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PHYSICOCHEMICAL CHARACTERIZATION AND BIOACTIVE POTENTIAL OF *Momordica Charantia* L

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ABSTRACT

Interest has grown to evaluate the use of underutilized plants, and plant by-products as sources of food ingredients to ameliorate the food security problem in the world. In this context, the aim of this work was to describe and quantify the main nutritional and bioactive compounds present in an unconventional and underutilized food fruit (*Momordica charantia*) found in southern Brazil. The physicochemical analyzes and antioxidant activity of peel and pulp fruit were performed. The fruits showed high fiber (18.59%) and carotenoid (267.00 µg g^{-1}) content in the peel, and high protein (17.84%), carotenoid (278.87 µg g^{-1}) and phenolic compounds (69.02 mg GAE g^{-1}) content in the pulp. The main identified sugar in both pulp and peel, were the fructose and glucose, being in greater quantity in the pulp. Through the analysis of antioxidant capacity by FRAP and ABTS methods it was found that the peel has greater antioxidant capacity than melon pulp. Based on this study, it is concluded that São Caetano melon is an unconventional food product with high potential for nutritional and technological exploitation.

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INTRODUCTION

Brazil is one of the most biodiversity countries in the world, with a large number of plants with domestic populations, there are over 3,000 potential food plant species still underexplored in Brazil, many of them being native species. However, the consumption of these plants has increased, it still fails to contribute to the country's agricultural development (de Souza Araújo & de Souza, 2019; Otero & Ferreira-Ribeiro, 2019). These species, which are rarely used or even totally unknown, are known as Unconventional Food Plants (UFP). These plants have arousing great interest among consumers who are increasingly seeking for foods based on natural products and also due to a market for modern gastronomy (gourmet). UFPs are characterized by having one or more parts with food potential, which have a limited consumption or are not used by the majority of the population (Kinupp & Lorenzi, 2014). In recent years, researchers have intensified their search for lesser-known crops in nature and not sold in supermarkets, many of which are important nutritional sources, and often functional, due to bioactive compounds and antioxidant capacity. In addition to the potential as human and animal food, they stand out for strengthening family farming, especially in tropical and subtropical regions of the world (Nkafamiya *et al.,* 2010). The melon of Sao Caetano (*Momordica charantia*) or bitter gourd, belonging to the family Cucurbitaceae has yellow colored berries with golden fruits which contain inside seeds surrounded by a film (pulp) (Islam & Jalaluddi, 2019; Yan *et al.,* 2019). This fruit is rich in and some proteins, phenolic compounds, which are attributed its antioxidant and medicinal properties, flavonoids, essential oils, fatty acids, amino acids, sterols and saponins constituents, which also exert antioxidant activity (Dandawate *et al.,* 2016; Tan & Gan., 2016; Jia *et al.,* 2019). Considering the lack of information about the Melon of Sao Caetano produced in southern of Brazil, the present study aimed to perform the physico-chemical characterization of the fruit, as well as the determination of the main bioactive compounds of the pulp and peel.

MATERIAL AND METHODS

Fruits: The melons of São Caetano (*Momordica charantia* L.) were purchased at a farm located in Cerrito Alegre, 3rd District of the municipality of Pelotas-RS (31º31'16.9 "S and 52º23'21.8" W). After harvesting, the fruits were selected and the sizes of each fruit (width and length) were determined through the use of a pachymeter. After they were sanitized and manually separated the pulp and peel. The samples were stored separately in ultra-freezer at -80 °C until the analyzes were performed.

Physical and chemical analyzes: The protein determination was conducted by digestion, distillation and titration steps, pH was determined in bench pH meter, titratable acidity was determined by potentiometric volumetry, moisture in oven at 105 °C, ash content was determined incinerated in muffle at 550 °C, fiber by gravimetric, the total soluble solids content was obtained by measuring the refractive index in Abbé refractometer (AOAC, 2012) and lipids concentration were determined by Bligh-Dyer (1959). The total content of carbohydrates (CH) was determined by difference: Total CH% = 100 - [% moisture +% ash +% lipids +% protein +% fibers]. All results of the analysis of proximate composition were expressed on a wet basis. The energy value was calculated from the levels of proteins, lipids and carbohydrates, using the specific coefficients that take into account the combustion heat 4,0; 9.0 and 4.0 Kcal, respectively. The content of vitamin C was determined by the method described by Otero *et al.,* (2020). For this, fruit juice was extracted, filtered and the quantification of ascorbic acid (vitamin C) was performed by titration, using standard solution of iodine and sodium thiosulphate and starch solution as indicator. The results were determined by equation 1, expressing the results in mg of ascorbic acid 100 mL^{-1} of juice.

$$Vit\ C = (V1\ x\ F1) - (V2\ X\ F2) \quad (1)$$

Where: V1= Volume of iodine spent in titration; V2 = Volume of thiosulfate spent in the titration; F = solution correction factor.

The color was evaluated objectively by the color space reflectance, using Minolta CR-300 colorimeter, with standard D65 illuminant and observation angle of 2 ° (Hunterlab, 1996). The readings were obtained in five distinct positions, such that practically the entire surface of the fruit was sampled. The mean of the readings was used for the statistical analysis. The electrical conductivity was measured at 20 ºC in a previously calibrated conductivity meter (HANNA INSTRUMENTS HI 98311), according to the methodology described by Dias, Pereira & Estevinho (2012). The results were expressed in milli Siemens per centimeter (mS cm^{-1}).

Sugars profile: For the quantification of individual sugars, 1 g of sample was used and 10 mL of 80% ethanol was added. The reaction occurred at 40 °C for 30 minutes. The supernatant was then removed and 10 mL of ethanol was added to the precipitate, and held for another 30 minutes in a water bath at 40 ° C. The supernatant was added to the other supernatant and centrifuged at 7000 rpm for 15 minutes. The material was taken to the rotavaporator at 50 ° C and filtered with filter paper. The plates were oven dried at 30 ° C, raised to 5 mL with acetonitrile: water (70:30) and 30 µL was injected into the HPLC. A system of high-performance liquid chromatography (HPLC Series 10, Shimadzu, Kyoto, Japan) was used. The chromatographic system consisted of a pump (LC-10 AT VP) with quaternary solvent (FCV-10AL VP), controlled by interface (SCL-10A VP) and degassing module (DGU-14A). The mobile phase used was a 75:25 (v / v) acetonitrile: water mixture at the 1.0 mL min^{-1} flow rate using a Shim-pack CLC-NH2 (M) (4.6 x 250 mm, 5 µm, Shimadzu), maintained at 30 °C (CTO-10AS VP). Detection was performed by refractive index detector (RID-10A, Shimadzu). Acquisition data and integration of peaks was performed using Class-VP software. Identification was done based on the retention times and addition of patterns to the sample. The quantification was done by external standardization using analytical calibration curves constructed from the areas of the chromatographic peaks, using 6 concentrations of the mixture of the standards. The calibration curves were linear (coefficient of determination $R^2 \geq 0.99$, for $p < 0.001$), in concentration intervals (dynamic working ranges) of 0.25 to 2.50% (m / v) for fructose, glucose and sucrose. The total sugar concentration was obtained by adding the individual areas of each peak of the chromatographic run. The results were expressed as g $100g^{-1}$ of dry matter (Caldas, 2015).

Fatty acid profile: To determine the fatty acid profile in melon, 20 g of sample were dried in an oven for about two hours (60 ºC). After the excess moisture was removed, fat determination (Bligh-Dyer, 1959) was performed. The solvent was evaporated in a water bath, and then the derivatization step of the sample was carried out according to Zambiazi, 1997. An aliquot of the n-hexane phase, which contained the fatty acid methyl esters, was placed in the vial for injection in a Perkin Elmer Clarus 500 gas chromatograph equipped with a FID detector and a Carbowax20 M ID 0,25 µm column with dimensions 30 mx 0.25 mm, coated with polyethylene glycol. The initial temperature of the column was 90 °C, maintained for 1.0 minutes, with a linear increase of 12 °C per minute until 160 °C, maintained for 3.5 minutes, followed by linear increase of 1.2 °C per minute until 190 ºC, occurring then linear increment of 15 ºC per minute until 230 ºC, which was maintained for 15 minutes. The injector was maintained at 230 ºC and the detector at 250 ºC. Nitrogen was used as carrier at 1.5 mL min^{-1} (ZAMBIAZI, 1997). Fatty acids were identified by comparison with the retention times of the methyl esters mixture of caproic, caprylic, caproleic, caproleic, lauric, dodecenoic, myristic, myristoleic, palmitic, palmitoleic, margicoic, heptadecenoic, stearic, oleic, linoleic, linolenic acids, arachidonic, gadoleic, eicosadienoic, eicosatrienoic, tetraenoic, lignoceric and nerve (Sigma Chemicals Co., St. Louis, USA). The results were expressed as relative percentage of fatty acids.

Determination of bioactive compounds

Preparation of the aqueous extract: The melon extracts were prepared as described by Tan et al. (2015), with few modifications. Three g of the peel and 3 g of the pulp of the São Caetano melon were used separately in 20 mL of water and extraction for 1 h at 45°C using stirring. The extracts were then centrifuged at 4350 xg for 10 min at 10 ° C, and the supernatant from each sample was filtered on filter paper. The final extract was used for the analysis of phenolic compounds, flavonoids and antioxidant activities. All extractions were performed in triplicate.

Assay of phenolic compounds content: For the determination of phenolic compounds in the melon, the Folin-Ciocalteu

method (Kubola & Siriamornpun, 2008) was used. 0.5 mL of the samples were collected and then mixed with 2.5 mL of 0.2 N reagent and after 5 minutes 2 mL of sodium carbonate solution (7.5%) was added. After incubation at room temperature in the dark for 2 h, the absorvance was measured at 725 nm in a spectrophotometer (JENWAY 6705 UV / Vis). The standard curve with gallic acid at concentrations of 30 to 500 µg mL^{-1} was used as the calibration curve. The results were expressed in mg equivalent of gallic acid per g (mg GAE g^{-1}) of dry matter.

Assay of flavonoids content: The total flavonoid content was determined using the Funari and Ferro (2006) adapted method, where 500 µl of 2% aluminum chloride in methanol were mixed with the same volume of the sample solution (100 µL of extract for 50 mL of distilled water). The reading was made at 425 nm, the total flavonoid content being determined using a standard quercetin curve. The results were expressed as milligram equivalents of quercetin per grams (mg QE g^{-1}) of dry matter.

Assay of carotenoids content: The total carotenoid content was determined according to the methodology described by Rodriguez-Amaya (2001). The readings were performed at the absorbances of 450 nm (β-carotene), 445 nm (α-carotene), 449 nm (zeaxanthin) and 470 nm (lycopene). Quantifications were performed through Equation 2 and the results expressed in micrograms per grams (µg g^{-1}) of dry matter.

$$Carotenoids = \frac{absorvance\ x\ extract\ volume\ (mL) x\ 10^6}{absorportion\ coef ficient\ x\ 100\ x\ sample\ weight\ (g)} \quad (2)$$

***Assay of tocopherols contents*:** For the extraction of tocopherols, the methodology adapted from Rodriguez-Amaya (1999) was used. The extract was transferred to eppendorf tubes, which were centrifuged at 9000 rpm for 6 min. The supernatant was used for the evaluation of tocopherols by liquid chromatography, injecting 20 µL into the liquid chromatograph consisting of the HPLC-Shimadzu system, equipped with automatic injector and fluorescence detector, with excitation and emission wavelengths 290 and 330 nm, respectively. The separation was carried out in RP-18 reverse phase column (5 µm x 4.6 mm x 150 mm) with octadecyl stationary phase, operating at 25 °C with flow of 1.0 mL min^{-1}. The separation was carried out using a gradient elution system, using as mobile phase methanol, acetonitrile and methanol, following the methodology adapted from Zambiazi (1997). Compounds quantification was performed through the peak areas for each retention time (RT) of standards: delta (6.5 min), gamma (7.4 min) and alpha (8.3 min). The results were expressed in micrograms per 100 grams (µg $100g^{-1}$) of dry matter.

Antioxidant capacity

Antioxidant capacity by FRAP (Iron reducing capacity): The FRAP ferric reducing antioxidant power was determined according to the method described by Silva et al. (2014). 100 µL of the aqueous melon extract at 1 mg mL^{-1} concentration in 300 µL of ultra pure water was mixed, then 3.0 mL of the FRAP reagent was added, homogenized in a tube shaker and kept in a bath -marine at 37 °C for 30 minutes. The reduction of the Fe^{3+} to Fe^{2+} complex was obtained by reading the wavelength absorvance at 595 nm in a spectrophotometer (JENWAY 6705 UV / Vis.). The procedure was carried out in triplicate and the values of Fe^{+2} found by means of the linear regression equation, through the construction of the analytical curve of the ferrous sulphate.

Antioxidant capacity by ABTS cations (2,2'-azino-bis (3-ethylbenzthiazoline-6-sulfonic acid))

The antioxidant activity determined by the ability of the compounds present in the samples to sequester the radical ABTS (2,2'-azino-bis (3-ethylbenzthiazoline-6-sulfonic acid)) was determined according to Re et al. (1999). For the quantification of the antioxidant activity, 100 µL of the sample extract was added to 3.9 mL of ABTS solution, then the mixture was homogenized using Ultra-Turrax. The sample was readed in UV / Visible Ultrospec 2,000 spectrophotometer (Pharmacia Biotech) after 6 min of reaction, at a wavelength of 734 nm. The free radical scavenging activity was determined by comparison with a standard Trolox (5,7,8-tetramethylchromane-2-carboxylic acid) curve, and the results expressed in µmol TEAC g^{-1} sample, the antioxidant capacity being equivalent to Trolox relative

Statistical analysis: The data was expressed as means ± standard deviation, and all analyzes were performed in triplicate, and then submitted to analysis of variance (ANOVA) using SAS 9.1 (Cary, NC). The Fischer test (LSD) ($p \leq 0.05$) was used to compare the results of the melon parts with regard to physico chemical composition, bioactive compounds, sugar content and antioxidant activity.

RESULTS AND DISCUSSION

Physical and chemical analyzes: The results of the physico-chemical characterization of the fruits of *Momordica charantia L* are presented in Table 1. The moisture content of the melon was 95.30% in peel and 88.74% in pulp. These values were closed to those described by Islam et al. (2011), between 92.4 to 93.5% in the peel and from 53.3 to 75.9% in the pulp for melons. It was observed the highest lipids (4.77%), soluble solids (11.75%) and proteins (17.84%) content in the melon pulp. According to Dandawate et al (2016) the crude protein content of bitter gourd is higher than very foods (egg, tomato, cucumber). The opposite was found for ashes (15.54%), fiber (18.59%) and acidity (0.19%) content, with the majority being in the peel. Yuwai et al. (1991) evaluated the chemical composition of bitter melon and found moisture content of 93.20%, and protein of 18.02%, results very close to those described in the present study; however, the lipid content reported was much lower (0.76%). Fruit coloring is an important attribute of quality, not only because it contributes to good appearance, but also because it influences consumer preference. During ripening, most fruits undergo changes in color, especially in the peel. Thus, color becomes an important attribute in determining the stage of maturity of fruits (Motta *et al.,* 2015). Melon peel presented a mean luminosity of 44.80, while for pulp it was 28.19, indicating that the pulp is darker than the peel, since the parameter L ranges from 0 (black) to 100 (white). The chromacity (C *) was higher in the pulp (48.85) than in the peel (39.73), indicating that the pulp showed a more intense coloration when compared to the peel. The values angle (H *) were similar in the peel and in the pulp, in general the fruits presented values between 88 and 95, both in the peel and in the pulp, which characterize the yellowish coloration.

Table 1. Physico-chemical composition of the peel and pulp of the São Caetano

Analyzes	Peel	Pulp
Moisture (%)	95.30±0.46[a]	88.74±0.46[b]
Ashes (%)	3.07±0.11[a]	3.05±0.05[a]
Lipids (%)	1.55±0.70[b]	4.77±0.75[a]
Proteins (%)	0.89±0.66[b]	2.01±0.41[a]
Carbohydrates (%)**	0.1±0.0[b]	0.8±0.30[a]
Fibers (%)	1.08±0.21[a]	0.63±0.15[b]
Calorific value (Kcal)	17.91	54.17
Vitamin C (mg acid ascorbic 100g^{-1})	1.52±0.36[b]	9.55±0.85[a]
Total Soluble Solids (TSS) (ºBrix)	4.50±0.71[b]	11.75±0.35[a]
Titratable Acidity (TA) (mg ac.	0.19±0.003[a]	0.16±0.02[b]
citric 100g^{-1})	23.01±2.23[b]	73.32±1.57[a]
Ratio (TSS/TA)	5.67±0.01[a]	6.22±0.04[a]
pH	372.33±0.31[a]	263.33±0.1[b]
Condutivity (µS)		
Color parameters		
L*	44.80±1.55[a]	28.19±0.76[b]
a*	11.06±0.86[b]	41.01±4.47[a]
b*	38.26±1.49[a]	26.52±3.48[b]
C*	39.73±1.44[b]	48.85± 5.56[a]
H*	89.67±0.002[a]	89.68±0.003[a]
Dimensions		
Diameter	4.73±0.47[a]	0.7±0.09[b]
Length	10.78±1.58[a]	1.4 ± 0.12[b]

Means accompanied by the same letter on the same line do not differ among themselves by Fischer's test (p≤0,05). ** Estimated by difference (100%).

Table 2. Determination of bioactive compounds from the peel and pulp of the São Caetano melon

Bioactive compounds	Peel	Pulp
Phenolic compounds (mg GAE g^{-1})	41.03±4.65[b]	69.02±4.30[a]
Flavonoids (mg QE g^{-1})	1.47±0.14[a]	0.71±0.04[b]
Carotenoids (µg g^{-1})	267.00±9.34[b]	278.87±0.60[a]
δ- tocoferol (µg 100g^{-1})	17.8±1.34[b]	21.2±0.81[a]
γ-tocopherol (µg 100g^{-1})	8.80±1.30[b]	10.0±0.64[a]
α-tocopherol (µg 100g^{-1})	7.20±1.42	

Means accompanied by the same letter on the same line do not differ among themselves by Fischer's test (p≤0,05)

The low values of a * (11.06) and high values of b * (38.26) characterize the yellow color of the peel, and the opposite it was observed in the pulp, which indicates the reddish coloration. The ratio is used as a parameter to define the flavor, also considered an indicator of maturity or fruit quality. The fruit had a mean ratio of 23.01 in the peel and 73.32 in the pulp, due to the high soluble solids present in the pulp (11.75) when compared to the peel (4.5 º Brix). The pH and titratable acidity showed that melon is a fruit with low acidity. For both the peel and pulp the acidity and pH parameters were related to each other, since for the peel the pH was 5.76 and acidity was 0.19, while for the pulp the pH was 6.22 and acidity of 0.16. In a study carried out by Assis et al. (2015), which evaluated the biometry of the São Caetano melon obtained in the state of Rio Grande do Norte, found average lengths and diameters of 6.88 and 5.51 cm, respectively.

The fruits analysed in the present study presented larger sizes when compared to the literature, since the average for diameter was 4.73 cm and the length of 10.78 cm. Conductivity indicates the facility with which a material is capable of conducting electric current, characterizing ionic dissociation through a potential difference. Therefore, the conductivity values are directly proportional to the concentration of dissolved ions (Rezende, 2010). The melon peel showed an electrical conductivity of 372.33 µS while that of the pulp was 263.33 µS, indicating a higher concentration of ions in the melon peel.

Table 3. Composition of sugars in the peel and pulp of the São Caetano melon, identified by Liquid Chromatography (HPLC)

Sugars (g 100g-1)*	Peel	Pulp
Fructose	2.50±0.24b	81.10±0.30a
Glucose	3.21±0.44b	15.23±1.38a
Sucrose	0.80±0.006b	2.24±0.24a
Raffinose	0.00±0.00b	0.14±0.02a
Estequiose	0.41±0.015a	0.00±0,00b

Means followed by the same letter on the same line do not differ from each other by the Fischer test (p<0.05). * Results expressed as dry basis.

Table 4. Fatty acids of the of the São Caetano melon

Fatt Acids	Percentual (%)
Palmitic acid (C16)	22.16±0.11
Palmitoleic acid (C16: 1)	2.87±0.30
Stearic Acid (C18)	4.56±0.50
Oleic acid (C18: 1)	19.65±1.14
Linoleic acid (C18: 2)	7.20±0.70
Linolenic Acid (C18: 3)	6.77±2.80
Heneicosanoic acid (C21)	25.43±1.20
Tricosanoic acid (C23)	2.26±1.10
Total saturated	67.58±0.87
Total unsaturated	32.45±0.87

Determination of the type of sugar present in the sample may indicate the quality of the fruit. The sugars identified in the peel and pulp of the São Caetano melon are presented in Table 3. Through the high-performance liquid chromatography, it was possible to identify that the pulp presented higher content of fructose, glucose, sucrose and raffinose when compared to the contents of the peel. Since the pulp is sweeter on the palate, this higher concentration of sugars was expected. The melon pulp presented fructose as main sugar, which accounted for about 81% of the total sugars in the pulp. The peel presented glucose as the major sugar (3.21 g 100g^{-1}), making up about 46% of the total sugar content of the peel. The content of monosaccharides was the majority in both pulp (97.65%) and peel (82.37%). The raffinose trisaccharide (0.14 g 100g^{-1}) was only identified in the pulp, whereas the tetrasaccharide stechiosis (0.41 g 100g^{-1}) was only detected in the peel. Melon bark showed about 33% of unsaturated fatty acids (Table 4), among which oleic acid (C18:1) is in the highest concentration (19.6%), among the saturated fatty acids found (67%), the heneicosanoic (C21) and palmitic acids (C16) presented prevalence (22 and 25% respectively). The oleic acid is called the essential fatty acids (EFA) as they provide nutrition to the human body. Among the fatty acids, oleic acid is considered most important fatty acid particularly during gestation-lactation period, it is naturally occurring and is classified as a mono-unsaturated omega-9 fatty acid. It is the most common monounsaturated omega fatty acid in human cells incorporated into cell membrane phospholipids, where it is important for proper membrane fluidity and is also a major source of energy for cells (Chaliha *et al.,* 2020).

Bioactive compounds: Carotenoids, liposoluble pigments, can also act as natural antioxidants, protecting the cells against reactive oxygen species and free radicals, by the absorption of energy due to the system of conjugated double bonds present in its structure (Quirós & Costa, 2006; Limon *et al.,* 2015). Among the bioactive compounds evaluated, it was observed that the pulp had a higher content of phenolic compounds and carotenoids when compared to the contents in the peel. The content of the bioactive compounds is shown in Table 2. More than 60% of the phenolic compounds were found in the melon pulp. Phenolic compounds are important constituents of many

fruits, and the quantification of these compounds reveals information about antioxidant activity, food quality and beneficial health potentials (Talcott *et al.,* 2003). Kevers et al. (2007) observed average values of phenolic compounds (0.070g $100g^{-1}$ of fresh pulp) for *Charentais* melons commercialized in Belgium. In a study carried out by Miguel (2008), phenol contents ranged from 0.036 to 0.051 g of gallic acid 100^{-1} g for yellow melon. Horax, Hettiarachchy & Chen (2010) determined the content of phenolic compounds in the peel and pulp of bitter gourd which results were lower than (42.03 mg GAE.g^{-1} in peel and 69.02 mg GAE g^{-1} in pulp) those described in our work (42.03 mg AE.g^{-1} in peel and 69.02 mg GAE g^{-1} in pulp). According to Wu and Ng (2007) *Momordica charantia* from Taiwan has a significant concentration of total phenol content (68.8 mg g^{-1}), these results are in agreement with the concentration of phenolic compounds found in the melon of southern Brazil. The pulp also had higher carotenoid content (278.87 µg g^{-1}) than peel (267.00 g g $^{-1}$). Once the peel showed a greenish yellow coloration and the flesh an intense red color, these results were already expected. On the other hand, melon peel had a higher content of flavonoids (1.47mg QE g^{-1}) when compared to pulp (0.71 mg QE g^{-1}), although this content was relatively low in both. Therefore, it can be predicted that the major classes of phenolic compounds present could be phenolic acids or tannic compounds. The tocopherol (vitamin E) levels found in this study varied according to the part of the fruit analyzed, being the total of 33.8 µg $100g^{-1}$ and 31.2 µg $100g^{-1}$ in the peel. In both parts of the fruit analyzed, δ-tocopherol was the major tocopherol.

It is observed that the bioactive compounds were in higher concentration in the pulp (mainly phenolic compounds and carotenoids) when compared to the peel that has greater concentration of flavonoids, vitamin C and α- tocopherol. In turn, the peel presented greater antioxidant capacity than the pulp, this may have occurred due to a higher inference of flavonoids, vitamin C and α- tocopherol or due to some compounds that may be present and have not been evaluated as tannins, saponins, among others. Although there are reports of the antioxidant activity of the São Caetano melon being attributed to the phenolic compounds content (Tan *et al.,* 2015), in the present study, although fruit peel presented lower phenolic content than pulp, and its antioxidant activity still remained superior. However, in the work of Kenny et al. (2013), the antioxidant activity of the aqueous extracts was also not linked to the phenolic content. The authors justified these differences because they did not heated in the extraction, besides the differences of origin of the fruit, as well as soil type and a series of climatic factors (temperature, humidity, sunlight etc.). However, when analyzed specifically the class of flavonoids, the peel presented higher results than those found in the pulp.

Antioxidant capacity

Three methodologies (ABTS and FRAP) were used in order to determine the antioxidant capacity of the peel and pulp of *Momocardia charantia L* (Figure 1). In spite of the antioxidant capacity of the peel and the pulp, it is observed that, regardless of the methodology used, the peel presented higher antioxidant activity, which can be related to the highest content of natural antioxidants, such as tocopherols and carotenoids, with β-carotene being the compound with the highest concentration in the peel (Table 3). However, the pulp presented the highest content of phenolic compounds, which may contribute to the antioxidant activity in the pulp, since phenolic compounds play a key role in the prevention of oxidation. The external aggressions suffered by the fruit, which occur mainly in the peel, activate the synthesis of compounds that play essential functions in the survival of the plant, which makes these compounds agents of defense against herbivores and pathogens (Gould & Lister, 2005). Moreira (2009) relates values of antioxidant capacity in Cantaloupe melon ranging from 0.395 to 0.459 µM TE g^{-1} of fresh pulp. By the FRAP method the value found was 889.91 mmol Trolox.g^{-1}, about two times higher than that of the pulp (436.46 mmol Trolox g^{-1}). The FRAP (Ferric Reducing Antioxidant Power) method is widely used to measure the antioxidant capacity of fruits. In the determination by ABTS the peel presented more than twice (2.95 mmol Trolox.g^{-1}) of the antioxidant capacity when compared to the pulp (1.29 mmol Trolox.g^{-1}).

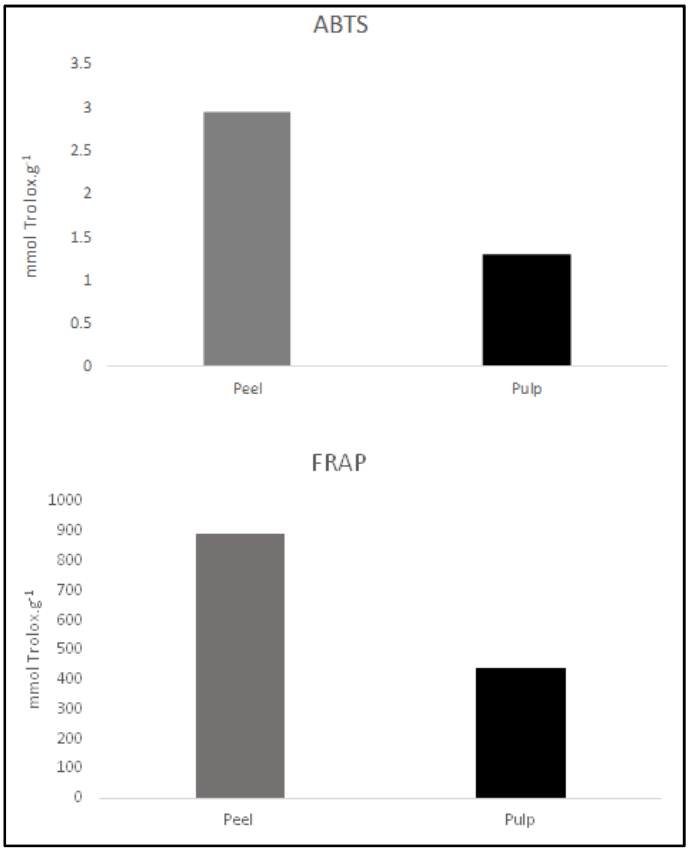

Figure 1. Antioxidant capacity of São Caetano melon pulp and peel evaluated by ABTS and FRAP

The results of the antioxidant capacity by the FRAP method were about 400 times higher than those found for ABTS, indicating that for this type of sample the FRAP is able to interact with more compounds present in the fruit and thus measure a greater antioxidant capacity. The methods used to determine the antioxidant activity of fruits, when applied alone, may not provide safe results, mainly due to the complexity of compounds with antioxidant capacity present in these vegetables. Due to the different types of radicals and the different sites of action, there is hardly a single method capable of representing in a safe and precise way the true antioxidant activity of a substance (Frankel & Mayer, 2000). Meanwhile, a study by Semiz & Sem (2007) concluded that the use of hexanic extract of São Caetano melon was able to induce a positive antioxidant effect on hepatotoxic rats. Rats receiving a positive dose of extract showed increased activity

of antioxidant enzymes, reducing several glutathione S-transferases and inhibiting cytochrome P450 oxidase (CYP) isoforms. However, this procedure does not extract a large amount of phenolics due to its low polarity, evidencing that there are other compounds present in this fruit that are also responsible for high antioxidant activity.

Conclusions

Based on the results it is possible to identify the São Caetano melon as a fruit with bioactive potential, being an unconventional food, since it presented high protein content, both in the peel and in the pulp; besides high fiber content, mainly in the shell. The peel is rich in vitamins, minerals and fibers, while pulp has higher concentration of carotenoids, phenolic compounds, vitamin C and sugars. The extracts of different fractions showed different levels of antioxidant activity in the tested systems. The peel presented higher antioxidant capacity when compared to pulp, based on the ferric reducing power. Thus, the fruit of *Momordica charantia L* deserves to be highlighted and more studies aiming to obtain more information on it is chemical composition, with the purpose of future food applications, can be a food to combat a food security problem.

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