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Determination of Selected Beneficial Substances in Peach Fruits

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Abstract: Peaches (*Prunus persica* L.) are a popular and sought-after dessert fruit. This is mainly due to their flavour, aroma, attractive appearance, and high content of substances that play an important role in human nutrition. The present study was carried out to determine some important analytical properties (sugars/sucrose, glucose, fructose and sorbitol), total acid, total phenolics, flavonoids, antioxidant capacity, carotenoids and anthocyanins of 34 selected peach varieties. The analyses are also complemented by colorimetric measurements of peach skin colour using CIELAB and other chromatic parameters. The results show, for example, that all peach varieties are good sources of phenolic compounds (9.43–577 mg gallic acid equivalent (GAE).100 g^{-1}), flavonoids (1.12–95.1 mg catechin equivalent (CAE).100 g^{-1}), and antioxidant capacity (136–462 mg Trolox equivalent (TE).100 g^{-1}).

Keywords: *Prunus persica* L.; colour; chemical contents; antioxidant capacity; sugar

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1. Introduction

There are a great variety of peach trees (*Prunus persica* L.), not only in terms of the length of ripening period, but also in terms of the pomological characteristics of the fruit, where we can distinguish yellow-fleshed, white-fleshed, red-fleshed, fully separable from the stone or clings, flat-shaped varieties, referred to as Peento, that are very popular in southern Italy and Asia. There are also well-known selections of varieties without any anthocyanin content, originating in Italy (the 'ice peach'), and the Californian 'Royal' series of varieties, which are characterised by their very hard flesh and very low acid content, giving the fruit a sweet taste.

From a nutritional point of view, peaches contain a number of beneficial substances, making them an interesting addition to the human diet. Peaches are a rich source of dietary fibre (1.5 g.100 g^{-1}) and provitamin A [1]. This fruit is considerably rich in antioxidants and is an important source of vitamins A, B, and C, carotenoids and phenolic compounds. Among the most important phenolic acids are chlorogenic and neochlorogenic acids, catechin, epicatechin, 3-glucoside of cyanidin (chrysanthemin), and quercetin derivatives [2–5]. Polyphenols represent the majority of antioxidants present in the diet and their daily intake should exceed 1 g/day, which is much higher than that of all other classes of phytochemicals and known dietary antioxidants [6]. They are low in fat and contain a lot of water, approximately 89 g per 100 g of fruit [7,8]. Peaches are very low in sugars (9–20 °Rf), with the main sugars present being sucrose, fructose, sorbitol, and glucose. The proportions of these sugars undergo changes during fruit ripening, with glucose and fructose being present in greater amounts in immature fruit and increasing as ripening progresses. At full maturity, sucrose content dominates [9–11]. Carbohydrates are an important source

of energy in the human diet and also play an important role in the regulation of the gut microbiota [12]. They also have low levels of organic acids (0.13–1.16%) such as malic, citric, and folic acids. The content of L-ascorbic acid (vitamin C) in peaches is relatively low compared to other fruits such as kiwifruit or oranges, in which it is the most important antioxidant. Quinic, fumaric, and shikimic acids are present in smaller concentrations [13,14]. Amino acids (arginine, asparagine, isoleucine, lysine, serine, threonine, valine, leucine, phenylalanine, tryptophan, tyrosine, proline, and alanine) also contribute to the flavour of fruit and are found in peaches in different concentrations depending on the cultivar [15,16]. Among the mineral elements, they contain nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, cooper, chromium, nickel, cobalt, lead, selenium, and fluoride [17,18]. Similar to apricots, the glycoside amygdalin (26%), protein amandine (3.8%), enzymes, lactase, and oleic acids are present in peach kernels. The leaves contain about 1% prunasin and are used against rheumatism, gastritis, headaches, and as a diuretic; when used externally, they are effective against eczema, ulcers, and other dermatoses [19].

The potential of peaches, especially those rich in phenolics, lies in delaying or even preventing the onset of neurogenerative diseases such as Alzheimer's and Parkinson's. They also help in the prevention of inflammation, atherosclerosis, diabetes, obesity, and cardiovascular disease. Due to their low sugar content, they can easily be included in nutritional therapy. They are easily digestible, have a strong alkaline effect on the body, and stimulate the secretion of digestive juices. They have both a laxative and a diuretic effect. Peach phenolics have been shown to display several biological activities such as antioxidant activity [20,21], anti-allergic and anti-inflammatory activities [22], antibacterial activity [23], hepatoprotective activity [24], nephroprotective activity [25], antiproliferative [26], chemopreventive, and anticancer activities [27,28].

The aim of this study was to compare varieties from different pomological groups as well as different geographical origins and thus get an overview of the differences in content composition from the point of view of titratable acidity, soluble solid content, sugars, phenolic compounds, flavonoids, antioxidant activity, carotenoids, and total anthocyanin content.

2. Materials and Methods

2.1. Site of Planting and Plant Material

In total, 34 peach cultivars of different origin were analysed in this study (Table 1). 20 cultivars from USA, 6 from Yalta, 5 from Italy, 1 from Czech Republic, 1 from France, and 1 from Slovakia. Trees of these cultivars were grown in the experimental orchard at the Faculty of Horticulture in Lednice, Mendel University in Brno (localisation 48.80°N/16.80°E, at an altitude of 172 m), with an average annual temperature of 9.7 °C.

Table 1. The cultivars obtained in this study and their flesh colour, fruit type, and origin.

Cultivars	Flesh Colour	Fruit Type	Origin	Cultivars	Flesh Colour	Fruit Type	Origin
Admiral de Wey	Yellow	Peach	USA	Iris Rosso	White	peach	Italy
Alexandra	White	Peach	USA	Krasava	Creamy	peach	Czech Republic
Anita	White	Peach	USA	Lakomyj	Yellow	peach	Yalta, Crimea
Aurelia	Yellow	Peach	Italy	Narjadnyj Nikitskij	Yellow	peach	Yalta, Crimea
Avalon Pride	Yellow	Peach	USA	Nerine	Yellow	peach	USA
Benedicte	Creamy	Peach	France	Otličnik	Yellow	peach	Yalta, Crimea
Candor	Yellow	Peach	USA	Queen Lady	Yellow	peach	USA
Carolina Belle	White	Peach	USA	Red Robin	White	peach	USA
Dixigem	Yellow	Peach	USA	Redhaven	Yellow	peach	USA
Dostojnyj	Yellow	Peach	Yalta, Crimea	Romea	Yellow	cling	Italy
Early Glo	Yellow	Peach	USA	Royal Glory	Yellow	peach	USA
Early Redhaven	Yellow	Peach	USA	Royal Majestic	Yellow	peach	USA
Favorita Morettini	Yellow	Peach	Italy	Sonet	Yellow	peach	Yalta, Crimea
Fénix	Yellow	Peach	Slovakia	Strelec	Yellow	peach	Yalta, Crimea
Fidelia	White	Peach	USA	Suncrest	Yellow	peach	USA
Harvester	Yellow	Peach	USA	Sunshine	Yellow	peach	USA
Helene	White	Peach	USA	UFO 3	White	peento	Italy

Five fruits from each variety were harvested at their harvest maturity and transported to the laboratory for chemical analyses.

2.2. Determination of Titratable Acidity

The determination of titratable acidity was performed by potentiometric titration, with a solution of 0.1 mol.L^{-1} NaOH of a known factor up to pH 8.1 measured by a combined SenTix™ 81 pH electrode (WTW™, Prague, Czech Republic) coupled with inoLab 7110 pH meter (WTW™, Prague, Czech Republic). Titratable acidity was expressed as % malic acid equivalent [29]. Mixed fruits were used as a sample for titration.

2.3. Preparation of the Plant Samples for Analysis of Total Phenolic Content, Total Flavonoids, and Total Antioxidant Capacity

Prior to determination of content of secondary metabolites (phenolic compounds, flavonoids, and antioxidant capacity), methanol extract from fresh fruit material was performed. Five grams of the sample was homogenized with a hand blender in 25 mL 75% methanol. The extract was left to stand for 24 h and then filtered through a filter paper into a 50 mL measuring flask. The filtrate was then adjusted to the line with 75% methanol. Samples were transferred into a 20 mL plastic bottles and kept at −20 °C until the analysis [30].

2.4. Determination of Total Phenolic Content, Total Flavonoids, and Total Antioxidant Capacity

Analyses of all parameters were carried out according to the protocols of Zloch et al. (2004) [31] by using a SPECORD® 50 PLUS spectrophotometer (Analytik, Jena, DE). Total phenolic content was measured after reaction of sample extracts with Folin–Ciocalteu reagent at a wavelength of 765 nm and expressed in milligrams GAE per 100 g FW. Total flavonoid content was determined by using chloride and sodium nitrite and the results were expressed in milligrams CAE per 100 g FW. For determination of total antioxidant activity, the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method was used. This method is based on the decolorizing property of the hydrogen radical of DPPH with hydrogen donors, which are included in phenolic compounds as well. Trolox (6-hydroxy-2.5.7.8-tetramethylchroman-2-carboxylic acid) was used as a standard, and the measurement was performed at 515 nm and then expressed in milligrams TE per 100 g FW.

2.5. Determination of Total Carotenoids

Prior to determination of the carotenoid content, sliced thin fruit sections were dried in a heat chamber FED 400 (Binder, Tuttlingen DE) at 50 °C for 24 h and pulverised in a mill Pulverisette 11 (Fritsch, Weimar, DE). Next, acetone was used to extract the pigments from the samples. Determination of photosynthetically active pigments (carotenoids) was performed with a SPECORD® 50 PLUS spectrophotometer (Analytic Jena AG, Germany) at 440 nm according to Holm (1954) [32]. Total carotenoids were expressed in milligrams per 100 g dry weight (DW).

2.6. Determination of Total Anthocyanin Content (TAC)

The determination of TAC was based on a pH differential method using changes in the colour of samples containing anthocyanins in various pH value environments. Five grams of homogenized whole fruit of peach was mixed with 25 mL of 0.1 M HCl. After 1 h of extraction, the solution was filtered and 0.5 mL of the filtrate was pipetted into 6 test tubes. A 2.5 mL (0.025 mol.L^{-1}) of KCl solution of pH 1 was added into the first 3 test tubes and 2.5 mL (0.4 mol.L^{-1}) solution of $C_2H_3NaO_2$ of pH 4.5 was added into the remaining 3 test tubes. Prepared rest tubes were measured at wavelengths of 510 nm and 700 nm with a spectrophotometer SPECORD® 50 PLUS (Analytic Jena AG, Germany). The results were expressed in mg.100 g^{-1} fresh weight (FW).

2.7. Determination of Sugar Content

The soluble solids content was determined using the Abbé refractometer and expressed in weight percentage.

The determination of sugar content was performed by high performance liquid chromatography (HPLC). Juice was squeezed from the fruit and diluted with distilled water at a 1:4 ratio (2 mL juice + 8 mL H_2O). The diluted sample was filtered through a microfilter and analysed. A Clarity chromatography station (Watrex, Prague, Czech Republic) with a Polymer IEX Ca_SN8422 column (250 × 8 mm; Watrex, Prague, Czech Republic) was used for making the analysis. The flow rate of the mobile phase (deionized water) was 0.5 mL.min^{-1}, pressure 1.9 MPa, temperature 80 °C. A refractometric detector was used for making the evaluation. Fructose, glucose, sucrose, and sorbitol contents were converted into the fresh weight of plant material and expressed as g sugar per 100 g fruit.

2.8. Colour Analysis

Colour of cleaned skin of 5 fruits was analysed using colorimeter CR-400 (Konica Minolta®, Tokyo, Japan), equipped with D65 illuminant. The over colour and ground colour were distinguished where possible within the analysis. The data were processed by software SpectraMagic NX Lite (Konica Minolta®, Tokyo, Japan). The analysis is based on CIELAB scale. The colour parameters L^*, a^*, b^* are directly measured in terms of standard observed and standard illuminant [33], where parameter L^* represents the lightness of the fruit, parameter a^* represents the axis in the direction from green to red and parameter b^* represents the axis in the direction from blue to yellow. Values were displayed with the mean ± standard deviation. Cylindrical coordinates C^*_{ab} and h°_{ab} were calculated from coordinates a^* and b^* by Equations (1) and (2) [34]:

$$C^*_{ab} = (a^{*2} + b^{*2})^{1/2} \quad (1)$$

$$h^\circ_{ab} = \tan^{-1}(b^*/a^*) \quad (2)$$

C^*_{ab} denotes the purity of saturation of the colour [35], which means the higher is the chroma (C^*_{ab}) the colour is more intense. Hue angle (h°_{ab}) refers to the colour wheel and is measured in angles [36]. The colour difference ΔE^*_{ab} was accomplished for cultivars with measurable ground and over colour. Values were displayed with the mean ± standard deviation of ten replications. Given two colours in the CIELAB colour space, (L^*_1, a^*_1, b^*_1) and (L^*_2, a^*_2, b^*_2), the CIE76 colour difference formula is defined as (3):

$$\Delta E^*_{ab} = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2} \quad (3)$$

$\Delta E^*_{ab} \approx 2.3$ corresponds to a JND (just noticeable difference) [37].

2.9. Statistical Analysis

Statistical analysis was performed in Statistica 12 (TIBCO, USA) and Microsoft Excel software. Single-factor ANOVA analysis (level of significance $\alpha = 0.05$) was used for statistical processing and the Tukey HSD test was subsequently used to evaluate the statistical significance of differences between the individually measured values (TAC and chromatic parameters L^*, a^*, b^*). Between colour parameters and TAC, the Spearman's correlation coefficient ρ was determined using Statistica 12 (TIBCO, USA) and regression function with coefficient of determination R^2 were determined using Microsoft Excel.

3. Results

The highest acid content was recorded in the fruit of the varieties 'Benedicte' (1.32% malic acid), 'Helene' (0.91% malic acid), and 'Royal Majestic' (0.85% malic acid). The varieties with the lowest acid content were 'UFO 3' (0.25% malic acid), 'Fidelia' (0.26% malic acid) and 'Royal Glory' (0.26% malic acid, Figure 1). The average value of the test set

was 0.59% malic acid. The differences between the varieties were confirmed as statistically highly significant (Table 2).

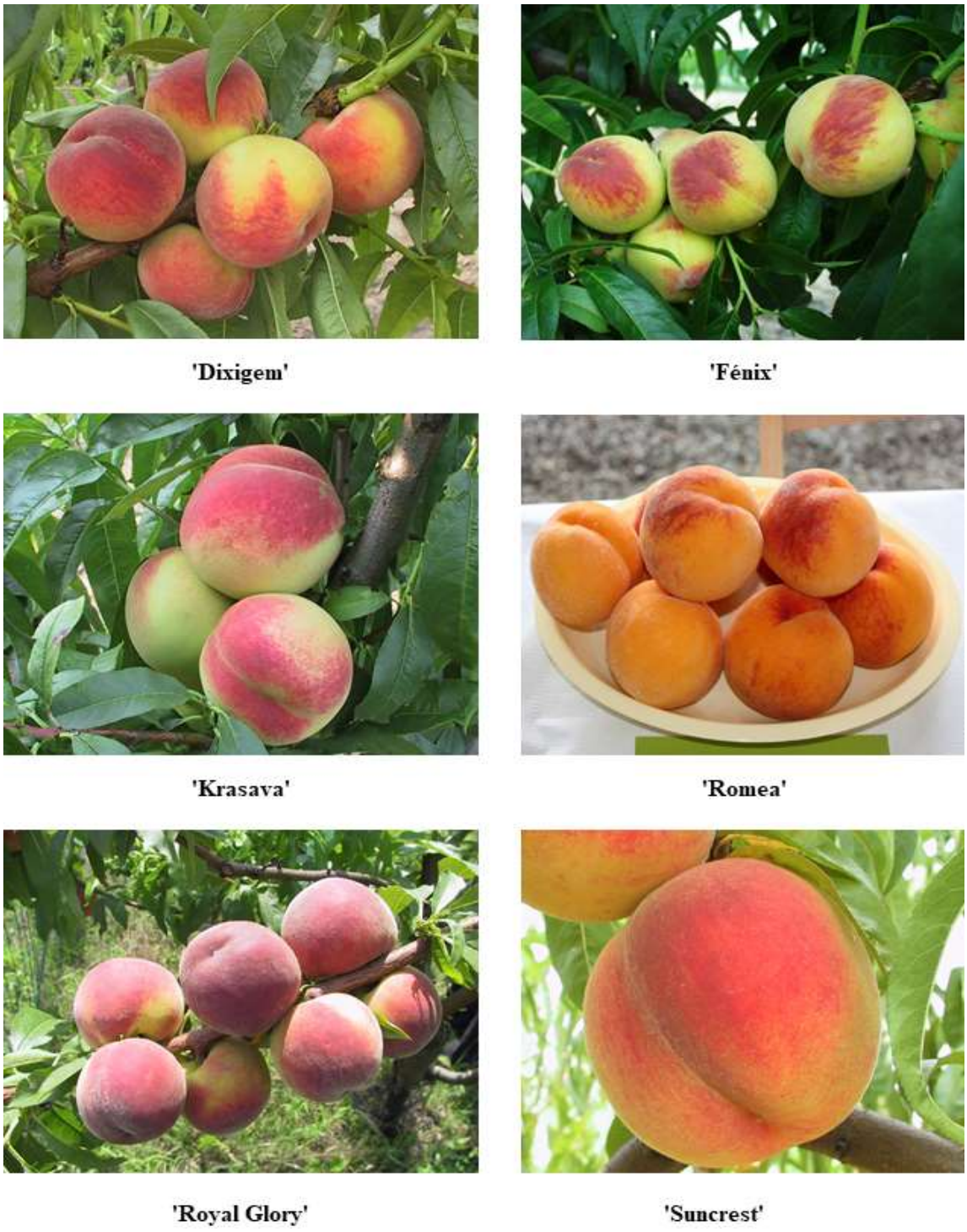

Figure 1. The photos of some cultivars obtained in this study.

Table 2. The total content of titratable acids in peach cultivars. The data are displayed as the mean ± standard deviation of three replications; a–p refer to the grouping based on the Tukey HSD test.

Cultivars	Titratable Acidity [%]	Cultivars	Titratable Acidity [%]
Admiral de Wey	$0.44 \pm 0.01^{b,c}$	Iris Rosso	$0.676 \pm 0.009^{j,k,l,m}$
Alexandra	$0.452 \pm 0.004^{b,c}$	Krasava	0.84 ± 0.02^{n}
Anita	$0.44 \pm 0.01^{b,c}$	Lakomyj	$0.591 \pm 0.007^{f,g,h}$
Aurelia	$0.643 \pm 0.004^{i,j}$	Narjadnyj Nikitskij	0.513 ± 0.002^{d}
Avalon Pride	$0.61 \pm 0.01^{g,h,i}$	Nerine	$0.450 \pm 0.002^{b,c}$
Benedicte	1.32 ± 0.04^{p}	Otličnik	$0.533 \pm 0.002^{d,e,f}$
Candor	$0.58 \pm 0.01^{f,g}$	Queen Lady	$0.636 \pm 0.004^{h,i,j}$
Carolina Belle	$0.691 \pm 0.006^{k,l,m}$	Red Robin	0.72 ± 0.01^{m}
Dixigem	$0.573 \pm 0.005^{e,f,g}$	Redhaven	$0.53 \pm 0.05^{d,e}$
Dostojnyj	0.415 ± 0.005^{b}	Romea	$0.562 \pm 0.009^{e,f,g}$
Early Glo	0.463 ± 0.006^{c}	Royal Glory	0.264 ± 0.006^{a}
Early Redhaven	$0.428 \pm 0.006^{b,c}$	Royal Majestic	0.850 ± 0.003^{n}
Favorita Morettini	$0.645 \pm 0.006^{i,j,k}$	Sonet	$0.564 \pm 0.005^{e,f,g}$
Fénix	$0.655 \pm 0.001^{j,k}$	Strelec	$0.712 \pm 0.006^{l,m}$
Fidelia	0.26 ± 0.01^{a}	Suncrest	$0.55 \pm 0.03^{d,e,f}$
Harvester	$0.712 \pm 0.001^{l,m}$	Sunshine	$0.668 \pm 0.007^{j,k,l}$
Helene	0.910 ± 0.008^{o}	UFO 3	0.25 ± 0.02^{a}

Significantly, the highest representation of total phenolic compounds was found in fruits of the variety 'Carolina Belle' (577.72 mg GAE.100 g^{-1} FW), then in the variety 'Krasava' (334.02 mg GAE.100 g^{-1} FW, Figure 1), 'Dixigem' (285.24 mg GAE.100 g^{-1} FW, Figure 1), and in the variety 'Benedicte' (238.09 mg GAE.100 g^{-1} FW). On the other hand, the lowest values of phenolic compounds content were observed in fruits of 'Favorita Morettini' (9.43 mg GAE.100 g^{-1} FW), 'Early Redhaven' (12.90 mg GAE.100 g^{-1} FW), and 'Strelec' (17.39 mg GAE.100 g^{-1} FW). In the studied set of cultivars, the total phenolic content in fruits ranged from 9.43 to 577 mg GAE.100 g^{-1} FW. The differences between the values were highly statistically significant (Table 3).

Table 3. Total phenolic content in peach cultivars. The data are displayed as the mean ± standard deviation of three replications; a–w refer to the grouping based on the Tukey HSD test.

Cultivars	Total Phenolic Content [mg GAE.100 g^{-1}]	Cultivars	Total Phenolic Content [mg GAE.100 g^{-1}]
Admiral de Wey	104.4 ± 0.4^{m}	Iris Rosso	103.4 ± 0.9^{m}
Alexandra	$19 \pm 1^{c,d}$	Krasava	334 ± 2^{v}
Anita	44.6 ± 0.4^{f}	Lakomyj	$18.4 \pm 0.4^{b,c}$
Aurelia	139.3 ± 0.7^{o}	Narjadnyj Nikitskij	66.7 ± 0.6^{h}
Avalon Pride	162.2 ± 0.8^{q}	Nerine	115 ± 2^{n}
Benedicte	238 ± 1^{t}	Otličnik	73 ± 2^{i}
Candor	54.8 ± 0.3^{g}	Queen Lady	151.2 ± 0.7^{p}
Carolina Belle	577 ± 2^{w}	Red Robin	65.6 ± 0.4^{h}
Dixigem	285.2 ± 0.4^{u}	Redhaven	193 ± 7^{r}
Dostojnyj	110.5 ± 0.3^{n}	Romea	72.8 ± 0.3^{i}
Early Glo	47.0 ± 0.2^{f}	Royal Glory	$78 \pm 4^{i,j}$
Early Redhaven	$12.9 \pm 0.3^{a,b}$	Royal Majestic	95 ± 3^{l}
Favorita Morettini	9.4 ± 0.3^{a}	Sonet	34.0 ± 0.4^{e}
Fénix	80 ± 1^{j}	Strelec	$17.39 \pm 0.04^{b,c}$
Fidelia	86.3 ± 0.9^{k}	Suncrest	197 ± 2^{r}
Harvester	203.0 ± 0.6^{s}	Sunshine	195.0 ± 0.6^{r}
Helene	152.0 ± 0.5^{p}	UFO 3	25 ± 2^{d}

The highest concentration of flavonoids was measured in the fruits of 'Carolina Belle' (95.1 mg CAE.100 g^{-1} FW), 'Benedicte' (53.2 mg CAE.100 g^{-1} FW), and 'Admiral de Wey' (50.8 mg CAE.100 g^{-1} FW). The lowest values were observed in 'UFO 3', 'Favorita Morettini', 'Alexandra' and 'Candor' (1.12; 3.37; 4.09 and 5.16 mg CAE.100 g^{-1} FW). The average flavonoid value in the test set was 22.3 mg CAE.100 g^{-1} FW. The differences between the varieties were confirmed as statistically highly significant (Table 4).

Table 4. Total flavonoid content in peach cultivars. The data are displayed as the mean ± standard deviation of three replications; a–v refer to the grouping based on the Tukey HSD test.

Cultivars	Flavonoids [mg CAE.100 g^{-1}]	Cultivars	Flavonoids [mg CAE.100 g^{-1}]
Admiral de Wey	50.8 ± 0.3^{t}	Iris Rosso	$12 \pm 1^{h,i}$
Alexandra	$4.1 \pm 0.5^{b,c}$	Krasava	45.1 ± 0.5^{s}
Anita	27.7 ± 0.2^{n}	Lakomyj	$10.6 \pm 0.1^{g,h}$
Aurelia	18.0 ± 0.2^{k}	Narjadnyj Nikitskij	31.8 ± 0.1^{p}
Avalon Pride	24.2 ± 0.4^{m}	Nerine	15.0 ± 0.1^{j}
Benedicte	53.2 ± 0.5^{u}	Otličnik	$9.60 \pm 0.09^{f,g}$
Candor	5.16 ± 0.06^{c}	Queen Lady	20.1 ± 0.1^{l}
Carolina Belle	95.1 ± 0.8^{v}	Red Robin	34.1 ± 0.2^{q}
Dixigem	35.6 ± 0.2^{r}	Redhaven	24.5 ± 0.2^{m}
Dostojnyj	12.7 ± 0.1^{i}	Romea	$8.2 \pm 0.1^{d,e}$
Early Glo	27.4 ± 0.8^{n}	Royal Glory	$9.5 \pm 0.7^{e,f,g}$
Early Redhaven	$8.68 \pm 0.09^{d,e,f}$	Royal Majestic	10.0 ± 0.7^{g}
Favorita Morettini	3.4 ± 0.3^{b}	Sonet	14.8 ± 0.2^{j}
Fénix	7.55 ± 0.08^{d}	Strelec	$11.8 \pm 0.2^{h,i}$
Fidelia	10.0 ± 0.3^{g}	Suncrest	46.1 ± 0.3^{s}
Harvester	23.3 ± 0.1^{m}	Sunshine	30.20 ± 0.09^{o}
Helene	18.4 ± 0.4^{k}	UFO 3	1.12 ± 0.02^{a}

Using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method, values of antioxidant activity in peach fruits ranging from 136 to 462 mg TE.100 g^{-1} FW were determined. Specifically, the cultivar 'Carolina Belle' (249.08 mg TE.100 g^{-1} FW) had the highest value. All other varieties analysed showed relatively high values. The results varied within a few units. High values were also found in the fruit of the variety 'Admiral de Wey' (280.46 mg TE.100 g^{-1} FW) and in the variety 'Dixigem' (255.61 mg TE.100 g^{-1} FW). The Czech variety 'Krasava' also had high antioxidant capacity (250.07 mg TE.100 g^{-1} FW). The lowest total antioxidant capacity was measured in the fruits of 'Favorita Morettini' (136.15 mg TE.100 g^{-1} FW) and 'Candor' (150.72 mg TE.100 g^{-1} FW). The differences in the values were highly statistically significant (Table 5).

Table 5. Antioxidant activity in peach cultivars. The data are displayed as the mean ± standard deviation of three replications; a–z refer to the grouping based on Tukey HSD test.

Cultivars	Antioxidant Activity [mg.100 g^{-1}]	Cultivars	Antioxidant Activity [mg.100 g^{-1}]
Admiral de Wey	280.5 ± 0.2^{y}	Iris Rosso	184.59 ± 0.09^{k}
Alexandra	184.09 ± 0.02^{k}	Krasava	250.1 ± 0.3^{w}
Anita	230.9 ± 0.2^{u}	Lakomyj	178.20 ± 0.07^{j}
Aurelia	203.44 ± 0.09^{p}	Narjadnyj Nikitskij	211.48 ± 0.09^{s}
Avalon Pride	184.54 ± 0.08^{k}	Nerine	204.4 ± 0.1^{q}
Benedicte	200.52 ± 0.08^{o}	Otličnik	188.07 ± 0.04^{l}
Candor	150.72 ± 0.06^{b}	Queen Lady	210.7 ± 0.1^{s}

Table 5. *Cont.*

Cultivars	Antioxidant Activity [mg.100 g^{-1}]	Cultivars	Antioxidant Activity [mg.100 g^{-1}]
Carolina Belle	462.41 ± 0.84 ^{z}	Red Robin	206.9 ± 0.1 ^{r}
Dixigem	256 ± 1 ^{x}	Redhaven	233.1 ± 0.2 ^{v}
Dostojnyj	175.11 ± 0.05 ^{h}	Romea	169.16 ± 0.06 ^{e}
Early Glo	220.1 ± 0.1 ^{t}	Royal Glory	165.0 ± 0.3 ^{c}
Early Redhaven	164.53 ± 0.06 ^{c}	Royal Majestic	199.84 ± 0.05 ^{o}
Favorita Morettini	136 ± 0 ^{a}	Sonet	176.8 ± 0.1 ^{i}
Fénix	166.76 ± 0.03 ^{d}	Strelec	195.18 ± 0.05 ^{n}
Fidelia	191.05 ± 0.07 ^{m}	Suncrest	231.07 ± 0.06 ^{u}
Harvester	203.9 ± 0.1 ^{p,q}	Sunshine	233.9 ± 0.2 ^{v}
Helene	173.5 ± 0.1 ^{g}	UFO 3	172.01 ± 0.05 ^{f}

The average carotenoids content in the fruits of the studied varieties reached 1.67g.100 g^{-1} DW. The varieties with the highest carotenoids (4.77 mg.100 g^{-1} DW) include fruits of the variety 'Romea' (3.50 mg.100 g^{-1} DW, Figure 1), followed by fruits of the variety 'Royal Majestic' (3.14 mg.100 g^{-1} DW), 'Favorita Morettini' (3.12 mg.100 g^{-1} DW), and 'Early Redhaven' (3.12 mg.100 g^{-1} DW). On the other hand, the lowest total carotenoids content was determined in the fruits of 'Krasava', 'Fidelia', and 'Anita' (0.05; 0.24 and 0.24 mg.100 g^{-1} DW). Total carotenoids content was not detected in the cultivars 'Benedicte' and 'Royal Glory'. The differences between the varieties were confirmed as statistically highly significant (Table 6).

Table 6. Total carotenoids in peach cultivars. The data are displayed as the mean ± standard deviation of three replications; a–j refer to the grouping based on the Tukey HSD test.

Cultivars	Carotenoids [mg.100 g^{-1}]	Cultivars	Carotenoids [mg.100 g^{-1}]
Admiral de Wey	2.20 ± 0.04 ^{d,e,f,g}	Iris Rosso	0.40 ± 0.01 ^{a,b}
Alexandra	0.45 ± 0.04 ^{a,b}	Krasava	0.05 ± 0.59 ^{a}
Anita	0.24 ± 0.02 ^{a,b}	Lakomyj	2.13 ± 0.02 ^{d,e,f}
Aurelia	1.1 ± 0.2 ^{c}	Narjadnyj Nikitskij	1.8 ± 0.6 ^{d}
Avalon Pride	2.0 ± 0.1 ^{d,e}	Nerine	1.88 ± 0.06 ^{d}
Benedicte	*	Otličnik	0.56 ± 0.01 ^{b}
Candor	2.46 ± 0.03 ^{e,f,g}	Queen Lady	2.24 ± 0.03 ^{d,e,f,g}
Carolina Belle	0.36 ± 0.02 ^{a,b}	Red Robin	0.67 ± 0.03 ^{b,c}
Dixigem	2.47 ± 0.04 ^{f,g}	Redhaven	2.27 ± 0.05 ^{d,e,f,g}
Dostojnyj	1.88 ± 0.04 ^{d}	Romea	4.8 ± 0.2 ^{j}
Early Glo	2.0 ± 0.01 ^{d,e,f}	Royal Glory	*
Early Redhaven	3.12 ± 0.01 ^{h,i}	Royal Majestic	3.51 ± 0.05 ^{i}
Favorita Morettini	3.14 ± 0.06 ^{i}	Sonet	2.26 ± 0.05 ^{d,e,f,g}
Fénix	3.03 ± 0.04 ^{h,i}	Strelec	1.904 ± 0.009 ^{d}
Fidelia	0.24 ± 0.06 ^{a,b}	Suncrest	2.300 ± 0.003 ^{a,b}
Harvester	2.64 ± 0.04 ^{g,h}	Sunshine	2.12 ± 0.02 ^{d,e,f}
Helene	0.31 ± 0.03 ^{a,b}	UFO 3	0.30 ± 0.03 ^{a,b}

* Not measured.

High levels of anthocyanins were measured in the fruits of 'Helene' (3.74 mg.100 g^{-1} FW), 'Royal Majestic' (2.64 mg.100 g^{-1} FW), and 'Favorita Morettini' (2.13 mg.100 g^{-1} FW). On the other hand, low values were recorded in fruits of 'Early Redhaven', 'UFO 3', 'Dostojnyj', 'Strelec' and 'Admiral de Wey' (0.05; 0.05 0.14; 0.18 mg.100 g^{-1} FW). The average value of total anthocyanins of the tested set of varieties reached 0.70 mg.100 g^{-1} FW. The differences between the varieties were confirmed as statistically highly significant (Table 7).

Table 7. Total anthocyanin content (TAC) in peach cultivars. The data are displayed as the mean ± standard deviation of three replications; a–p refer to the grouping based on the Tukey HSD test.

Cultivars	Total Anthocyanin Content [mg.100 g^{-1}]	Cultivars	Total Anthocyanin Content [mg.100 g^{-1}]
Admiral de Wey	$0.2 \pm 0.4^{a,b,c,d,e}$	Iris Rosso	$1.13 \pm 0.08^{j,k,l}$
Alexandra	$1.4 \pm 0.3^{l,m}$	Krasava	*
Anita	1.65 ± 0.06^{m}	Lakomyj	*
Aurelia	$0.63 \pm 0.06^{f,g,h,i}$	Narjadnyj Nikitskij	$0.5 \pm 0.1^{c,d,e,f,g,h}$
Avalon Pride	$1.2 \pm 0.2^{k,l,m}$	Nerine	$0.47 \pm 0.06^{c,d,e,f,g,h}$
Benedicte	*	Otličnik	*
Candor	$0.26 \pm 0.07^{a,b,c,d,e,f}$	Queen Lady	$0.58 \pm 0.06^{e,f,g,h,i}$
Carolina Belle	$0.95 \pm 0.03^{i,j,k}$	Red Robin	$0.56 \pm 0.04^{d,e,f,g,h,i}$
Dixigem	$0.5 \pm 0.1^{c,d,e,f,g,h}$	Redhaven	*
Dostojnyj	$0.14 \pm 0.04^{a,b,c}$	Romea	*
Early Glo	$0.9 \pm 0.3^{h,i,j,k}$	Royal Glory	$1.3 \pm 0.2^{k,l,m}$
Early Redhaven	$0.05 \pm 0.03^{a,b}$	Royal Majestic	2.6 ± 0.1^{o}
Favorita Morettini	2.13 ± 0.08^{n}	Sonet	$0.815 \pm 0.003^{g,h,i,j}$
Fénix	$0.37 \pm 0.03^{a,b,c,d,e,f}$	Strelec	$0.17 \pm 0.03^{a,b,c,d}$
Fidelia	$0.55 \pm 0.07^{d,e,f,g,h,i}$	Suncrest	$0.4 \pm 0.1^{b,c,d,e,f,g}$
Harvester	$0.2 \pm 0.1^{a,b,c,d,e,f}$	Sunshine	$0.38 \pm 0.05^{a,b,c,d,e,f}$
Helene	3.7 ± 0.2^{p}	UFO 3	$0.05 \pm 0.06^{a,b}$

* Not measured.

In the set of varieties studied, the total soluble solids content of the fruit ranged from 8.3 to 14.7 °Rf. The varieties with the highest content were 'Royal Majestic' (14.7 °Rf), followed by 'Helene' (13.8 °Rf) and 'Nerine' (13.7 °Rf). The lowest values of the evaluated set of varieties were measured for the fruits of the 'Fénix' variety (8.3 °Rf, Figure 1), 'Krasava' and 'Romea', which had the same soluble solids value for both varieties (9.2 °Rf). The differences in the values found were highly statistically significant (Table 8).

Table 8. Soluble solid content (SSC) in peach cultivars. The data are displayed as the mean ± standard deviation of three replications; a–k refer to the grouping based on Tukey HSD test.

Cultivars	Soluble Solid Content [°Rf]	Cultivars	Soluble Solid Content [°Rf]
Admiral de Wey	$10.7 \pm 0.6^{b,c,d}$	Iris Rosso	$12.5 \pm 0.5^{d,e,f,g,h,i}$
Alexandra	$10.2 \pm 0.3^{a,b}$	Krasava	$12.2 \pm 0.3^{c,d,e,f,g,h,i}$
Anita	$11.8 \pm 0.8^{b,c,d,e,f,g,h}$	Lakomyj	$12.3 \pm 0.3^{d,e,f,g,h,i}$
Aurelia	$12.2 \pm 0.3^{c,d,e,f,g,h,i}$	Narjadnyj Nikitskij	$13.5 \pm 0.5^{g,h,i,j}$
Avalon Pride	$11.30 \pm 1.04^{b,c,d,e,f}$	Nerine	$13.7 \pm 0.8^{h,i,j}$
Benedicte	15.7 ± 0.3^{k}	Otličnik	$12.0 \pm 0.5^{b,c,d,e,f,g,h,i}$
Candor	$12.3 \pm 0.3^{d,e,f,g,h,i}$	Queen Lady	$11.0 \pm 0.9^{b,c,d,e}$
Carolina Belle	$11.8 \pm 0.3^{b,c,d,e,f,g,h}$	Red Robin	$10.8 \pm 0.8^{b,c,d}$
Dixigem	$11.8 \pm 0.3^{b,c,d,e,f,g,h}$	Redhaven	$13 \pm 1^{e,f,g,h,i,j}$
Dostojnyj	$13.2 \pm 0.3^{f,g,h,i,j}$	Romea	$11.8 \pm 0.8^{b,c,d,e,f,g,h}$
Early Glo	$10.3 \pm 0.3^{b,c}$	Royal Glory	$13.3 \pm 0.6^{g,h,i,j}$
Early Redhaven	$11.7 \pm 0.3^{b,c,d,e,f,g}$	Royal Majestic	$14.7 \pm 0.3^{j,k}$
Favorita Morettini	$11.8 \pm 0.8^{b,c,d,e,f,g,h}$	Sonet	$13.5 \pm 0.5^{g,h,i,j}$
Fénix	8.3 ± 0.5^{a}	Strelec	$12.8 \pm 0.3^{e,f,g,h,i,j}$
Fidelia	$12.1 \pm 0.5^{c,d,e,f,g,h,i}$	Suncrest	$13.8 \pm 0.8^{i,j,k}$
Harvester	$12.2 \pm 0.3^{c,d,e,f,g,h,i}$	Sunshine	$11.2 \pm 0.3^{b,c,d,e}$
Helene	$13.8 \pm 0.3^{i,j,k}$	UFO 3	$10.8 \pm 0.3^{b,c,d}$

The average sucrose, glucose, fructose, and sorbitol contents of the fruit were determined for each variety. The average sucrose content was 9.62 g.100 g^{-1} FW. The highest sucrose content was measured in the varieties 'Narjadnyj Nikitskiy' (16.57 g.100 g^{-1}) and

'Sonet' (16.44 g.100 g^{-1}). The lowest contents were observed in the cultivars 'Alexandra', 'Suncrest'(Figure 1), and 'Iris Rosso' (4.89, 4.69 and 4.66 g.100 g^{-1}, respectively). The glucose content ranged from 0.74 to 3.67 g.100 g^{-1}. The highest contents were determined in the varieties 'Sunshine' (3.67 g.100 g^{-1}) and 'Admiral de Wey' (3.50 g.100 g^{-1}). The lowest content was measured in the varieties 'UFO 3' (0.82 g.100 g^{-1}) and 'Nerine' (0.74 g.100 g^{-1}). The average value of glucose content was 1.94 g.100 g^{-1}. In the studied set of varieties, the total fructose content ranged from 0.48 to 2.39 g.100 g^{-1}, with an average value of 1.37 g.100 g^{-1}. The highest content was measured in the cultivars 'Sunshine' and 'Dixigem' (2.39 and 2.36 g.100 g^{-1}). The lowest fructose content was observed in the variety 'UFO 3' (0.48 g.100 g^{-1}). The average value of alcoholic sugar sorbitol in our study was 0.23 g.100 g^{-1}. The variety 'Benedicte' greatly exceeded all other varieties in sorbitol content, with its content being determined at 1.57 g.100 g^{-1}. Very low amounts were measured in the cultivars 'Lakomyj', 'Nerine', 'Iris Rosso', and 'Alexandra' (0.09; 0.09; 0.08 and 0.06 g.100 g^{-1}). The differences in the values found were highly statistically significant (Table 9).

Table 9. Sugars in peach cultivars. The data are displayed as the mean ± standard deviation of three replications; a–p refer to the grouping based on the Tukey HSD test.

Cultivars	Sucrose (g.100 g^{-1})	Glucose (mg.100 g^{-1})	Fructose (mg.100 g^{-1})	Sorbitol (g.100 g^{-1})
Admiral de Wey	$14.6 \pm 0.2^{m,n}$	$3.5 \pm 0.2^{j,k}$	$2.22 \pm 0.08^{j,k}$	$0.18 \pm 0.05^{d,e,f,g,h,i,j}$
Alexandra	$4.9 \pm 0.1^{a,b}$	$1.24 \pm 0.06^{a,b,c,d}$	$0.92 \pm 0.04^{b,c,d,e}$	0.055 ± 0.002^{a}
Anita	12.2 ± 0.6^{k}	$2.8 \pm 0.4^{g,h}$	$2.24 \pm 0.05^{j,k}$	$0.17 \pm 0.02^{c,d,e,f,g,h,i,j}$
Aurelia	$6.6 \pm 0.1^{c,d,e}$	$1.3 \pm 0.1^{a,b,c,d}$	$0.99 \pm 0.02^{b,c,d,e}$	$0.151 \pm 0.007^{b,c,d,e,f,g,h}$
Avalon Pride	$7.22 \pm 0.07^{c,d,e,f,g,h}$	$1.71 \pm 0.06^{d,e}$	$1.12 \pm 0.05^{b,c,d,e,f}$	$0.16 \pm 0.02^{b,c,d,e,f,g,h,i}$
Benedicte	$8.06 \pm 0.04^{f,g,h,i}$	$3.37 \pm 0.03^{i,j,k}$	$1.9 \pm 0.1^{i,j}$	1.57 ± 0.03^{o}
Candor	$7.0 \pm 0.3^{c,d,e,f,g}$	$1.22 \pm 0.03^{a,b,c,d}$	$1.0 \pm 0.1^{b,c,d,e}$	$0.12 \pm 0.02^{a,b,c,d,e}$
Carolina Belle	$8.09 \pm 0.06^{g,h,i}$	$2.288 \pm 0.007^{f,g}$	$1.4 \pm 0.2^{f,g,h}$	$0.28 \pm 0.02^{k,l,m}$
Dixigem	$15.3 \pm 0.3^{m,n,o,p}$	3.4 ± 0.1^{k}	2.36 ± 0.05^{k}	$0.29 \pm 0.02^{k,l,m}$
Dostojnyj	$16 \pm 1^{n,o,p}$	$2.7 \pm 0.7^{f,g,h}$	$1.85 \pm 0.09^{h,i,j}$	$0.17 \pm 0.07^{c,d,e,f,g,h,i,j}$
Early Glo	$6.80 \pm 0.08^{c,d,e,f}$	$1.31 \pm 0.07^{b,c,d}$	$1.03 \pm 0.04^{b,c,d,e}$	$0.114 \pm 0.002^{a,b,c,d,e}$
Early Redhaven	$13.09 \pm 0.05^{k,l}$	$2.393 \pm 0.006^{f,g}$	$1.7 \pm 0.1^{g,h,i}$	$0.13 \pm 0.01^{a,b,c,d,e,f}$
Favorita Morettini	$15.57 \pm 0.03^{n,o,p}$	$2.72 \pm 0.02^{f,g,h}$	$1.45 \pm 0.01^{f,g,h}$	$0.21 \pm 0.01^{f,g,h,i,j,k}$
Fénix	$6.11 \pm 0.09^{b,c}$	$1.20 \pm 0.02^{a,b,c,d}$	$0.80 \pm 0.01^{a,b}$	$0.128 \pm 0.002^{a,b,c,d,e,f}$
Fidelia	$7.86 \pm 0.05^{e,f,g,h,i}$	$1.38 \pm 0.03^{b,c,d}$	$1.32 \pm 0.05^{e,f,g}$	$0.28 \pm 0.01^{k,l,m}$
Harvester	$8.8 \pm 0.2^{i,j}$	$1.71 \pm 0.05^{d,e}$	$1.1 \pm 0.1^{b,c,d,e,f}$	$0.23 \pm 0.03^{h,i,j,k}$
Helene	$7.1 \pm 0.5^{c,d,e,f,g,h}$	$1.12 \pm 0.02^{a,b,c}$	$0.90 \pm 0.03^{b,c,d}$	$0.24 \pm 0.01^{i,j,k,l}$
Iris Rosso	4.7 ± 0.3^{a}	$1.4 \pm 0.4^{c,d}$	$1.0 \pm 0.1^{b,c,d,e}$	$0.077 \pm 0.003^{a,b}$
Krasava	$6.6 \pm 0.3^{c,d,e}$	$1.4 \pm 0.2^{c,d}$	$1.25 \pm 0.07^{c,d,e,f}$	$0.22 \pm 0.01^{g,h,i,j,k}$
Lakomyj	$7.03 \pm 0.03^{c,d,e,f,g,h}$	$1.26 \pm 0.04^{a,b,c,d}$	$0.9 \pm 0.2^{a,b,c}$	$0.092 \pm 0.004^{a,b,c,d}$
Narjadnyj Nikitskij	16.6 ± 0.3^{p}	$2.9 \pm 0.2^{g,h,i}$	$2.0 \pm 0.4^{i,j,k}$	$0.16 \pm 0.02^{b,c,d,e,f,g,h,i}$
Nerine	$7.3 \pm 0.3^{c,d,e,f,g,h}$	0.740 ± 0.005^{a}	$0.90 \pm 0.06^{b,c,d}$	$0.087 \pm 0.005^{a,b,c}$
Otličnik	$12.83 \pm 0.05^{k,l}$	$2.16 \pm 0.08^{e,f}$	$1.69 \pm 0.01^{g,h,i}$	$0.181 \pm 0.002^{e,f,g,h,i,j}$
Queen Lady	$14.1 \pm 0.5^{l,m}$	$3.1 \pm 0.3^{h,i,j,k}$	$2.0 \pm 0.2^{i,j,k}$	$0.33 \pm 0.09^{l,m}$
Red Robin	$7.621 \pm 0.004^{d,e,f,g,h,i}$	$1.47 \pm 0.03^{c,d}$	$0.9 \pm 0.1^{b,c,d,e}$	$0.2 \pm 0.0^{b,c,d,e,f,g,h}$
Redhaven	$8.73 \pm 0.03^{i,j}$	$1.56 \pm 0.04^{c,d}$	$1.11 \pm 0.04^{b,c,d,e,f}$	$0.138 \pm 0.001^{a,b,c,d,e,f,g}$
Romea	9.7 ± 0.2^{j}	$1.57 \pm 0.03^{c,d}$	$1.14 \pm 0.09^{b,c,d,e,f}$	$0.144 \pm 0.009^{b,c,d,e,f,g,h}$
Royal Glory	$7.39 \pm 0.08^{c,d,e,f,g,h}$	$1.462 \pm 0.003^{c,d}$	$1.2 \pm 0.1^{c,d,e,f}$	$0.21 \pm 0.03^{f,g,h,i,j,k}$
Royal Majestic	$8.3 \pm 0.7^{h,i}$	$1.3 \pm 0.1^{b,c,d}$	$1.1 \pm 0.3^{b,c,d,e,f}$	0.44 ± 0.05^{n}
Sonet	$16 \pm 1^{o,p}$	$3.1 \pm 0.4^{h,i,j}$	$2.0 \pm 0.2^{i,j,k}$	$0.25 \pm 0.02^{j,k,l}$
Strelec	$6.5 \pm 0.3^{c,d}$	$1.14 \pm 0.04^{a,b,c,d}$	$0.86 \pm 0.08^{a,b,c}$	$0.144 \pm 0.007^{b,c,d,e,f,g,h}$
Suncrest	4.7 ± 0.1^{a}	$1.50 \pm 0.05^{c,d}$	$1.30 \pm 0.03^{d,e,f,g}$	$0.124 \pm 0.002^{a,b,c,d,e,f}$
Sunshine	$15.3 \pm 0.1^{m,n,o}$	3.67 ± 0.03^{k}	2.4 ± 0.1^{k}	0.34 ± 0.02^{m}
UFO 3	$8.19 \pm 0.03^{g,h,i}$	$0.819 \pm 0.006^{a,b}$	0.475 ± 0.009^{a}	$0.21 \pm 0.03^{f,g,h,i,j,k}$

Colorimetric parameters L^*, a^*, b^* for the basic skin colour of the fruit were measured for all varieties. In the varieties 'Alexandra', 'Anita', 'Helene', 'Iris Rosso', 'Royal Glory'

and 'Royal Majestic', the skin was completely covered by the blush. The average values of L^*, a^*, b^* are summarised in Table 10. The highest values of L^* were found for the basic colour in the varieties 'Krasava', 'Aurelia', 'Sunshine' and for the cheek in the varieties 'Romea', 'Dostojnyj', 'Carolina Belle'. In our study the highest value of a^* were found for 'Nerine', 'Admiral de Wey', 'Avalon Pride', the lowest value were found for 'Krasava', 'Otličnik', 'Carolina Belle' and 'Queen Lady'. For chromatic parameter b^* the highest values were measured for 'Romea', 'Otličnik', 'Lakomyj' and the lowest values were found for 'Fidelia', 'UFO 3' and 'Red Robin'. Colour intensity is represented by the chromatic parameter C^*_{ab}, which was determined using the chromatic parameters a^* and b^*, and its highest values were found for the basic colour of 'Romea', 'Otličnik', 'Lakomyj' and for the cheek colour of 'Romea', 'Sunshine', 'Admiral de Wey'. From the measured values for base colour and cheek colour, the greatest colour difference ΔE^*_{ab} (Table 11) was found for the cultivars 'Otličnik', 'Lakomyj', 'Queen Lady'. These varieties had the richest cheeks when compared to the base colour. On the other hand, the lowest ΔE^*_{ab} were found for the varieties 'Red Robin', 'Romea', 'UFO 3', where the cheek almost merged with the base colour. Figure 2 captures the exact colour found in the L^*, a^*, b^* coordinates.

Table 10. The average values of individual chromatic parameters for peach skin ground colour and over colour of peach.

Ground Colour	***L****	***a****	***b****	***C****	***h****
Average	69.3	7.17	43.8	45.0	0.96
Deviation	3.83	7.12	8.04	7.67	1.01
Over colour	*L**	*a**	*b**	*C**	*h**
Average	36.5	29.8	17.0	34.5	0.51
Deviation	4.83	4.67	5.44	6.06	0.11

Table 11. Values of chromatic parameters for ground colour skin and over colour skin of the peach cultivars.

	Ground Colour					**Over Colour**					ΔE^*_{ab}
Cultivar	***L****	***a****	***b****	***C****	***h***	***L****	***a****	***b****	***C****	***h***	
Admiral de Wey	65.5	19.3	39.1	43.6	1.1	35.8	37.6	18.0	41.7	0.45	40.8
Alexandra	-	-	-	-	-	29.1	21.9	10.2	24.2	0.43	-
Anita	-	-	-	-	-	36.0	33.5	15.5	37.0	0.43	-
Aurelia	73.6	1.96	50.8	50.8	1.53	39.6	30.0	19.1	35.6	0.57	54.3
Avalon Pride	67.5	16.8	40.8	44.1	1.18	37.8	33.6	18.2	38.2	0.50	41.0
Benedicte	72.5	0.36	29.8	29.8	1.56	33.1	32.1	16.6	36.1	0.48	52.3
Candor	68.7	10.8	44.3	45.7	1.33	35.3	33.7	17.3	37.9	0.48	48.6
Carolina Belle	71.9	−2.44	32.3	32.4	−1.50	42.5	29.6	18.8	35.1	0.57	45.5
Dixigem	73.2	9.21	47.6	48.5	1.38	37.4	29.3	14.5	32.7	0.46	52.7
Dostojnyj	69.9	0.78	52.4	52.4	1.56	48.4	25.7	32.5	41.4	0.90	38.4
Early Glo	72.6	9.38	45.9	46.9	1.37	39.4	31.8	18.8	37.0	0.53	48.4
Early Redhaven	72.4	8.69	48.9	49.7	1.40	36.8	33.1	19.0	38.2	0.52	52.5
Favorita Morettini	64.1	10.3	43.6	44.8	1.34	39.0	25.3	13.4	28.6	0.49	42.1
Fénix	65.9	9.11	43.2	44.1	1.36	35.5	27.9	17.1	32.7	0.55	44.2
Fidelia	66.7	16.2	28.5	32.8	1.05	33.0	33.0	14.9	36.2	0.42	40.0
Harvester	69.2	7.98	48.0	48.6	1.41	36.0	30.0	15.7	33.9	0.48	51.3
Helene	-	-	-	-	-	30.8	28.5	12.3	31.0	0.41	-
Iris Rosso	-	-	-	-	-	33.2	16.0	7.01	17.5	0.41	-
Krasava	74.5	−6.95	33.8	34.5	−1.37	40.1	34.1	19.9	39.5	0.53	55.4
Lakomyj	73.1	0.71	52.7	52.7	1.56	37.7	35.3	20.6	40.9	0.53	58.9
Narjadnyj Nikitskij	62.3	13.1	43.1	45.0	1.28	35.0	29.7	16.9	34.2	0.51	41.4
Nerine	64.9	20.3	45.8	50.1	1.15	37.8	34.8	20.3	40.3	0.53	39.9
Otličnik	71.6	−6.38	53.5	53.9	−1.45	37.5	26.8	16.5	31.4	0.55	60.2
Queen Lady	69.9	−2.00	47.2	47.2	−1.53	34.3	29.3	16.0	33.4	0.50	56.8
Red Robin	59.8	11.4	29.2	31.3	1.20	36.2	30.1	16.2	34.2	0.49	32.7

Table 11. *Cont.*

Cultivar	Ground Colour					Over Colour					ΔE^*_{ab}
	*L**	*a**	*b**	*C**	*h*	*L**	*a**	*b**	*C**	*h*	
Redhaven	71.3	9.62	49.3	50.3	1.38	37.1	30.6	18.8	35.9	0.55	50.4
Romea	71.9	13.7	54.5	56.2	1.32	50.4	32.1	33.1	46.1	0.80	35.5
Royal Glory	-	-	-	-	-	25.6	30.0	10.0	31.6	0.32	-
Royal Majestic	-	-	-	-	-	27.0	20.3	7.17	21.6	0.34	-
Sonet	66.5	6.81	48.3	48.8	1.43	37.4	32.5	20.9	38.6	0.57	47.5
Strelec	69.5	4.39	47.8	48.0	1.48	34.1	28.3	14.3	31.7	0.47	54.3
Suncrest	70.9	5.23	50.2	50.5	1.47	35.2	25.3	13.6	28.7	0.49	54.0
Sunshine	73.7	4.27	48.4	48.6	1.48	39.0	36.4	21.8	42.4	0.54	54.3
UFO 3	65.7	8.29	28.8	29.9	1.29	36.3	23.8	12.1	26.7	0.47	37.2

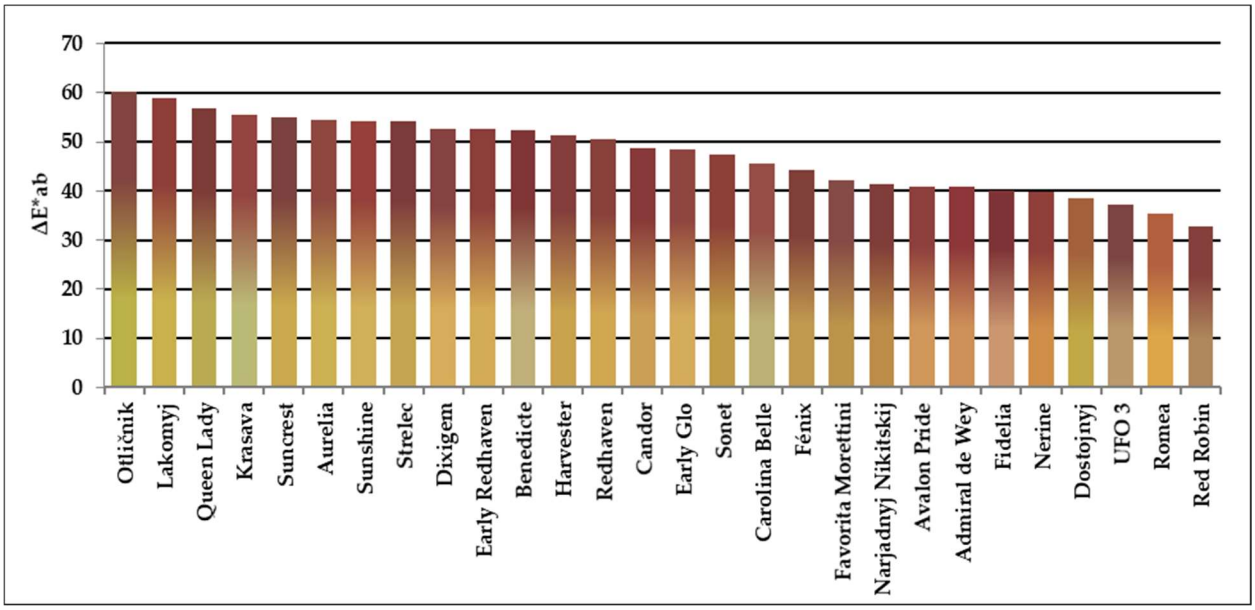

Figure 2. Values of ΔE^*_{ab} of individual peach cultivars. The ground colour is shown in the lower part of the column, and over colour is shown in the upper part according to the measured coordinates *L**, *a**, *b**.

4. Discussion

The acid content of fruit is a key quality parameter and is an important factor in determining the taste of the fruit. Titratable acidity indicates the concentration of organic acids present in the fruit. Peaches have a very low level of organic acids. The total titratable acid content found in our set of varieties ranged from 0.26 to 1.32% malic acid on fresh weight. These values are similar to the results found in many other publications. Scordino et al. (2012) [38] reported TA contents ranging from 0.52–0.86% malic acid in Sicilian yellow flesh peaches on fresh weight. Similar values were also found in the work by Tomás-Barberán et al. (2010) [39], where the contents ranged from 0.53–0.97% malic acid in yellow flesh peaches on fresh weight, and 0.15–0.34% malic acid in white flesh peaches on fresh weight. Gil et al. (2002) [40] investigated the differences between white- and yellow-fleshed peach cultivars grown in California. The average TAC content found in the white-fleshed varieties was 0.22%, and in the yellow-fleshed varieties it was 0.69%.

In a publication by Cantin et al. (2009) [41], the total phenolic content ranged from 12.7 to 71.3 mg GAE.100 g^{-1} FW, with an average of 36.4 mg GAE.100 g^{-1} FW. In our selected set of cultivars, the average content reached 122.4 mg GAE.100 g^{-1} FW. Marinova et al. (2005) [42] investigated the determination of all phenolic compounds in fruit grown in Bulgaria. The total phenolic content in peach fruits was 50.9 mg GAE.100 g^{-1} FW, and similar values were reached by figs—*Ficus carica* (59.0 mg GAE.100 g^{-1} FW). Another

publication by Saidani et al. (2017) [43] dealt with the determination of phenolic compounds separately in the peel and in the pulp. In the peel, contents ranging from 88.9 to 277 mg GAE.100 g^{-1} FW were determined, while in the pulp, contents ranging from 25.1 to 139 mg GAE.100 g^{-1} FW were determined. Previously, Zhao et al. (2015) [44] monitored the content of total phenolics in selected Chinese peach cultivars, ranging from 4.58 to 12.68 mg gallic acid equivalent (GAE).100 g^{-1} DW in the peel and from 0.82 to 6.52 mg GAE.100 g^{-1} DW in the pulp.

The obtained results of total flavonoids content in the tested set of varieties ranged from 1.1 to 95.1 mg CAE.100 g^{-1} FW. Di Vaio et al. (2015) [45] determined the total flavonoid content, and it ranged from 35.05-58.85 g CAE.kg^{-1} FW within the test set. In another publication by Cantin et al. (2009) [40], total flavonoid content ranged from 1.8 to 30.9 mg CAE.100 g^{-1} FW, with an average of 8.8 mg CAE.100 g^{-1} FW. Marinova et al. (2005) [42] investigated the determination of all phenolic compounds, as well as flavonoids in crops grown in Bulgaria. The total flavonoid content in peach fruits was 15.0 mg CAE.100 g^{-1} FW; similar values are seen in figs—*Ficus carica* (20.2 mg CAE.100 g^{-1} FW) and sweet cherries (19.6 mg CAE.100 g^{-1} FW). The highest representation of flavonoids was found in this work in blueberries (190.3 mg CAE.100 g^{-1} FW). Saidani et al. (2017) [43] determined the flavonoid content in the skin of peach fruits to be between 39 and 245 mg CAE.100 g^{-1} FW, and in the flesh between 8.18 and 112 mg CAE.100 g^{-1} FW.

Analyses of antioxidant components in products are fast becoming a recognized profile, primarily emphasizing antioxidant capacity as a quality index for many fruits and vegetables. The high phenolic content showed an increased antioxidant capacity in the studied varieties. The average value of antioxidant capacity determined by the DPPH (1-diphenyl-2,2-picrylhydrazyl) method showed values of 205.7 mg TE.100 g^{-1} FW. The authors of Di Vaio et al. (2015) [45] determined average antioxidant capacity values of 111.1 mg TE.100 g^{-1} FW in four peach cultivars. Saidani et al. (2017) [43], in a tested set of peach cultivars, determined the antioxidant capacity value in the skin of the fruit ranging from 133 to 401 mg TE.100 g^{-1} FW, and in the flesh ranging from 22.7 to 194 mg TE.100 g^{-1} FW. Zhao et al. (2015) [44] found antioxidant capacity contents in Chinese peach cultivars from 6.35 to 19.84 mg trolox equivalent antioxidant capacity (TE).100 g^{-1} DW in the peel and from 1.05 to 15.01 mg TE.100 g^{-1} DW in the pulp.

The content of carotenoids (especially β-carotene, zeaxanthin, lutein, neoxanthin) and anthocyanins increases with fruit maturity, largely due to the colouring of the fruit (formation of the cheek). The results obtained for total anthocyanin content in the tested set of cultivars ranged from 0.04 to 3.74 mg.100 g^{-1} FW. Cantín et al. (2009) [41] monitored the content of total anthocyanins in selected cultivars and found contents ranging between 0.1 and 26.7 mg of C3GE.kg^{-1} FW (0.1-26.7 mg of cyanidin-3-glucoside equiv. (C3GE) per kg of FW). In another publication by Saidani et al. (2017) [43], they discussed the determination of total anthocyanins separately in the peel and in the pulp. The average anthocyanin content in the peel was 5.53 mg C3GE.100 g^{-1} FW, while in the pulp the average content was 0.37 mg C3GE.100 g^{-1} FW. In other research on total anthocyanin content in apricot fruits, Rababah et al. (2011) [46] reported an average anthocyanin content of 2.54 mg.100 g^{-1} FW, whereas Contessa et al. (2013) [47] reported an anthocyanin content of 0.99 mg C3GE.100 g^{-1} FW.

The carotenoids content found in the set of cultivars ranged from 0.00 to 4.77 mg.100 g^{-1} DW. Gil et al. (2002) [40] observed differences in carotenoids content between white- and yellow-skinned peach cultivars. The average carotenoids content found in white-fleshed cultivars was 11.6 μg.100 g^{-1}, while in yellow-fleshed cultivars it was 131.6 μg.100 g^{-1}. Vizzotto et al. (2007) [48] also found higher carotenoids content in genotypes with yellow flesh (0.8 to 3.7 milligrams β-carotene per 100 g tissue) than in peaches with white flesh (0.0 to 0.1 milligrams β-carotene per 100 g tissue).

Soluble solid content (SSC) is an important characteristic of fruit, as it is closely related to consumer satisfaction and how well the fruit is liked. Zhao et al. (2015) [44] evaluated the soluble solid content of different Chinese peach cultivars; their findings ranged from 8.34

to 15.48 °Rf. These results are similar to ours, with values ranging from 8.30 to 14.70 °Rf in our set of cultivars. In another work, Gil et al. (2002) [40] investigated the differences between white- and yellow-fleshed peach cultivars grown in California. The average SSC content found in the white-fleshed varieties was 11.22 °Rf, while in the yellow-fleshed varieties it was 11.90 °Rf. For the Spanish varieties, Legua et al. (2011) [49] found SSC contents between 9.98 and 18.36 °Rf. Tavarini et al. (2008) [50] determined an average SSC value of 12.42 °Rf for Italian varieties.

In this study, sucrose, glucose, fructose, and sorbitol were determined as the basic sugars of peaches and there were differences found among the cultivars (Table 10). The mean values of sucrose, glucose, fructose, and sorbitol were 9.62 g.100 g^{-1}, 1.94 g.100 g^{-1}, 1.37 g.100 g^{-1} and 0.23 g.100 g^{-1}, respectively. These values are very similar to those determined by Forcada et al. (2014) [9]. The values found ranged from 3.5–9.8 g.100 g^{-1} sucrose, 0.4–1.5 g.100 g^{-1} glucose, 0.2–1.4 g.100 g^{-1} fructose, and 0.2–3.5 g.100 g^{-1} sorbitol. Nowicka et al. (2019) [51] investigated the sugar content of 20 peach cultivars. They determined sucrose content ranging from 3.4–5.4 g.100 g^{-1}, glucose 0.27–0.84 g.100 g^{-1}, fructose 0.41–1.03 g.100 g^{-1}, and sorbitol content ranging from 0.15–0.74 g.100 g^{-1}. Colaric et al. (2005) [13] determined sucrose levels between 46.14-66.92 g.kg^{-1} in some nectarine and peach cultivars. Cantin et al. (2009) [41] determined a similar sucrose content (47.10–64.00 g.kg^{-1}), and further investigated the determination of glucose (5.60–8.00 g.kg^{-1}) and fructose (6.9–10.3 g.kg^{-1}) in peach and nectarine fruits. Gecer (2020) [52] measured sucrose (5216.3–9122.4 mg.100 g^{-1}), glucose (721.7–1902.1 mg.100 g^{-1}), and fructose (325.7–1048.1 mg.100 g^{-1}) in some peach and nectarine cultivars. Robertson et al. (1990) [53] determined the average sorbitol content in yellow-fleshed cultivars, 0.46% and in white-fleshed cultivars, 0.37%. The colour of the fruit is an important parameter that influences the attractiveness of the fruit to consumers. A colorimetric analysis can also provide information on the degree of ripeness of the fruit. The colour of peaches using CIELAB was measured in studies before [54–57]. The value of a^* has been suggested as colour index maturity [54]. The study was associated with changes of a^* with chlorophyl degradation and an increase of anthocyanin content. Because of low values of anthocyanin in most cultivars of peaches, Ferrer et al. (2010) [55] found that changes of chromatic parameter b^* can be a good indicator of ripeness of peach fruit. These changes correlated to an increase of carotenoids pigments. In our study the correlation relationship between carotenoids and chromatic parameter b^* with a correlation coefficient R = 0.7951 and C^* with R = 0.8051 were found (Figure 3). The cultivars 'Otličnik' and 'Aurelia' were accomplished as outliers and they are not included in the correlations; this can be attributed to insufficient maturity of these two cultivars.

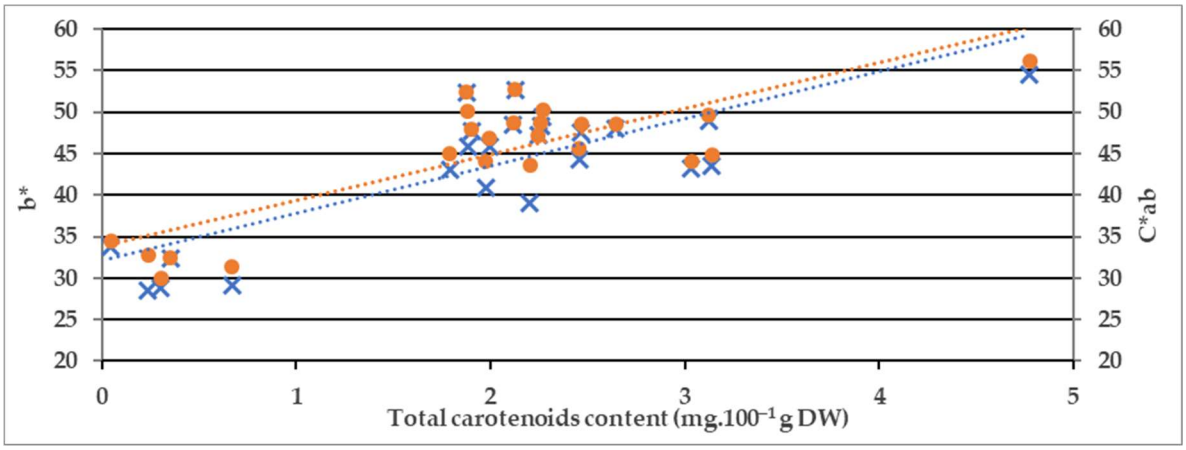

Figure 3. Relationship between b^*, C^*_{ab}, and total carotenoids content (TCC) in peach cultivars. Blue points represent correlation between b^* and TCC, orange points represent correlation between C^*_{ab} and TCC.

5. Conclusions

Peach fruits have an important specific nutritional status among stone fruits. This means that peaches can serve as a source of sugars, mainly sucrose, as well as phenolics, carotenoids, and anthocyanins, and can also provide valuable antioxidants. The Czech 'Krasava' variety was found to be a variety that has a very high content of titratable acids, phenolics, flavonoids, and antioxidant capacity. It can be said that this variety is very interesting from a biochemical point of view and offers a certain potential. Peach consumption represents one of the main fruit incomes during the summer months and is subject to seasonal demand, i.e., the short period of availability in the year. While pome fruits may form the bulk of typical dietary intake during longer periods of the year, peaches are only a seasonal concern.

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