Carotenoids, Phenolic Profile, Mineral Content and Antioxidant Properties in Flesh and Peel of Prunus persica Fruits during Two Maturation Stages

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Abstract

Carotenoids and phenolic profile, antioxidant activity as well as concentrations of selectedmacronutrients (K, N, Mg, Ca and Na) and micronutrients (Zn, Cu and Mn) in flesh and peel of peach fruit were recorded at two harvest dates. Predominant mineral was potassium, followed by calcium, magnesium and sodium. The concentration of most micronutrients was greater in the peel than in the flesh especially in early season. The concentration of most elements in flesh and peel decreased during fruit maturation. Total carotenoids content varied with respect to the cultivar. β-cryptoxanthin and β-carotene were the major carotenoids in both tissues and flesh contain the lowest amounts. Neochlorogenic acid, chlorogenic acid, catechin, epicatechin, gallic acid, rutin, quercetin-3-O-galactoside, cyanidin-3-Oglucoside, cyanidin-3-O-rutinoside, were detected in both peel and flesh, with chlorogenic acid and catechin being the predominant components. Peel extracts showed markedly higher antioxidant activities, when estimated by ABTS or DPPH assays, than the flesh counterparts, consistent with the observed higher phenolic content. Overall, total phenolics levels increased at full ripening stage in both peel and flesh. The results found herein provide important data on carotenoids, phenolic and macro- and micronutrient changes during fruit growth, and emphases peach fruit as a potential functional food.

Keywords: *Prunus persica*, Carotenoids, Mineral elements, Phenolic profile, Antioxidant activity, Ripening

Abbreviations

ABTS+ 2,2-azinobis-3-ethylbenzothiazoline-6-sulfonic acid radical cation

DPPH• 2,2-diphenyl-1-picrylhydrazyl radical

EC_{50} Effective concentration

Introduction

Peach (*Prunus persica* (L.) Batsch) is one of the most popular fruits in the world during summer, because of its high water and mineral content [1] and the presence of carotenoids and antioxidant molecules, such as procyanidins, anthocyanins, catechins and phenolic acids [2–4], which determine the nutritive values and, together with sugars and organic acids, contribute to the sensory quality of the fruits.

The phytochemical content of fruits is strongly influenced by different factors, such as cultivar [5–7], rootstock [8, 9], climatic conditions, agronomic practices [10, 11] and ripening stage at harvest [12, 13]. The fruit peel is usually rejected because it is thought to be indigestible or contaminated by sprays or human disease agents [8]. However, it is richer in nutritive compounds than the edible fleshy parts. In particular, peel of peach and nectarine contains at least twice as much phenolics [2], carotenoids and ascorbic acid as the flesh [6]. Being a potential source of bioactive compounds, peach fruit presents relevant health implications [1]. The dietary intake of peach can reduce the generation of reactive oxygen species and provide protection from a number of chronic diseases [14]. Peach shows laxative properties and is appropriate to prevent constipation and for the treatment of duodenum ulcers [6, 15]. β-carotene, α-carotene, and β-cryptoxanthin are precursors of vitamin A, essential for normal growth, reproduction, vision and resistance to infection. A severe deficiency in vitamin A can lead to xerophtalmia and irreversible blindness [16]. Furthermore, chlorogenic and neochlorogenic acids were found to be the two specific phenolic acid components of peaches and plums able to kill breast cancer cells [17].

To the best of our knowledge, information about nutritional values of peach fruit from Tunisia at different ripening stages is scarce. In a previous paper [18], we reported a genotype influence on fatty acid and volatile compounds composition of the three peach cultivars studied in the present research. Moreover, a ripening-dependent effect was observed, suggesting that the best harvesting time to achieve optimal characteristics should be the commercial ripening date. In this context, this paper aims to characterize the nutraceutical properties (carotenoids and phenolic profile, antioxidant and reducing power) and the mineral composition of flesh and peel from three peach cultivars produced in Tunisia to determine the adequate date of maturity for each variety.

Materials and Methods

Plant Material

Three peach (*Prunus persica* (L.) Batsch) cultivars (‘Earl May Crest’, ‘Sweet Cap’ and ‘O’Henry’) were grown in the two seasons 2013–2014 at an experimental orchard (Regional Center of Agricultural Research Farm in the region of Sidi Bouzid), Center-West of Tunisia (35°2′0″N,

9°30′0″E; at 313 m a.s.l.) [18]. The study was conducted at two harvest dates. The first harvest date, named commercial ripening, represents the beginning of ripening and is performed when the fruit is fully developed and the full degree of color is almost attained but the flesh is firm and the fruit would stand shipping. This date is preferred by farmers since fruit is very resistant to marketing conditions (refrigeration, export, etc.). The second harvest date represents the full ripening of fruits from the point of view of taste, color, etc. For each ripening stage, three replicates were made. Each replicate consisted of 20 fruits collected from three trees in order to obtain a representative set of fruits.
Once fruits were hand harvested, peel and flesh were separated within 24 h, lyophilised and stored at -20 °C until analysis.

Methods

Please see electronic supplementary material as File 1 and Fig. S1.

Results and Discussion

Macro and Micro Elements

The microelements (Cu, Mn and Zn) and macroelements (Ca, Mg, Na, N and K) profiles in peel and flesh of three different peach cultivars are listed in Table 1. Similar profiles were present in peel and flesh for the three peach cultivars, whereas significant differences were observed for each individual mineral.

In this study, the peach fruit proved to be one of the most suitable sources of macroelements, especially potassium (Table 1). This finding is in accordance with previous results obtained for Prunus persica cultivars [19] where potassium levels were higher in flesh than peel. High potassium intake was positively associated with bone metabolism, lower blood pressure and reduced cardiovascular disease morbidity and mortality [20, 21]. Magnesium is generally present in high amounts in the peel of the three peach cultivars (Table 1). Only few changes were observed in the content of macroelements throughout ripening. Sodium and nitrogen were relatively less concentrated, which might be considered as a favorable result in view of the need to consume low quantities of these minerals.

Zinc, copper and manganese, essential microelements for human enzymes metabolism [22], were more concentrated in peel than in flesh, with zinc and copper being the major elements in all samples (Table 1). All micronutrients, with few exceptions, were similarly concentrated during ripening.

Nutraceutical Compounds

Carotenoids Color changes that take place specially during ripening process strongly influence both visual and eating quality of peaches and nectarines. Genotypic differences markedly affect color intensity, the main pigments responsible for color (both skin and flesh) being carotenoids [23]. Total carotenoids content varied among cultivars (Table 1), with 'O'Henry' showing the highest contents. In both tissues, β-cryptoxanthin and β-carotene were the major carotenoids, even if cultivar-dependent differences were observed, in agreement with previous reports [6, 24, 25]. In particular, β-carotene was the main carotenoid in 'O'Henry', while 'Sweet Cap' presented higher β-cryptoxanthin concentration. In 'Early May Crest' differences were observed between the two tissues, β-cryptoxanthin being more concentrated in the peel and β-carotene in the flesh. Both β-carotene and β-cryptoxanthin are vitamin A precursors, even if β-carotene seems to be a preferred substrate of enzymes involved in carotenoid absorption and conversion to vitamin A [26]. All carotenoids were less concentrated in the flesh, confirming previous results [25]. Differences between the two tissues were particularly evident in 'Sweet Cap', where flesh total carotenoids were about 86 and 92% lower than in the peel, at commercial and full ripening, respectively. Comparing the two ripening stages, no statistical differences were found for 'Sweet Cap'; however, an increase was observed from commercial to full ripening for 'Early May Crest' and 'O'Henry' cultivars (Table 1).

Phenolics

Table 2 shows the phenolic profile of peel and flesh of the three peach cultivars at the two different ripening stages. In both tissues, neochlorogenic acid was generally less concentrated than chlorogenic acid, in accordance with published findings [2, 3, 7, 24]. Cholorogenic and neochlorogenic acids are reported to be more concentrated in immature fruits [27]. A ripening dependent decrease of neochlorogenic acid was observed in 'O'Henry' peel, while chlorogenic acid underwent a decrease in the flesh of 'Early My Crest' and 'O'Henry'. Conversely, 'Sweet Cap' peel showed the highest values of both acids at full ripening (Table 2). Similar amounts of neochlorogenic acid were detected in peel and flesh of 'O'Henry' and, limited to commercial ripening, of 'Sweet Cap' fruit, while 'Early May Crest' exhibited higher concentration of neochlorogenic acid in the flesh at both ripening stages (Table 2).

In accordance with previous reports [2, 9], catechin was the main monomeric flavan-3-ol, and epicatechin was present in lower amounts in any cultivar and tissue and for any ripening stage (Table 2). Catechin showed a wide range of concentration among samples. Sweet Cap' exhibited the highest concentration in both tissues, while 'Early May Crest', particularly at commercial ripening, showed the lowest values.

Cyanidin-3-glucoside and cyanidin-3-rutinoside were quantitatively higher in peel than flesh tissue. Cyanidin-3-glucoside represented the main anthocyanin in ‘Early May Crest’ and ‘O’Henry’, while ‘Sweet Cap’ mainly contained cyanidin-3-rutinoside. Generally, peel anthocyanins are more concentrated in yellow-fleshed than white-fleshed cultivars [2, 5], as observed in our work for the yellow-fleshed cultivars ‘Early May Crest’ and ‘O’Henry’ (Table 2). This latter also showed good amounts of anthocyanins in the flesh, particularly at full ripening.

‘Sweet cap’ presented the highest amount of total phenolics at both harvest dates, although it showed very low anthocyanin concentration. ‘Early May Crest’ and ‘O’Henry’ exhibited the lowest amount at commercial and full ripening, respectively (Table 2).

Two different flavonols were quantified: quercetin-3-rutinoside and quercetin-3-galactoside, which is consistent with previous works [2, 3, 12]. Their contents differed between peel and flesh and were dependent on cultivar and ripening stage (Table 2). As for the other phenolics, the peel contained significantly higher flavonol concentration than the flesh (2- to 7-fold), the highest concentration being found in ‘Sweet Cap’ and ‘O’Henry’. These results are in accordance with previous reports in a wide range of both peach and nectarine round cultivars [5, 6].

Overall, no clear trend was observed in phenolic content with ripening, in accordance with previous findings [2]. Peel total phenols of ‘Sweet Cap’ and ‘Early May Crest’ increased with ripening, while no change occurred in the flesh. In ‘Sweet Cap’ peel such an increase was due to the higher concentration of hydroxycinnamic acids (86 %), flavan-3-ols (79 %) and hydroxybenzoic acids (90 %) in respect to commercial ripening, while ‘Early May Crest’ showed an increased concentration of flavan-3-ols (61 %), flavonols (54 %) and anthocyanins (272 %). Other works found significant decrease in phenolic compounds during fruit ripening [12].

Antioxidant Activities

Antioxidant activity was assessed by free radical scavenging (DPPH• and ABTS•+) and reducing power assays (Table 2). The data were normalized and expressed as EC50 values (mg kg-1 FW) for comparison. Differences related to cultivar, tissue and ripening stage were observed. For any cultivar, ABTS• scavenging activity was higher in the peel than in the flesh at commercial ripening, in accordance with the findings of Loizzo et al. [4] in fruits of *Prunus persica*, var. platycarpa. However, an opposite trend was shown at full ripening, when ‘Early May Crest’ and ‘O’Henry’ showed higher activity in the flesh (Table 2). All the cultivars exhibited the highest flesh ABTS• scavenging activity at full ripening, while no change was observed in the peel, except for ‘Early May Crest’, whose activity decreased with ripening (Table 2). At both stages, the highest peel antioxidant activity was

observed in ‘Early May Crest’ and the lowest in ‘O’Henry’. In the flesh, cultivar dependent differences were less evident, with Sweet Capuse’ showing the lowest activity at both stages.

Some discrepancies can be found between phenolic concentration and ABTS• scavenging activity. At both ripening dates, peel was a richer source of phenols than flesh. However, at full ripening, except for ‘Sweet Cap’, antioxidant activity was higher in the flesh. Moreover, at commercial ripening, ‘Early May Crest’ showed the highest antioxidant activity among the different cultivars, but it contained the lowest total phenolic concentration. This discrepancy could be related to differences in the concentration of single phenolics, known to possess different antioxidant capacity, as well as to phenolics not measured in the present work, such as proanthocyanidins, which are present in high levels in Prunus sp. [28, 29].

DPPH• scavenging activity showed no clear trends during ripening as well as between the two tissues (Table 2). The only differences between flesh and peel activity were observed in ‘O’Henry’ and ‘Early May Crest’ fruits, at commercial and full ripening, respectively. DPPH• scavenging activity increased in ‘Sweet Cap’ peel and ‘Early May Crest’ flesh at full ripening while, at this stage, it decreased in ‘O’Henry’ peel. Among the cultivars, ‘Sweet Cap’ displayed the lowest activity at commercial ripening in the peel and at full ripening in the flesh. At full ripening the highest DPPH• antioxidant activity in the flesh was shown by ‘Early May Crest’, similarly to what observed for ABTS• scavenging.

Reducing potential differed among the cultivars (Table 2).

As for DPPH• scavenging activity, the lowest reducing power of the peel at commercial ripening was displayed by ‘Sweet Cap’, which at full ripening exhibited instead the highest activity in both tissues. No cultivar-dependent difference was observed in the flesh at commercial ripening. During ripening, flesh activity generally underwent an increase while in the peel it showed an opposite trend in ‘Sweet Cap’ (increase) and ‘O’Henry’ (decrease). Peel reducing potential was higher than flesh one in ‘Early May Crest’ and ‘O’Henry’ fruit at commercial ripening and in ‘Sweet Cap’ at full ripening (Table 2).

Summarizing data recorded by the three different assays, it emerges that at commercial ripening ‘Early May Crest’ peel has always the highest antioxidant activity, while at full ripening ‘O’Henry’ peel displays the lowest antioxidant activity among the tested cultivars. Generally, peel activity is higher than flesh at commercial ripening while at full ripening differences between tissues are less clear. Finally, flesh antioxidant activity tends to increase during ripening, while in the peel this trend is only shown by ‘Sweet Cap’ fruit.

Conclusion

Evaluation of the nutritional value of fruit during the ripening process can help to estimate the optimal date for harvesting to achieve the best quality for both fresh consumption and processing.

Carotenoids levels were higher in the peel than in the flesh at commercial ripening, while phenolics, particularly total hydroxycinnamic acids, total flavonols and total anthocyanins, were more concentrated in the peel irrespective of the harvesting stage. 'O'Henry' was the richest in carotenoids despite a ripening-dependent decrease in the peel, whereas 'Sweet Cap' had the highest phenols content, which further increased in the peel during ripening. The micronutrients content was balanced, which can be considered as a positive fact with respect to ideal quality of fruit, suggesting the peel peach as a potential source of high-value components for functional foods and nutraceutical applications, as well as for nutritional and pharmaceutical purposes.

Compliance with Ethical Standards

Conflict of Interest

We declare not conflict of interest.

Human and Animal Rights

This article does not contain any studies with human or animal subjects.

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Table 1 Minerals (mg 100 g^{-1} DW) and carotenoids (μg 100 g^{-1} FW) evaluated in peel and flesh from *Prunus persica* cultivars harvested at two different dates

	Commercial ripening					
	Sweet Cap		Early May Crest		O'Henry	
	Peel	Flesh	Peel	Flesh	Peel	Flesh
Minerals						
Mg	76.87 ± 6.46f	79.07 ± 7.56b,**	116.55 ± 11.79e	107.87 ± 9.82a	90.60 ± 8.47f,§	80.34 ± 6.22b
Ca	74.53 ± 11.16f,++	33.13 ± 7.29b	85.95 ± 12.51e,f	66.56 ± 12.74a	103.97 ± 16.42e,++	39.68 ± 1.52b,**
Zn	1.95 ± 0.51e	1.07 ± 0.16b,*	1.35 ± 0.40e,f	1.07 ± 0.03b	0.92 ± 0.03f,+	1.46 ± 0.27a,*
Mn	0.36 ± 0.08f,+	0.07 ± 0.03b	0.76 ± 0.07e	0.64 ± 0.10a,*	0.44 ± 0.05f,++	0.17 ± 0.06b
Cu	1.16 ± 0.03f,§,++	0.87 ± 0.10a,*	0.28 ± 0.10f	0.18 ± 0.06b,*	4.88 ± 1.61e,§§,+	0.92 ± 0.08a,**
K	1415.01 ± 120.31e,+	1774.55 ± 49.72a,**	1405.70 ± 21.44e	1485.86 ± 171.50a	1283.67 ± 143.76e	1567.51 ± 295.38a
Na	19.01 ± 2.37g	24.63 ± 4.71b	33.02 ± 8.41f	34.59 ± 4.95a	58.41 ± 7.51e,§,++	16.73 ± 3.23b
N	6.37 ± 0.13e	5.12 ± 0.53b,*	6.43 ± 0.28e	6.92 ± 0.66a,*	5.00 ± 0.18f,+	3.82 ± 0.93b
Carotenoids						
Lutein	nd	nd	10.54 ± 1.45e,§§,++	2.49 ± 1.04a,*	7.66 ± 0.38f,§§,++	3.79 ± 0.44a,++
Lycopene	221.09 ± 42.81e,+	22.00 ± 5.29a,*	45.57 ± 2.08f,§§,++	13.51 ± 3.31b,**	57.66 ± 6.24f,§§,++	17.86 ± 2.55c,*
β-carotene	385.13 ± 49.35f,++	61.30 ± 8.83a,*	653.93 ± 84.46f,§§,++	358.10 ± 71.91	2276.90 ± 265.19e,§§,++	1065.65 ± 288.16b
β-cryptoxanthin	2160.77 ± 362.88e,++	293.30 ± 25.73a,*	830.15 ± 51.32f,§§,++	173.54 ± 31.57a,**	1849.42 ± 563.72e,§,++	291.94 ± 105.75a
Total carotenoids	2766.985 ± 452.021f,++	376.596 ± 13.642a,*	1540.18 ± 133.43g,§§,++	547.64 ± 86.54a,b,*	4191.64 ± 760.70e,§§,++	1379.24 ± 244.83b
	Full ripening					
	Sweet Cap		Early May Crest		O'Henry	
	Peel	Flesh	Peel	Flesh	Peel	Flesh
Minerals						
Mg	66.90 ± 9.27q,+	47.11 ± 6.68z	109.85 ± 14.16p	105.04 ± 11.59x	111.98 ± 6.13p,+	76.61 ± 10.86y
Ca	61.42 ± 3.04q,++	23.97 ± 3.89y	87.02 ± 13.54pq,+	55.71 ± 9.40x	93.02 ± 19.12p,+	58.81 ± 1.81x
Zn	1.06 ± 0.16q,+	0.68 ± 0.12y	1.58 ± 0.25 p,+	1.01 ± 0.02x	1.03 ± 0.12q	0.74 ± 0.17y
Mn	0.26 ± 0.03r	0.11 ± 0.07y	0.64 ± 0.01 p,++	0.40 ± 0.05x	0.53 ± 0.03 q,++	0.17 ± 0.06y
Cu	1.62 ± 0.19p,++	0.64 ± 0.05x	0.41 ± 0.07q	0.31 ± 0.03y	0.07 ± 0.03r	0.16 ± 0.08z
K	1308.10 ± 100.67pq	1418.23 ± 89.83xy	1408.23 ± 30.05p	1557.80 ± 141.27x	1191.38 ± 109.94q	1340.84 ± 70.01y
Na	16.03 ± 3.46r	19.02 ± 7.99x	47.97 ± 7.89p	31.46 ± 6.44x	33.21 ± 5.95q	29.66 ± 6.60x
N	5.97 ± 0.36p,+	3.71 ± 0.59y	4.80 ± 0.29 p	5.54 ± 0.07x	5.22 ± 0.80p	3.85 ± 0.62y
Carotenoids						
Lutein	nd	nd	nd	5.20 ± 1.24x,++	12.02 ± 2.30p,++	5.62 ± 0.65x,++
Lycopene	327.90 ± 85.89p,+	17.66 ± 4.07y	140.04 ± 34.17q,++	25.32 ± 2.32x	36.92 ± 4.93r,+	22.64 ± 4.48z
β-carotene	410.13 ± 97.00q,+	35.75 ± 5.50y	1569.65 ± 260.41p,++	405.24 ± 133.91x	2730.95 ± 616.09r,+	1108.50 ± 88.85y
β-cryptoxanthin	2352.85 ± 597.97p,+	181.83 ± 53.10y	1664.12 ± 336.68p,++	330.91 ± 29.68x	814.45 ± 289.46q,+	341.28 ± 40.92z

Total carotenoids	3090.88 ± 776.26p,+	235.23 ± 61.94y	3373.81 ± 612.48p,++	766.67 ± 103.70x	3594.35 ± 899.57q,+	1478.03 ± 47.62z

Values are the means of three different peach samples (n = 3) ± standard deviation. Different superscripts for the same parameter mean significant differences among cultivars at $p < 0.05$, as detailed below. Different letters a–c and e-g, for the same parameter, within columns indicate significant differences $p < 0.05$ with respect to harvest period for peel. Different letters p-r and x-z, for the same parameter, within columns indicate significant differences $p < 0.05$ with respect to harvest period for flesh. Different symbols *, **, for the same parameter, within columns indicate significant differences $p < 0.05$with respect to harvest period for flesh at each harvest $p < 0.05$. Different symbols §, §§, for the same parameter, within columns indicate significant differences $p < 0.05$ with respect to harvest period for peel at each harvest $p < 0.05$. Different symbols +,++, for the same parameter, within columns indicate significant differences between peel and flesh with respect to cultivar

Table 2 Phenolic profile (mg kg^{-1} FW) and effective concentration (EC50) values (mg kg^{-1} FW) evaluated in peel and flesh from *Prunus persica* cultivars harvested at two different dates

	Commercial ripening					
	Sweet Cap		Early May Crest		O'Henry	
	Peel	Flesh	Peel	Flesh	Peel	Flesh
Phenolic profile						
Neochlorogenic acid	53.87 ± 2.68e,§	56.28 ± 4.85a	19.65 ± 4.49g,++	50.00 ± 7.83ab	34.97 ± 4.19f,§	41.42 ± 5.43b
Chlorogenic acid	110.40 ± 9.95e,§§	89.13 ± 1.64a	63.92 ± 10.43g	85.42 ± 14.61a,*	89.09 ± 5.28f,+	55.54 ± 7.09b,*
Total hydroxycinnamic acids	164.28 ± 12.51e,§§	145.42 ± 5.22a	83.58 ± 12.73g,+	135.42 ± 19.79a,*	124.06 ± 9.44f,+	96.96 ± 12.51b
Catechin	117.59 ± 4.89e,§§	176.42 ± 49.91a,*	24.18 ± 6.17g	12.95 ± 4.83b	55.44 ± 15.61f	37.65 ± 17.34b
Epicatechin	41.16 ± 7.76e,§	25.63 ± 2.08a,*	12.65 ± 4.19f	4.17 ± 0.54b,*	19.37 ± 3.26f,§,++	8.46 ± 1.10b
Total flavan-3-ols acids	158.75 ± 12.56e,§§	202.06 ± 51.91a,*	36.83 ± 10.34g	17.12 ± 5.18b	74.81 ± 15.67f	46.11 ± 18.34b
Gallic acid	44.67 ± 2.76e,§§	30.53 ± 4.61b,**	54.97 ± 7.58e	28.60 ± 2.98a	45.02 ± 15.53e	31.45 ± 1.12b
Total hydroxybenzoic acids	44.67 ± 2.76e,§§	30.53 ± 4.61b,**	54.97 ± 7.58e	28.60 ± 2.98a	45.02 ± 15.53e	31.45 ± 1.12b
Quercetin-3-rutinoside	27.80 ± 9.44e,+	2.47 ± 0.41a	12.50 ± 5.55e,+	.27 ± 0.35b	127.98 ± 9.56e,++	1.44 ± 0.21b,*
Quercetin-3-galactoside	52.95 ± 10.67e,+	16.19 ± 1.92 a,*	16.65 ± 7.79f	4.31 ± 1.34b	45.49 ± 12.28e,+	10.13 ± 6.86ab
Total flavonols	80.75 ± 20.07e,++	18.66 ± 2.29a,*	29.15 ± 13.34f	5.58 ± 1.01b	73.47 ± 21.69e,++	11.57 ± 6.84ab
Cyanidin-3-glucoside	1.43 ± 0.31f,++	0.03 ± 0.01b,**	30.62 ± 8.33e,§§,++	0.59 ± 0.43b	38.45 ± 8.88e,+	3.03 ± 1.66a
Cyanidin-3-rutinoside	10.10 ± 2.83e,++	0.09 ± 0.04 a,*	12.59 ± 2.81e,§,++	0.25 ± 0.18a	15.62 ± 4.89e,++	0.32 ± 0.32a
Total anthocyanins	11.53 ± 3.10f,++	0.12 ± 0.06b,**	43.21 ± 10.99e,§§,++	0.84 ± 0.61b	54.07 ± 13.66e,++	3.35 ± 1.98a
Total phenols identified	459.98 ± 8.68e,§§	396.80 ± 57.03a	247.73 ± 42.86g,§	187.56 ± 23.57b	371.43 ± 28.38f,++	189.45 ± 37.76b
EC50 values						
+ ABTS	31.69 ± 5.34f, ++	7.55 ± 1.84b,**	70.88 ± 15.33e,§,++	8.02 ± 2.24a,**	20.23 ± 4.92f,+	11.87 ± 0.94a,**
+ DPPH	19.07 ± 2.33f,§§	22.83 ± 3.50b	57.02 ± 21.57e	16.56 ± 5.13b,**	48.01 ± 4.89e,§§,+	34.43 ± 3.86a
++Reducing power	9.60 ± 0.59f,§§	8.63 ± 2.46a	13.18 ± 1.82e,++	4.43 ± 0.72a,**	14.38 ± 2.30e,§,+	5.14 ± 0.51a,**
	Full ripening					
	Sweet Cap		Early May Crest		O'Henry	
	Peel	Flesh	Peel	Flesh	Peel	Flesh
Phenolic profile						
Neochlorogenic acid	98.25 ± 10.90p,++	57.50 ± 5.52(x)	21.81 ± 4.45q,+	37.51 ± 15.49xy	24.77 ± 4.10q	28.94 ± 7.52y
Chlorogenic acid	206.97 ± 17.89p,++	89.37 ± 4.60x	64.57 ± 2.29q	44.33 ± 8.36y	85.58 ± 7.94q,+	38.35 ± 6.64y
Total hydroxycinnamic acids	305.22 ± 27.10p,++	146.88 ± 8.41x	86.38 ± 6.64q	81.83 ± 21.28y	110.36 ± 12.01q,+	67.29 ± 14.06y
Catechin	218.00 ± 10.96p,+	188.05 ± 38.68x	52.91 ± 15.35q	22.58 ± 8.36y	50.26 ± 18.22q	25.20 ± 11.06y
Epicatechin	65.57 ± 3.87p	24.30 ± 4.60x	6.36 ± 0.57q	2.09 ± 1.06y	10.25 ± 2.38q	6.45 ± 3.36y
Total flavan-3-ols acids	283.57 ± 14.1(p	212.35 ± 43.27x	59.27 ± 15.81q	24.67 ± 9.06y	60.52 ± 20.59q	31.65 ± 14.17y
Gallic acid	84.77 ± 8.32p	42.80 ± 2.84x	45.79 ± 1.24q	22.86 ± 12.36y	46.85 ± 3.67q	37.72 ± 4.31y
Total hydroxybenzoic acids	84.77 ± 8.32p	42.80 ± 2.84x	45.79 ± 1.24q	22.86 ± 12.36y	46.85 ± 3.67q	37.72 ± 4.31y
Quercetin-3-rutinoside	30.51 ± 2.42p,++	3.34 ± 0.36++	16.59 ± 1.65q,++	1.28 ± 0.18 y	15.89 ± 5.42 q,++	0.88 ± 0.25 z

Quercetin-3-galactoside	57.48 ± 10.16p	8.61 ± 2.35x	28.36 ± 9.65q	22.23 ± 18.12x	30.82 ± 11.53q	11.48 ± 3.73x
Total flavonols	88.00 ± 12.35p,++	11.95 ± 2.89x	44.95 ± 9.60q	23.51 ± 18.30x	46.71 ± 16.93q,+	12.36 ± 3.91x
Cyanidin-3-glucoside	2.43 ± 0.59r,++	0.28 ± 0.03 y	97.04 ± 1.14p,++	0.57 ± 0.41y	39.44 ± 3.23q,++	7.39 ± 5.42x
Cyanidin-3-rutinoside	12.90 ± 3.17q,++	0.23 ± 0.04x	63.54 ± 11.56 p,+	.11 ± 0.02 y	0 11.48 ± 3.08 q,++	nd
Total anthocyanins	15.33 ± 2.99r,++	0.51 ± 0.01y	160.58 ± 11.81p,++	0.68 ± 0.40y	50.92 ± 6.18q,++	7.39 ± 5.42x
Total phenols identified	776.89 ± 54.93p	414.49 ± 51.90x	396.97 ± 19.75p,++	153.55 ± 22.38y	315.35 ± 55.78p,+	156.41 ± 35.32y
EC50 values						
+ ABTS	24.91 ± 4.39q	31.80 ± 3.80y,*	44.26 ± 1.33p,+	63.54 ± 5.02x,*	10.21 ± 3.20r,+	43.46 ± 10.57y,*
+ DPPH	49.95 ± 10.54p	26.55 ± 1.43z	38.99 ± 0.81pq,+	63.62 ± 5.23x	33.50 ± 2.43q	41.32 ± 7.79y
++Reducing power	16.37 ± 1.22p,++	11.30 ± 1.27x	9.69 ± 0.46q	8.75 ± 0.28y	8.83 ± 0.29q	9.01 ± 0.99y

Values are the means of three different peach samples (n = 3) ± standard deviation. Different superscripts for the same parameter mean significant differences among cultivars at $p < 0.05$, as detailed below. Different letters a–c and e-g, for the same parameter, within columns indicate significant differences $p < 0.05$ with respect to harvest period for peel. Different letters p-r and x-z, for the same parameter, within columns indicate significant differences $p < 0.05$ with respect to harvest period for flesh. Different symbols *, **, for the same parameter, within columns indicate significant differences $p < 0.05$ with respect to harvest period for flesh at each harvest $p < 0.05$. Different symbols §, §§, for the same parameter, within columns indicate significant differences $p < 0.05$ with respect to harvest period for peel at each harvest $p < 0.05$. Different symbols +,++, for the same parameter, within columns indicate significant differences between peel and flesh with respect to cultivar. ABTS+ (2,2-azinobis-3-ethylbenzothiazoline-6-sulfonic acid radical cation); DPPH• (2,2-diphenyl-1-picrylhydrazyl radical). + EC50 (mg kg^{-1} FW): effective concentration at which 50 % of DPPH or ABTS radicals are scavenged. ++ EC50 (mg kg^{-1} FW): effective concentration at which the absorbance is 0.5