecular weight, and their MS/MS fragments. Compounds were identified by chromatographic comparisons with authentic markers (catechin, epicatechin, quercetin 3-rutinoside, and chlorogenic acid from Sigma, St. Louis, MO; cyanidin 3-rutinoside and 3-glucoside from Apin Chemicals Ltd., Oxon, U.K.; and procyanidins B1, B2, and B4, gifts from Prof. Santos, University of Salamanca, Spain). Individual procyanidins were quantified by comparisons with an external standard of catechin at 280 nm, hydroxycinnamic acid derivatives as chlorogenic acid (5-caffeoylquinic acid) at 320 nm, and flavonols as quercetin 3-rutinoside at 360 nm. Individual anthocyanins were quantified by comparisons with an external standard of cyanidin 3-rutinoside at 510 nm.

Statistical Analysis. All values are means of three replicates along with standard deviations. Duncan's multiple-range test was used to identify significant differences among mean values of the different phenolic compounds in relation with the flesh color. Correlation coefficients were determined between phenolic compounds and flesh color by the coefficient of Pearson. Statistical analyses were performed using SPSS 11.5 software.

RESULTS AND DISCUSSION

HPLC-DAD and HPLC-ESIMS Analysis of Phenolic Compounds. The HPLC analysis of the extracts obtained from apricot peel and flesh showed the occurrence of four main groups of phenolic compounds readily identified by their distinctive UV spectra. These included procyanidins, hydroxycinnamic acid derivatives, flavonols, and anthocyanins. These groups coincide with those found previously in other stone fruits (peach and nectarine) (*12*) and apricots of cultivar Canino (*14*).

These compounds were identified by comparisons with markers and characterized by HPLC coupled to an MS/MS detector with an ion trap. The results of the HPLC-DAD-MS analyses are shown in **Table 1**.

This study showed a number of chromatographic peaks with characteristic UV spectra of procyanidin derivatives in the chromatograms. The HPLC-MS/MS analyses allowed the characterization of some of these compounds by their molecular weights and fragments obtained after ion isolation and MS/MS fragmentation (*23*). This analysis showed that flavan-3-ol monomers (catechin or epicatechin) were not detected in sufficient amounts for quantitation in these extracts, although they were present as traces as shown in the HPLC-MS/MS analyses using the extracted ion chromatogram form. The main compounds detected were procyanidin dimers and trimers that showed characteristic [M−H]− ions at *m*/*z* 577 and 865, respectively, and fragments that were consistent with those previously published for these compounds in peaches and nectarines (*12*). Procyanidins B1, B2, and B4 were identified by chromatographic comparisons with authentic markers. In addition, two main trimers were detected, although other trimers were also present in smaller amounts. It is relevant to mention

Table 1. HPLC-DAD and HPLC-ESIMS Analyses of Phenolic Compounds in Apricot Peel Extract

phenolic	no.	HPLC-UV-DAD (nm)	HPLC-ESIMS (*m*/*z*)
	Procyanidins		
procyanidin B 1	1	280	577, 451, 425, 407, 289
procyanidin trimer 1	2	280	865, 739, 713, 695, 575, 543, 452, 407, 289
procyanidin B 4	3	280	577, 451, 425, 407, 289
procyanidin trimer 2	4	280	865, 847, 739, 713, 695, 651, 577, 451, 425, 407, 287
procyanidin B 2	5	280	577, 425, 407, 289
	Hydroxycinnamates		
neochlorogenic	6	332, 295	353, 179
chlorogenic	7	332, 295	353, 179
	Flavonols		
quercetin 3-rutinoside	8	355, 254	609, 301
kaempferol 3-rhamnosoyl-hexoside + quercetin 3-acetyl-hexoside	9 + 10	355, 254	593, 285 506, 463, 301
	Anthocyanins		
cyanidin 3-rutinoside	11	520, 280	595, 449, 287
cyanidin 3-glucoside	12	520, 280	449, 287

that other procyanidins were detected in the chromatograms by their UV spectrum but were not identified either by their MS or by the chromatographic comparisons with markers.

This study also revealed the occurrence of two main monocaffeoylquinic acid derivatives with $[M-H]^-$ ions at *m*/*z* 353 and fragment at *m*/*z* 179 and with retention times that coincided with those of authentic markers of chlorogenic (5-caffeoylquinic) and neochlorogenic (3-caffeoylquinic) acids.

Two main peaks with UV spectra like flavonols were detected in the chromatograms. The MS/MS analysis showed that the first peak eluting in the chromatogram was quercetin 3-rutinoside, although it coeluted with traces of quercetin 3-hexoside. The second peak also consisted of two overlying compounds, namely, kaempferol 3-rhamnosyl-hexoside (M − H at *m*/*z* 593) and quercetin 3-acetyl-hexoside (M − H at *m*/*z* 505). This last compound showed fragments at *m*/*z* 463 (acetyl loss to give quercetin-3-glucoside) and *m*/*z* 301 (quercetin aglycone).

Regarding the anthocyanin pigments, two main peaks were detected in a very small concentration in those cultivars with a reddish skin. In this case the HPLC-MS/MS analysis was carried out in the positive mode to optimize the specific conditions for anthocyanin analysis. The pigment present in larger amounts was identified as cyanidin 3-glucoside (M + H, *m*/*z* 449, and fragment at *m*/*z* 287 corresponding to the cyanidin aglycone) and the second one as cyanidin 3-rutinoside (M + H, *m*/*z* 595, and fragments at *m*/*z* 449 and 287 for the aglycone).

Phenolic Content of Apricot Selections. The content in individual phenolics in the skin and flesh of the different apricot varieties analyzed in the present work was evaluated by HPLC-DAD, and the results obtained are shown in **Tables 2**−**6**.

The procyanidin analysis (**Table 2**) shows that all of the varieties have a similar profile characterized by the occurrence in all cases of the procyanidin dimers B1, B2, and B4 and the presence of one trimer (trimer 1), whereas the second trimer was detected in only some of the varieties and mainly located in the peel.

The procyanidin concentration was always greater in the peel than in the flesh of the different varieties.

The procyanidins present in a larger content were procyanidin B1 and the first eluting procyanidin trimer. In the white flesh apricots, the content ranged between 10.4 and 69.0 mg 100 g^{-1} of fresh weight (fw) of flesh, between 12.3 and 99.9 mg 100 g^{-1} in yellow flesh ones, between 18.4 and 53.5 mg 100 g^{-1} in the flesh of light orange apricots, and between 15.6 and 101.7 mg 100 g^{-1} in orange flesh fruits. In the skin, the content ranged between 95.6 and 216.8 mg 100 g^{-1} of peel in white flesh varieties, between 62.5 and 199.3 mg 100 g^{-1} in yellow flesh fruits, between 52.0 and 185.7 mg 100 g^{-1} in light orange flesh varieties, and between 32.6 and 333.1 mg 100 g^{-1} in the case of orange flesh apricots. These values are in the range of the contents previously reported for nectarine and peach cultivars (*12*), and these values were higher than those recently reported for apricots in a database in which the cultivar is not specified (*24*). In this database, the presence of procyanidin dimers and trimers was reported as well as the occurrence of monomers and polymeric forms with higher size.

Both chlorogenic and neochlorogenic acids were detected in the peel and flesh of the analyzed varieties (**Table 3**). In all cases the content in the peel was higher than that of the flesh. The largest content in the peel was found in some orange flesh apricots with concentrations >100 mg 100 g^{-1} of fw material. The smallest concentration in peel of chlorogenic derivatives was also found in the same group of orange flesh varieties, with a concentration slightly above 20 mg 100 g^{-1} of fw. In the flesh tissues, the largest content was found in the white flesh of the Currot cultivar, with nearly 30 mg 100 g^{-1} of fw, whereas the smallest concentration was found in the orange flesh cultivar Selene with values below 5 mg 100 g^{-1} of fw. These values are also similar to those reported for peaches and nectarines (*12*).

The flavonols were detected in only the peel tissue of the apricots analyzed, except two varieties with a small content in the flesh (Rojo Pasión and Z 505/2, with 2.6 and 0.4 mg 100 g^{-1} of fw of flesh, respectively) (**Table 4**). The main compound was always rutin (plus traces of quercetin 3-hexoside), whereas kaempferol rhamnosyl-hexoside (plus quercetin-acetyl-hexoside) was always in smaller amounts. The largest flavonoid content was found in one of the orange flesh varieties (S 102/43) with contents above 150 mg 100 g^{-1} of fw of plant material and one of the white flesh varieties (Z 109/58) with a similar content (146 mg 100 g^{-1} of fw).

The anthocyanin pigments were detected in only small amounts in the peel of some of the red varieties (**Table 5**). This red pigmentation was often present as a reddish blush. The pigment concentration was always rather small. The largest concentration was detected in the new cultivar Rojo Pasión, with a content of 6.2 mg 100 g^{-1} of fw of peel, whereas all other red peel varieties had levels below 3.2 mg 100 g^{-1} of fw. These amounts, despite being in such small concentrations, had a clear impact in apricot skin color, providing a red blush. The

Table 2. Procyanidins in Apricot Varieties[a,b]

cultivar	part	peel color	B1	trimer 1	B4	trimer 2	B2	other procyanidins	total
				White Flesh Varieties					
Z 501/28	flesh		–	25.1 (4.8)	18.8 (3.0)	–	4.1 (0.4)	20.9 (2.7)	69.0 (10.0)
	peel	yellow (red)[c]	17.2 (5.5)	30.8 (5.5)	7.4 (6.7)	2.9 (1.4)	6.2 (0.6)	30.9 (7.2)	95.5 (1.9)
Z 604/12	flesh		2.2 (1.3)	15.1 (1.6)	3.6 (0.4)	–	5.0 (1.7)	15.8 (1.9)	41.7 (3.8)
	peel	yellow	14.4 (2.0)	34.2 (3.1)	2.4 (2.0)	– –	10.5 (0.4)	38.4 (12.9)	99.9 (16.3)
Z 115/26	flesh		–	8.2 (0.6)	7.2 (0.7)	– –	6.3 (1.8)	14.2 (0.7)	35.9 (0.7)
	peel	white (dark rose)	38.7 (14.2)	51.4 (8.8)	3.7 (0.3)	6.9 (1.1)	12.2 (3.1)	58.2 (4.6)	171.1 (31.1)
Z 109/58	flesh		2.6 (0.7)	9.8 (2.2)	2.0 (0.7)	–	4.3 (0.9)	14.2 (0.5)	33.0 (2.6)
	peel	white (light red)	48.0 (6.0)	80.8 (12.0)	6.2 (3.2)	11.3 (5.0)	4.8 (0.8)	65.6 (16.3)	216.8 (38.0)
Z 108/38	flesh		–	3.6 (1.6)	0.7 (0.4)	–	6.3 (2.3)	14.7 (3.6)	25.4 (7.5)
	peel	white	18.9 (6.2)	37.7 (6.3)	2.6 (0.4)	6.7 (0.8)	9.7 (1.2)	44.3 (5.8)	120.0 (16.9)
Currot	flesh		–	1.5 (1.6)	–	–	5.2 (0.4)	3.7 (1.9)	10.4 (3.4)
	peel	yellow (light red)	3.4 (0.9)	32.1 (2.8)	5.2 (2.0)	4.8 (8.2)	8.7 (3.2)	46.8 (17.3)	101.1 (30.6)
				Yellow Flesh Varieties					
S 406/22	flesh		2.0 (0.3)	27.6 (3.1)	6.0 (0.5)	12.2 (3.1)	3.0 (0.4)	49.2 (6.6)	99.9 (12.3)
	peel	yellow (red)	15.2 (6.2)	40.0 (8.5)	0.3 (0.4)	25.4 (9.4)	7.6 (1.6)	110.7 (24.4)	199.3 (49.0)
Z 102/19	flesh		–	16.9 (3.1)	14.2 (1.5)	–	4.8 (1.3)	19.5 (2.8)	54.8 (3.5)
	peel	yellow	9.7 (1.2)	20.2 (2.3)	10.0 (3.0)	2.5 (0.8)	4.7 (1.5)	38.6 (9.3)	85.8 (14.3)
Z 209/1	flesh		–	5.6 (1.4)	1.5 (0.7)	–	6.9 (1.3)	21.4 (0.2)	35.4 (0.6)
	peel	yellow	2.4 (0.9)	12.2 (2.5)	– (0.7)	5.5 (0.3)	6.3 (1.2)	47.4 (15.5)	73.9 (17.8)
S 407/8	flesh		–	15.2 (1.1)	–	–	4.8 (1.0)	7.1 (2.1)	27.1 (2.6)
	peel	yellow (red)	6.6 (3.2)	23.3 (1.7)	1.6 (0.6)	–	3.3 (1.0)	27.8 (1.8)	62.5 (2.1)
Mauricio	flesh		–	3.0 (2.1)	0.5 (0.1)	–	4.0 (0.6)	7.4 (2.0)	15.0 (0.7)
	peel	yellow	11.7 (1.9)	35.6 (0.9)	4.8 (1.4)	–	9.4 (0.2)	31.3 (5.4)	92.7 (8.7)
Z 405/17	flesh		–	–	1.0 (0.7)	–	1.1 (0.6)	10.3 (0.6)	12.3 (0.5)
	peel	yellow (red)	2.2 (0.7)	30.4 (4.9)	1.4 (2.0)	–	6.8 (2.4)	28.5 (9.9)	69.4 (18.6)
				Light Orange Flesh Varieties					
Z 111/61	flesh		–	16.0 (1.3)	14.3 (1.1)	–	5.1 (0.6)	18.0 (1.8)	53.5 (3.7)
	peel	yellow (light red)	9.5 (0.5)	22.9 (2.5)	6.4 (0.9)	– –	4.6 (0.8)	39.6 (10.0)	83.0 (11.1)
Z 502/6	flesh		1.8 (1.0)	11.0 (2.2)	0.6 (0.2)	0.0 (0.0)	5.7 (0.3)	14.7 (1.7)	33.9 (4.7)
	peel	light orange (dark rose)	37.9 (6.6)	77.8 (13.6)	2.3 (0.1)	4.2 (1.9)	8.8 (2.9)	54.5 (7.1)	185.7 (31.0)
Rojo Pasión	flesh		1.3 (1.0)	14.2 (1.0)	2.8 (0.4)	–	1.7 (0.2)	12.7 (2.3)	32.7 (2.5)
	peel	yellow (red)	9.3 (6.6)	28.9 (8.7)	3.5 (1.2)	–	7.5 (3.3)	47.1 (1.7)	96.3 (16.6)
Dorada	flesh		1.4 (0.3)	7.8 (0.7)	4.5 (0.3)	–	1.8 (0.2)	16.7 (2.1)	32.2 (2.7)
	peel	light orange	8.2 (3.0)	15.9 (1.6)	2.2 (0.9)	– –	3.7 (1.6)	24.0 (5.9)	55.0 (10.4)
Z 115/13	flesh		–	6.7 (0.6)	5.3 (0.7)	–	3.7 (2.0)	7.4 (0.3)	23.1 (3.0)
	peel	white (light red)	15.7 (2.8)	26.8 (3.0)	2.1 (0.5)	– –	3.9 (0.7)	44.7 (6.6)	93.2 (12.0)
Búlida	flesh		0.8 (0.7)	5.4 (0.4)	0.4 (0.2)	–	2.9 (0.9)	12.8 (4.0)	22.4 (4.1)
	peel	light orange	4.4 (0.6)	13.7 (1.6)	2.5 (0.3)	–	13.0 (1.1)	32.6 (0.8)	66.2 (2.8)
Z 506/7	flesh		–	11.6 (0.9)	1.0 (0.1)	–	0.9 (0.3)	6.1 (0.8)	18.7 (1.7)
	peel	light orange (red)	5.1 (1.7)	21.0 (1.0)	2.8 (0.8)	–	4.0 (1.2)	34.8 (5.2)	67.7 (7.5)
Murciana	flesh		–	6.9 (1.0)	1.0 (0.5)	–	1.4 (0.3)	9.0 (2.6)	18.4 (3.7)
	peel	light orange (red)	1.9 (1.7)	14.1 (1.9)	3.9 (1.3)	–	6.6 (0.7)	25.4 (5.8)	52.0 (4.0)
				Orange Flesh Varieties					
Z 207/4	flesh		1.4 (0.1)	27.2 (0.7)	15.8 (0.1)	11.9 (2.2)	8.5 (0.8)	36.8 (1.5)	101.7 (3.0)
	peel	orange (orange-red)	53.5 (13.4)	74.2 (2.6)	12.2 (3.6)	47.2 (1.9)	7.8 (2.8)	138.3 (11.6)	333.1 (18.8)
Z 308/6	flesh		1.7 (0.3)	40.7 (2.3)	13.5 (0.7)	–	3.9 (0.5)	13.8 (0.4)	73.6 (2.1)
	peel	light orange (red)	13.3 (5.9)	39.6 (6.1)	12.0 (2.7)	4.1 (1.2)	10.1 (2.1)	31.9 (4.7)	111.0 (19.6)
Z 209/17	flesh		1.2 (0.1)	14.6 (2.9)	4.4 (2.2)	9.3 (3.8)	9.2 (1.0)	34.4 (11.7)	73.1 (20.2)
	peel	orange (orange-red)	42.8 (6.8)	73.1 (6.5)	2.9 (3.0)	40.5 (12.5)	7.4 (3.3)	144.6 (26.8)	311.5 (44.3)
Z 203/8	flesh		1.5 (0.3)	15.4 (2.4)	5.2 (0.6)	7.8 (1.8)	6.0 (0.8)	28.0 (0.4)	63.9 (2.7)
	peel	light orange	25.4 (2.0)	46.0 (1.3)	1.6 (2.8)	21.0 (2.3)	7.6 (1.6)	96.6 (16.7)	198.2 (14.8)
Z 211/18	flesh		7.8 (2.7)	21.0 (3.6)	1.7 (0.5)	4.3 (1.4)	2.9 (1.3)	26.1 (5.7)	63.7 (9.0)
	peel	orange	70.3 (7.6)	93.6 (5.5)	8.3 (4.0)	15.9 (0.5)	8.3 (2.9)	64.9 (12.9)	261.4 (31.9)
S 102/43	flesh		2.2 (0.4)	12.6 (2.5)	2.0 (0.6)	7.5 (1.5)	2.8 (1.2)	29.1 (4.4)	56.3 (10.3)
	peel	orange	40.2 (2.5)	75.4 (3.7)	0.8 (1.5)	37.6 10.6)	11.8 (1.1)	119.4 (6.5)	285.3 (14.3)
Z 402/16	flesh		11.6 (2.7)	14.5 (1.6)	0.9 (0.2)	4.7 (0.5)	2.4 (1.5)	20.3 (5.1)	54.4 (9.7)
	peel	orange (red)	39.0 (6.8)	49.8 (8.7)	7.7 (2.7)	8.2 (2.5)	4.0 (1.3)	63.1 (4.6)	171.8 (22.9)
Z 203/15	flesh		1.1 (1.3)	10.8 (1.2)	5.0 (0.7)	9.2 (1.0)	4.6 (1.2)	16.6 (14.4)	47.3 (14.1)
	peel	orange (light red)	29.2 (1.3)	45.5 (5.5)	1.4 (2.4)	25.3 (2.1)	3.2 (1.4)	84.2 (4.1)	188.7 (8.8)
Z 201/13	flesh		–	7.8 (0.7)	3.9 (0.7)	0.9 (0.5)	6.0 (1.2)	14.7 (2.3)	33.4 (2.9)
	peel	light orange (red)	31.4 (10.0)	59.7 (4.3)	8.8 (1.4)	10.5 (2.3)	13.1 (3.1)	74.3 (11.3)	197.8 (25.6)
S 401/33	flesh		2.2 (0.8)	14.1 (1.3)	3.8 (0.8)	–	3.3 (0.0)	7.8 (0.9)	31.2 (3.5)
	peel	orange	2.7 (1.5)	33.0 (2.9)	5.9 (1.1)	–	8.7 (1.2)	33.6 (2.8)	84.1 (2.9)
Z 212/6	flesh		2.6 (1.1)	11.9 (2.1)	0.4 (0.4)	0.9 (0.2)	2.4 (0.6)	12.9 (3.7)	31.1 (6.1)
	peel	orange	37.5 (0.4)	80.5 (7.6)	5.7 (1.0)	12.7 (2.6)	8.0 (3.4)	63.9 (8.6)	208.4 (1.6)
S 404/42	flesh		2.4 (2.5)	7.0 (2.4)	0.6 (0.5)	0.5 (0.5)	2.3 (0.9)	11.9 (4.9)	25.0 (6.8)
	peel	orange	9.5 (8.2)	27.3 (24.0)	2.2 (2.0)	– –	8.3 (0.4)	24.6 (7.6)	71.9 (42.0)
Z 308/9	flesh		–	4.6 (0.4)	1.1 (0.3)	–	2.0 (0.3)	12.6 (0.5)	20.4 (1.2)
	peel	light orange (red)	1.6 (1.7)	6.7 (1.7)	0.6 (1.1)	3.9 (0.9)	6.1 (1.8)	31.2 (4.8)	50.1 (8.9)
Z 505/2	flesh		–	8.9 (1.1)	0.7 (0.4)	–	3.3 (1.3)	7.5 (1.8)	20.3 (4.4)
	peel	light orange (red)	5.9 (2.2)	16.1 (4.2)	2.9 (0.9)	–	2.0 (1.2)	22.8 (1.2)	49.7 (6.5)
Z 403/2	flesh		–	3.8 (0.4)	0.7 (0.1)	–	3.8 (0.3)	10.9 (0.4)	19.2 (0.6)
	peel	light orange (red)	2.7 (2.3)	9.4 (3.7)	–	– –	4.7 (1.2)	15.7 (3.4)	32.6 (10.3)
Z 308/12	flesh		–	2.9 (0.4)	1.1 (0.2)	2.4 (0.7)	1.9 (0.9)	9.4 (1.3)	17.7 (3.1)
	peel	orange (red)	9.1 (3.1)	20.4 (4.8)	–	12.6 (4.2)	3.3 (0.4)	53.9 (13.6)	99.3 (25.8)
Selene	flesh		0.8 (0.9)	4.0 (0.5)	–	–	2.8 (1.2)	8.0 (3.2)	15.6 (5.0)
	peel	orange	37.3 (7.6)	42.9 (7.9)	2.2 (1.1)	4.2 (0.8)	3.6 (1.0)	33.7 (7.3)	123.9 (17.1)

[a] Means in mg 100 g^{-1} of fresh weight. Standard deviations ($n = 3$) in parentheses. [b] Procyanidins quantified as catechin. [c] Blush color of skin given in parentheses.

Table 3. Hydroxycinnamic Acid Derivatives in Apricot Varieties[a,b]

cultivar	part	peel color	neochlorogenic	chlorogenic	other	total
			White Flesh Varieties			
Currot	flesh		16.0 (1.0)	11.4 (0.7)	1.7 (0.1)	29.2 (1.6)
	peel	yellow (light red)[c]	46.6 (4.2)	38.4 (3.4)	2.9 (0.2)	87.9 (7.7)
Z 501/28	flesh		5.9 (1.0)	10.6 (2.4)	2.8 (0.4)	19.4 (3.3)
	peel	yellow (red)	16.8 (3.9)	37.9 (7.3)	5.5 (0.1)	60.2 (11.3)
Z 604/12	flesh		4.8 (0.4)	8.5 (1.0)	1.4 (0.2)	14.7 (1.5)
	peel	yellow	32.0 (2.5)	33.0 (3.4)	8.2 (1.3)	73.2 (7.1)
Z 109/58	flesh		3.8 (0.7)	6.9 (1.4)	1.2 (0.3)	12.0 (2.4)
	peel	white (light red)	23.2 (1.9)	35.8 (2.8)	–	59.0 (4.6)
Z 108/38	flesh		1.7 (0.2)	4.8 (0.5)	0.8 (0.4)	7.3 (1.0)
	peel	white	10.8 (2.6)	18.4 (4.0)	4.2 (0.2)	33.4 (6.3)
Z 115/26	flesh		2.3 (0.4)	3.9 (0.4)	0.5 (0.2)	6.7 (0.9)
	peel	white (dark rose)	13.6 (2.8)	19.2 (3.5)	5.1 (0.8)	37.9 (6.7)
			Yellow Flesh Varieties			
Z 102/19	flesh		7.7 (2.4)	13.2 (3.0)	2.6 (0.7)	23.5 (6.1)
	peel	yellow	11.8 (5.0)	24.8 (9.3)	5.1 (1.0)	41.7 (15.3)
S 407/8	flesh		7.1 (0.9)	9.8 (1.2)	3.0 (1.8)	20.0 (3.7)
	peel	yellow (red)	23.4 (1.3)	37.4 (2.1)	3.7 (0.3)	64.6 (3.0)
Z 405/17	flesh		7.5 (1.2)	4.6 (0.6)	2.5 (0.4)	14.6 (2.2)
	peel	yellow (red)	22.2 (4.5)	19.3 (1.2)	2.7 (0.6)	44.1 (2.8)
S 406/22	flesh		4.7 (0.4)	8.1 (0.4)	1.5 (0.1)	14.3 (0.6)
	peel	yellow (red)	27.1 (2.2)	50.3 (2.2)	5.1 (0.0)	82.6 (4.2)
Z 209/1	flesh		6.3 (1.2)	3.8 (0.8)	2.6 (0.4)	12.7 (2.3)
	peel	yellow	16.1 (4.3)	7.2 (1.6)	6.1 (1.6)	29.5 (7.2)
Mauricio	flesh		3.5 (1.9)	3.3 (1.1)	0.7 (0.2)	7.5 (3.2)
	peel	yellow	22.6 (1.2)	15.4 (0.2)	5.0 (0.4)	43.0 (1.4)
			Light Orange Flesh Varieties			
Búlida	flesh		8.1 (0.3)	14.7 (1.1)	3.9 (0.6)	26.7 (1.9)
	peel	light orange	23.7 (1.4)	53.8 (3.4)	9.9 (1.0)	87.4 (5.5)
Rojo pasión	flesh		10.6 (1.0)	11.0 (0.7)	4.8 (1.0)	26.4 (2.6)
	peel	yellow (red)	20.2 (4.1)	34.8 (6.0)	6.6 (1.9)	61.6 (9.4)
Z 506/7	flesh		9.2 (0.3)	9.4 (0.1)	3.8 (0.2)	22.5 (0.4)
	peel	light orange (red)	15.1 (1.7)	28.4 (1.9)	8.6 (0.6)	52.1 (3.1)
Murciana	flesh		6.1 (0.9)	10.7 (1.4)	3.8 (0.2)	20.6 (2.3)
	peel	light orange (red)	24.6 (7.2)	42.7 (11.3)	8.5 (1.6)	75.7 (20.0)
Z 111/61	flesh		2.3 (0.7)	5.7 (1.5)	1.0 (0.1)	9.0 (2.1)
	peel	yellow (light red)	7.3 (0.5)	13.0 (0.9)	2.4 (0.0)	22.7 (0.9)
Z 502/6	flesh		2.5 (0.4)	5.3 (0.4)	1.1 (0.1)	8.9 (0.7)
	peel	light orange (dark rose)	13.2 (1.9)	15.3 (0.6)	3.5 (0.8)	31.9 (2.6)
Dorada	flesh		3.8 (0.9)	3.0 (0.5)	1.2 (0.4)	8.0 (1.7)
	peel	light orange	11.9 (2.5)	11.4 (3.7)	3.4 (0.8)	26.7 (7.0)
Z 115/13	flesh		1.6 (0.2)	4.1 (0.5)	0.7 (0.1)	6.4 (0.7)
	peel	white (light red)	7.9 (1.8)	19.1 (2.4)	3.0 (0.3)	29.9 (4.4)
			Orange Flesh Varieties			
Z 203/8	flesh		3.6 (0.8)	16.5 (1.5)	0.5 (0.1)	20.6 (2.4)
	peel	light orange	32.0 (1.3)	67.3 (4.8)	10.0 (0.6)	109.2 (5.1)
S 401/33	flesh		13.6 (0.4)	4.1 (0.2)	1.4 (0.3)	19.1 (0.8)
	peel	orange	46.1 (10.6)	16.0 (3.4)	3.8 (0.7)	65.9 (14.5)
Z 207/4	flesh		5.0 (1.0)	12.9 (1.3)	0.6 (0.3)	18.5 (2.6)
	peel	orange (orange-red)	33.3 (1.8)	55.8 (3.0)	3.9 (0.5)	93.1 (5.2)
Z 209/17	flesh		4.2 (0.5)	10.5 (1.6)	0.6 (0.1)	15.3 (2.1)
	peel	orange (orange-red)	36.9 (4.0)	44.6 (2.2)	8.8 (1.4)	90.3 (7.2)
Z 505/2	flesh		6.4 (0.9)	7.6 (0.8)	1.2 (0.2)	15.2 (1.5)
	peel	light orange (red)	17.1 (3.1)	33.0 (4.9)	8.2 (2.2)	58.4 (7.8)
Z 402/16	flesh		3.5 (0.1)	9.8 (0.8)	0.6 (0.2)	13.9 (1.1)
	peel	orange (red)	22.6 (0.5)	55.2 (1.4)	5.3 (0.2)	83.1 (1.4)
Z 211/18	flesh		7.7 (0.4)	4.9 (0.5)	1.3 (0.2)	13.9 (0.9)
	peel	orange	47.3 (2.7)	20.5 (1.7)	3.1 (0.2)	71.0 (4.5)
Z 212/6	flesh		6.6 (0.4)	4.9 (0.2)	1.5 (0.3)	13.1 (0.8)
	peel	orange	73.9 (2.6)	26.7 (1.3)	7.9 (0.6)	108.5 (4.4)
S 102/43	flesh		4.6 (0.7)	8.3 (0.5)	0.5 (0.0)	13.4 (1.1)
	peel	orange	39.7 (3.3)	53.8 (5.0)	6.7 (1.1)	100.3 (9.3)
Z 308/12	flesh		3.0 (0.6)	8.7 (0.8)	1.2 (0.4)	12.9 (1.5)
	peel	orange (red)	17.1 (6.8)	26.9 (10.2)	9.1 (2.1)	53.2 (19.2)
Z 203/15	flesh		2.7 (1.0)	8.4 (2.6)	0.5 (0.1)	11.6 (3.7)
	peel	orange (light red)	19.0 (1.1)	28.3 (0.8)	6.6 (0.7)	53.8 (1.8)
Z 308/9	flesh		2.5 (1.2)	6.5 (2.5)	0.7 (0.2)	9.7 (3.9)
	peel	light orange (red)	3.7 (1.5)	16.1 (6.7)	4.6 (1.4)	24.4 (9.6)
Z 201/13	flesh		1.6 (0.2)	5.6 (0.3)	0.3 (0.1)	7.5 (0.6)
	peel	light orange (red)	20.0 (0.1)	34.0 (0.9)	6.4 (0.4)	60.4 (0.7)
S 404/42	flesh		1.0 (0.8)	4.5 (0.8)	0.1 (0.0)	5.7 (1.5)
	peel	orange	20.6 (1.8)	16.9 (5.7)	5.2 (0.1)	42.7 (3.8)
Z 308/6	flesh		1.0 (0.3)	4.2 (1.1)	0.3 (0.0)	5.6 (1.4)
	peel	light orange (red)	7.8 (2.4)	11.3 (2.8)	3.4 (0.6)	22.5 (5.4)
Z 403/2	flesh		2.1 (1.1)	3.0 (1.3)	0.5 (0.1)	5.5 (2.3)
	peel	light orange (red)	10.3 (4.9)	8.1 (3.4)	2.7 (0.6)	21.1 (8.5)
Selene	flesh		1.2 (0.1)	3.1 (2.6)	0.2 (0.1)	4.5 (2.5)
	peel	orange	13.6 (2.3)	36.2 (6.3)	4.7 (0.4)	54.6 (8.1)

[a] Means in mg 100 g^{-1} of fresh weight. Standard deviations ($n = 3$) in parentheses. [b] Hydroxycinnamic acid derivatives quantified as chlorogenic acid. [c] Blush color of skin given in parentheses.

Table 4. Flavonols in Apricot Varieties[a,b]

cultivar	part	peel color	Q-3-rut + Q-3-hx	K-3-rh-hex + Q-3-ac-hx	other	total
			White Flesh Varieties			
Z 109/58	peel	white (light red)[c]	116.6 (11.0)	27.6 (2.6)	2.2 (0.3)	146.4 (13.9)
Currot	peel	yellow (light red)	103.2 (7.8)	16.3 (0.8)	–	119.5 (8.6)
Z 115/26	peel	white (dark rose)	79.6 (9.6)	10.9 (1.3)	4.7 (0.9)	95.2 (11.6)
Z 108/38	peel	white	70.6 (5.8)	9.5 (0.8)	4.7 (1.1)	84.8 (6.3)
Z 604/12	peel	yellow	78.0 (11.8)	6.1 (2.8)	0.2 (0.1)	84.2 (14.6)
Z 501/28	peel	yellow (red)	69.9 (7.6)	11.3 (2.3)	2.4 (0.2)	83.6 (9.8)
			Yellow Flesh Varieties			
S 406/22	peel	yellow (red)	65.5 (11.0)	11.8 (2.8)	2.4 (0.3)	79.8 (14.1)
Mauricio	peel	yellow	65.3 (7.9)	10.6 (1.3)	1.1 (0.2)	76.9 (9.4)
Z 209/1	peel	yellow	60.7 (5.7)	3.3 (2.2)	1.5 (0.1)	65.5 (8.0)
Z 405/17	peel	yellow (red)	52.7 (6.0)	12.1 (1.6)	–	64.8 (7.4)
S 407/8	peel	yellow (red)	45.5 (8.1)	7.3 (1.5)	–	52.9 (9.6)
Z 102/19	peel	yellow	36.1 (5.8)	2.5 (1.1)	1.3 (0.1)	40.0 (6.8)
			Light Orange Flesh Varieties			
Rojo Pasión	peel	yellow (red)	101.1 (28.5)	22.2 (12.9)	6.5 (1.3)	127.2 (38.3)
	flesh		2.2 (3.0)	0.3 (0.6)	–	2.6 (3.6)
Z 111/61	peel	yellow (light red)	93.9 (9.1)	11.3 (1.1)	2.8 (0.1)	108.0 (10.3)
Z 506/7	peel	light orange (red)	84.8 (19.2)	14.5 (1.6)	2.7 (0.5)	102.0 (21.4)
Murciana	peel	light orange (red)	87.4 (10.5)	8.7 (1.5)	4.5 (0.2)	100.6 (12.0)
Búlida	peel	light orange	75.0 (8.0)	10.9 (1.1)	3.7 (0.7)	89.6 (9.3)
Z 502/6	peel	light orange (dark rose)	64.4 (1.4)	7.9 (0.7)	1.2 (0.1)	73.6 (1.7)
Dorada	peel	light orange	55.2 (12.4)	7.5 (2.5)	1.2 (0.5)	64.0 (15.2)
Z 115/13	peel	white (light red)	52.7 (11.2)	7.4 (1.7)	1.7 (0.4)	61.9 (13.3)
			Orange Flesh Varieties			
S 102/43	peel	orange	124.5 (15.2)	20.0 (3.8)	6.3 (1.7)	150.8 (20.5)
Z 207/4	peel	orange (orange-red)	117.6 (8.3)	17.8 (1.6)	1.4 (0.1)	136.8 (9.7)
Z 212/6	peel	orange	102.8 (14.2)	18.7 (1.6)	4.0 (0.6)	125.4 (16.4)
Z 203/15	peel	orange (light red)	93.8 (2.5)	14.6 (0.8)	3.5 (0.5)	111.9 (3.7)
Z 505/2	peel	light orange (red)	94.7 (13.6)	13.6 (2.9)	3.0 (0.4)	111.3 (16.9)
	flesh		0.3 (0.6)	–	–	0.3 (0.6)
Z 211/18	peel	orange	82.1 (17.4)	19.1 (4.8)	1.7 (0.3)	102.9 (22.5)
Z 308/9	peel	light orange (red)	67.1 (18.8)	15.2 (5.1)	2.7 (1.2)	85.0 (25.2)
Z 201/13	peel	light orange (red)	69.6 (5.3)	5.6 (1.0)	3.1 (1.1)	78.3 (6.4)
Z 209/17	peel	orange (orange-red)	62.9 (3.9)	7.0 (0.8)	2.0 (0.1)	71.9 (4.7)
Z 402/16	peel	orange (red)	51.9 (6.7)	10.1 (1.5)	9.0 (6.5)	71.0 (14.6)
S 401/33	peel	orange	50.4 (7.0)	10.0 (2.5)	–	60.4 (9.6)
Z 308/12	peel	orange (red)	54.7 (8.9)	3.2 (0.5)	1.0 (0.1)	58.9 (9.4)
Z 403/2	peel	light orange (red)	52.5 (6.2)	4.7 (0.8)	1.6 (0.1)	58.8 (6.9)
Selene	peel	orange	51.6 (6.7)	4.4 (0.8)	1.3 (0.2)	57.4 (7.6)
Z 203/8	peel	light orange	52.1 (6.2)	3.6 (0.9)	1.3 (0.1)	57.0 (7.2)
S 404/42	peel	orange	34.8 (3.1)	5.4 (0.9)	1.9 (0.3)	42.0 (4.4)
Z 308/6	peel	light orange (red)	34.3 (3.9)	2.2 (0.4)	0.7 (0.1)	37.2 (4.5)

[a] Means in mg 100 g^{-1} of fresh weight. Standard deviations ($n = 3$) in parentheses. Abbreviations: Q-3-rut + Q-3-hx, quercetin 3-rutinoside + quercetin 3-hexoside; K-3-rh-hx + Q-3-ac-hx, kaempferol 3-rhamnosyl-hexoside + quercetin 3-acetil-hexoside. [b] Flavonols quantified as rutin. [c] Blush color of skin given in parentheses.

Table 5. Anthocyanins in Apricot Varieties[a,b]

cultivar	part	peel color	Cy-3-glc	Cy-3-rut	other	total
		White Flesh Varieties				
Z 115/26	peel	white (dark rose)[c]	1.6 (0.7)	–	–	1.6 (0.7)
		Yellow Flesh Varieties				
S 406/22	peel	yellow (red)	0.8 (0.8)	–	–	0.8 (0.8)
		Light Orange Flesh Varieties				
Rojo Pasión	peel	yellow (red)	4.4 (3.5)	1.4 (1.5)	0.3 (0.6)	6.2 (5.5)
Murciana	peel	light orange (red)	1.2 (0.5)	–	–	1.3 (0.5)
Z 111/61	peel	yellow (light red)	1.5 (0.4)	–	–	1.2 (0.4)
		Orange Flesh Varieties				
Z 505/2	peel	light orange (red)	2.9 (0.3)	0.3 (0.3)	–	3.2 (0.2)
Z 402/16	peel	orange (red)	1.2 (0.3)	–	–	1.2 (0.3)
Z 308/9	peel	light orange (red)	0.4 (0.7)	–	–	0.4 (0.7)

[a] Means in mg 100 g^{-1} of fresh weight. Standard deviations ($n = 3$) in parentheses. Abbreviations: Cy-3-glc, cyanidin 3-glucoside; Cy-3-rut, cyanidin 3-rutinoside. [b] Anthocyanins quantified as cyanidin 3-rutinoside. [c] Blush color of skin given in parentheses.

anthocyanin content of the studied apricots was considerably smaller than the values reported for peaches and nectarines (3−31 mg 100 g^{-1} of fw of peel) (*12*).

A summary of the content of different phenolic types in the studied varieties is shown in **Table 6**, as well as the differences between peel and flesh contents. The higher overall total phenolics content was found in the peels of Z 207/4 and S 102/43, both orange flesh varieties with amounts >500 mg of phenolics 100 g^{-1} of peel tissue. On the basis of the content per edible portion (91% flesh and 9% peel in an apricot serving of 100 g), then the largest phenolic content was found for Z 207/4, which showed a content of 160 mg 100 g^{-1} of edible portion. Some other varieties had phenolic contents >100 mg of phenolic 100 g^{-1} of edible portion. The traditional cultivars Mauricio and Currot and the new releases Murciana, Selene, and Dorada generally contained smaller amounts of phenolics compared to other apricot varieties from the same flesh color group. However, only the new release Rojo Pasión showed the largest phenolic content of the light orange flesh group (80 mg 100 g^{-1} of edible portion). Of the traditional cultivars, Búlida was the only one showing a larger phenolic content, with 66 mg 100 g^{-1} of edible portion.

A wide range of variability was found among the apricot varieties with regard to the content of phenolic compounds. This

Table 6. Total Phenolic Compounds in Apricot Varieties per Serving[a]

cultivar	part	peel color	procyanidins	cinnamic deriv[b]	flavonols	anthocyanins	total phenolics	total edible[c]
			White Flesh Varieties					
Z 501/28	flesh		69.0 (10.0)	19.4 (3.3)	0.0 (0.0)	0.0 (0.0)	88.4 (13.3)	102.0 (13.0)
	peel	yellow (red)[d]	95.5 (1.9)	60.2 (11.3)	83.6 (9.8)	0.0 (0.0)	239.3 (13.3)	
Z 109/58	flesh		33.0 (2.6)	12.0 (2.4)	0.0 (0.0)	0.0 (0.0)	44.9 (5.0)	78.9 (2.7)
	peel	white (light red)	216.8 (38.0)	59.0 (4.6)	146.4 (13.9)	0.0 (0.0)	422.3 (21.1)	
Z 604/12	flesh		41.7 (3.8)	14.7 (1.5)	0.0 (0.0)	0.0 (0.0)	56.3 (5.0)	74.4 (7.1)
	peel	yellow	99.9 (16.3)	73.2 (7.1)	84.3 (14.6)	0.0 (0.0)	257.4 (34.9)	
Z 115/26	flesh		36.0 (0.7)	6.7 (0.9)	0.0 (0.0)	0.0 (0.0)	42.6 (1.1)	66.3 (5.2)
	peel	white (dark rose)	171.1 (31.1)	37.9 (6.7)	95.2 (11.6)	1.6 (0.7)	305.8 (47.4)	
Currot	flesh		10.5 (3.4)	29.2 (1.6)	0.0 (0.0)	0.0 (0.0)	39.6 (4.7)	63.8 (7.1)
	peel	yellow (light red)	101.1 (30.6)	87.9 (7.7)	119.5 (8.6)	0.0 (0.0)	308.5 (32.2)	
Z 108/38	flesh		25.5 (7.5)	7.3 (1.0)	0.0 (0.0)	0.0 (0.0)	32.7 (8.5)	51.2 (6.7)
	peel	white	120.0 (16.9)	33.4 (6.3)	84.8 (6.3)	0.0 (0.0)	238.2 (26.4)	
			Yellow Flesh Varieties					
S 406/22	flesh		99.9 (12.3)	14.3 (0.6)	00.0 (0.0)	0.0 (0.0)	114.2 (12.9)	136.6 (16.4)
	peel	yellow (red)	199.3 (49.0)	82.6 (4.2)	79.8 (14.1)	0.8 (0.8)	362.5 (52.9)	
Z 102/19	flesh		54.8 (3.5)	23.5 (6.1)	0.0 (0.0)	0.0 (0.0)	78.3 (5.6)	86.3 (6.0)
	peel	yellow	85.8 (14.3)	41.7 (15.3)	40.0 (6.8)	0.0 (0.0)	167.4 (34.7)	
S 407/8	flesh		27.1 (2.6)	20.0 (3.7)	0.0 (0.0)	0.0 (0.0)	47.1 (5.8)	59.1 (5.9)
	peel	yellow (red)	62.5 (2.1)	64.6 (3.0)	52.9 (9.6)	0.0 (0.0)	179.9 (13.3)	
Z 209/1	flesh		35.4 (0.6)	12.7 (2.3)	0.0 (0.0)	0.0 (0.0)	48.1 (2.8)	59.0 (4.0)
	peel	yellow	73.9 (17.8)	29.5 (7.2)	65.5 (8.0)	0.0 (0.0)	168.8 (16.7)	
Z 405/17	flesh		12.4 (0.5)	14.6 (2.2)	0.0 (0.0)	0.0 (0.0)	27.0 (1.8)	40.6 (3.7)
	peel	yellow (red)	69.4 (18.6)	44.1 (2.8)	64.8 (7.4)	0.0 (0.0)	178.3 (24.6)	
Mauricio	flesh		15.0 (0.7)	7.5 (3.2)	0.0 (0.0)	0.0 (0.0)	22.5 (2.7)	39.6 (1.7)
	peel	yellow	92.8 (8.7)	43.0 (1.4)	76.9 (9.4)	0.0 (0.0)	212.7 (13.1)	
			Light Orange Flesh Varieties					
Rojo Pasión	flesh		32.7 (2.5)	26.4 (2.6)	0.0 (0.0)	0.0 (0.0)	59.2 (4.3)	80.1 (3.6)
	peel	yellow (red)	96.3 (16.6)	61.6 (9.4)	127.2 (38.3)	6.2 (5.5)	291.3 (66.9)	
Z 111/61	flesh		53.5 (3.7)	9.0 (2.1)	2.6 (3.6)	0.0 (0.0)	65.1 (6.9)	78.6 (5.9)
	peel	yellow (light red)	83.0 (11.1)	22.7 (0.9)	108.0 (10.3)	1.3 (0.4)	214.9 (12.4)	
Búlida	flesh		22.4 (4.1)	26.7 (1.9)	0.0 (0.0)	0.0 (0.0)	49.1 (5.8)	66.5 (5.5)
	peel	light orange	66.2 (2.8)	87.4 (5.5)	89.7 (9.3)	0.0 (0.0)	243.3 (6.0)	
Z 502/6	flesh		33.9 (4.7)	8.9 (0.7)	0.0 (0.0)	0.0 (0.0)	42.7 (4.6)	65.1 (7.1)
	peel	light orange (dark rose)	185.7 (31.0)	31.9 (2.6)	73.6 (1.7)	0.0 (0.0)	291.2 (32.3)	
Z 506/7	flesh		18.7 (1.7)	22.5 (0.4)	0.0 (0.0)	0.0 (0.0)	41.2 (2.1)	57.5 (1.6)
	peel	light orange (red)	67.7 (7.5)	52.1 (3.1)	102.0 (21.4)	0.0 (0.0)	221.9 (17.3)	
Murciana	flesh		18.4 (3.7)	20.6 (2.3)	0.0 (0.0)	0.0 (0.0)	39.1 (5.9)	56.2 (4.9)
	peel	light orange (red)	52.0 (4.0)	75.7 (20.0)	100.7 (12.0)	1.3 (0.5)	229.7 (6.3)	
Dorada	flesh		32.2 (2.7)	8.0 (1.7)	0.0 (0.0)	0.0 (0.0)	40.2 (4.4)	49.7 (2.4)
	peel	light orange	55.0 (10.4)	26.7 (7.0)	64.0 (15.2)	0.0 (0.0)	145.8 (28.0)	
Z 115/13	flesh		23.1 (3.0)	6.4 (0.7)	0.0 (0.0)	0.0 (0.0)	29.5 (3.4)	43.5 (4.7)
	peel	white (light red)	93.2 (12.0)	29.9 (4.4)	61.9 (13.3)	0.0 (0.0)	185.0 (25.0)	
			Orange Flesh Varieties					
Z 207/4	flesh		101.7 (3.0)	18.5 (2.6)	0.0 (0.0)	0.0 (0.0)	120.2 (4.5)	160.0 (6.6)
	peel	orange (orange-red)	333.1 (18.8)	93.1 (5.2)	136.8 (9.7)	0.0 (0.0)	563.0 (28.1)	
Z 209/17	flesh		73.1 (20.2)	15.3 (2.1)	0.0 (0.0)	0.0 (0.0)	88.4 (22.3)	123.1 (17.1)
	peel	orange (orange-red)	311.5 (44.3)	90.3 (7.2)	71.9 (4.7)	0.0 (0.0)	473.7 (42.6)	
S 102/43	flesh		56.3 (10.3)	13.4 (1.1)	0.0 (0.0)	0.0 (0.0)	69.7 (10.5)	111.7 (11.2)
	peel	orange	285.3 (14.3)	100.3 (9.3)	150.8 (20.5)	0.0 (0.0)	536.4 (19.1)	
Z 211/18	flesh		63.7 (9.0)	13.9 (0.9)	0.4 (0.6)	0.0 (0.0)	78.0 (8.7)	110.1 (13.1)
	peel	orange	261.4 (31.9)	71.0 (4.5)	102.9 (22.5)	0.0 (0.0)	435.2 (57.8)	
Z 203/8	flesh		63.9 (2.7)	20.6 (2.4)	0.0 (0.0)	0.0 (0.0)	84.5 (4.9)	109.7 (4.3)
	peel	light orange	198.2 (14.8)	109.2 (5.1)	57.1 (7.2)	0.0 (0.0)	364.5 (16.5)	
Z 402/16	flesh		54.4 (9.7)	13.9 (1.1)	0.0 (0.0)	0.0 (0.0)	68.4 (10.3)	91.6 (9.9)
	peel	orange (red)	171.8 (22.9)	83.1 (1.4)	71.0 (14.6)	1.3 (0.3)	327.1 (16.0)	
Z 308/6	flesh		73.6 (2.1)	5.6 (1.4)	0.0 (0.0)	0.0 (0.0)	79.2 (3.0)	87.5 (5.1)
	peel	light orange (red)	111.0 (19.6)	22.5 (5.4)	37.2 (4.5)	0.0 (0.0)	170.7 (26.3)	
Z 203/15	flesh		47.3 (14.1)	11.6 (3.7)	0.0 (0.0)	0.0 (0.0)	58.9 (17.1)	85.5 (14.8)
	peel	orange (light red)	188.7 (8.8)	53.8 (1.8)	111.9 (3.7)	0.0 (0.0)	354.5 (11.6)	
Z 212/6	flesh		31.1 (6.1)	13.1 (0.8)	0.0 (0.0)	0.0 (0.0)	44.1 (6.3)	79.9 (7.4)
	peel	orange	208.4 (1.6)	108.5 (4.4)	125.4 (16.4)	0.0 (0.0)	442.3 (19.6)	
Z 201/13	flesh		33.4 (2.9)	7.5 (0.6)	0.0 (0.0)	0.0 (0.0)	40.9 (3.0)	67.5 (3.0)
	peel	light orange (red)	197.8 (25.6)	60.4 (0.7)	78.3 (6.4)	0.0 (0.0)	336.4 (30.4)	
S 401/33	flesh		31.3 (3.5)	19.1 (0.8)	0.0 (0.0)	0.0 (0.0)	50.3 (3.4)	64.7 (3.6)
	peel	orange	84.1 (2.9)	65.9 (14.5)	60.4 (9.6)	0.0 (0.0)	210.4 (7.8)	
Z 505/2	flesh		20.3 (4.4)	15.2 (1.5)	0.0 (0.0)	0.0 (0.0)	35.4 (3.9)	52.3 (2.8)
	peel	light orange (red)	49.7 (6.5)	58.4 (7.8)	111.3 (16.9)	3.2 (0.2)	222.6 (12.0)	
Z 308/12	flesh		17.7 (3.1)	12.9 (1.5)	0.0 (0.0)	0.0 (0.0)	30.7 (3.3)	46.9 (6.4)
	peel	orange (red)	99.3 (25.8)	53.2 (19.2)	58.9 (9.4)	0.0 (0.0)	211.4 (51.3)	
S 404/42	flesh		25.0 (6.8)	5.7 (1.5)	0.0 (0.0)	0.0 (0.0)	30.7 (8.3)	42.0 (4.8)
	peel	orange	71.9 (42.0)	42.7 (3.8)	42.0 (4.4)	0.0 (0.0)	156.6 (43.0)	
Z 308/9	flesh		20.4 (1.2)	9.7 (3.9)	0.0 (0.0)	0.0 (0.0)	30.1 (5.1)	41.8 (8.3)
	peel	light orange (red)	50.2 (8.9)	24.4 (9.6)	85.0 (25.2)	0.4 (0.7)	160.0 (42.9)	
Selene	flesh		15.6 (5.0)	4.5 (2.5)	0.0 (0.0)	0.0 (0.0)	20.2 (4.6)	39.6 (6.3)
	peel	orange	124.0 (17.1)	54.6 (8.1)	57.4 (7.6)	0.0 (0.0)	235.9 (23.9)	
Z 403/2	flesh		19.2 (0.6)	5.5 (2.3)	0.0 (0.0)	0.0 (0.0)	24.8 (2.9)	32.7 (3.7)
	peel	light orange (red)	32.6 (10.3)	21.1 (8.5)	58.8 (6.9)	0.0 (0.0)	112.5 (20.5)	

[a] Means in mg 100 g^{-1} of fresh weight. Standard deviations ($n = 3$) in parentheses. [b] Cinnamic deriv, hydroxycinnamic acid derivatives. [c] Total phenolic compounds in the edible portion = mg 100 g^{-1} of fresh weight from the edible portion (91% flesh + 9% peel). [d] Blush color of skin given in parentheses.

Table 7. Average of Flesh Hue Angle ($H°$) and Phenolic Compounds in the Edible Portion of Apricot Varieties in Different Color Groups[a]

apricot flesh color	$H°$ flesh[b]	total phenolics[b]	procy-anidins[b]	hydroxy-cinnamic acid derivatives[b]	flavonols[b]	antho-cyanins[b]
white	88.1 a	72.8 a	44.7 a	18.8 a	9.2 a	0.0 a
yellow	85.0 a	70.2 a	45.8 a	18.6 a	5.7 b	0.0 a
light orange	77.5 b	62.1 a	34.6 a	19.0 a	8.5 a b	0.1 a
orange	72.4 c	79.2 a	54.7 a	16.9 a	7.5 a b	0.0 a

[a] Total phenolic compounds in the edible portion = mg 100 g^{-1} of fresh weight from the edible portion (91% flesh + 9% peel). [b] Values with different letters showed statistically significant differences at the 5% level, according to Duncan's multiple-range test.

Table 8. Correlation Coefficients between Phenolic Compounds and Flesh Color

	procy-anidins	hydroxy-cinnamic acid derivatives	flavonols	antho-cyanins	total phenolics
$H°$ flesh	–0.241	–0.060	–0.039	–0.059	–0.235

[a] Pearson's correlation coefficients. *, ** significant at $P \leq 0.05$ or 0.01, respectively.

could be due to the genetic differences of the evaluated samples because the apricot varieties were obtained from a breeding program, which used apricot parents coming from different genetic origins.

Correlation between Phenolic Content and Flesh Color. In a recent work we have shown that there is a close relationship between flesh color and the carotenoid content of apricot varieties (*22*). This study concluded that the studied apricots can be classified in accordance with their flesh hue angle measured with a Minolta spectrophotometer. The average of phenolic content in the edible portion and flesh color values in white, yellow, light orange, and orange flesh apricots is shown in **Table 7**. These results indicate that there was no significant difference in phenolic compounds between apricot varieties with different flesh colors, with the exception of flavonol compounds, for which white flesh varieties had higher levels than yellow, light orange, and orange varieties.

When the correlation between these color values and the phenolic content (total phenolics, hydroxycinnamic acid derivatives, procyanidins, flavonols, and anthocyanins) was evaluated, no correlation was observed (**Table 8**). In a previous work a similar trend was observed in the case of white and yellow flesh peaches and nectarines, in which no correlation between color and phenolic content was observed (*14*).

In conclusion, a great variability in the content of phenolic compounds has been observed among apricot varieties that differ in flesh color. Thus, the content of phenolics as health-promoting phytochemicals could be an important quality parameter for the selection of new varieties in breeding programs, although there is no correlation with the flesh color.

ABBREVIATIONS USED

SSC, soluble solids content; TA, titratable acidity; $H°$ hue angle; HPLC-DAD, high-performance liquid chromatography−diode array detector; HPLC-MS/MS, high-performance liquid chromatography−tandem mass spectrometry.

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