


Antioxidant potential and physicochemical characterization of yellow, purple and orange passion fruit

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Revised: 13 October 2017 / Accepted: 23 April 2018 / Published online: 3 May 2018
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Abstract This study evaluated yellow, purple and orange passion fruit in pulp, peel, and seed for physicochemical characteristics, proximate composition, minerals, antioxidant capacity (DPPH and ABTS), phenolic compounds, carotenoids, flavonoids and anthocyanins. Yellow passion fruit presented higher concentrations of pectin (37.37 g/100 g) in peels; high cryptoxanthin, α -carotene, β -carotene, provitamin A, quercetin, and kaempferol in pulps and higher values of ash and total dietary fiber in seeds. The purple fruit was highlighted by a great value of anthocyanins (103.68 mg/100 g) in peels and seeds and the orange fruit reported higher levels of ash, carotenoids (mainly β -carotene with 21,274 μ g/100 g), kaempferol in peels, higher contents of total soluble solids, lycopene (4405 μ g/100 g), lutein, zeaxanthin, total carotenoids in

pulps and phenolics in general. This research revealed that the pulp of passion fruit and his residues have a significant content of bioactive compounds, differing in type according the species analyzed.

Keywords Pectin · Total dietary fiber · Lycopene · Quercetin · Anthocyanin

Introduction

Passion fruit is a popular name given to several species of the genus *Passiflora* that belongs to *Passifloraceae* family, which there are more than 500 species distributed in regions of tropical and subtropical climate of the world. The variety *Passiflora edulis* Sims fo. *flavicarpa*, known as sour or passion fruit, is the most produced and marketed, and represents 95% of its fruit farm. Its cultivation is primarily focusing on the juice and pulp industry, especially due to its higher acidity and pulp yield. However, the species *Passiflora edulis* Sims fo. *edulis* and *Passiflora caerulea*, known as purple and orange passion fruit, respectively, have the sweetest flavor, so are best consumed as juice or as fresh pulp (Zeraik and Yariwake 2010). These fruits are of interest not only due to the pulps but also due to its peels and seeds which contain high levels of bioactive compounds. Furthermore, regarding species *Passiflora caerulea*, no research has been reported about bioactive compounds content.

The ideal condition for the development of passion fruit occurs in places where the tropical climate prevails, and it is emphasizing that the water content in the soil is one of the factors that most influences the flowering of passion fruit crop. The regions that this fruit is widely using are American and European countries, due to the favorable

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s13197-018-3190-2>) contains supplementary material, which is available to authorized users.

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weather. The best variety known and more used is *Passiflora edulis*, not only because of its pulp but also due of the infusions made with the leaves (Silva et al. 2013).

The common consumption of fruit and vegetable in the diet can protect our organism of Manu chronic diseases such as cancer, neurological diseases, cardiovascular diseases, obesity, inflammations and infections (Volp et al. 2009). However, passion fruit appears to be an excellent source of nutrients as carbohydrates, vitamins, and minerals that are essential nutrients for life. The fruit has a high content in nutraceuticals, as phenolic acids, where anthocyanins and flavonoids are the majoritarian compounds of this group; carotenoids and β -carotene appear to be the principal component, with consequently increased provitamin A activity. These nutraceutical compounds have biological activities in the health, protective effect against degenerative and chronic diseases and act as mutagenesis and carcinogenesis inhibitors. Also, these compounds have been associated with antiviral, antiallergic, antiplatelet and anti-inflammatory activities (Morais et al. 2016; Castañeda-Ovando et al. 2009; Tanwar and Modgil 2012; González-Gallego et al. 2014).

A major problem of passion fruit juice in the manufacturing industry is the amounts of waste generated come from discarded that are the peels and seeds. These residues are excellent sources of nutrients, bioactive compounds and studies about your potential can even indicate a future application as food ingredients in the formulation of new products, encouraging the reutilization of food and offering a nutritious alternative diet at low cost.

Based on this, the aim of this study was to evaluate the physicochemical characteristics, color parameters, pectin, proximate composition, minerals, the content of bioactive compounds and antioxidant capacity in pulp, peel, and the seed of yellow, purple and orange passion fruit to future use of parts as functional ingredients.

Materials and methods

Sample preparation

The yellow passion fruit (*Passiflora edulis* Sims fo. *flavicarpa*) samples were obtained CEASA (Central Supply of Rio Grande do Sul), Caxias do Sul, RS, Brazil. The purple (*Passiflora edulis* Sims fo. *edulis*) and orange passion fruit (*Passiflora caerulea*) samples were collected from farmers in the Criuva District (Caxias do Sul), the Rio Grande do Sul, Brazil. The fruits were harvested when fully ripe, with their skin color (yellow, purple or orange). After the crop, the fruits were transported immediately to the laboratory where they were cleaned in running water. Then the fruits were cut in half and made a separation of the pulp, peel

(albedo and flavedo) and seed, the parts were packed in plastic bags and stored in a freezer at $-18\text{ }^{\circ}\text{C}$ until analysis.

Physicochemical and chemical analysis

Total soluble solids (TSS) were determined in pulps with a Brix refractometer. The pH was measured using a pH meter (Quimis, model Q-400A). The yield was calculated by the percentage ratio (%) of the weight of the fruit with and without seed. The titratable acidity was determined by titration method using standardized 0.1 M NaOH solution, and the results analyzing in g/100 g of citric acid following the Analytical Standards Instituto Adolfo Lutz (2008). All of these analyses were made in triplicate.

Yield

The yield calculation of the pulp was calculated by weight of whole fruit (one by one) and weight of the fruit without peel and seed (pulp). The result was expressed as percentage (%). The average number of passion fruit analyzed was around 30 units.

Color parameters

The color was analyzed using a portable colorimeter (Konica Minolta Model CR 400, Singapore) by the *Commission Internationale de l'Eclairage* (CIELAB system) by determining the values of L^* (lightness), a^* (component red-green) and b^* (yellow-blue component). All of these analyses were made in triplicate.

Proximate composition

All analyses were performed according to AOAC (2000). Protein content was determined by the Kjeldahl method with a conversion factor of 5.75. Lipids were obtained by cold extraction and ash was determined in a muffle furnace at $550\text{ }^{\circ}\text{C}$. Total dietary fiber was determined by the enzymatic–gravimetric method, moisture by gravimetry. Carbohydrates were estimated by the difference of 100 per cent of the sum between proteins, lipids, water and ash. The results were expressed as % and the data presented is the average of triplicate analysis.

Determination of pectin

The pectin of peels was extracted using a method of Canteri-Schemin et al. (2005) and Seixas et al. (2014) with some modifications. The extraction process was carried out in beakers (600 mL), followed by heating in a microwave

oven (Electrolux, ME21S 800 W). Each 2 g of passion fruit peel flour was added to 50 mL of distilled water in a beaker. Then, an addition of a tartaric acidic solution (10%), was added to maintain a final pH of 2 for the solutions. The beaker was put in a microwave heating for 3 min. The solution (still warm), was vacuum filtered on a filter paper and the filtrate (containing the soluble pectin) was cooled to 4 °C.

To isolate the soluble pectin from the filtrate, the solution was slowly added under magnetic stirring to two volumes of absolute ethyl alcohol. This mixture was stirred for 10 min, after which it was allowed to rest for 30 min to facilitate the flotation of the pectin. The pectin was separated by vacuum filtration on a filter paper. The extracted pectin in a gel form was immersed in absolute ethyl alcohol for about 12 h and then was partially dehydrated by immersion in acetone. The drying pectin was put in an air-circulated oven at 50 °C until constant weight (approximately 8 h). The results were expressed as g of pectin/100 g dry peels (triplicate).

Determination of minerals

All the samples (pulp, peel, and seed) of yellow, purple and orange passion fruit were lyophilized (Liotop, L101, Brazil) before mineral analysis. The analysis of minerals in the passion fruit samples were made in Plant Soil Laboratory Faculty of Agronomy, Federal University of Rio Grande do Sul (UFRGS), according to the methodology of atomic emission spectrometry with inductively coupled plasma source (ICP–OES) described by Tedesco and Gianello (2004) This method is compiling in Table 1S (supplementary material). The results were expressed as % and the data presented is the average of duplicate analysis.

Determination of carotenoid profile and provitamin A content

The profile of carotenoids was determined according to Mercadante and Rodriguez-Amaya (1998). The extraction of pigments was with acetone and the saponification in a KOH solution (10% in methanol) overnight. The extract was rotary evaporated (Fisatom, Model 801) ($T < 25$ °C) and stored in a freezer (-18 °C) for quantification by high-performance liquid chromatography (HPLC).

For HPLC (High Performance Liquid Chromatography) analysis, the samples stored in a freezer were diluted with methyl *tert*-butyl ether (MTBE–JT Baker, CAS. Number 1634-04-4, purity 99.96%), sonicated (Unique, Model USC 1400) for 1 min and filtered (Millex LCR 0.45 μ m, 13 mm) for injection into the HPLC (Agilent 1100 Series, Santa Clara, CA, USA), a UV–visible detector and with a quaternary system.

The column used was a C30 polymeric reverse phase (250 \times 4.6 mm ID, 3 μ m, YMC, model CT99SO3-2546WT). The mobile phase gradient (water:methanol:MTBE) (JT Baker, CAS Number 04.04.1634, 99.96% purity) commenced at 5:90:5, reaching 0:95:5 at 12 min, 0:89:11 at 25 min, 0:75:25 at 40 min, and finally 00:50:50 at 60 min. The temperature of column was 33 °C and a flow rate of 1 mL/min (Spectra were obtained at a fixed wavelength of 450 nm for carotenoids).

Compounds were identified by comparing the sample retention time's with the retention times obtained for controls. For quantification, a standard curve was constructed for carotenoids over the following ranges: lutein 1–65 μ g/mL ($\geq 95\%$, Sigma-Aldrich); zeaxanthin 1–40 μ g/mL ($\geq 95\%$, Sigma-Aldrich); cryptoxanthin 4–100 μ g/mL ($\geq 97\%$, Sigma-Aldrich); α -carotene 2–25 μ g/mL ($\geq 95\%$, Sigma-Aldrich); β -carotene 5–50 μ g/mL ($\geq 97\%$, Sigma-Aldrich) and lycopene ($\geq 85\%$ Sigma-Aldrich).

The limits of detection (LOD) and quantification (LOQ) were calculated by injecting 10 times the blank of the sample at very low level were used for measurement of LOD and LOQ which were determined as follows: LOD = mean value + 3 standard deviation (SD) LOQ = mean value + 10 SD where, mean value is zero (Ertas et al. 2007). Lutein: 6.9×10^{-3} and 1.15×10^{-2} μ g/g; zeaxanthin: 9.56×10^{-2} and 1.59×10^{-2} μ g/g; cryptoxanthin: 2.11×10^{-2} and 3.51×10^{-2} μ g/g; α -carotene: 1.97×10^{-2} and 3.28×10^{-2} μ g/g; β -carotene: 6.53×10^{-2} and 10.89×10^{-2} μ g/g and lycopene were 7×10^{-3} and 33×10^{-3} μ g/g.

Provitamin A activity was calculated by the bioconversion factor following Institute of Medicine (2001), yielding a value of 12 mg of β -carotene with 1 mg of Retinol Activity Equivalent (RAE). The results were expressed as % and the data presented is the average of triplicate analysis.

Determination of phenolic compounds

Samples (5 g) were homogenized by exhaustive extraction with 20 mL of ethanol and centrifuged at 15 °C (Cientec, CTR—5000R, Brazil) at 5000 \times g for 20 min. Then, 20 μ L of supernatant was added to 1.58 mL of water and 100 μ L of Folin-Ciocalteu (0.4 mol/L). After reaction (3 min), 300 μ L of Na_2CO_3 was added, and the mixture kept at room temperature for 2 h. The absorbance was then read at 765 nm on a UV–visible spectrophotometer (Shimadzu, UV-1700 PharmaSpec, Japan). The ethanol was used as the blank and gallic acid was used for calibration of the standard curve (0–0.50 mg/L). The results were expressed as mg of gallic acid equivalent (GAE) per 100 g of dry sample (triplicates) (Swain and Hillis 1959).

Determination of quercetin and kaempferol

Quercetin and kaempferol contents were analyzed according to Zeraik and Yariwake (2010) with modifications. The sample (10 g) were homogenised in an Ultra-Turrax (T25, IKA, China) with 30 mL of methanol at room temperature. The extracts were centrifuged at $15,000 \times g$, 4°C for 20 min and after in rotary evaporator giving 2 mL of extract. The resulting aqueous solution was filtered through a $0.45 \mu\text{m}$ Millex-HV PVDF membrane (Millipore, New Bedford, MA, USA) before HPLC analysis. The samples were prepared and analyzed in triplicate and the results were expressed as %.

The HPLC-/DAD analyses were carried out on a Waters Alliance 2695 (Milford, MA, USA) liquid chromatograph connected to a model 2996 (DAD) diode array detector and controlled by Waters Empower software. The separation was performed using a C18 polymer column ($250 \text{ mm} \times 4.6 \text{ mm}$ id, $5 \mu\text{m}$ Vydac, 218TP). The samples were injected automatically ($10.0 \mu\text{L}$). A flow rate of $0.8 \text{ mL}/\text{min}$ was applied, using a linear gradient of 0.2% formic acid in water (solvent A) and 0.2% formic acid in acetonitrile (solvent B). The gradients were: 0–10 min, 15% B in 85% A and 10–30 min, 20% B in 80% A. The chromatogram was monitored at 330 nm, and UV spectra of individual peaks were recorded in the range of 200–400 nm.

The contents of quercetin and kaempferol were determined by comparison with an external standard, injecting a new standard daily at $30 \text{ mg}/\text{mL}$ for Quercetin ($\geq 98\%$, Sigma-Aldrich) and $4 \text{ mg}/\text{mL}$ for kaempferol ($\geq 99\%$, Sigma-Aldrich).

Determination of anthocyanins

The anthocyanins were analyzed according to Zanatta et al. (2005), so 5 g of sample were homogenized in an Ultra-Turrax (T25, IKA, China) with acidified methanol (HCl 1%) and then quantified by HPLC (Agilent 1100 Series, Santa Clara, CA, USA) equipped with a quaternary pump system solvent and a UV–visible detector was used with a C18Shim-PakCLC-ODScolumn($5 \mu\text{m}$, $250 \times 4.6 \text{ mm}$).

The mobile phase was 5% aqueous formic acid/methanol 85:15 (v/v) to 20:80 over 25 min and this isocratic ratio was maintained for 15 min. The mobile phase flow were $0.8 \text{ mL}/\text{min}$, the injection volume was $5 \mu\text{L}$, and 29°C was the temperature of column. The chromatograms were processed at a fixed wavelength of 520 nm.

The standards were from Sigma-Aldrich (USA): cyanidin-3-glucoside (CAS 7084-24-4, $\geq 95.0\%$), cyanidin-3,5-glucoside (CAS 2611-67-8, $\geq 90.0\%$), delphinidin-3- β -glucoside (CAS 6906-38-3, $\geq 97\%$), pelargonidin-3-glucoside (CAS 17334-58-6, $\geq 90\%$), aglycone delphinidin

(CAS 528-53-0, $\geq 95\%$), aglycone cyaniding (CAS 528-58-5, $\geq 95\%$), malvidin-3,5-diglucoside (CAS 643-84-5, $\geq 95\%$) and aglycone pelargonidin (CAS 17334-58-6, $\geq 90\%$). The quantification and identification of compounds were performed by comparing peak areas and retention times with their respective standards under the same chromatographic conditions. The results were expressed as % and the data presented is the average of triplicate analysis.

Determination of antioxidant capacity

The methodology used to determine antioxidant capacity was based on the sequestration of DPPH (2,2-diphenyl-1-picryl-hydrazyl) and ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) radicals according to Brand-Williams et al. (1995). Samples (5 g) were placed in 20 mL of ethanol and then centrifuged at 15°C at $5000 \times g$ (Cientec, CTR—5000R, Brazil) for 20 min. The liquid was diluted in three concentrations (10, 30, and 100%). For the DPPH assay, aliquots of each concentration were treated with 2 mL of DPPH (0.06 mM). The absorbance was read at 517 nm (Shimadzu, UV-1700 PharmaSpec, Japan). The results were presented as IC (Effective Concentration of 50% radical inhibition) 50 (mg/100 mL).

For the ABTS assay, aliquots of each concentration were treated with 2 mL of ABTS (7 mM). The absorbance was read at 734 nm (Shimadzu, UV-1700 PharmaSpec, Japan). The results were presented as IC 50 (mg/100 mL).

Statistical analysis

Data were analyzed by ANOVA and Tukey's mean comparison test with a significance level of 5%, followed by a principal component analysis (PCA) using the software Statistica 12.0 (Statsoft Inc, São Paulo, Brasil). Pearson's correlation was to the results of phenolic compounds and antioxidant capacity using Statistica 12.0 (Statsoft, São Paulo, Brazil).

Results and discussion

Physicochemical analysis

The results of the physicochemical analysis in pulps of different species of passion fruit were: 9.10% of TSS (total soluble solids), 9.06% of titratable acidity (citric acid) and a pH of 2.66 in yellow passion fruit pulp. For purple passion fruit the results were 11.60% of TSS, 2.83% of titratable acidity and a pH of 2.72 and for orange passion fruit pulp, we found 12.30% of TSS, 2.21% of

titratable acidity and a pH of 3.97. So, the pulp of orange passion fruit is sweeter because it showed the higher content of total soluble solids (TSS), pH and consequently, lower content of acidity. The pulp of yellow passion fruit showed higher acidity and lower pH and TSS and then it is more acid. Some factors such as soil type, fertilization, climate, irrigation and genetic traits of the cultivar can explain the variations between the physicochemical parameters.

Kishore et al. (2011) evaluated the physicochemical attributes as TSS and titratable acidity in purple passion fruit pulp (*Passiflora edulis* Sims) who the values were 15.30 and 3.80%, respectively. These results were higher when compared to purple passion fruit pulp of this research. In another study realized by Souza et al. (2012), who analysed the pH, titratable acidity and total soluble solids in sweet passion fruit pulp (*Passiflora alata* Dryand), the results were 3.31, 2.00, and 13.33%, respectively. These values were more similar to specie *Passiflora caeurea* analysed by us that was the passion fruit sweeter. Janzanti et al. (2012) did a research with yellow passion fruit pulp (*P. edulis* Sims f. *flavicarpa* Deg.) and the higher values were 4.32% for titratable acidity, 14.71% soluble solids and 3.53 for pH, different values found by us when compared to yellow passion fruit. López-Vargas et al. (2013) evaluated the pH in pulp and seed of yellow passion fruit (*Passiflora edulis* var. *flavicarpa*) and the results were 3.75. They found higher values of pH in relation to the same variety (yellow passion fruit) of our research. Pongener et al. (2013) found the highest total soluble solids of 16.2° Brix in purple passion fruit pulp (*Passiflora edulis* Sims) and titratable acidity of 2.34 g citric acid/100 mL extract. These values were different both for total soluble solids and titratable acidity when compared to purple passion fruit pulp analysed in this study.

The yield of different species of passion fruit was evaluated, and the results are shown in Table 1. As expected, pulp and peel of yellow passion fruit presented higher yield when compared to purple and orange passion fruit, but for seed, orange passion fruit showed higher yield. Thus, it appears that the residues that represent most of the fruit should be characterized to indicate the possible applications and uses. For example, replacing wheat flour in some formulations such as pasta, breads, cakes, biscuits, which will have a higher content of fibers and bioactive compounds.

PCA (Principal Component Analysis) is a statistical technique used to reduce the dimensionality of a data set containing a large number of inter-related variables. The analysis is performed to maintain the maximum variance present in the data. This reduction produces a new reduced and uncorrelated set of variables, called principal components. These components are then chosen to ensure that the

Table 1 Yield color parameters and pectin in different species of passion fruit (mean and standard deviation)

	Yellow	Purple	Orange
Yield (%)			
Pulp	27.71 ± 1.00 ^a	25.23 ± 1.02 ^c	26.54 ± 0.98 ^b
Peel	64.05 ± 2.03 ^a	62.11 ± 1.90 ^b	57.28 ± 2.05 ^c
Seed	8.24 ± 0.05 ^c	12.66 ± 0.12 ^b	16.18 ± 0.08 ^a
Color L*			
Pulp	58.05 ± 0.64 ^b	77.65 ± 0.57 ^a	26.90 ± 0.17 ^c
Peel	43.16 ± 1.47 ^a	21.58 ± 2.15 ^c	36.94 ± 0.45 ^b
Seed	33.86 ± 0.80 ^a	28.16 ± 0.78 ^b	26.96 ± 0.49 ^b
Color a*			
Pulp	8.44 ± 0.01 ^b	0.29 ± 0.08 ^c	10.78 ± 0.11 ^a
Peel	2.29 ± 0.25 ^b	2.20 ± 0.22 ^b	13.23 ± 0.49 ^a
Seed	1.91 ± 0.09 ^b	0.30 ± 0.08 ^c	8.25 ± 0.24 ^a
Color b*			
Pulp	42.83 ± 1.28 ^a	17.18 ± 1.08 ^b	6.08 ± 0.07 ^c
Peel	31.33 ± 0.53 ^b	3.83 ± 1.75 ^c	35.78 ± 1.64 ^a
Seed	19.36 ± 0.45 ^a	5.90 ± 0.21 ^c	8.89 ± 0.55 ^b
Pectin			
Peel	37.67 ± 0.97 ^a	32.85 ± 1.20 ^b	21.55 ± 0.55 ^c

^{a,b,c}Different superscript letters in the same row indicate statistically significant difference ($p < 0.05$)

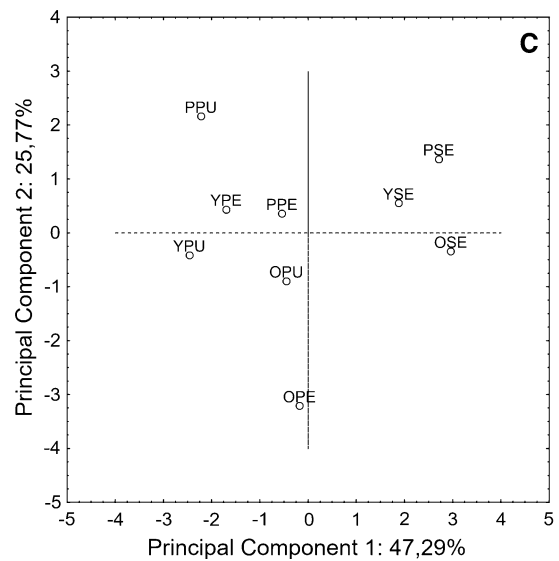
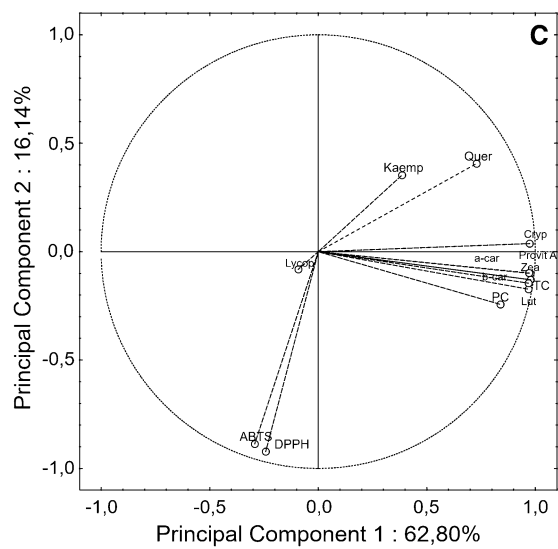
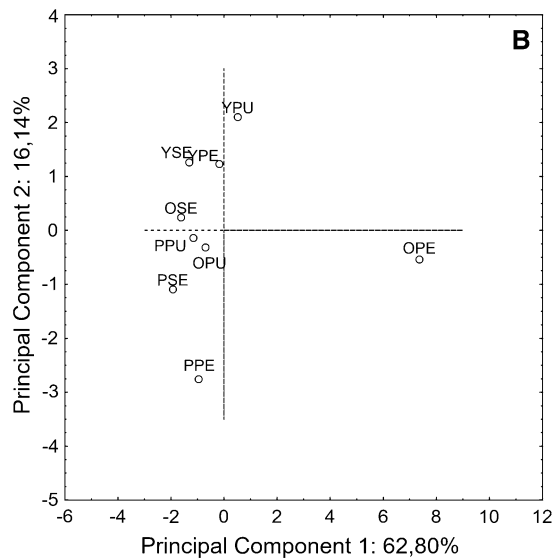
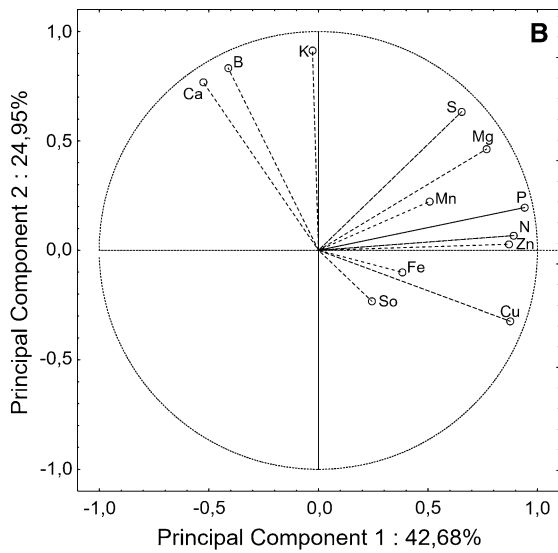
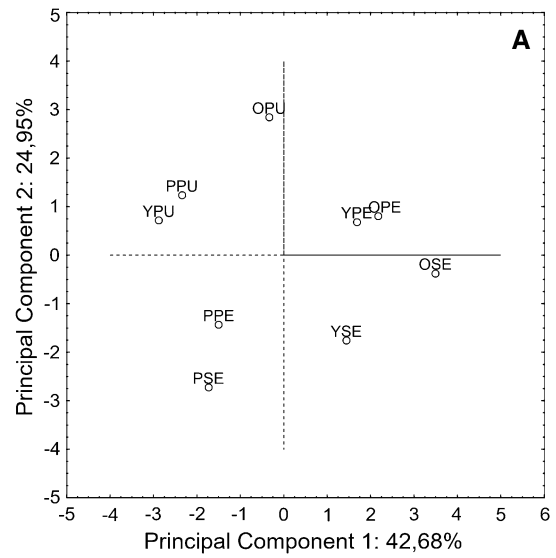
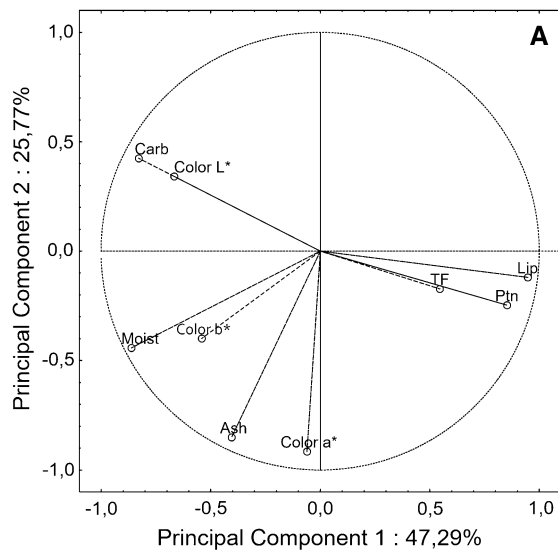
former retain the greater part of the variance present in the original variables.

The three passion fruits were evaluated for the color parameters, proximate composition, minerals, carotenoids, flavonoids, phenolic compounds, antioxidant capacity and the results are showed in Fig. 1.

By analyzing the components, the variance of the data was accounted for the significant contributions of 47.29% for the first principal component representing variable ash, color b and color L and 25.77% for the second principal components representing other variables (Fig. 1a).

Color

The passion fruit was evaluated within the context of color parameters (Fig. 1a). It was observed that for color L*, the pulp of purple passion fruit showed higher brightness. For color a* that indicates the intensity of colors red-green, orange passion fruit showed higher levels for pulp, peel, and seed when compared to yellow and purple passion fruit. For color b*, which indicates the intensity of colors yellow-blue, both for pulp and seed, yellow passion fruit presented more intensity, and for the peel, orange passion fruit showed more intensity when compared to other species of passion fruit. The differences in the color



◀**Fig. 1** Principal component analysis of yellow, purple and orange passion fruit in pulp, peel, and seed: proximate composition and color parameters (a); minerals (b); carotenoids, phenolic compounds and flavonoids (c). Legend: YPU: yellow passion fruit pulp; YPE: yellow passion fruit peel; YSE: yellow passion fruit seed; PPU: purple passion fruit pulp; PPE: purple passion fruit peel; PSE: purple passion fruit seed; OPU: orange passion fruit OPE: orange passion fruit peel; OSE: orange passion fruit seed; Moist: moisture; Ptn: protein; Lip: lipids; Carb: carbohydrates; TF: total fibre; N: nitrogen; P: phosphorus; K: potassium; Ca: calcium; Mg: magnesium; S: sulphur; Cu: copper; Zn: zinc; Fe: iron; Mn: manganese; B: boron; So: sodium; Lut: lutein; Zea: Zeaxanthin; Cryp: Cryptoxanthin; a-car: α -carotene; b-car: β -carotene; Lycop: lycopene; Provit A: provitamin A; TC: total carotenoids; PC: phenolic compounds; Quer: quercetin; Kaemp: kaempferol

parameters can be explained mainly the species, soil and harvesting period are different.

Proximate composition

By principal component analysis (Fig. 1a) can be seen that the orange passion fruit stands out for its red coloration in the peel, high ash content present in the pulp and peel and the high content of proteins and lipids in the seeds. The yellow passion fruit, in turn, showed a high content of carbohydrates in the peel, probably due to the high content of pectin (37.37 g/100 g) in this species. The total fiber content in the pulp was greater in this species compared with others. The purple passion fruit highlights to have a high content of carbohydrates in the pulp compared with orange and yellow passion fruit (Table 2).

Souza et al. (2012) analyzed the proximate composition in sweet passion fruit pulp (*Passiflora alata* Dryand), and the results were (dry weight, except for moisture): 84.12% of moisture, 8.50% proteins, 0.63% lipids, 82.17% carbohydrates, 4.40% dietary fiber and 4.28% ash. The results of proteins and carbohydrates were similar with yellow passion fruit analyzed in this study, but for moisture, lipids, dietary fiber, and ash we found higher values.

Thereby, the peels and seeds of yellow, purple and orange passion fruit showed to be richer in total dietary fiber, proteins (seeds) and lipids, which should have an unsaturated origin.

Pectin

As it can be seen in Table 1, the peel of yellow passion fruit showed higher levels of pectin when compared to the purple and orange passion fruit (the latter presented the lowest content).

Liew et al. (2014) evaluated the production of pectin yellow passion fruit peel (*Passiflora edulis f. flavicarpa*) in extraction with citric acid. The authors found 14.60% yield

Table 2 Proximate composition of different species of passion fruit (g/100 g of dry weight—except for moisture) with mean and standard deviation

	Yellow	Purple	Orange
Moisture			
Pulp	90.06 ± 0.00 ^a	83.44 ± 0.99 ^b	88.18 ± 0.87 ^a
Peel	87.14 ± 3.29 ^b	87.02 ± 1.22 ^b	94.25 ± 0.26 ^a
Seed	57.09 ± 2.36 ^a	45.91 ± 0.97 ^b	58.46 ± 0.38 ^a
Proteins			
Pulp	8.57 ± 0.10 ^b	6.53 ± 0.23 ^c	9.90 ± 0.35 ^a
Peel	3.40 ± 0.06 ^c	6.47 ± 0.04 ^b	11.60 ± 0.44 ^a
Seed	13.07 ± 0.12 ^b	13.23 ± 0.48 ^b	15.84 ± 0.15 ^a
Lipids			
Pulp	1.11 ± 0.04 ^b	1.09 ± 0.04 ^b	2.92 ± 0.09 ^a
Peel	4.20 ± 0.03 ^c	4.89 ± 0.07 ^b	10.25 ± 0.12 ^a
Seed	12.31 ± 0.78 ^c	14.94 ± 0.41 ^b	19.64 ± 0.30 ^a
Ash			
Pulp	6.94 ± 0.01 ^a	2.95 ± 0.14 ^b	7.31 ± 0.22 ^a
Peel	6.62 ± 0.24 ^c	7.93 ± 0.05 ^b	13.29 ± 0.41 ^a
Seed	3.56 ± 0.05 ^a	1.85 ± 0.06 ^c	3.23 ± 0.18 ^b
Carbohydrates			
Pulp	83.37 ± 0.00 ^b	89.42 ± 0.00 ^a	79.87 ± 0.00 ^c
Peel	85.78 ± 0.00 ^a	80.71 ± 0.00 ^b	64.86 ± 0.00 ^c
Seed	71.07 ± 0.00 ^a	69.98 ± 0.00 ^a	61.38 ± 0.00 ^b
Total fibre			
Pulp	7.15 ± 0.07 ^a	1.40 ± 0.18 ^c	2.17 ± 0.11 ^b
Peel	61.16 ± 1.02 ^a	61.68 ± 1.31 ^a	62.14 ± 2.62 ^a
Seed	65.60 ± 0.52 ^a	55.06 ± 0.35 ^b	51.47 ± 0.60 ^c

^{a,b,c} Different superscript letters in the same row indicate statistically significant difference ($p < 0.05$)

of pectin from passion fruit peel. Kulkarni and Vijayanand (2010) also conducted a study to evaluate the pectin content of passion fruit peel (*Passiflora edulis f. flavicarpa* L.) yellow variety. The passion fruit peels were dehydrated for pectin extraction experiments. The conditions for the extraction of pectin from the passion fruit peel promoted a yield of 14.80 g/100 g of the dried peel. In another research carried out by Seixas et al. (2014), pectin extraction was investigated from the passion fruit peel (*Passiflora edulis f. flavicarpa*). The highest yield was found to be 18.20%. Different species of passion fruit of this study showed better results compared to the yield of pectin compared to all kinds of passion fruit analyzed.

Minerals

The minerals content of passion fruit is shown in Fig. 1B. By analyzing the components, the variance of the data was accounted for the significant contributions of 42.66% for

the first and 24.95% for the second principal components. It can be observed that pulps of three species have high calcium, potassium, and boron. The yellow and orange passion fruit peels showed high zinc, manganese, copper, phosphorus, and sulfur. As for the purple passion fruit peel, these minerals had low content. Regarding seeds, orange passion fruit presented a considerable amount of copper followed by yellow passion fruit (Table 3).

Gondim et al. (2005) determined the mineral concentration in yellow passion fruit peels (*Passiflora edulis*). They found 44.51 mg of calcium, 0.89 mg of iron, 43.77 mg sodium, 27.82 mg magnesium, 0.32 mg zinc, 0.04 mg copper and 178.40 mg potassium in 100 g of fresh sample. These values were lower (except for sodium) when compared to the yellow passion fruit peel analyzed in this research due to they did not present the values in dry basis.

Souza et al. (2012) evaluated the mineral content (phosphorus, potassium, calcium, magnesium and iron) in passion fruit pulp (*Passiflora alata* Dryand). The authors found values of 34.95 mg for phosphorus, 375.42 mg potassium, 4.76 mg calcium, 19.82 mg magnesium and 1.06 mg of iron in 100 g of fresh pulp. They found significant amounts of calcium and potassium in pulp compared to our pulps studied.

As example, in adults above 19 years old, a portion of 100 g of orange passion fruit pulp presents 81 and 59% of recommended daily intake of zinc in women and men, respectively; 70 and 55% for magnesium in women and men; 111% for copper; 55% for phosphorus and 33% for calcium. In orange passion fruit peel (100 g), potassium presents 85% of recommended daily intake and manganese 405 and 317% in women and men. The pulp of yellow passion fruit (100 g) gives 30 and 69% of iron recommended daily intake for women and men; the concentrations of boron and sodium of all parts in passion fruit (portion of 100 g) is according to tolerable upper intake levels from 1 year old; sulphur and nitrogen not appears in recommended daily intake and tolerable upper intake levels.

Thus, it can be seen that from the nutritional matrix, we can ingest the recommended daily amount of minerals through the passion fruit, noting that the pulps have higher concentrations of minerals than peels.

Carotenoid profile and provitamin A content

The content of carotenoids and provitamin A are shown in Fig. 1c. By analyzing the components, the variance of the data was accounted for the significant contributions of 62.80% for the first and 16.14% for the second principal components. For peel, orange passion fruit stands out to all carotenoids evaluated and provitamin A about other species of passion fruit, where the majoritarian carotenoid was

Table 3 Mineral composition of different species of passion fruit (mg/100 g of dry weight) with mean and standard deviation

	Yellow	Purple	Orange
Zinc			
Pulp	5.20 ± 0.10 ^b	2.10 ± 0.05 ^c	6.50 ± 0.12 ^a
Peel	1.00 ± 0.02 ^b	0.90 ± 0.01 ^c	5.80 ± 0.05 ^a
Seed	4.10 ± 0.09 ^c	4.60 ± 0.05 ^b	8.90 ± 0.04 ^a
Iron			
Pulp	5.50 ± 0.03 ^a	2.90 ± 0.02 ^c	3.20 ± 0.01 ^b
Peel	3.20 ± 0.04 ^c	4.60 ± 0.03 ^a	3.90 ± 0.02 ^b
Seed	5.20 ± 0.02 ^a	4.30 ± 0.03 ^c	4.50 ± 0.03 ^b
Boron			
Pulp	0.70 ± 0.02 ^a	0.20 ± 0.01 ^b	0.70 ± 0.02 ^a
Peel	1.30 ± 0.03 ^c	1.40 ± 0.03 ^b	1.60 ± 0.04 ^a
Seed	0.40 ± 0.01 ^b	0.50 ± 0.02 ^a	0.50 ± 0.02 ^a
Manganese			
Pulp	1.20 ± 0.05 ^a	0.40 ± 0.01 ^b	1.20 ± 0.01 ^a
Peel	0.50 ± 0.0 ^c	0.70 ± 0.02 ^b	7.30 ± 0.02 ^a
Seed	2.20 ± 0.05 ^c	2.30 ± 0.03 ^b	8.90 ± 0.01 ^a
Copper			
Pulp	0.60 ± 0.02 ^b	0.20 ± 0.01 ^c	1.00 ± 0.02 ^a
Peel	0.10 ± 0.01 ^c	0.20 ± 0.01 ^b	0.30 ± 0.01 ^a
Seed	0.90 ± 0.02 ^b	0.70 ± 0.02 ^c	1.30 ± 0.03 ^a
Phosphorus			
Pulp	380 ± 1.98 ^b	150 ± 1.70 ^c	390 ± 2.76 ^a
Peel	140 ± 1.30 ^b	70.00 ± 1.12 ^c	240 ± 1.71 ^a
Seed	310 ± 2.05 ^b	63.00 ± 1.19 ^c	390 ± 2.90 ^a
Sulfur			
Pulp	170 ± 2.00 ^b	90.00 ± 0.85 ^c	330 ± 3.92 ^a
Peel	70.00 ± 0.40 ^c	160 ± 1.35 ^b	280 ± 2.80 ^a
Seed	150 ± 1.23 ^b	32 ± 0.10 ^c	230 ± 2.09 ^a
Sodium			
Pulp	1.40 ± 0.02 ^c	5.30 ± 0.04 ^b	9.40 ± 0.20 ^a
Peel	2.20 ± 0.02 ^c	7.30 ± 0.12 ^b	11.50 ± 0.15 ^a
Seed	3.46 ± 0.07 ^c	4.80 ± 0.03 ^a	4.40 ± 0.05 ^b
Magnesium			
Pulp	200 ± 1.23 ^b	120 ± 0.95 ^c	220 ± 1.30 ^a
Peel	120 ± 0.90 ^c	130 ± 0.97 ^b	140 ± 1.34 ^a
Seed	150 ± 1.10 ^c	290 ± 1.80 ^a	200 ± 1.22 ^b
Nitrogen			
Pulp	2400 ± 20.0 ^a	1100 ± 8.0 ^c	1700 ± 12.0 ^b
Peel	620 ± 9.00 ^c	920 ± 7.50 ^b	940 ± 7.00 ^a
Seed	1800 ± 15.0 ^b	380 ± 1.50 ^c	2200 ± 18.5 ^a
Potassium			
Pulp	3800 ± 25.5 ^a	1600 ± 16.0 ^c	2900 ± 18.5 ^b
Peel	2600 ± 15.7 ^c	2800 ± 16.3 ^b	4000 ± 32.0 ^a
Seed	760 ± 6.40 ^b	112 ± 3.00 ^c	1000 ± 7.80 ^a
Calcium			
Pulp	50.00 ± 0.40 ^a	20.00 ± 0.12 ^c	30.00 ± 0.10 ^b
Peel	250 ± 1.98 ^b	310 ± 1.69 ^a	30.00 ± 0.11 ^c
Seed	30.00 ± 0.35 ^b	6.00 ± 0.02 ^c	330 ± 1.18 ^a

^{a,b,c} Different superscript letters in the same row indicate statistically significant difference ($p < 0.05$)

β -carotene because his peel color is orange. This species also presented in the pulp the highest content of lycopene (Table 4).

Souza et al. (2012) analyzed the content of β -carotene and lycopene in sweet passion fruit pulp (*Passiflora alata* Dryand), and they found 8249 and 5478 $\mu\text{g}/100\text{ g}$ dry weight, confirming that these results were higher than our study for both β -carotene and lycopene. Pongener et al. (2013) evaluated the total carotenoids in purple passion fruit, and the higher value was 1467 $\mu\text{g}/100\text{ mL}$, being higher when compared to purple passion fruit analyzed in this research, but lower values compared to yellow and orange pulps.

Silva et al. (2014) evaluated the content of β -carotene and lycopene in pulp and peel of yellow passion fruit (*Passiflora edulis* Sims). They found 1362.07 and 57.93 μg β -carotene/100 g (dry basis), respectively and lycopene was not detected both in pulp and peel. The values of β -carotene were similar to our research for pulp (1333.97 $\mu\text{g}/100\text{ g}$ dry basis), but for the peel, we detected more content of this compound (272.52 $\mu\text{g}/100\text{ g}$ dry basis).

However, Pertuzatti et al. (2015) analyzed the carotenoids profile in yellow passion fruit (*Passiflora edulis*) and found: for lutein + zeaxanthin 1 $\mu\text{g}/100\text{ g}$, β -cryptoxanthin 24,990 $\mu\text{g}/100\text{ g}$, lycopene 28 $\mu\text{g}/100\text{ g}$ and total carotenoids 25,100 $\mu\text{g}/100\text{ g}$. The values of β -cryptoxanthin and total carotenoids were much higher than our study, but for lutein + zeaxanthin, we found higher concentrations in all varieties and for lycopene, the variety ‘orange’ were higher too.

In another research realized by Septembre-Malaterre et al. (2016) where the content of β -carotene in passion fruit pulp (*Passiflora edulis*) was investigated, the values found were 3829.20 μg β -carotene equivalent/100 g. These

results were higher when compared to all varieties analyzed in this study.

As an example (Institute of Medicine 2002), pulp of yellow passion fruit (100 g) presents 15 and 11% of DRI (dietary reference intakes) of vitamin A in women and men (> 14 years old), respectively. A portion of 100 g of orange passion fruit peel could contribute with 233 and 181% for women and men (> 14 years old), respectively according to recommended a daily intake of vitamin A.

Phenolic compounds

The presence of phenolic compounds in passion fruit makes this fruit an excellent candidate to evaluate several effects in vivo. As can be seen in Fig. 1c, the pulps and peels revealed the higher content of phenolic compounds, where the orange passion fruit stands out due to the higher concentrations. Therefore, the peels are residues that can be used and applied in formulations that would enrich the food due to the presence of these compounds (Table 5).

Silva et al. (2014) measured the total phenolic content in yellow passion fruit (*Passiflora edulis* Sims). They found 765.09 mg gallic acid equivalent/100 g (dry basis) in pulp and 451.06 mg gallic acid equivalent/100 g in peel (dry basis), similar values to our purple pulp. Already Septembre-Malaterre et al. (2016), found 286.6 mg gallic acid equivalent/100 g in passion fruit pulp (*Passiflora edulis*), different values about our research.

In summary, genotype, geographic effect, crop year, maturation and storage conditions are some characteristics that can influence the content of phenolic compounds, anthocyanins, flavonoids, carotenoids and other bioactive compounds in all fruit (Souza et al. 2008; Cardeñosa et al. 2016).

Table 4 Analysis of carotenoids in different species of passion fruit ($\mu\text{g}/100\text{ g}$ dry weight; mean and standard deviation)

	Pulp			Peel		
	Yellow	Purple	Orange	Yellow	Purple	Orange
Lutein	44.28 \pm 2.33 ^b	10.68 \pm 0.11 ^c	105.36 \pm 3.24 ^a	504.97 \pm 24.77 ^b	366.88 \pm 17.89 ^b	2881 \pm 148.7 ^a
Zeaxanthin	65.51 \pm 0.86 ^b	7.49 \pm 0.05 ^c	91.22 \pm 1.89 ^a	65.61 \pm 0.22 ^b	48.70 \pm 2.85 ^b	323.98 \pm 11.11 ^a
Cryptoxanthin	254.38 \pm 3.32 ^a	30.85 \pm 0.07 ^b	nd	75.31 \pm 0.05 ^b	74.56 \pm 0.12 ^b	617.23 \pm 37.71 ^a
α -carotene	86.43 \pm 4.59 ^a	67.65 \pm 2.16 ^b	nd	nd	37.19 \pm 1.29 ^b	420.07 \pm 15.02 ^a
β -carotene	1334 \pm 78.8 ^a	171.88 \pm 2.12 ^c	744.60 \pm 15.47 ^b	272.52 \pm 11.77 ^b	716.32 \pm 30.65 ^b	21,274 \pm 676 ^a
Lycopene	nd	nd	4405 \pm 135.1 ^a	nd	nd	nd
Provitamin A*	111.16 \pm 6.57 ^a	14.32 \pm 0.18 ^c	62.05 \pm 1.29 ^b	22.71 \pm 0.98 ^b	59.69 \pm 2.55 ^b	1773 \pm 56.4 ^a
Total carotenoids	1785 \pm 81.5 ^b	288.56 \pm 0.03 ^c	5346 \pm 145.4 ^a	918.41 \pm 36.81 ^b	1244 \pm 52.5 ^b	25,516 \pm 561.9 ^a

^{a,b,c}Different superscript letters in the same row indicate statistically significant difference ($p < 0.05$)

nd not detected

*Expressed as μg RAE (Retinol Activity Equivalent)

Table 5 Analysis of phenolic compounds (mg/100 g dry weight), flavonoids (mg/100 g dry weight) and anthocyanins ($\mu\text{g}/100$ g dry weight) in different species of passion fruit with mean and standard deviation

	Pulp			Peel			Seed		
	Yellow	Purple	Orange	Yellow	Purple	Orange	Yellow	Purple	Orange
	Phenolic compounds	1297.31 \pm 13.43 ^b	788.93 \pm 3.99 ^c	1559.15 \pm 5.33 ^a	1061.87 \pm 25.00 ^c	1570.80 \pm 26.76 ^b	2584.91 \pm 96.67 ^a	346.69 \pm 6.58 ^b	325.69 \pm 1.18 ^c
Quercetin	506.45 \pm 23.79 ^a	229.79 \pm 10.99 ^b	16.28 \pm 0.19 ^c	760.21 \pm 32.07 ^a	nd	800.13 \pm 24.18 ^a	nd	nd	120.41 \pm 2.82
Kaempferol	199.66 \pm 1.10 ^a	12.35 \pm 0.08 ^b	nd	nd	74.70 \pm 1.44 ^b	229.27 \pm 8.90 ^a	375.32 \pm 13.50	nd	Nd
Cyanin	nd	nd	nd	nd	1477.47 \pm 20.85	nd	nd	nd	Nd
Delphinidin-3,5-Glu	nd	nd	nd	nd	8679.60 \pm 341.32	nd	nd	nd	Nd
Cyanidin-3-Glu	nd	nd	nd	nd	2852.92 \pm 177.93	nd	nd	nd	Nd
Pelargonidin-3-Glu	nd	nd	183.95 \pm 6.52	nd	1551.94 \pm 239.03	nd	nd	nd	Nd
Aglycone Delphinidin	nd	nd	nd	nd	90.998.72 \pm 5218.53	nd	nd	nd	Nd
Aglycone Cyanidin	nd	nd	nd	nd	1237.73 \pm 37.68	nd	nd	nd	159.18 \pm 5.92
Malvidin 3,5-Di	nd	nd	nd	nd	nd	nd	4598.70 \pm 119.73 ^b	8232.41 \pm 6.54 ^a	Nd
Aglycone Pelargonidin	nd	nd	nd	nd	nd	nd	nd	nd	134.18 \pm 0.84
Total anthocyanins	nd	nd	183.95 \pm 6.52	nd	103,686.48 \pm 542.11	nd	4598.70 \pm 119.73	8232.41 \pm 6.54 ^a	293.36 \pm 6.75
DPPH*	0.20 \pm 0.03 ^a	3.32 \pm 0.02 ^c	2.41 \pm 0.01 ^b	1.69 \pm 0.03 ^a	6.98 \pm 0.20 ^c	2.45 \pm 0.03 ^b	1.18 \pm 0.03 ^a	6.30 \pm 0.08 ^c	2.68 \pm 0.03 ^b
ABTS*	0.82 \pm 0.03 ^a	4.59 \pm 0.01 ^c	3.72 \pm 0.05 ^b	2.22 \pm 0.01 ^a	9.37 \pm 0.05 ^c	2.95 \pm 0.02 ^b	3.84 \pm 0.08 ^a	4.76 \pm 0.03 ^b	3.87 \pm 0.00 ^a

^{a,b,c}Different superscript letters in the same row and to the same part indicate statistically significant difference ($p < 0.05$)

nd not detected

*IC50 (g/100 mL): Effective Concentration of 50% radical inhibition

Flavonoids

Flavonoids were analyzed in all parts of different species of passion fruit, but the anthocyanins were analyzed only in seeds of all species of passion fruit, peel of purple passion fruit (because his color is purple) and pulp of orange passion fruit (because his color is red). In the other parts, we did not analyze because contains a negligible amount of these compounds.

The pulp of yellow passion fruit presented to be richer in quercetin and kaempferol than other species; for the peel, orange passion fruit showed more retention of kaempferol and for seed, only the species of yellow passion fruit detected this component.

Zeraik and Yariwake (2010) evaluated the total flavonoids, expressed as rutin and isoorientin in yellow passion fruit pulp (*Passiflora edulis* Sims f. *flavicarpa* Degener) and found 158.03 mg/L and 16.22 mg/L, respectively, suggesting that *P. edulis* fruits may be comparable with other flavonoid food sources such as orange juice or sugarcane juice.

Li et al. (2011) analyzed the flavonoid composition of *Passiflora edulis* 'edulis' and *Passiflora edulis* 'flavicarpa' more known as 'purple' and 'yellow.' The chromatograms revealed that the six major flavonoids obtained from *Passiflora edulis* 'flavicarpa' had not been detected in *Passiflora edulis* 'edulis' which suggested that the two populations are originally disparate and that the fruit color is closely correlated with some other variabilities of the species.

Silva et al. (2014) measured the content of yellow flavonoids in pulp and peel of yellow passion fruit (*Passiflora edulis* Sims). They found 60.37 and 43.08 mg/100 g (dry basis), respectively, different values when compared to our study, because they analyzed by spectrophotometry and us by high-performance liquid chromatography.

In another research realized by Septembre-Malaterre et al. (2016) in which the content of total flavonoid content in passion fruit pulp (*Passiflora edulis*) was investigated, the values found were: 70.10 mg quercetin equivalent/100 g. Our study found different values to yellow (506.45 mg/100 g), purple (229.79 mg/100 g) and orange (16.28 mg/100 g).

Consequently, these fruit residues and pulp of passion fruit analyzed in this study can be regarded as a natural source of flavonoids and the part (pulp, peel, seed) where the color will indicate the concentration and type of flavonoid present in this matrix.

Anthocyanins

A large variety of anthocyanins were found in each part of different species passion fruit. As expected, the peel of

purple passion fruit reveals a lot of anthocyanins, among them: cyanin, delphinidin-3,5-glucoside, cyanidin-3-glucoside, pelargonidin-3-glucoside, aglycone delphinidin (the majoritarian anthocyanin) and aglycone cyanidin. They were also found pelargonidin-3-glucoside in pulp of orange passion fruit (his color is red), aglycone cyanidin and aglycone delphinidin in seed of orange passion fruit and malvidin 3,5-diglucoside in seeds of yellow and purple passion fruit, which are the same species (*Passiflora edulis*), the purple showed higher content of this anthocyanin when compared to yellow passion fruit (Table 5).

As no data were found in the literature about the content of anthocyanins in purple passion fruit peel, we compared with fruits that have purple color in the peel. In a study realized by Todaro et al. (2009), delphinidin-3-rutinoside was extracted and identified as the major anthocyanin in eggplant peel (*Solanum melongena* var. *esculentum* peel). Leite-Legatti et al. (2012) analyzed the content of anthocyanins in jaboticaba peel (*Myrciaria jaboticaba*). They found delphinidin 3-glucoside and cyanidin 3-glucoside (634.75 and 1963.57 mg/100 g, respectively) as anthocyanins. Cyanidin-3-O-glucoside was the dominant anthocyanin with 75.6% of the total anthocyanins.

Our results indicate promising perspectives for the exploitation of pulps of passion fruit species and their residues with significant levels of bioactive substances mainly peels of purple passion fruit which is rich in several anthocyanins.

Antioxidant capacity

The DPPH radical has purple color and ABTS the green color. With the addition of the radical fruit extract, the DPPH and ABTS are reduced, presenting yellow color, with consequent disappearance of absorption. From the results, it determines the percentage of antioxidant activity and scavenging of free radicals.

In the antioxidant capacity, pulp, peel and seed of yellow passion fruit has a greater power to scavenge the free radicals DPPH and ABTS (Table 5), which means that this fruit has a higher antioxidant capacity when compared to purple and orange passion fruit, except for seeds of yellow and orange passion fruit in ABTS analysis that no significant difference was detected.

Souza et al. (2012) evaluated the antioxidant capacity of different fruit, and they concluded that the smallest antioxidant capacity was observed in the jenipapo pulps, followed by sweet passion fruit, soursop, murici and marolo.

López-Vargas et al. (2013) also evaluated the antioxidant capacity DPPH in pulp and seed and albedo of yellow passion fruit (*Passiflora edulis* Sims fo. *flavicarpa*). They concluded that the albedo showed a higher ability to inhibit

DPPH radical than the pulp and seed samples. Our study showed different results because we had higher antioxidant capacity in pulps compared with the peels, mainly due to the presence of high concentrations of β -carotene, lycopene, and quercetin in pulps.

Septembre-Malaterre et al. (2016) concluded that the highest antioxidant capacity was found in passion fruit (*Passiflora edulis*) pulp (64% of DPPH reduced) when compared to other fruits including mango, pineapple, banana, and litchi exerted lower free radical-scavenging activities (45–58%). In agreement with data of DPPH assays, passion fruit exercised the highest free radical scavenging capacity too through oxygen radical absorbance capacity (ORAC) (14.08 μ M Trolox equivalent).

The antioxidant properties of yellow, purple and orange passion fruit are not affected by phenolic compounds by the Pearson's Correlation analysis. So, the antioxidant capacity measured in passion fruit samples is certainly related to the content of carotenoids and anthocyanins of these samples, mainly in the content of lycopene (as can be seen in the Fig. 1c).

Conclusion

This research showed that pulp of passion fruit and its residues as peels and seeds have a significant content of bioactive compounds, differing in type according to the species examined, as example, peel of purple passion fruit has more anthocyanins; pulp of orange passion fruit present a good source of lycopene and his peels a large content of β -carotene and phenolic compounds; the pulp of yellow passion fruit present more content of quercetin and antioxidant capacity ABTS and DPPH. These residues can be added to formulations that can enrich the foods and have therapeutic effects to the human health and too reduce the waste promoting a positive environmental and economic impact.

Acknowledgments The authors are grateful to the Brazilian Research Agency (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—CAPES) for their financial support.

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