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Comparison of biometric characteristics, physicochemical composition, mineral elements, nutrients and bioactive compounds of *Hylocereus undatus* and *H. polyrhizus*†

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Abstract: Pitaya (*Hylocereus* sp) is an exotic and attractive fruit with promising consumption due to its nutritional qualities and its flavor and color. However, this fruit and its nutritional benefits for the human diet is not widespread. This paper compared biometric and physicochemical characteristics, mineral elements, nutrients and bioactive compounds of Pitaya with white and red pulps. Nutrients and bioactive compounds were analyzed by HPLC. Total phenolic compounds and the antioxidant capacity were determined by spectrophotometry. Pitaya red pulp showed higher vitamin E (140.76Gg $\mu g.100g^{-1}$), antioxidant capacity (36.41 AAT%), eriodictyol (178.75 $\mu g.100g^{-1}$) and anthocyanins. The α-carotene was more expressive in white pulp (110.21 $\mu g.100g^{-1}$). Total phenolic was similar in both fruits. Pitaya consumption should be encouraged due to the presence of nutrients and bioactive compounds relevant to our basic nutrition.

Keywords: anthocyanins; antioxidant; exotic fruit; flavonoids; dragon fruit; vitamins

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1. Introduction

The interest of the industry, local growers, and consumers with Pitaya (*Hylocereus* sp) has been increased nowadays due to its flavors and exotic appearance. Pitaya is an edible, rustic, exotic fruit, commonly known as pitaya, that belongs to Cactaceae family [1]. It is originated from Latin America, covered with bracts; epiphytic, rupicolous or terrestrial, depending on the species, with white, nocturnal and aromatic flowers pollinated by insects [2]. Depending on the species, it may have red or yellow flesh, and white or red mucilaginous mesocarp (pulp) with small seeds distributed throughout the pulp, giving the fruit an attractive appearance to consumers and industry [3].

Studies indicate that the peel and pulp of different species of Pitaya show vitamins, phenolic compounds and antioxidant capacity [4, 5 6 7], dietary fibers and minerals elements such as N, K, Fe, Mn and Zn [8]. Pitaya is known to have nutraceutical and therapeutic properties [1]. Its consumption is also related to the cholesterol decrease and antidiabetic activity [9].

However, to date, there are no studies regarding the comparison and complete characterization (physicochemical composition, minerals elements, nutritional value, and composition of bioactive compounds) of Pitaya with white pulp (*H. undatus*) and red pulp (*H. polyrhizus*), which are the most currently commercialized species.

This study is important to include more information about Pitaya varieties, regarding their biometric characteristics, physiochemical composition, minerals elements, vitamins, and bioactive compounds.

2. Material and Methods

Fruit material and sampling Red skinned with white pulp (*H. undatus*) and red pulp (*H. polyrhizus*) Pitaya at the same stage of ripeness were collected during the morning, in a consortium cultivated area, located in the rural area of Viçosa, Minas Gerais, Brazil. The fruits were selected by appearance, excluding those with no epidermal injury or mechanical damage due to transport. Then, they were washed and dried.

Determination of biometric characteristics Fruits of each species were randomly assigned to measure length (cm) and diameter (cm) using a pachymeter (Disma, 150 mm) and weight (g) using an analytical scale (Gehaka, AG200). All Pitayas were manually peeled with a sharp knife and the pulps were homogenized in a domestic multiprocessor (Phillips Wallita) and stored at -18 °C ± 2 °C until the time of analyses, which occurred in up to 36 hours (carotenoids) and 72 hours (vitamin E) after fruit collection.

Analyses of physicochemical composition and centesimal composition The pH of 10 g of sample was analyzed using a pHmeter (Denver Instrument UB-10). Soluble solids were determined by refractometry (28 A, 65 Brix, model 105) using 15 g of sample, and titrable acidity was analyzed by volumetric neutralization using 1 g of sample, according to Instituto Adolfo Lutz [10].

Moisture was determined in an oven at 65 °C using 10 g of the fruit pulp; total lipids were determined by Soxhlet using 10 g of the lyophilized fruit pulp. The total ash was quantified using muffle (Quimis, model Q320 M, Brazil) at 550 °C using 2 g of the lyophilized fruit. The protein was determined by the Kjeldahl method using 40 mg of the lyophilized fruit; and the total dietary fiber was determined by the non-enzymatic gravimetric method using 1 g of the lyophilized fruit [11].

The carbohydrates in pulp were calculated following the equation: [100 - (% moisture + % lipids + % protein + % total dietary fiber + % ash)].

Determination of minerals elements The minerals elements (calcium-Ca, potassium-K, phosphorus-P, magnesium-Mg, sulfur-S, copper-Cu, iron-Fe, zinc-Zn, manganese-Mn, sodium-Na, chrome-Cr and the inorganic contaminants cadmium-Cd, aluminum-Al, nickel-Ni and lead-Pb) were determined by optical emission spectrometry with inductively coupled plasma (ICP-OES) (Varian Medical Systems, Belrose, Australia), according to recommended instrument conditions, using 1 g of lyophilized fruit.

Extraction and analyses of vitamins, carotenoids and flavonoids The analyses of vitamin E methodology of Pinheiro-Sant'Ana [11], with modifications; carotenoids methodology of Rodriguez-Amaya [13], with modifications; flavonoids the identification and quantification of flavonoids were conducted according to [14] and modified by Cardoso [15] and anthocyanins followed the methodology of [16, 17].

For all analyses the Pitaya pulp was performed in four replicates in a high-performance liquid chromatography system (HPLC). During the analyses, the samples and the extracts were protected from light and heat using amber glass, aluminum foil and blackout curtains.

Total phenolic compounds and antioxidant capacity The total phenolic compounds were determined according to [18]. The antioxidant capacity was used the DPPH solution (1.1-diphenyl-2-picrylhydrazyl) and the absorbance was read using spectrophotometer (Thermo scientific, 606 Evolution, EUA) at 517 nm [19].

Experimental design and statistical analysis A completely randomized design was used with four replicates for vitamin E, carotenoids, flavonoids, anthocyanins, total phenolics, and antioxidant capacity. For physicochemical analyses of centesimal composition and minerals elements analysis, triplicates were used. Data were submitted to ANOVA and Student t-test using IBM SPSS Statistics software, version 22 (IBM, 2013), adopting a significance level (α) of 5%. All numerical data are expressed as mean ± standard deviation.

3. Results and Discussion

The white and red Pitaya pulp analysed showed yellow-green bracts, indicating ripe fruits. The fruits showed a slightly elliptical shape, with no external differences. The table 1 show us the biometric feature and physical chemical composition and centesimal composition no difference between the Pitayas.

The values found for pH in white Pitaya was close to that observed by Lima et al. [20], with pH variation between 5.70 and 4.87 and Jerônimo et al., 2015 found pH 5.00 in red pulp close to our study. The variation found in the literature for pH values and titratable acidity may be related to ripening aspects of fruits. In the present study, soluble solids were close to those reported [20], with variation of 13.90º to 14.60º Brix in white Pitaya, Jerônimo et al., 2015 found 11.40 Brix in red pulp, higher than the value of our study for the same species. White and red pulp showed high moisture (around 85%), similar to that found by [12] in white (86.08%) and red Pitayas (85.52%).

In the studies [21] also found moisture values 86% in Pitaya. The high moisture is related to the perishability in Pitaya. Differing from our study, Abreu et al. [7] reported higher concentrations of protein in Pitaya pulp white (0.87%) and in red fruit (1.06%). This difference between this study and our results may be related to the ripening of the fruit as well as the edaphoclimatic characteristics of each region. Among the minerals analyzed, the most abundant was potassium (average 256.46 mg/100g) and the least abundant was chromium (average 0.02 mg/100g) in the two species of Pitaya pulp.

α-tocopherol is the most significant component in the two species of Pitaya, followed by γ-tocopherol (Table 2). The concentration of α-tocopherol, α-tocotrienol, and γ-tocopherol were higher ($p<0.05$) in red Pitaya, whereas the concentration of β-tocopherol was higher in white Pitaya ($p<0.05$). γ-tocotrienol was found only in red fruit. White Pitaya pulp showed higher concentrations of α-carotene and β-carotene ($p<0.05$) (Table 2). Among the flavonoids, only eriodictyol was identified in white Pitaya pulp (Table 2). Due to lack of studies that analyzed flavonoids in Pitayas by HPLC, it is difficult to compare.

Table 1. Biometric characteristics, physical-chemical composition and centesimal composition in Pitaya pulp white H. undatus and red H. polyrhizus.

Parameters	***Pitaya***	
	White pulp	***Red pulp***
Biometric feature		
lenght (cm)	*8.00 ± 0.33* [a]	*7.24 ± 0.22* [b]
diameter (cm)	*6.89 ± 0.69* [a]	*6.68 ± 0.40* [a]
weight of the fruit (g)	*227.02 ± 8.88* [a]	*196.79 ± 9.02* [a]
weight of pulp (g)	*131.22 ± 37.08* [a]	*115.20 ±17.44* [a]
weight of peel (g)	*95.38 ± 1.96* [a]	*81.63 ± 1.631* [a]
Physical chemical composition [1]		
pH	*4.37 ± 0.21* [a]	*3.78 ± 0.12* [b]
soluble solids	*14.86 ± 0.97* [a]	*13.34 ± 0.55* [b]
acidity (% citric acid)	*0.41 ± 0.02* [a]	*0.40 ± 0.02* [a]
total dietary fiber [3] *($g.100g^{-1}$)*	*2.19 ± 0.15*	*2.31 ± 0.49*
insoluble fiber [3] *($g.100g^{-1}$)*	*1.81 ± 0.12*	*2.02 ± 0.31*
soluble fiber [3] *($g.100g^{-1}$)*	*0.38 ± 0.02*	*0.29 ± 0.18*
Centesimal composition ($g.100g^{-1}$)		
moisture	*85.16 ± 0.60* [a]	*84.37 ± 0.90* [a]
lipids [2]	*0.39 ± 0.08* [a]	*0.44 ± 0.05* [a]
total ashes [2]	*0.30 ± 0.00* [a]	*0.27 ± 0.10* [a]
proteins [2]	*0.43 ± 0.05* [a]	*0.41 ± 0.18* [a]
carbohydrates [2]	*11.51 ± 0.08* [a]	*12.18 ± 0.24* [a]
energy value ($kcal.100g^{-1}$)	*51.27*	*54.32*

*Means followed by the same letter in the columns, for each characteristic, did not differ statistically at 5% probability by the Student t test; 1 Values expressed on fresh matter, as mean of 3 replicates ± standard deviation (SD). 2 Values expressed on fresh matter, as mean of triplicates ± standard deviation (SD). 3 Values expressed in fresh matter, as mean of duplicates ± standard deviation (SD).

Among the flavonoids, only eriodictyol was identified in white Pitaya pulp (Table 2). Due to lack of studies that analyzed flavonoids in Pitayas by HPLC, it is difficult to compare with the result obtained in the present study. The study analyzed red Pitaya seeds by HPLC and found catechin, epicatechin, quercetin, myricetin, and kaempferol [22].

Although our results were not detected anthocyanins in white pulp. A recent study [23] identified five anthocyanin compounds in Hyloceurus sp., including cyanidin 3-glucoside, cyanidin 3- rutinoside in red and white pulp. According to those authors, there is a correlation between the red pulp and the amount of anthocyanins compounds present in the fruit, with the red pulp showing a higher level of anthocyanins in relation to the white pulp.

There was no difference in the concentration of total phenolic compounds (p>0,05) between the two species of Pitaya (Table 2). Similar values were found by Wu et al., 2006. (42.2 mg GAE/100g) in red Pitaya pulp [5] found lower values in white and red Pitayas. The antioxidant capacity of red Pitaya was higher than that of white fruit (Table 2), which may be related to the higher concentration of total phenolic compounds in red fruit. The higher antioxidant capacity observed in the red pulp fruit may be related to the difference between the composition of lipoplilic compounds among the studied species. Differing from our study, [5] found no significant difference between white and red fruit antioxidant capacity.

Table 2. Occurrence and concentration of vitamins, carotenoids and bioactive compounds in Pitaya pulp white (H. undatus) and red (H. polyrhizus).

Variables	***Pitaya***	
	White pulp	***Red pulp***
Total vitamin E (µg.100g⁻¹)	***100.00a***	***140.76b***
α-tocopherol	*70.46 ± 4.01 a*	*85.71 ±1.46 b*
α-tocotrienol	*11.53 ± 0.55 a*	*16.03 ± 1.58 b*
β-tocopherol	*4.21 ± 0.51 a*	*1.12 ± 0.08 b*
β-tocotrienol	*Nd*	*Nd*
γ-tocopherol	*13.80 ± 0.71 a*	*33.07 ± 3.06 b*
γ-tocotrienol	*Nd*	*4.83 ± 0.52a*
δ-tocopherol	*Nd*	*Nd*
δ-tocotrienol	*Nd*	*Nd*
Carotenoids (µg.100g⁻¹)		
α-carotene	*110.21 ± 5.51 a*	*92.51 ± 8.46 b*
β-carotene	*19.92 ± 0.58 a*	*15.73 ± 0.39 b*
Lutein	*Nd*	*Nd*
Flavanones (µg.100g⁻¹)		
eriodictiol	*178.75 ± 8.48a*	*Nd*
naringenin	*Nd*	*Nd*
Anthocyanin (µg.100g⁻¹)		
cyanidin 3-glycoside	*Nd*	*3604.574 ± 77.00a*
cyanidin 3-rutinoside	*Nd*	*2350.036 ± 27.45 a*
Total phenolics (mg GAE.100g⁻¹)	***52.11 ± 4.57 A***	***52.83 ± 7.05 A***
Antioxidant capacity (AAT%)	***27.11 ± 1.94 A***	***36.41 ±1.28 B***

* Means followed by the same letter in the rows do not differ statistically at 5% probability by t test 1Data expressed on fresh matter ; nd: not detected.

4. Conclusion

The results showed that white and red Pitaya pulp showed low concentrations of lipids and proteins and low caloric value. They are fruits with high perishability due to its high value of moisture according to the study. Different minerals elements beneficial to human health were found in the two species of Pitaya. Vitamin E was higher in red Pitaya, while carotenoids were more expressive in white fruit. Total phenolic in white and red Pitaya were similar. Red fruit showed higher antioxidant capacity, besides the presence of anthocyanins. This diffences found in our study probably is influence by species. Hereby our study is relevant to encourage its consumption and cultivation like a way to contribute to the food diversity and to guarantee the sovereignty and food and nutritional security of the agricultural families.

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