Nutritional and physicochemical profile of the pitahaya cultivated in the central coast of Peru

Perfil nutricional y fisicoquímico de la pitahaya cultivada en la costa central del Perú

Perfil nutricional e físico-químico da pitahaya cultivada na costa central do Peru

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Abstract

Pitahaya, known as "dragon fruit", is an exotic fruit with excellent nutritional properties; however, the species from the Peruvian coast have been little studied. The objective of the present study was to determine the physicochemical and nutritional composition of two species of pitahaya *Hylocereus undatus* (Haw.) Britt and Rose (red pitahaya) and *Hylocereus megalanthus* (yellow pitahaya), cultivated in the central coast of Peru. Proximal analysis, physicochemical and mineral contents were determined by standardized methods. From the results found, the fiber content of red pitahaya (4.30 ± 0.75 g.100 g^{-1}) and vitamin C (14.74 ± 0.53 mg.100 g^{-1}) stand out. The macroelement with the highest proportion corresponded to potassium (215.83 ± 11.72 and 98.41 ± 5.54 mg.100 g^{-1}, for red and yellow pitahaya, respectively). This was followed by phosphorus (28.70 ± 0.28 and 17.99 ± 1.48 mg.100 g^{-1}, for red and yellow pitahaya, respectively) and magnesium (29.88 ± 0.53 and 16.09 ± 2.80 mg.100 g^{-1}, for red and yellow pitahaya, respectively). Regarding the content of microelements, the contents of manganese (5.48 ± 0.1 mg.kg^{-1}) and zinc (5.39 ± 0.25 mg.kg^{-1}) for red pitahaya stood out; and in the case of yellow pitahaya, the highest values corresponded to iron (21.07 ± 0.18 mg.kg^{-1}) and manganese (7.49 ± 1.12 mg.kg^{-1}). The study concluded that red and yellow pitahaya fruits represent an important source of fiber, minerals and vitamin C and they can be used for the benefit of human health and nutrition.

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Resumen

La pitahaya, conocida como "fruta del dragón", es un fruto exótico con excelentes propiedades nutricionales; sin embargo, las especies procedentes de la costa peruana han sido poco estudiadas. El objetivo del presente estudio fue determinar la composición físico-química y nutricional de dos especies de pitahaya: *Hylocereus undatus* (Haw.) Britt y Rose (pitahaya roja) y *Hylocereus megalanthus* (pitahaya amarilla), cultivadas en la costa central del Perú. Se determinó el análisis proximal, físico-químico y el contenido de minerales, mediante métodos estandarizados. De los resultados encontrados, destaca el contenido de fibra de la pitahaya roja (4.30 ± 0.75 g.100 g^{-1}); así como el de la vitamina C (14.74 ± 0.53 mg.100 g^{-1}). El macroelemento en mayor proporción correspondió al potasio (215.83 ± 11.72 y 98.41 ± 5.54 mg.100 g^{-1}, para la pitahaya roja y amarilla, respectivamente). Le siguen el fósforo (28.70 ± 0.28 y 17.99 ± 1.48 mg.100 g^{-1}, para pitahaya roja y amarilla, respectivamente) y el magnesio (29.88 ± 0.53 y 16.09 ± 2.80 mg.100 g^{-1}, para pitahaya roja y amarilla, respectivamente). Respecto al contenido de microelementos, destaca el contenido de manganeso (5.48 ± 0.1 mg.kg^{-1}) y zinc (5.39 ± 0.25 mg.kg^{-1}) para la pitahaya roja; y en el caso de la pitahaya amarilla, los mayores valores correspondieron al hierro (21.07 ± 0.18 mg.kg^{-1}) y al manganeso (7.49 ± 1.12 mg.kg^{-1}). Los frutos de pitahaya roja y amarilla representan una fuente importante de fibra, minerales y vitamina C, beneficiosa para la salud y la alimentación humana.

Palabras clave: macroelementos, microelementos, fibra, composición de los alimentos, vitamina C, *Hylocereus* spp.

Resumo

A Pitahaya, conhecida como "fruto do dragão", é um fruto exótico com excelentes propriedades nutricionais; contudo, as espécies da costa peruana têm sido pouco estudadas. O objectivo do presente estudo era determinar a composição físico-química e nutricional de duas espécies de pitahaya *Hylocereus undatus* (Haw.) Britt e Rose (pitahaya vermelha) e *Hylocereus megalanthus* (pitahaya amarela), cultivadas na costa central do Peru. A análise proximal, o conteúdo físico-químico e mineral foram determinados por métodos padronizados. Dos resultados encontrados, destaca-se o teor de fibras de pitahaya vermelha (4.30 ± 0.75 g.100 g^{-1}); bem como o de vitamina C (14.74 ± 0.53 mg.100 g^{-1}). O macroelemento em maior proporção correspondeu ao potássio (215.83 ± 11.72 e 98.41 ± 5.54 mg.100 g^{-1}, para o pitahaya vermelho e amarelo, respectivamente). É seguido pelo fósforo (28.70 ± 0.28 e 17.99 ± 1.48 mg.100 g^{-1}, para pitahaya vermelha e amarela, respectivamente) e magnésio (29.88 ± 0.53 e 16.09 ± 2.80 mg.100 g^{-1}, para pitahaya vermelha e amarela, respectivamente). Relativamente ao conteúdo de microelementos, o conteúdo de manganês (5.48 ± 0.1 mg.kg^{-1}) e zinco (5.39 ± 0.25 mg.kg^{-1}) destaca-se para o pitahaya vermelho; e no caso do pitahaya amarelo, os valores mais elevados corresponderam ao ferro (21.07 ± 0.18 mg.kg^{-1}) e ao manganês (7.49 ± 1.12 mg.kg^{-1}). O estudo concluiu que as frutas pitahaya vermelhas e amarelas representam uma importante fonte de fibras, minerais e vitamina C e podem ser utilizadas em benefício da saúde humana e da nutrição.

Palavras-chave: macroelementos, microelementos, fibra, composição de alimentos, vitamina C, *Hylocereus* spp.

Introduction

The pitahaya (*Hylocereus* spp.), is an exotic fruit, native to Central America and the Peruvian jungle (Verona-Ruiz *et al.*, 2020). Recently,
it is considered as a profitable exotic fruit crop, suitable for large-scale cultivation in dry lands, as it has the ability to retain water in drought conditions (de Oliveira *et al.*, 2020).

Depending on the species, the fruits may present characteristics that differentiate them, as the shape, presence of spines; pericarp and pulp color, reflecting a high genetic variability (Junqueira et al., 2010). There are 14 species of Hylocereus spp. reported in the world, but only four of them are commercially cultivated: H. undatus, H. monocanthus, H. costariscensis and H. megalanthus (Abirami et al., 2021).

Therefore, pitahaya is a promising tropical fruit given its adaptation and cultivation in different parts of the world. Its benefits for the human health are due to its content of essential nutrients such as vitamins, minerals, complex carbohydrates, dietary fiber and antioxidants. Pitahaya is an essential source of betacyanin, a red pigment with antioxidant properties (Abirami *et al*., 2021). This has driven its popularity, attracting the worldwide attention, being widely used for its functional and organoleptic characteristics and for its commercial value (Abirami *et al*., 2021; Verona-Ruiz *et al*., 2020).

Although pitahaya has increased in popularity, the knowledge about its nutrients supply, particularly of the commercial species that grow in the Peruvian coastal desert, has been little studied. The widely cultivated species is Hylocereus megalanthus. In this sense, Obregón- La Rosa *et al.* (2021) studied the proximal analysis of this species, cultivated in the jungle of Peru; and Chauca Aguilar & Chávez Quintana (2020) reported the maturity index of the same species native to the Amazon region of Peru and Brazil. Regarding to the Hylocereus undatus (Haw.) species, Britt and Rose, no reports of the fruits grown in Peru were found. Therefore, in the present research the proximal composition and physicochemical and nutritional characteristics of two species of pitahaya: Hylocereus undatus (Haw.) Britt and Rose (red pitahaya) and Hylocereus megalanthus (yellow pitahaya) cultivated in the Peruvian coastal desert were determined and their potential for the benefit of health and human nutrition was determined, in order to provide knowledge about these varieties cultivated in Peru.

Materials and methods

Plant material

The pitahaya fruits came from the farm of Corporación Abregú, located in the Granados section, Esperanza Baja, province of Huaral, department of Lima, Peru; whose geographical coordinates are Latitude -11.416 and Longitude -77.234. The farm is located in the central coastal area of Peru, at 246.4 mamsl, average annual temperature of 18.3 °C, average annual rainfall of 10 mm and 83.8% average relative humidity per year. The species studied were red pitahaya and yellow pitahaya. Five lots of 10 kg of fruit were randomly selected for each species from the plants with the best phenotype, expressing the results as the mean of each lot (n=5).

Samples preparation

The fruits analyzed corresponded to a stage of maturity for consumption, established in the ICONTEC standard (1996). The fruits were washed, grounded, freeze-dried and stored at - 20 °C for their respective analyses. Subsequently, they were identified by

specialists from the Universidad Nacional Mayor de San Marcos, Lima-Peru (table 1).

Table 1. Scientific names and varieties of the analyzed fruits.

Scientific name	Common name	Family	References
Hylocereus undatus (Harwoth) Britton and Rose	Pitahaya roja tasajo, pitaya, flor de caliz, pitajava	Cactaceae	(Gunasena *et al.*, 2006).
Selenicereus megalanthus or *Hylocereus megalanthus* (K. Schum. ex Vaupel) Moran	Pitahaya, pitaya amarilla, pitaia	Cactaceae	(Sanín *et al.*, 2020).

Proximal analysis

The proximate analysis was evaluated according to the methods described by AOAC (1995). Water content was determined by the conventional method, drying the sample in an oven at 105 °C for approximately 4 hours until constant mass. Protein was determined by the Kjeldahl method (the factor used was 6.25). Fiber content was determined by the gravimetric method after acid hydrolysis of the samples. The Soxhlet extraction method was used to quantify the content of fatty ether extract, using petroleum ether as solvent. The ash content was determined by incineration in a muffle at 550 °C ± 15 °C, and the carbohydrates were obtained by difference, subtracting from 100 the content of water, protein, fiber, fat and ash.

Physicochemical analysis

Soluble solids were measured with a refractometer (ALLA FRANCE, 0-32) at 20 °C and the results were expressed as °Brix. Total acidity was determined by titration, using a potentiometer (TRANS Instruments brand, TI 9000 Model, Singapore) with a 0.1 M NaOH solution and expressed as a percentage of citric acid. The maturity index was obtained by dividing soluble solids by total acidity (AOAC, 1995). Total sugars were determined by the modified Dubois spectrophotometric method, which is a colorimetric method based on the ultraviolet absorption of furfural derivatives produced by the hydrolysis of concentrated sulfuric acid (Albalasmeh *et al*., 2013).

Determination of the mineral content

For the determination of the mineral content, the AOAC (1995) method was used. The samples were incinerated in a muffle at 550 °C and the ashes obtained were dissolved in 10 mL of 50 % HCl (v/v). Mineral extracts were measured using an atomic absorption spectrophotometer (Perkin Elmer, 3030-B model, USA). A standard calibration curve and a respective control were prepared for each mineral. Phosphorus content was measured using the spectrophotometric technique with molybdenum blue.

Determination of vitamin C content

The determination of vitamin C was carried out using the modified 2.6 dichlorophenol indophenol titration method (AOAC, 1995). For the extraction of ascorbic acid, a 4% (m/v) solution of oxalic acid was used, as recommended by Benassi & Antunes (1988). This solution was titrated with a 0.01 % 2.6-dichloro-phenol-indophenol solution. The endpoint was considered when the solution turns to a faint pink color for 15 s. The results were expressed in mg of ascorbic acid equivalents per 100 g of sample.

Design and statistical analysis

A completely randomized design (CRD) was used, whose linear additive model is:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

Where: Y_{ij} represents the response variable obtained by applying the treatment (content of each component) i in the j-th experimental unit (pitahaya species); μ is the effect of the general mean; τ_i represents the effect of the i-th treatment and ε_{ij} is the experimental error obtained by applying treatment i in the j-th experimental unit. The results were analyzed using a one-way analysis of variance, with a significance level of $p < 0.05$; differences between means were evaluated using Tukey's test. Minitab software version 18 was used (Minitab, 2018).

Results and discussion

Table 2 shows the results of the proximal evaluation of the fruits studied.

Table 2. Proximal evaluation of Pitahaya (*Hylocereus*) native to the central coast of Peru.

	Red pitahaya *(Hylocereus undatus)*		Yellow pitahaya *(Hylocereus megalanthus)*	
	Wet basis g.100 g^{-1} sample	**Dry basis g.100 g^{-1} dry sample**	**Wet basis g.100 g^{-1} sample**	**Dry basis g.100 g^{-1} dry sample**
Total solids	15.85 ± 0.55^{a}		15.54 ± 0.71^{a}	
Water	84.15 ± 0.55^{a}		84.46 ± 0.71^{a}	
Total protein*	0.12 ± 0.03^{a}	0.76 ± 0.16^{b}	0.22 ± 0.07^{a}	1.44 ± 0.47^{c}
Ether extract	0.72 ± 0.04^{a}	4.54 ± 0.28^{b}	0.41 ± 0.08^{a}	2.63 ± 0.42^{c}
Ash	0.57 ± 0.05^{a}	3.62 ± 0.30^{b}	0.56 ± 0.04^{a}	3.63 ± 0.28^{b}
Crude Fiber	4.30 ± 0.75^{bc}	27.13 ± 4.72^{a}	1.27 ± 0.08^{c}	8.17 ± 0.54^{b}
Carbohydrates	10.14 ± 1.06^{c}	63.94 ± 6.67^{a}	13.07 ± 0.66^{c}	84.13 ± 4.28^{b}
Caloric value (Kcal)	47.50 ± 4.07^{a}		56.86 ± 2.67^{a}	

[1]Mean value ± standard deviation of fresh weight; n=5; *Protein factor=6.25
$^{a, b, c}$ Means with different letters differ significantly ($p < 0.05$).

With regard to the moisture content, red (84.15 ± 0.55 g.100 g^{-1}) and yellow (84.46 ± 0.71 g.100 g^{-1}) pitahaya fruits from the central Peruvian coast were found within the range (82.3-89.4 g.100 g^{-1} sample) of moisture of pitahaya fruits grown in tropical areas, reported by Mercado-Silva (2018), Obregón-La Rosa *et al*. (2021), Cañar *et al*. (2014), Menezes-Cordeiro *et al*. (2015), Morales de León *et al*. (2015) and Gunasena *et al*. (2006).

Regarding to the total protein content, the results for red and yellow pitahaya (0.12 ± 0.03 and 0.22 ± 0.07 g.100 g^{-1}, respectively) were slightly lower than those reported by Obregón-La Rosa *et al*. (2021) for native pitahaya fruits (*Selenicereus megalanthus*) from the Peruvian jungle (0.5 g.100 g^{-1}). This difference could be due to the origin of the fruit, the maturity stage and the harvest conditions, among others.

Ether extract (fat) values of 0.72 ± 0.04 and 0.41 ± 0.08 g.100 g^{-1} were found for red and yellow pitahaya, respectively, which were higher than those reported by Mercado-Silva (2018), for pitahaya fruits from Brazil (of 0.1 g.100 g-1). On the other hand, Jaafar *et al*. (2009), studied the proximal composition of red pulp pitahaya of *Hylocereus* spp. species from Malaysia, finding fat values in the range of 0.21 to 0.61 g.100 g^{-1}, slightly lower than those obtained in the present study (0.72 ± 0.04 g. 100 g^{-1}).

Regarding to the ash content (0.57 ± 0.05 and 0.56 ± 0.04 g.100 g^{-1} sample, for red and yellow pitahaya, respectively), the

values obtained were within the range of pitahaya fruits grown in tropical zones (0.32-0.60 g.100 g^{-1} sample) reported by Mercado-Silva (2018), Obregón-La Rosa *et al*. (2021), Cañar *et al*. (2014), Menezes-Cordeiro *et al*. (2015), Morales de León *et al*. (2015) and Gunasena *et al*. (2006).

The fiber content of red pitahaya (4.30 ± 0.75 g.100 g-1) was statistically significant ($p < 0.05$), higher than that of yellow pitahaya (1.27 ± 0.08 g.100 g^{-1}). In this regard, Menezes-Cordeiro *et al.* (2015), found mean crude fiber values of 11.5 g.100 g^{-1}, higher than those obtained in the present study, for red pulp pitahaya (*Hylocereus polyrhizus*) varieties from Brazil. On the other hand, Sato *et al*. (2014), reported fiber values for red pulp pitahaya of the *Hylocereus costaricences* variety that varied between 1.84 and 2.0 g.100 g^{-1}, lower than those found in the present study (4.30 ± 0.75 g. 100 g^{-1}), probably due to the variety and maturity stage of the fruit (Sanín *et al*., 2020).

The fiber content of yellow pitahaya was higher than that reported (1.27 ± 0.08 g.100 g^{-1}) by Obregón-La Rosa *et al.* (2021) (0.3 g.100 g^{-1}) who evaluated the proximal composition of the yellow pitahaya (*S. megalanthus*) from the Peruvian jungle.

The carbohydrate content of the red pitahaya (10.14 ± 1.06 g.100 g^{-1}) and yellow pitahaya (13.07 ± 0.66 g.100 g^{-1}) were found within the range (9.1-13.55 g.00 g^{-1}) of the pitahayas from tropical areas, reported by Mercado-Silva (2018), Obregón-La Rosa *et al.* (2021), Cañar *et al.* (2014), Menezes-Cordeiro *et al.* (2015), Morales de León *et al.* (2015) and Gunasena *et al.* (2006).

Regarding to the caloric intake (47.50 and 56.86 kcal.100 g^{-1}, for red and yellow pitahaya, respectively), this fruit presents low levels. Reduced caloric intake is associated with a lower risk of cardiovascular disease, cancer, cognitive impairment and better quality of life (Pistollato *et al*., 2020). Table 3 presents the results obtained from physicochemical analyses of pitahaya (*Hylocereus* spp.)

Table 3. Physicochemical analysis of pitahaya (*Hylocereus* spp.) from the central coast of Peru.

	Red pitahaya *(Hylocereus undatus)* (Wet basis)	**Yellow pitahaya** (*Hylocereus megalanthus*) (Wet basis)
Vitamin C (mg.100 g^{-1})	14.74± 0.53[a]	11.34 ± 0.71[b]
Total sugars (g.100 g^{-1})	10.96 ± 1.53[a]	13.52 ± 0.98[b]
Total acidity (g.100 g^{-1}) (ATT)	0.26 ± 0.04[a]	0.23 ± 0.06[a]
pH	4.16 ± 0.17[a]	4.82 ± 0.31[b]
Soluble solids (°Brix) (SST)	13.83 ± 0.24[a]	16.70 ± 0.19[b]
Maturity Index (SST/ ATT)	53.17 ± 7.12[a]	76.47 ± 16.06[b]

[1]Mean value ± standard deviation of fresh weight; n = 5;
[a,b] With different letters are significantly different ($p < 0.05$).

Vitamin C levels of red pitahaya (14.74 ± 0.53 mg.100 g^{-1}) were statistically different ($p < 0.05$) and higher than those of yellow pitahaya (11.34 ± 0.71 mg.100 g^{-1}). These values are within the range of 4.0 - 25.8 mg.100 g^{-1}, in pitahaya grown in tropical areas, reported by Mercado-Silva (2018), Obregón-La Rosa *et al*. (2021), Cañar *et al*. (2014), Menezes-Cordeiro *et al*. (2015), Morales de León *et al*. (2015) and Gunasena *et al*. (2006). Jaafar *et al.* (2009), analyzed fruits of *Hylocereus polyrhizus* with red peel and pulp, finding vitamin C values (8 - 9 mg.100 g^{-1}) lower than those found in the present study.

It should be noted that the vitamin C values found for red pitahaya are higher than those of other fruits native to the Andean region such as: chirimoya (*Annona cherimola*) (3.3 mg.100 g^{-1}), coco (*Cocos nucifera*) (0.9 mg.100 g^{-1}), cocona (*Solanum sessiliflorum*) (4.4 mg.100 g^{-1}), granada (*Punica granatum*) (5.2 mg.100 g^{-1}), guayaba (*Psidium guajava*) (7.0 mg.100 g^{-1}), higo (*Ficus carica*) (2.9 mg.100 g^{-1}), lúcuma (*Lucuma pouteria*) (2.2 mg.100 g^{-1}) and níspero (*Eriobotrya japonica*) (1.2 mg.100 g^{-1}), among other fruits of the region (Reyes *et al.*, 2017).

According to Fuster & Marín (2007), the recommended daily requirement of vitamin C for adults varies from 45 to 90 $mg.day^{-1}$. Therefore, the consumption of 100 grams of red pitahaya would provide between 17 to 33% of the daily requirement and the contribution of yellow pitahaya between 13 to 25% of the daily requirement, in adults.

The total sugars content of yellow pitahaya (13.52 ± 0.98 g.100 g^{-1} sample) was significantly higher ($p < 0.05$) than red pitahaya (10.96 ± 1.53 g.100 g^{-1} sample). Wall & Khan (2008), studied *Hylocereus* spp. clones and found glucose and fructose as major sugars. Total sugar concentrations ranged from 10.1 to 8.9 g.100 g^{-1}, lower than those obtained in this research. On the other hand, Nerd *et al.* (1999) found total sugar values ranging from 8 to 9 g.100 g^{-1} of sample for fruits of *Hylocereus undatus* and *Hylocereus polyrhizus* from Israel, slightly lower than those reported in the present study.

Regarding to total acidity of pitahaya fruits, there were no significant statistical differences ($p < 0.05$), between both varieties, and the values obtained were higher than those reported by Lima *et al*. (2013), who found total acidity values ranging from 0.09 to 0.17 g citric acid.100 g^{-1} of sample for *Selenicereus megalanthus*, *Selenicereus setaceus*, *Hylocereus undatus* and *Hylocereus costaricensis* pitahaya varieties.

Regarding to pH levels, Lima *et al*. (2013) reported values from 4.80 to 5.67 for pitahaya fruits of the varieties noted above, similar to those found in the present study (4.16 and 4.82) for red and yellow pitahaya, respectively.

Regarding to soluble solids content, Mercado-Silva (2018), Obregón-La Rosa *et al.* (2021), Cañar *et al.* (2014), Menezes-Cordeiro *et al.* (2015), Morales de León *et al.* (2015) and Gunasena *et al.* (2006) reported different values (11-16.2 g.100 g^{-1}), which are directly related to fruit maturity stage. In the present study, mean soluble solids values (16.70 ± 0.19 g.100 g^{-1}) were found for the yellow variety, significantly higher ($p < 0.05$) than the red variety (13.83 ± 0.24 g.100 g^{-1}), slightly lower than those reported by Torres-Grisales *et al.* (2017), who found soluble solids levels for the *Selenicereus megalanthus* variety of 17.67 ± 0.06 g.100 g^{-1} sample.

The maturity index values (53.17 ± 7.12 and 76.47 ± 16.06, for red and yellow pitahaya, respectively) determined from the ratio between soluble solids and total acidity, resulted lower than those reported by Obregón-La Rosa *et al.* (2021) of 168, mainly due to the origin and maturity stage of the fruit after harvest (Sanín *et al*., 2020). In the case of yellow pitahaya, Chauca-Aguilar & Chávez-Quintana (2020) reported maturity index values of 87 and 73.91, for varieties from the Amazon region of Peru and Brazil, respectively.

Table 4 shows the macro and microelement mineral content of red and yellow pitahaya fruits.

Table 4. Mineral content in red Pitahaya (*Hylocereus undatus*) and yellow Pitahaya (*Hylocereus megalanthus*) from the central coast of Peru.

	Red pitahaya (*Hylocereus undatus*)		Yellow pitahaya (*Hylocereus megalanthus*)	
	Wet basis	Dry basis	Wet basis	Dry basis
		Macrominerals		
Phosphorus (mg.100 g^{-1})	28.70 ± 0.28^{a}	181.05 ± 1.79^{c}	17.99 ± 1.48^{ab}	115.75 ± 9.51^{bc}
Potassium (mg.100 g^{-1})	215.83 ± 1.72^{c}	1361.70 ± 73.97^{a}	98.41 ± 5.54^{d}	633.27 ± 35.66^{b}
Calcium (mg.100 g^{-1})	20.10 ± 0.92^{c}	126.80 ± 5.81^{a}	11.73 ± 0.99^{b}	75.47± 6.36^{d}
Magnesium (mg.100 g^{-1})	29.88 ± 0.53^{ab}	188.50 ± 3.32^{c}	16.09 ± 2.80^{a}	103.53 ± 18.00^{bc}
Sulfur (mg.100 g^{-1})	13.64 ± 0.45^{ab}	86.07 ± 2.83^{c}	12.14 ± 1.44^{a}	78.119.26^{bc}
Sodium (mg.100 g^{-1})	1.52 ± 0.10^{a}	9.56 ± 0.61^{b}	1.43 ± 0.28^{b}	9.20± 1.82^{a}
		Microminerals		
Zinc (mg.kg^{-1})	5.39 ± 0.25^{ab}	34.00 ± 1.58^{c}	4.35 ± 0.31^{a}	28.00 ± 2.00^{bc}
Copper (mg.kg^{-1})	0.82 ± 0.13^{c}	5.20 ± 0.84^{b}	1.34 ± 0.18^{c}	8.60 ± 1.14^{a}
Manganese (mg.kg^{-1})	5.48 ± 0.18^{a}	34.60 ± 1.14^{bc}	7.49 ± 1.12^{ab}	48.20 ± 7.22^{a}
Iron (mg.kg^{-1})	1.24 ± 0.28^{a}	7.80 ± 1.79^{ab}	21.07 ± 0.18^{bc}	135.60 ± 1.14^{c}

[1]Mean value ± standard deviation of fresh weight; n = 5; $^{a, b, c}$ Means within a row with different letters are significantly different ($p < 0.05$).

The macroelement found in higher proportion corresponded to potassium (215.83 ± 11.72 and 98.41 ± 5.54 mg.100 g^{-1}, for red and yellow pitahaya, respectively. It was followed in higher proportion by phosphorus (28.70 ± 0.28 and 17.99 ± 1.48 mg.100 g^{-1}, for red and yellow pitahaya, respectively), and magnesium (29.88 ± 0.53 and 16.09 ± 2.80 mg.100 g^{-1}, for red and yellow pitahaya, respectively), similar to the results of Leterme *et al.* (2006) in a study about the mineral content of the tropical fruits from the Andes of Colombia, finding that potassium (36 – 1.782 mg.100 g^{-1}) is the mineral in higher proportion of the fruits of chirimoya (*Anonna cherimola* Miller), carambola (*Averrhoa carambola* L.), tomate del árbol (*Cyphomandra betacea* (Cav.) Sendtn), mamey (*Mammea americana* L.), among others, which is related to what was found in the present study.

Regarding to the content of mineral microelements for pitahaya fruits, the content of manganese (5.48 ± 0.1 mg.kg^{-1}) and zinc (5.39 ± 0.25 mg.kg^{-1}) for red pitahaya stand out; and in the case of the yellow pitahaya, the highest values corresponded to iron (21.07 ± 0.18 mg.kg^{-1}) and manganese (7.49 ± 1.12 mg.kg^{-1}). Juárez-Cruz *et al.* (2012), found important values of the minerals of zinc and potassium (34.02 mg.kg^{-1} and 4.82 g.100 g^{-1}, expressed on a dry basis, respectively), for tender stems of the *Hylocereus undatus* variety from Mexico.

The yellow pitahaya in micronutrients provides 19.14 % of the recommended average daily intake (IA) of copper in adults, 26.81 % of manganese in adult women and 26.34 % of iron in adult men (Food and Nutrition Board, Institute of Medicine, 2000). On the other hand, Menezes-Cordeiro *et al.* (2015) determined the content of micro and macronutrients of the red pitahaya *Hylocereus polyrhizus* variety, finding values expressed on a dry basis, similar to those of the present study in terms of macronutrients, such as phosphorus (230 mg.100 g^{-1}), potassium (1260 mg.100 g^{-1}) and sulfur (100 mg.100 g^{-1}); however, in the case of the micronutrients such as iron (337.58 mg.kg^{-1}) and zinc (116.20 mg.kg^{-1}) the values were much higher than those of the present study.

Conclusions

The red and yellow pitahaya fruits grown in the Peruvian coastal desert are an important source of nutrients such as fiber, vitamin C, and minerals (potassium, phosphorus, magnesium, manganese, zinc, and iron).

The red pitahaya has a higher content of fiber, vitamin C and zinc, but it has a lower content in total sugars and iron, compared to the yellow pitahaya.

Pitahaya fruits from the central Peruvian coast differ in total protein, fat and fiber content compared to pitahaya fruits from tropical regions.

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