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PHYSICOCHEMICAL CHARACTERISTICS OF RED PITAYA IN TWO REGIONS OF THE MATO GROSSO DO SUL STATE, BRAZIL

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ABSTRACT

The pink pitaya with red pulp(*Hylocereus spp.*) is spreading in the Brazilian markets for its exotic characteristics and nutritional value; however, there is still not enough reports about its postharvest characteristics. The aim of this research was to characterize physical and chemical features and nutritional values of postharvest pitayas. The fruits were collected in two different regions of Mato Grosso do Sul State, Brazil, and these samples were subjected to the following evaluations: length, diameter, freshmatter, moisture content, fixed mineral residue; soluble solids, pH, titratable acidity, carbohydrate, protein, lipids, total phenolic compounds, tannins ;and total antioxidants. Pitaya has low lipid and protein levels, with high water contents (86-89%) and carbohydrates being the highest macronutrient value present in the fruit. The soluble solids content (°Brix 14,9) and the low titratable acidity suggests that the fruit is a good option of *in natura*consumption. Bioactiveswere more present in the pulp than in the peel, except in tannins contents. Pitaya can be classified as a functional food, thus acting in the prevention of diseases, because it contains compounds that fight free radicals.

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INTRODUCTION

Pitaya *(Hylocereus spp.)* is an exotic fruit, originated from America, that belongs to the Cactaceae family. In Brazil, the growing demand for exotic fruits and their high added value arouse the interest of commercialization of Pitaya, with the Southeast region being the major producer (Bastos *et al*., 2006). Between 2007 and 2012 there was an increase in production from 81 to 299 tons / year, corresponding to more than 250% in the marketing of pitaya at the Company of General Warehouses of the State of São Paulo (CEAGESP) with greater demand from December to April (Watanabe and Oliveira, 2014). Because of its appearance and shape is commonly known as dragon fruit. It is found in countries such as Costa Rica, Venezuela, Panama, Uruguay, Brazil, Colombia and Mexico, being the two-last cited, the largest world producers (Canto *et al*., 1993). Currently, the main commercial Pitaya species are the white-fleshed red pitaya (*Hylocereusundatus* (Haw.) Britton & Rose) and the white-fleshed yellow pitaya (*Selenicereusmegalanthus* (K Schum ex Vaupel) (Nerd *et al*., 2002). Pitaya is harvested between December to April and its fruits develop at temperatures between 18ºC and 26ºC. Although its species are usually cultivated in a dry tropical climate (Junqueira *et al*., 2002) and are influenced directly by rainy periods, they can adapt to different types of climates (Donadio, 2009). There is a diversity of characteristics between the species such as: shape, presence of thorns, color of the peel and the pulp, as well as its pH and soluble solids content. In general, pitaya has a sweet and mild flavor, a firm pulp, being sources of vitamins and minerals, attracting consumer interest (Cordeiro *et al*., 2015).

Red Pitaya is pointed out as a functional food due to the presence of phenolic compounds, mainly betalains, that have considerable antioxidant activity, and also can be used as natural source for food pigments. Thus, being associated with the prevention of diseases such as cancer and to reduced risk of mortality from cardiovascular diseases (Stintzing *et al*., 2004; Vaillant *et al*., 2005; Herbach *et al*., 2006; Wu *et al*., 2006). In addition to the betalains, the Pitaya pulp is also composed by other antioxidants such as flavonoids (Stintzing *et al*., 2004), oligosaccharides with prebiotic properties (Escribano *et al*., 2002), soluble fibers that can assist the digestive process, also associated with the regulation of sugar blood levels in patients with type 2 diabetes (Zainoldin and Baba, 2009). The seeds are small and soft, and well distributed by the pulp, constituting 1-2% of the fruit. The pitaya seeds oil is rich in essential fatty acids, especially linoleic acid, that can present a mild laxative function (Crane and Balerdi, 2005), also contributing to the decrease of LDL cholesterol (low density lipoprotein), by inhibiting the absorption of cholesterol in the intestine (Sato *et al*., 2014). Although the Pitaya consumption has been growing worldwide, there is still a lack of sufficient database of the chemical composition of this potentially nutritive fruit, especially regarding the red pitaya (*Hylocereus spp*). Based on this, the objective of this study was to evaluate the physical and chemical differences of the red pitaya pulp and peel between two different regions in the Mato Grosso do Sul State.

MATERIALS AND METHODS

Collection of the fruits: Pitaya's fruits were collected in two different regions of the Mato Grosso do Sul State, in the cities of Campo Grande and Ponta Porã. The chemical analyzes were carried out at the Food Technology and Public Health Unit (UTASP) located at the Federal University of Mato Grosso do Sul (UFMS) in Campo Grande, MS. One kilogram of fruits was collected from each location, properly cleaned with a 1% hypochlorite solution for 15 minutes, and subsequently rinsed under water to eliminate chlorine residues. Physicalmeasurements were performed, and diameter, weight of the total fruit mass, weight of the pulp and peel were obtained.

Longitudinal and transversal diameter and fresh weight: The total mass of the fruit, peel, pulp, total length and total diameter were determined using the methodology of Lima (2013). The fruits were weighted on a semi-analytical scale, and the diameter was measured with the aid of a pachymeter.

Titratable acidity, soluble solids and pH: The soluble solids content was determined with the aid of a portable refractometer (Brasil, 2005). The total titratable acidity was performed in the pulp and peel of the crushed and homogenized fruit by titration with 0.10 M NaOH solution until a pH 8.1. This experiment was performed with constant monitorization of a pHmeter and the results expressed in g / 100g of citric acid (% m / v).

Centesimal composition and caloric value of the fruit: The compounds of moisture, protein, carbohydrates, lipids and fixed mineral residue were determined in the pulp and peel crushed and homogenized according to the methodologies of the Adolfo Lutz Institute (Brasil, 2005) and AOAC (2002). The carbohydrate content was measured by difference. The caloric value was calculated by the protein, carbohydrate and lipid content of the samples, using the Atwater factors, described by Mahan and Escott-Stumo(2005). The results were expressed in kilocalories (kcal), according to the following equation:

Calories value (kcal) = (protein content x 4.0) + (carbohydrate content x 4.0) + (lipid content x 9.0)
% Carbohydrates = 100 - (% moisture +% fixed mineral residue +% proteins +% lipids)

Antioxidant activity: The antioxidant activity was determined by spectrophotometry in the visible region (λ = 517 nm) using the DPPH radical sequestration method (2,2 diphenyl-1-picrilhidrazil) with modifications from Rufino *et al*.(2007). The results were expressed using the following equation, where % SRL = percentage of free radical scavenging; Ac = absorbance of the control; Ae = absorbance of the extract:
% SRL = (Ac – Ae) x100/Ac

Total phenolic compounds: The phenolic compounds were dosed with spectrophotometry in the visible region (λ = 760 nm) as proposedby Waterhouse (2002), using the Folin-Ciocalteureagent. The results were expressed in mg of gallic acid equivalent (GAE) per 100g of pulp or peel.

Tannins: The tannins were extracted and its quantification was performed by the colorimetric method of Folin- Denis nº 952.03 fromthe AOAC (2002).The results were expressed in mg of tannic acid equivalent (TAE) per 100g of pulp or peel.

Statistical Analysis: The physical-chemical data obtained was evaluated using the analysis of variance (ANOVA), the Tukey test and student's t test in order to compare means.

RESULTS AND DISCUSSION

Fruits total mass average had a variation of 100g between the investigated locations. Ponta Porã fruits obtained the great variation in the weight, achieving the minimum of 232.95g and the maximum of 357.78g. The parameters (length and height) were similar between them, as shown in Table 1. The fresh mass of pitaya fruits found in our study was similar to some previous researches of other groups, that described an average of 411.22g ± 26.17 for the fresh mass (Cordeiro *et al*., 2015).

Table 1. Physical characteristics of *Hylocereus spp* fruits from two different regions of the Mato Grosso do Sul State

Parameters	Campo Grande	Ponta Porã
Freshmass (g)	416,77 ±28,73	305,44 ±119,83
Lenght (cm)	28,40 ±0,2	26,23 ±2,0
Height (cm)	30,20 ±2,0	27,50 ±4,1
Peel (%)	16,40	16,63
Pulp (%)	77,86	76,66

Other research, that analyzed fruits from three different cities in the Pará State, also in Brazil, found values between 351.25g and 430g for the total weight of the fruit, indicating a great variation between locations. However, they found no significant variation in the pulp percentage, and other measurements, even for fruits grown with different types of fertilizer (Sato *et al*., 2014). However, the parameters of the present study were higher when compared to other authors, with a length of 8.59 - 10.7 cm and diameter of 7.77 - 8.70 cm (Pinto *et al*., 2010; Takata, 2012; Sato *et al*., 2014; Cordeiro *et al*., 2015), while in this study, the values were 25 - 28.3 cm for length and 25 - 31.1 cm in diameter for both regions studied. Pitaya pulp accounts for about 60 to 80% of the fruit weight, and consists of 82-88% of water according to Oliveira *et al*. (2010). The values found in the present work were approximately 77% of the fruit weight for the pulp and 16% for the peel (Table 1). The pulp was in a higher proportion than found by Jamilah *et al*. (2011), corresponding to 65% and 22% for peel. Humidity was 86-87% for the pulp, and slightly higher for the peel, 89% (Table 3). The soluble solids content was higher in the pulp, as well as titratable acidity. The median part is the sweetest of the fruit. The values found for pH are similar between peel and pulp (Lima, 2013). The soluble solids values were higher than that found by Oliveira *et al*.(2010), which obtained 11.00°Brix for pulp, and similar to that obtained by Cordeiro *et al*. (2015), of 13.14°Brix. The present study found a value of 0.26 in titratable acidity (g. 100g-1), and pH 4.88 (Table 2). Having the tendency of low acidity, pitaya fruits require post-harvest care, since foods with pH higher than 4.5 may have a higher chance of microbial proliferation, both pathogenic and deteriorating strains, while in an acid medium, that is pH ranging from 4.0 to 4.5, there is a higher presence of yeasts, molds and some specific bacterial strains such as the lactic ones (Franco and Landgraf, 2003). Soluble solids consist mainly of glucose and fructose and the higher this value the better the acceptability of *in natura* consumption of these fruits, also related to their low sugar values and little acidity (Stintzing and Schieber, 2003; Vaillant *et al*., 2005). According to Wall and Khan (2008), sucrose corresponds to 2% of total sugar from pitaya fruit while Esquival, *et al*.(2007), found sucrose values lower than 1%. Some authors point out that white pitaya has a higher soluble solids content than red pitaya, and that the distribution in the fruit is not homogeneous, being the central part richer in sugars than the extremities. When ripe, fruits generally present higher values of soluble solids, which are advantageous for the agro-industrial sector, aiming at reducing sugar addition during the process (Chitarra and Chitarra, 2005). However, low soluble solids levels require a greater potential for post-harvest conservation, as excess sugars may be associated with faster decay time (Brunini *et al*., 2003).

Table 2. Chemical characteristics of *Hylocereus spp.* fruits from two different regions of the Mato Grosso do Sul State

Parameters	Campo Grande		Ponta Porã	
	Pulp	Peel	Pulp	Peel
Soluble Solids (°Brix)	14,9 ±0,0	5,5 ±0,0	14,9 ±0,0	5,3 ±0,0
Titratable Acidity*	0,26 ±0,01	0,18 ±0,01	0,27 ±0,01	0,26 ±0,01
pH	4,5 ±0,0	4,6 ±0,0	4,7 ±0,0	4,3 ±0,0

*g/ 100g citric acid

Table 3. Centesimal composition and caloric value of *Hylocereus spp.* fruits from two different regions of the Mato Grosso do Sul State

Parameters	Campo Grande		Ponta Porã	
	Pulp	Peel	Pulp	Peel
Moisture (%)	87,64 ± 0,87	89,99 ±0,31	86,91 ±0,63	89,81 ±0,37
Fixed Mineral Residue (%)	0,67 ±0,07	1,62 ±0,25	0,73 ±0,05	2,00 ±0,05
Proteins (%)	1,14 ±0,43	0,83 ±0,14	1,69 ±0,0	0,80 ±0,05
Carbohydrates (%)	10,01 ±0,0	7,53 ±0,0	10,12 ±0,0	7,09 ±0,0
Lipids (%)	0,54 ±0,03	0,17 ±0,05	0,56 ±0,26	0,20 ±0,08
Antioxidants (IC50 mg/mL)	297,85 ±0,0	283,21 ±0,0	380,71 ±0,0	169,17 ±0,0
Phenols*	16,58 ±0,0	12,77 ±0,0	30,97 ±0,0	14,35 ±0,0
Tannins**	5,29 ±0,0	13,87 ±0,0	12,31 ±0,0	24,37 ±0,0
Caloric Value (Kcal)	49,42		52,28	

*mg GAE/ 100 g^{-1}
**mg TAE/ 100 g^{-1}

Protein content was higher in pulp than in the peel, corresponding to 1.14-1.69% and 0.80-0.83%, respectively. These values were similar to the mean values of 1.12% found by Sato*et al*. (2014), and slightly higher than the value of 1.06% found by Oliveira *et al*. (2010). The pulp obtained higher lipid levels than the peel, 0.54 and 0.56% for the pulp and 0.17 and 0.20% for the peel from Campo Grande and Ponta Porã samples, respectively. Pitaya fruits have low lipid content (Pimentel *et al*., 2005). Sato and co-workers (2014) report lipid values of 0.18 - 0.21% with similar values among three regions studied by them, and are also lower than in other studies, where a value of 0.36% of lipids was found (Oliveira *et al*., 2010). Such values are mainly provided from pitaya seed, which are numerous and well spread in the mucilaginous fruit pulp. These seeds are rich in essential fatty acids, especially linoleic acid, and can be found in a higher amount than other foods sources, such as flaxseed and canola (Crane and Balerdi, 2005)]. Oliveira *et al*. (2010) concluded that pitaya pulps are rich in carbohydrates and peels are rich in fibers. The total carbohydrates found in the present study were 10.01-10.12% for pulp and 7.53 -7.09% for peel on samples from Campo Grande and Ponta Porã, respectively. These results were slightly lower than presented by other authors, ranging from 10.93 to 12.34% of total carbohydrates (Santo *et al*., 2014; Oliveira *et al*., 2010).

Cordeiro *et al*. (2015) obtained a high crude fiber content in their research, of 11.35g in 100g of sample., being considered a fruit of high crude fiber content. Sato *et al*. (2014) concluded in their experiments that pitayas can be considered natural sources of insoluble fibers, finding values of up to 2%. Such results are higher in amount of fiber than fruits such as papaya and cajá (Carvalho *et al*., 2011). Proper fiber intake has been related to benefits on the digestive tract, among them, action on reducing glucose absorption and combating cardiovascular diseases, obesity and colon diseases (Pimentel *et al*., 2005). The Food and Drug Administration (FDA) recommends a daily total fiber consumption of 25g based on a 2,000-calorie diet (Cordeiro *et al*. 2015). Sato *et al*. (2014) states that pitaya has a low energy value of about 52 Kcal/100 g, which allows the inclusion of the fruit for healthy eating. Pitayas from Campo Grande presented 49.42Kcal/ 100g, and those from

Ponta Porã, 52.28Kcal/ 100g. This number of calories is similar to fruits like kiwi, red guava and pineapple. The red pitaya has significant mineral contents, especially in relation to calcium, since the high content of this mineral may indicate a higher resistance of the fruit after harvest (Cordeiro *et al*. 2015), because it has a direct relationship between softening, firmness and shelf life (Natale *et al*., 2005). The present study found a total phenol content higher in the pulp than in the peel. However, some studies have found high levels of phenolic compounds for red pitaya peel, ranging from 40.68mg GAE.100g^{-1}(Mello *et al*., 2015) to 39.7 mg GAE.100g^{-1}(Wu *et al*., 2006). The difference between the results of these two regions is probably due to climate variation, and the ripeness state of fruits (Lima, 2013). The values found were considerably lower when compared to other fruits such as orange (75 mg GAE. 100g^{-1}), guava (138 mg GAE. 100g^{-1}) and banana (51 mg GAE. 100g^{-1}). Ascorbic acid present in pitaya contributes significantly to antioxidant activity, as well as acts synergistically with the phenolic capacity to combat the action of free radicals (Cho and Yong, 2011).

Tannins are characterized as phenolic compounds of high molecular mass, which have the ability to precipitate proteins (Efraim and Tucci, 2006). Compounds with antioxidant activity play an important role in preventing oxidative diseases, but in large quantities these same compounds may present undesirable characteristics, such as enzymatic darkening of fruits, interaction with proteins, carbohydrates and minerals (Imeh and Khokhar, 2002). The peel has a greater amount of tannins than compared to the pulp, however, such quantities are not high enough to add undesirable factors to the fruit. No studies were found to compare tannin values for pitaya. Some authors indicate that using the DPPH method for antioxidant analyses in pitayas present a lower activity of this compound. Some authors noted that pitaya peel had higher antioxidant activity when analyzed by a stable radical reduction method, DPPH (177.14μmol AEAC. 100g^{-1}) than by the iron reducing method, FRAP (109.29μmol AEAC. 100g^{-1}) (Abreu *et al*., 2012). The pulp values found in the literature were 306.81μmol AEAC. 100g^{-1}(Muñoz *et al*., 2002), similar to the present study for both pulp and peel, with the exception of Ponta Porã peel (IC_{50}:169,0μmol DPPH). The higher the phenolic compound content, the greater the antioxidant action (Wu and Ng, 2008). Antioxidant activity decreases according to fruit ripening time, which is due to the reduction in vitamin C levels and phenolic compounds, since these compounds act as antioxidant factors (Santos *et al*., 2016).

Betalains are also the main responsible for the antioxidant capacity of red pulp pitaya (Esquival *et al*., 2007), having a positive correlation where the higher betalain content, the greater the antioxidant capacity of this fruit (Vaillant *et al*., 2005). Pitaya peels can be used for natural pigment extraction due to the high presence of betalains, being a good alternative to use of the whole fruit by food industry. In addition, betalains incorporated into blood cells can protect them from oxidative hemolysis and also act inducing quinone reductase, an enzyme associated with cancer chemoprevention(Mello *et al*., 2015). The variety of genotypes within a pitaya species and consequently different nutrient content in the fruit may have an environmental component, considering that not all fruits analyzed in studies were produced at the same site. Fruits present quantitative and qualitative variations regarding their physicochemical characteristics, due to intrinsic factors (cropping, variety, ripeness stage) and extrinsic (climatic and edaphic conditions) (Reynerston *et al*., 2008). Plant coloration is based on some factors such as pigment structure and concentration, pH, temperature, local light intensity, sugars, among others (Stintzing and Carle, 2004). Thus, it is concluded that red pitaya characteristics vary chemically, physically and nutritionally according to the region. Pitaya has characteristics that suggest greater acceptance for *in natura* consumption, highlighting the low acidity and soluble solids content. In addition, almost 90% of the fruit is composed of water, has low concentration of proteins, lipids and the most outstanding content of macronutrients is carbohydrates. The antioxidant compounds present in the fruit can make it act and be classified as a functional fruit, acting in reducing the risk of chronic noncommunicable diseases.

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