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Bioactive compounds and antioxidant activity of fruit of temperate climate produced in subtropical regions

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Abstract

Temperate fruit species, originate from regions with cold winters and well-defined climatic seasons. These fruits are also produced in subtropical and tropical regions. The aim of this study was to determine the bioactive compounds and antioxidant activity of different fruit cultivars from fruit trees of temperate climate, such as peach, pear, quince, and fig, able to be produced in subtropic regions. Analyzes of antioxidant activity, total phenolics and ascorbic acid were carried out. In peaches, 'Biuti' had the highest phenolic content, and 'Bonão' stood out in relation of antioxidant activity (ABTS) and ascorbic acid. For quinces, 'Lageado' had higher phenolic content, 'Provence' and 'CTS' showed higher antioxidant activity (ABTS), and 'Alaranjado' stood out in relation of antioxidant activity (DPPH). 'Fuller', 'Smyrna' and 'Portugal' are the ones with the highest levels of ascorbic acid. In pears, 'Seleta' showed the highest phenolic content, antioxidant activity (DPPH) and ascorbic acid. 'Centenaria' presented the highest antioxidant activity (ABTS). In figs, 'Três num Prato', 'Lemon' and 'Brunswick' had the highest ascorbic acid content. 'Três num prato' and 'Roxo de Valinhos' showed the highest phenolic content and antioxidant activity consecutively. It was found that cultivars of these evaluated fruits showed great variability, even under similar conditions.

Keywords: temperate fruits; fruit quality; nutritional quality; subtropical regions.

Practical Aplication: The fruits evaluated showed great variability among themselves in relation to the characteristics.

1 Introduction

Temperate fruit species originate from regions with cold winters and well-defined climatic seasons, which are characterized by providing ideal temperatures for growth during spring and summer. The domestication of most temperate fruit trees began in Europe and Asia, but recently their cultivation has extended to non-traditional areas in tropical and subtropical regions around the world, with mild, dry winters and hot and rainy summers (Barbosa et al., 2010, Pio et al., 2019).

The cultivation of temperate fruit trees has increased substantially, specifically in regions with a mild winter, due to the adaptability of cultivars, and results show that the production in these areas present high productivity when compared to traditionally producing temperate regions (Pio et al., 2019). Peach, pear, quince and fig trees are species that have selected cultivars with high performance in subtropical regions (Bisi et al., 2016; Bisi et al., 2019; Coutinho et al., 2019; Tadeu et al., 2019)

The peach tree (*Prunus persica* (L.) Batsch) produces fruit with a very pleasant aroma and color that fits the list of economically important fruits, not only because of its exotic appearance, but also because it is an excellent source of bioactive compounds, (Cantín et al., 2009) like phenolic compounds (35.97 mg/100 g) and carotenoids (μg/100 g) (Legua et al., 2011). Peach is very much appreciated, mainly for having organoleptic characteristics, due to this the growing consumption of this fruit is evident (Instituto Brasileiro de Geografia e Estatística, 2020). Thus, there is an enormous market potential, since national production has not yet reached sufficient volume to meet domestic demand. For this reason, several measures have been taken, mainly in relation to peach production in subtropical and tropical regions (Souza et al., 2013). This fruit tree has an area of approximately 17.60 ha and reaches productivity of 12.5 ton/ha (Instituto Brasileiro de Geografia e Estatística, 2020).

Pear production in Brazil is insignificant, around 15.4 ton/ha and an area of 1.28 ha (Instituto Brasileiro de Geografia e Estatística, 2020). However, consumption is approximately eight times higher than the total produced, which makes the country one of the main importers of this fruit (Fachinello et al., 2011). Even though the pear is classified as temperate fruit, some cultivars are adapted to subtropical climate, such as hybrid cultivars between *Pyrus communis* x *Pyrus pyrifolia* (Nogueira et al., 2016). Due to the unique and attractive flavor and being rich in bioactive compounds (Saeeduddin et al., 2016), such as vitamin C (11.51 mg/dl), phenolic compounds (69.70 mg/100 g), anthocyanins (2.77 mg/100 g), among others (Gonçalves et al., 2019).

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Quince (*Cydonia oblonga* Mill.) is an important cultivation option, it is very rustic and has a probability of cultivation in practically all areas that provide a mild winter. They offer many benefits due to their functional properties (Szychowski et al., 2014), mainly related to the flavonoids (5.3-10.7 mg/100g), vitamin C (26.9-44.4 mg/100g), antioxidant (66.07%-81.11% - DPPH method) (Moradi et al., 2016). In Brazil there is an area of 70 ha, with a productivity of 10 ton/ha (Instituto Brasileiro de Geografia e Estatística, 2020).

The fig (*Ficus carica* L.) is originally from the Mediterranean region and is among the most cultivated species in Mediterranean countries (Food and Agriculture Organization, 2018). It is an excellent source of bioactive compounds, like flavonoids (7 mg of CE/100 g), proanthocyanidin (7.2 mg of CYD/100 g), anthocyanin (5.9 mf of C3G/100 g), and antioxidants (86.0 mg of TE/100 g – DPPH) (96.0 mg of TE/100 g – FRAP) (Kamiloglu & Capanoglu, 2015). Brazil is considered the largest producer of figs in the southern hemisphere, with a cultivated area of approximately 2.41 ha, which it allocates as one of the largest producers with productivity of 9.8 ton/ha (Instituto Brasileiro de Geografia e Estatística, 2020). The reason for the good productive results obtained in the country is linked to wide climatic adaptation (Pio et al., 2019). It is exploited for the production of ripe figs, for the fresh fruit or immature fruit market, in which case they are still harvested green for the production of jams (Curi et al., 2019a, b).

The climate can have a great influence on the nutritional characteristics of the fruits. In studies with temperate fruit produced in tropical and subtropical regions, (Souza et al., 2014), it was clarified that based on works in the literature that temperate fruits produced in subtropical regions are more nutritionally rich. Therefore, the objective of this study was to determine the bioactive compounds and the antioxidant activity of different cultivars of temperate fruit such as peach, pear, quince and fig, able to be produced in subtropic regions.

2 Material and methods

The fruits were collected at physiological maturity in the fruit sector orchard of the Federal University of Lavras, Lavras-MG (Brazil). After harvest, the fruits were selected for size, uniformity and maturation and were then cold stored in the Post-Harvest Laboratory. Lavras is located at 21°14’ South latitude and 45°00’ West longitude, at an average altitude of 918 meters. The climate is tropical climate of altitude, with dry winter and rainy summer (Alvares et al., 2013).

The cultivars used in this work were: peach: Aurora, Biuti, Bonão, Centenário, Diamante, Douradão, Libra, Régis, and Tropical; quince: Fuller, Smyruna, Portugal, Provence, Mendonza Inta-37, Alaranjado, Lageado, CTS 207, Dangers, and Bereczy; pear: Tenra, Centenária, Cascatence, Primorosa and Seleta; fig: Roxo de Valinhos, Mini Figo, Troiano, Três num Prato, Bêbara Branca, Lemon, Brunswick, and Pingo de Mel. These cultivars were chosen because they adapt to subtropical conditions (Bisi et al., 2016; Bisi et al., 2019; Coutinho et al., 2019; Tadeu et al., 2019).

2.1 Analyses

The analyses of fruits were performed in triplicate. To characterize the cultivars, analyses were performed on fresh fruits.

2.2 Total phenolics and antioxidant activity

The extracts for analysis of antioxidants and phenolics were prepared according to the method described by Larrauri et al. (1997) using methanol and acetone as solvents in the first and second extraction, respectively.

Total phenolic analysis was performed according to the Folin-Ciocalteu method with certain modifications (Waterhouse, 2002). The extracts (0.5 mL) were combined with 2.0 of distilled water, 0.25 mL of Folin-Ciocalteu reagent (10%) and 0.25 mL of saturated sodium carbonate solution. The tubes were placed in a 37 °C bath for a period of 30 min for colour enhancement. The absorbance was measured at 750 nm in a spectrophotometer (Ultrospec 2000, Pharmacia Bioteche, Cambridge, England). Aqueous gallic acid solutions were used to calibrate the equipment. The results were expressed as mg of gallic acid equivalents per 100 g of fresh weight (mg GAEs/ 100 g f.w.).

The antioxidant activity of the different cultivars was obtained by two methods: ABTS and DPPH. In the ABTS method, the procedure described in Re et al. (1999) was followed. Briefly, 5 mL of an aqueous ABTS solution (7 μM) was mixed with 88 μL of potassium persulfate 140 μM (final concentration: 2.45 mM) to yield the ABTS radical cation. After 16 hours in the dark, this reagent was diluted with ethanol to obtain an absorbance of 0.7 ± 0.05 units at 734 nm. Then, 30 μL of the sample was mixed with 3 mL of the ABTS radical, and the absorbance was measured at 743 mn in a spectrophotometer (Ultrosp Ultrospec 2000, Pharmacia Bioteche, Cambridge, England). Trolox was used for the calibration. The results are expressed as micromoles of Trolox equivalents (TEs) per gram of fresh weight (μM TEs/g f.w.).

The antioxidant activity was determined through the reduction of DPPH (2,2- diphenyl-1-picrylhydrazyl) (Sigma ChemicalCo., St.louiz, USA) by the antioxidant present in the sample; a method proposed by Brand-Williams et al. (1995) with a few modifications. Therefore, 50 μL of the extracts in methanol obtained in 3:2:1 were taken and 250 μL of methanol solution of DPPH (0.05 M) was added. Using a spectrophotometer, the absorbance decrease readings at 515 nm were performed at both the initial time and after 30 min. The results were expressed in sequestration percentage for peach, quince, and pear.

In fig, the DPPH free radical scavenging activity was measured by the method of Brand-Williams et al. (1995). In a dark environment, an aliquot (0.10 mL) of the samples was added to 3.9 mL of 0.06 mM DPPH solution. The mixture was vigorously stirred and incubated for 30 min at 37 °C. The absorbance of the samples was then determined at 515 nm. The results were expressed in EC_{50} g fresh weight per g DPPH (g f.w./g of DPPH).

2.3 Ascorbic acid

The ascorbic acid analysis was performed using the colorimetric method with 2,4-dinitrophenylhydrazine (2,4-DNPH), as described by Strohecker & Henning (1967). Samples were analysed at 520 nm absorbance against a blank in a spectrophotometer (Ultrospec 2000, Pharmacia Bioteche, Cambridge, England). The results were expressed as mg ascorbic acid per 100 g fresh weight (mg/100 g f.w.).

2.4 Statistical analysis

Univariate statistical analysis (ANOVA) and Tukey for comparing the means, test were used to check for significant differences among the samples at a significance level of 5% ($p \leq 0.05$). Principal Component Analysis (PCA) was applied as means of bioactive compounds and antioxidant activity for all fruit cultivars analyzed, in order to facilitate data visualization. The data from the mean test and the PCA were analyzed using the software SensoMaker v. 1.91 (UFLA, Lavras, MG, Brasil, 2017).

3 Results and discussion

Table 1 shows the phenolic compounds content, antioxidant activity and ascorbic acid content of the different peach cultivars. There was a significant difference among the peach cultivars for all the evaluated parameters ($p \leq 0.05$).

The Biuti cultivar had the highest phenolic content (91.14 mg GAEs/100 g f.w.) (Table 1 and Figure 1a). According to the classification proposed by Vasco et al. (2008) for the phenolic compound content, the fruits are divided into three categories: low phenol content (<100 mg GAEs/100 g), medium phenol content (100-500 mg GAEs/100 g) and high phenol content (> 500 mg GAEs/100 g). According to this classification all peach cultivars can be classified as having a low concentration of phenols.

Phenolic compounds have been extensively evaluated in fruits of temperate climate, such as apple (321-474 mg GAEs/100 g f.w.), pear (271-408 mg GAEs/100 g f.w.), kiwi fruit (274.4 mg GAEs/100 g f.w.), plum (471.4 mg GAEs/100 g f.w.) (Imeh & Khokhar, 2002); grape (117.1 mg GAEs/100 g f.w.), blackberry (mg GAEs/100 g f.w.) and strawberry (132.1 mg GAEs/100 g f.w.). As with other tropical fruits, such as mango (544.9 mg GAEs/100 g f.w.), açaí (136.8 mg GAEs/100 g f.w.), guava (83.0 mg GAEs/100 g f.w.), soursop (84.3 mg GAEs/100 g f.w.), passion fruit (20.0 mg GAEs/100 g f.w.) (Kuskoski et al., 2006) and coquinho-sour (78-166 mg GAEs / 100 g fw) (Faria et al., 2008). However, little is known about the content and composition of phenolic compounds in different cultivars. It is worth mentioning that when compared with plums, which are a fruit of the same family and genus as peaches, these results are inferior, proving the classification of low concentration.

The cultivar Bonão presented the highest antioxidant activity values (3.26 μM TEs/g f.w. - ABTS method) (Table 1 and Figure 1a) and lowest sequestration percentage by the DPPH method (82.43% sequestration) and had a higher highest content of ascorbic acid (40.75 mg/100 g f.w.). The fruit can also be classified into three categories according to the ascorbic acid content: low (<30 mg/100 g), medium (30-50 mg/100 g) and high (> 50 mg/100) of ascorbic acid (Ramful et al., 2011). According to this classification, the cultivars Centenário, Bonão, Libra and Tropical have medium content, while the others are classified as low. Santos et al. (2013), evaluating the ascorbic acid content of different peach cultivars (Aurora, Biuti, Diamante and Douradão), obtained a variation among cultivars from 17.57 to 23.28 mg/100 g, close to that found in our study for these cultivars.

It is worth mentioning that all peach cultivars showed higher vitamin C values, when compared to plums (also fruit of temperate climate) presenting levels in the range of 12.69 mg/100 g (Gonçalves et al., 2019).

Table 2 shows the phenolic compound and ascorbic acid content and antioxidant activity of the different quince cultivars. It can be verified that there was a significant difference among the quince cultivars for all the evaluated parameters ($p \leq 0.05$).

From the average values of the bioactive compounds and antioxidant activity (Table 2), it can be seen that the Lageado cultivar was characterized by the highest phenolic content (19.39 mg GAEs/100 g f.w.). According to the classification proposed by Vasco et al. (2008) for the phenolic compound content, all quince cultivars can be classified as having a low concentration of phenols.

As for the antioxidant activity, Provence (3.65 μM TEs/g f.w.) and CTS 207 (3.73 μM TEs/g f.w.) cultivars, showed the highest

Table 1. The total phenolics, antioxidant activity (DPPH and ABTS) and ascorbic acid in different peach cultivars.

Cultivars	Total phenolics	Antioxidant activity – ABTS	Antioxidant activity – DPPH	Ascorbic acid
Aurora	19.49^{e}	1.06^{c}	89.36^{c}	15.52^{f}
Biuti	91.14^{a}	2.37^{ab}	87.20^{d}	28.17^{bc}
Bonão	28.03^{cd}	3.26^{a}	82.43^{e}	40.75^{a}
Centenário	35.69^{b}	2.08^{b}	87.13^{d}	30.20^{bc}
Diamante	22.08^{de}	1.80^{bc}	91.00^{b}	22.26^{de}
Douradão	10.05^{f}	0.93^{c}	93.46^{a}	16.74^{ef}
Libra	17.87^{e}	2.33^{ab}	87.16^{d}	32.07^{b}
Regis	33.52^{bc}	2.40^{ab}	87.20^{d}	26.11^{cd}
Tropical	33.81^{bc}	2.20^{b}	87.33^{d}	37.96^{a}
CV(%)	6.68	16.27	0.41	7.21

Mean values with common letters in the same column indicate that there is no significant difference between samples ($p \leq 0.05$) by Tukey's mean test. Abbreviations: GAE: gallic acid equivalent. Total phenolics (mg GAEs/100 g f.w.); Antioxidant activity – ABTS (μM trolox/g f.w.); Antioxidant activity – DPPH (% of sequestration); Ascorbic acid (mg/100 g f.w.)

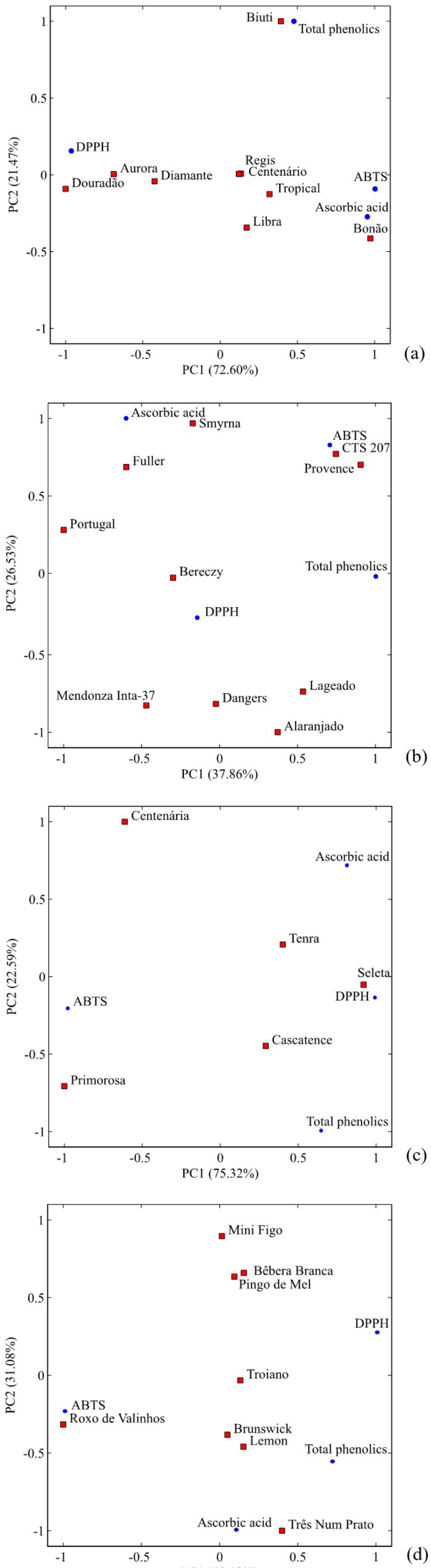

Figure 1. Principal Component Analysis (PCA) for total phenolics, antioxidant activity (DPPH and ABTS) and ascorbic acid in different peach (a), quince (b), pears (c), and fig (d) cultivars. Note: Red squares represent the cultivars and the blue circles represent the analyzes.

antioxidant activity by the ABTS method, according to Table 2 and Figure 1b. These ABTS values are very close to those found by Wojdyło et al. (2013) in quince cultivars. The highest antioxidant activity by the DPPH sequestration method was observed in Alaranjado cultivar (90.44% sequestration). In addition, according to Yıkmış et al. (2019), quinces contain bioactive compounds and are considered an important economic factor and nutritional source that assist in health.

The Fuller, Smyrna and Portugal cultivars are those whice presented the highest ascorbic acid levels (Table 2 and Figure 1b). According to Ramful et al. (2011) the three quince cultivars mentioned above are regarded as having high ascorbic acid content, with others classified as having medium or low ascorbic acid content.

Table 3 shows the content of phenolic compounds, ascorbic acid and antioxidant activity of the different pear cultivars. There was a significant difference among the pear cultivars for all the evaluated parameters ($p \leq 0.05$).

Regarding the bioactive compounds, the Seleta cultivar presented the highest phenolic content (57.68 mg GAEs/100 g f.w.). These results are in accordance with Kolniak-Ostek (2016), in which values from 1033.5 to 400.8 mg GAEs/100 g f.w. were observed in different pear cultivars. According to Chaves Neto et al. (2018) the amount of these compounds varies depending on the fruit species, edaphoclimatic conditions of the growing region, harvest maturity stage and processing and storage methods.

Vitamin C is an important natural antioxidant, as it absorbs free radicals and inhibits the chain of initiation or interrupts the chain of propagation of oxidative reactions promoted by radicals (Silva et al., 2010). The cultivar Seleta still stands out due to its higher ascorbic acid (3.59 mg/100 g f.w.), results similar to those found by Saeeduddin et al. (2016), in which the value was 3.56 mg/100 g f.w. The Centenaria cultivar showed higher antioxidant activity by the ABTS method (2.44 µM TEs/g f.w.) and Seleta cultivar showed higher antioxidant activity by the DPPH method (13.56% DPPH sequestration) (Table 3 and Figure 1c).

Table 4 shows the phenolic compound and ascorbic acid content and antioxidant activity of the different fig cultivars. It can be verified that there was a significant difference among the quince cultivars for all the evaluated parameters ($p \leq 0.05$).

The ascorbic acid content ranged from 31.72 (Bêbera Branca) to 58.94 mg/100 g f.w. (Brunswick), with the cultivars Três num Prato, Lemon and Brunswick exhibiting the highest values (57.21, 56.17, 58.94 mg/100 g f.w., respectively), with no significant difference among them (Table 3). According to the classification proposed by Ramful et al. (2011), the cultivars Lemon, Três num Prato and Brunswick are classified as having high ascorbic acid content, whereas the other fig cultivars are classified as having medium ascorbic acid content. In works by Silva et al. (2018), with fig tree Roxo de Valinhos in Oeste Potiguar, results of vitamin C were lower (9.01 mg/100 g f.w.), when compared with the present study. This shows that the region can also influence the ascorbic acid.

According to Table 4 acurill the cultivars differed significantly in total phenolic contents, with the cultivar Três num Prato

Table 2. The total phenolics, antioxidant activity (DPPH and ABTS) and ascorbic acid in different quince cultivars.

Cultivars	Total phenolics	Antioxidant activity – ABTS	Antioxidant activity – DPPH	Ascorbic acid
Fuller	8.53h	2.34bc	88.70ab	54.28a
Smyrna	12.58f	2.58b	87.56bcd	55.27a
Portugal	6.13i	1.65cd	89.10ab	53.88a
Provence	17.20b	3.65a	86.58cde	38.08bc
Mendonza Inta-37	6.45i	1.38d	86.35de	29.92de
Alaranjado	13.13e	2.44bc	90.44a	24.75e
Lageado	19.39a	1.60cd	88.43abc	34.18cd
CTS 207	15.07c	3.73a	86.47cde	38.33bc
Dangers	13.19d	1.27d	87.20bcd	33.15cd
Bereczy	11.91g	1.25d	85.10e	44.22b
CV(%)	1.47	0.79	13.81	6.51

Mean values with common letters in the same column indicate that there is no significant difference between samples ($p \leq 0.05$) by Tukey's mean test. Abbreviations: DPPH: 2-diphenyl-1-picryhydrazyl radical scavenging activity; GAE: gallic acid equivalent. Total phenolics (mg GAEs/100 g f.w.); Antioxidant activity – ABTS (μM trolox/g f.w); Antioxidant activity – DPPH (% of sequestration); Ascorbic acid (mg/100 g f.w.)

Table 3. The total phenolics, antioxidant activity (DPPH and ABTS) and ascorbic acid in different pears cultivars.

Cultivars	Total phenolics	Antioxidant activity – ABTS	Antioxidant activity – DPPH	Ascorbic acid
Tenra	43.93b	1.41c	10.89b	2.95b
Centenária	21.28c	2.44ab	3.78c	2.79b
Cascatence	52.79ab	1.65bc	10.96b	2.38c
Primorosa	44.73b	3.18a	2.53c	1.32d
Seleta	57.68a	1.25c	13.56a	3.59a
CV(%)	7.90	14.23	7.99	4.98

Mean values with common letters in the same column indicate that there is no significant difference between samples ($p \leq 0.05$) by Tukey's mean test. Abbreviations: DPPH: 2-diphenyl-1-picryhydrazyl radical scavenging activity; GAE: gallic acid equivalent. Total phenolics (mg GAEs/100 g f.w.); Antioxidant activity – DPPH (% de sequestration); Antioxidant activity – ABTS (μM de trolox/g of fresh fruit); Ascorbic acid (mg/100 g f.w.).

Table 4. Total phenolics, antioxidant activity (ABTS and DPPH) and ascorbic acid in different fig cultivars.

Cultivars	Total phenolics	Antioxidant activity – ABTS	Antioxidant activity – DPPH	Ascorbic acid
Roxo de Valinhos	45.86g	56.32a	1920.42d	46.22abc
Mini Figo	54.67f	27.48f	3663.73b	32.51c
Troiano	69.63c	27.59e	3665.21b	49.14ab
Três Num Prato	114.75a	28.77b	3655.58b	57.21a
Bêbera Branca	75.98b	28.45c	3760.99a	31.72c
Lemon	76.64b	27.96d	3564.41c	56.16a
Brunswick	60.94e	27.62e	3505.99c	58.94a
Pingo de Mel	65.16d	27.43f	3697.37ab	35.47bc
CV(%)	29.40	21.98	17.92	26.95

Mean values followed by the same letter in the same column indicate that there is no significant difference between samples ($p < 0.05$) according to Tukey's means test. Ascorbic acid (mg 100 g/f.w.); Total phenolics (mg GAEs 100/g f.w.); Antioxidant activity – DPPH (EC_{50} - g f.w/g of DPPH); Antioxidant activity – ABTS (μM TEs g/f.w.); β-carotene (% protection). Abbreviations: DPPH: 2-diphenyl-1-picrylhydrazyl radical scavenging activity; ABTS: 2,2′-azinobis-(3-ethylbenzothiazoline-6-sulfonate) and GAE: gallic acid equivalent).

(114.75 mg GAE/100 g f.w.) exhibiting the highest content. According to Vasco et al. (2008) all fig cultivars can be classified as exhibiting low phenolic content, except for Três num Prato, which exhibits medium phenolic content (114.75 mg GAEs 100/g f.w.).

Regarding antioxidant activity, a significant difference among the cultivars was also observed for the two methods (Table 4). The antioxidant activity according to the ABTS method was from 27.43 (Pingo de Mel) to 56.32 μM TEs/g f.w. (Roxo de Valinhos); by the DPPH method it ranged from

1920.42 (Roxo de Valinhos) to 3760.99 EC_{50} – g f.w./g DPPH (Bêbera Branca). Regarding antioxidant activity, the Roxo de Valinhos cultivar presented the highest activity by the ABTS (56.32 µM TEs/g f.w.) (Table 4 and Figure 1d) and DPPH (1920.42 EC_{50} - g f.w./g of DPPH) methods. According to Alves et al. (2019) the concentration of the antioxidant activity of fruits is influenced by species, variety, cultivar, cultivation places, among other factors.

Generally, the Brunswick, Três num Prato, and Lemon cultivars (58.94, 57.21, and 56.16 mg 100 g/f.w., respectively) presented the highest ascorbic acid content. According to Curi et al. (2019a), fig cultivars (*Ficus carica*) grown in subtropical regions produce fruits with different physicochemical and nutritional characteristics.

Figure 1 presents the Principal Component Analysis (PCA), with the samples and attributes evaluated in the spatial distribution, facilitating the visualization of the results for different peach, quince, pears, and fig cultivars evaluated.

Through Tables 1 and 2, and Figure 1 (a and b), it is possible to observe that the peach and quince cultivars differed in terms of antioxidant activity and the evaluated bioactive compounds. Figure 1 (c and d) also presents the Principal Component Analysis (PCA), with the samples and attributes evaluated in the spatial distribution, facilitating the visualization of the results for different pears and fig cultivars evaluated. Through Tables 2 and 3, and Figure 1 (c and d), it is possible to observe that the pears and fig cultivars differed in terms of antioxidant activity and the evaluated bioactive compounds.

In addition to the distribution of the samples that was verified by the evaluated characteristics, the relationship between the characteristics themselves was also analyzed, although this relationship is not the same among all the evaluated fruits.

In Figure 1a, in the case of peaches cultivars, ABTS is close to acorbic acid, this is justified because ascorbic acid is the vitamin that has a high antioxidant content, therefore in this fruit, the one that most contributes to antioxidant activity is ascorbic acid and secondary the total phenolics. The results of DPPH are the opposite, as this method expresses antioxidant activity in reverse. In Figure 1b, in quince cultivars, ABTS is located between ascorbic acid and total phenolics, and these compounds contributed to the antioxidant activity of these cultivars, however, there are other compounds in fruits that can contribute to antioxidant activity.

In Figure 1c, in pear cultivars, ascorbic acid and total phenolics are distant from ABTS, however there are other bioactive compounds that can contribute to the antioxidant activity of these pear cultivars, and in Figure 1d, in fig cultivars, ABTS is close to acorbic acid, being the bioactive compound that most contributed to antioxidant activity, followed by total phenolics.

5 Conclusions

In peaches, 'Biuti' had the highest phenolic content, and 'Bonão' stood out in relation of antioxidant activity (ABTS) and ascorbic acid. For quinces, 'Lageado' had higher phenolic content, 'Provence' and 'CTS' showed higher antioxidant (ABTS), and 'Alaranjado' stood out in relation of antioxidant (DPPH). 'Fuller', 'Smyrna' and 'Portugal' are the ones with the highest levels of ascorbic acid. In pears, 'Seleta' showed the highest phenolic content, antioxidant activity (DPPH) and ascorbic acid. 'Centenaria' presented the highest antioxidant activity (ABTS). In figs, 'Três num Prato', 'Lemon' and 'Brunswick' had the highest ascorbic acid content. 'Três num prato' and 'Roxo de Valinhos' showed the highest phenolic content and antioxidant activity consecutively.

In this study it was found that the peach, quince, pear and fig cultivars evaluated showed wide variability among themselves in relation to the bioactive compounds and antioxidant activity, although they are varieties of the same fruit and grown in the same place under similar conditions. The results found contribute to genetic improvement work in the selection of cultivars for a given macroclimate, since the selection is always based on the phenophases and the productive characteristics of the cultivars.

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