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Nutrient content in ora-pro-nóbis (*Pereskia aculeata* Mill.): unconventional vegetable of the Brazilian Atlantic Forest

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Abstract

Ora-pro-nóbis (*Pereskia aculeata* Mill.) is an unconventional vegetable found in the Brazilian Atlantic Forest and consumed, mainly by the rural population who lives in this biome. The present study investigated the nutritional value and contribution potential this species to the recommendations of daily nutrient intake for adults. Moisture and ash content were determined by gravimetry after oven drying and muffle incineration, respectively. Proteins were determined by the micro-Kjeldhal method; lipids by gravimetric lipids using soxhlet extractor; Total dietary fiber (TDF) by non-enzymatic gravimetry; Carotenoids and vitamin C by High Performance Liquid Chromatography (HPLC) with Diodes Array Detector; Vitamin E by HPLC and fluorescence detection; and minerals by inductively coupled plasma atomic emission spectrometry (ICP-AES). Ora-pro-nóbis presented concentrations of TDF (3.73 g 100 g^{-1}), ash (0.96 g 100 g^{-1}), lipids (1.45 g 100 g^{-1}), protein (1.27 g 100 g^{-1}), carotenoids (3.15 mg 100 g^{-1}), total vitamin E (438.68 µg 100 g^{-1}), Ca (427.08 mg 100 g^{-1}), Mg (88.84 mg 100 g^{-1}), Mn (3.46 mg 100 g^{-1}), Fe (13.89 mg 100 g^{-1}) and K (689.41 mg 100 g^{-1}). The species was considered a source of TDF, a good source of Mg, Cu and K, and an excellent source of vitamin A, Ca, Mn, Fe and Se.

Keywords: *Pereskia aculeata* Mill.; carotenoids; vitamins; minerals.

Practical Application: The work shows a complete study about the chemical composition (moisture content, total dietary fiber, lipids, proteins, carbohydrates and ash), carotenoids (α-carotene, β-carotene, β-cryptoxanthin and lycopene) and minerals (P, K, Ca, Mg, Cu, Fe, Zn, Mn, Na, Cr, Se and Mo) in ora-pro-nóbis, and their contribution to the Daily Recommendation of Nutrients in adults 19 to 30 years.

1 Introduction

A diversity of unconventional vegetable species can be found in the Atlantic Forest biome. Those species are still widely consumed mainly by the populations living in the rural area of this region (Barreira et al., 2015). It is observed that the use of these species is directly related to the dietary habits and that they can present important contribution to the strategies of food and nutritional security of the families that consume them (Paula et al., 2015).

Amid these vegetables, *Pereskia aculeata*, a species of the Cactaceae family, with a herbaceous growth habit, stands out. It is found in native environments, and grown in vegetable gardens, usually consumed braised and added to sauces and broths (Barreira et al., 2015).

Like other unconventional vegetables, *Pereskia aculeata* has been used for several generations as food resources. However, there is a lack of studies that report the nutritional value of this species, and evaluate its contribution to the recommendations of nutrient intake for the human organism. The state of the art on this crop has some works related only to the concentration of some nutrients (Takeiti et al., 2009), and on the use of this species for medicinal purposes in which present healing (Carvalho et al., 2014) and anti-inflammatory activities (Pinto et al., 2015).

So, the present study investigated the centesimal composition, the concentration of carotenoids, vitamin C, vitamin E and minerals in *Pereskia aculeata* plants collected from natural environments of the Brazilian Atlantic Forest, and it analyzed their contribution to nutrient intake in 19-30-year-old adults.

2 Material and methods

2.1 Sample collection and preparation

Samples of *Pereskia aculeata* were collected in November 2012, in the rural area of the city of Viçosa (20°45'14" S and 42°52'44" W), Minas Gerais, Brazil. The samples were transported to the laboratory in Styrofoam boxes containing dry ice within two hours after collection, washed in running water and after that, dried with paper towel. Then, they were homogenized in a food processor, packed in polyethylene bags, wrapped in aluminum foil and stored in a freezer (-18 ± 1 °C).

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Analyses of vitamin C and carotenoid were performed within 36 h after collection, while vitamin E analysis were performed within 72 h after collection. Analyzes of the centesimal and mineral composition were performed within 120 hours after collection.

2.2 Centesimal composition analysis

Analyses of moisture, ash, protein and lipid were carried out in three replicates according to the methods of the Association of Official Analytical Chemists (2010).

Moisture was determined in oven at 65 ± 1 °C for 72 h and ashes in a muffle oven at 550 °C for 6 h. Protein concentration was determined by the micro-Kjeldhal method in which crude protein was calculated by multiplying the nitrogen (N) content by 6.25. Total dietary fiber content was determined using the non-enzymatic gravimetric method (Guerra et al., 2004).

Carbohydrates were calculated by difference using the equation: [100 -% moisture -% lipids -% protein -%TDF -% ash]. The caloric density was estimated considering the conversion factors of 4 kcal g^{-1} protein or carbohydrate and 9 kcal g^{-1} lipids (Frary & Johnson, 2005).

2.3 Extraction and analyses of carotenoids and vitamins

Carotenoids were extracted in acetone and transferred to petroleum ether (Rodriguez-Amaya et al., 1976). Vitamin A value was calculated according to the recommendations of the U.S. Institute of Medicine (2001). Vitamin C was analyzed as ascorbic acid (AA) and extracted in buffer solution (3% metaphosphoric acid, 8% acetic acid, 0.3 N sulfuric acid and 1 mM EDTA) (Campos et al., 2009). For the analysis of AA, the chromatographic conditions proposed by Campos et al. (2009) was used.

This study investigated the complete profile of vitamin E (α-, β-, γ- and δ- tocopherols and tocotrienols) in *Pereskia aculeata*. For extraction and analysis, the technique described by Pinheiro-Sant'Ana et al. (2011) was adopted.

Carotenoid and vitamin C analyzes were performed in a High-Performance Liquid Chromatography (HPLC) system composed of a high-pressure pump (LC 10AT VP); 50-μL loop auto-injector (SIL-10AF) and DAD-diodes array detector (SPD-M10A). In the vitamin E analysis, a CLAE system composed of a high-pressure pump with valve for a low-pressure quaternary gradient (LC 10AD VP) was used; automatic injector with 50-μL loop (SIL-10AF) and fluorescence detector (rf-10A XL) was also used.

2.4 Mineral determination

The minerals (P, K, Ca, Mg, Zn, Mn, Fe, Cu, Na, Cr, Se and Mo) were extracted according to Gomes & Oliveira (2011). The resulting solution was used reading of the concentration of minerals by ICP-AES.

For the quantification, analytical curves were constructed using mineral standards. Two multielement standard solutions (MESS) were prepared in 100-mL flasks, as a result of the concentration of the minerals. MESS 1 was prepared for Cr, Se, Mo, Zn, Cu, Fe and Mn. MESS 2 was prepared for Na, P, Mg, Ca and K. When mixing of MESS standards was finalized, the volume of the standards was filled with deionized water. For the construction of the analytical curves, increasing volumes of MESS 1 (0 to 2 mL) and MESS 2 (0 to 20 mL) were used, completed to 50 mL with white and deionized water to construct six points of the curve.

After the readings, the concentrations found in the samples, in mg L^{-1}, were converted to concentrations of minerals, considering the dilutions and their possible difference in relation to the white.

2.5 Calculation of Pereskia aculeata potential contribution as a nutrient source

The potential contribution of *Pereskia aculeata* as a nutrient source was estimated based on the Recommended Dietary Allowance (RDA) for 19-30-year-old adult men according to the recommendations of the U.S. Institute of Medicine (2001). Portions of *Pereskia aculeata* were calculated according to the Food Guide for the Brazilian Population (Brasil, 2008), considering the caloric density, where a portion of vegetables is equivalent to 30 kcal.

Pereskia aculeata was classified as a nutrient "source" when it presented the potential to supply from 5 to 10% of the Dietary Reference Intake (DRI); "good source" when it presented 10 to 20% potential of DRIs and as "excellent source", when it presented potential greater than 20% of DRIs (Philippi, 2008).

2.6 Experimental design and statistical analysis of the data

This study used a completely randomized design with five replicates for carotenoids and vitamins, and three replicates for centesimal composition. Descriptive statistics (mean, standard deviations and range of parameters) was used to present the results. Regarding linearity range of analytical standards, the data obtained from the peak areas were used for linear regression analysis and for calculation of the correlation coefficient (R^2). The statistical analysis was performed using SAS (Statistical Analysis System) software,9.2 version.

3 Results and discussion

The results found for the centesimal composition of *Pereskia aculeata* (Table 1) show that the species presented all the investigated nutrients. Their comparison with other results was difficult since studies on the nutritional potential of this species are still minimal. At the same time, *Pereskia aculeata* is the only edible species within the genus *Pereskia*, which makes the comparison even more difficult, at least, with other species of the same botanical similarity.

By comparing the results of this study with those found by Takeiti et al. (2009) in *Pereskia aculeata* collected in Serra da Cantareira, São Paulo, Brazil, a difference can be seen among the results found by these authors, since they found concentration of protein (28.4 g 100 g^{-1}), total dietary fiber (39.1 g 100 g^{-1}); lipids (4.1 g 100 g^{-1}) and ashes (16.1 g 100 g^{-1}) that were much higher than those found in this study.

The possible difference between these results and those of the present study may be related to the fact that Takeiti et al. (2009) analyzed the *in vitro* digestibility of proteins as well as dietary fibers, lipids and ashes by the American Association of Cereal Chemists method, whose methodology differs from that used in the present study.

According to the Food Guide for the Brazilian Population, a portion of vegetables is equivalent to 30 kcal (Brasil, 2008). Considering these recommendations, a portion of *Pereskia aculeata* (90 g) contains 2.54 g of total dietary fiber 3.67 g of carbohydrates and 1.93 g of proteins. So, this vegetable may contribute with 7%, 3% and 4% of RDA for adults, respectively.

Considering the methodology proposed by Philippi (2008) for classifying foods in source, good source or excellent source of some nutrient, it can be considered that *Pereskia aculeata* is a source of total dietary fiber for providing 7% of this nutrient according to the *RDA*.

According to Figure 1 and Table 2, it is observed that *Pereskia aculeata* presented carotenoids and vitamin E, however vitamin C was not found. These results differ from those found by Oliveira et al. (2013), who found 192.2 mg 100 g^{-1} of ascorbic acid in leaves of *Pereskia aculeata* collected in the State of Mato Grosso, Brazil. However, these authors analyzed these concentrations using the spectrophotometric method, which is different from the methodology used in the present study.

Agostini-Costa et al. (2012) used the analysis method which was also used in this study to evaluate the concentration of carotenoids in *Pereskia aculeata*. However, those authors analyzed the fruits and found lower concentrations of α-carotene (0.022 mg 100 g^{-1}). In this same study, the authors found β-crytoxanthin (0.002 mg 100 g^{-1}), which was different from what occurred in the present study, where this compound was not found.

Studies that analyzed vitamin E in *Pereskia aculeata* were not found. In the present study, α--tocopherol was the major component (400.34 µg 100 g^{-1}), representing 91% among the analyzed compounds.

By considering the recommendations of the Food Guide for the Brazilian Population (Brasil, 2008), a portion of *Pereskia aculeata* is equivalent to 90 g, and it may contribute with 22% of the vitamin A required daily, so that it can be considered an excellent source of this nutrient. In relation to vitamin E, a portion of *Pereskia aculeata* (0.36 g of this nutrient) cannot be considered as a source of this nutrient, since its contribution percentage is of only 2%.

Among the investigated minerals, the concentrations of K, Ca and Mg stood out. Chromium and Mo were not identified in *Pereskia aculeata* samples (Table 3). Oliveira et al. (2013) investigated the occurrence of some minerals in *Pereskia aculeata* leaves using atomic absorption spectrophotometry, and found results, on average, six times higher than those found in the present study for K (3740 mg 100 g^{-1}), Ca (2160 mg 100 g^{-1}), Mg (680 mg 100 g^{-1}) and Cu (0.9 mg 100 g-1). Takeiti et al. (2009) also quantified minerals in *Pereskia aculeata* and found higher results than those found in this study for Ca (3420 mg 100 g^{-1}), Mg (1900 mg 100 g^{-1}), K (1632 mg 100 g^{-1}), Mn (46.4 mg 100 g^{-1}), Zn (26.7 mg 100 g^{-1}) and Cu (1.4 mg 100 g^{-1}).

The difference in the concentration of the minerals found by these authors in relation to the present work can be attributed to the differences in the botanical structure of native plants. Since

Table 1. Centesimal composition, caloric value and nutritional contribution potential for adults (19 to 30 years old) in *Pereskia aculeata*.

Variables	Mean ± standard deviation	Contribution potential (1 portion = 90 g[1])	
		g/portion	%[2]
Moisture (g 100 g^{-1})	91.10 ± 2.24	-	-
Total dietary fiber (g 100 g^{-1})	3.73 ± 0.03	2.54	7
Ash (g 100 g^{-1})	0.96 ± 0.01	-	-
Carbohydrates (g 100 g^{-1})	2.87 ± 0.61	3.67	3
Lipids (g 100 g^{-1})	1.45 ± 0.01	-	-
Proteins (g 100 g^{-1})	1.27 ± 0.07	1.93	4
Caloric value (kcal 100 g^{-1})	29.17 ± 3.28	-	-

Values expressed in fresh matter; mean of three replicates; [1]vegetable portion equivalent to 30 kcal (Brasil, 2008); [2]calculated on the basis of *RDA* for 19-30-year-old adults (Institute of Medicine, 2001).

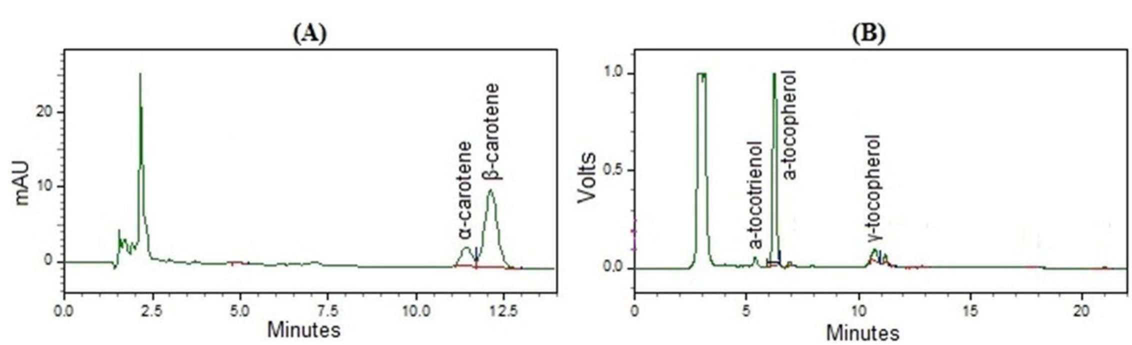

Figure 1. Chromatographic profile of carotenoids (A) and vitamin E (B) found in *Pereskia aculeata*.

Table 2. Concentration of carotenoids and vitamins and nutritional contribution potential for adults (19 to 30 years old) in *Pereskia aculeata*.

Compounds	Mean ± standard deviation	%	Contribution potential (1 portion = 90 g[1])	
			g/portion	%[2]
Total carotenoids (mg 100 g^{-1})	3.15 ± 0.14	100		
α-carotene (mg 100 g^{-1})	0.97 ± 0.08	*30*		
β-carotene (mg 100 g^{-1})	2.23 ± 0.18	*70*		
β-criptoxanthin (mg 100 g^{-1})	*nd*	--		
Licopene (mg 100 g^{-1})	*nd*	--		
Vitamin A (RAE µg 100 g^{-1})	221.61 ± 9.63	100	199.45	22
Total vitamin C (mg 100 g^{-1})	nd	--		
Ascóribic acid	*nd*	--		
Dehydroascorbic acid	*nd*	--		
Total vitamin E (µg 100 g^{-1})	438.68 ± 33.62	100	0.36	2[3]
α-tocopherol (µg 100 g^{-1})	*400.34 ± 29.65*	*91*		
α-tocotrienol (µg 100 g^{-1})	*10.98 ± 0.27*	*3*		
β-tocopherol (µg 100 g^{-1})	*5.85 ± 2.95*	*1*		
β-tocotrienol (µg 100 g^{-1})	*nd*	--		
γ-tocopherol (µg 100 g^{-1})	*21.51 ± 0.75*	*5*		
γ-tocotrienol (µg 100 g^{-1})	*nd*	--		
δ-tocopherol (µg 100 g^{-1})	*nd*	--		
δ-tocotrienol (µg 100 g^{-1})	*nd*	--		

Values expressed in fresh matter; mean of five replicates; [1]vegetable portion equivalent to 30 kcal (Brasil, 2008); [2]calculated on the basis of *RDA* for 19-30-year-old adults (Institute of Medicine, 2001); [3]Only α-tocopherol concentration was considered.

Table 3. Mineral concentration and nutritional contribution potential for adults (19 to 30 years old) in *Pereskia aculeata*.

Minerals (mg 100 g^{-1})	Mean ± standard deviation	Contribution potential (%[1])
K	689.41 ± 18.53	15
Ca	427.08 ± 9.9	38
Mg	88.84 ± 19.62	20
Cu	0.12 ± 0.03	12
Fe	13.89 ± 3.34	156
Zn	0.05 ± 0.02	0.4
Mn	3.46 ± 0.02	135
Na	1.19 ± 0.66	0.07
Cr	nd	--
Se	0.13 ± 0.01	213
Mo	nd	--

Values expressed in dry matter; mean of three replicates; [1]calculated on the basis of *RDA* for 19-30-year-old adults (Institute of Medicine, 2001).

they are collected in natural environments and there is no control of environmental factors such as water, light and temperature, as well as the mineral composition of the soil where these plants are grown, as observed in a study by Subramanian et al. (2012) on the analysis of minerals and heavy metals in some medicinal plants collected at a local market in Salem, India.

By analyzing the contribution potential of the minerals investigated in this study (Table 3), it is observed that *Pereskia aculeata* may be considered a good source of K and Cu, and an excellent source of Ca, Mg, Fe, Mn and Se. However, even if the contribution potential of some minerals is above the RDA, it is stressed that the mineral concentration is not a conclusive indicator of the amount absorbed and used by the organism. Therefore, it is necessary to evaluate the antinutritional factors of this vegetable, since studies with those objectives are not found.

4 Conclusions

High concentrations of micronutrients were found in *Pereskia aculeata*, which was also a source of total dietary fiber a good source of K and Cu, and an excellent source of vitamin A, Ca, Mg, Fe, Mn and Se.

The occurrence of this species in native environments of the Brazilian Atlantic Forest becomes important since it is part of the dietary habits of the families that live there, mainly and due to its important potential of nutritional contribution, making *Pereskia aculeata* a fundamental food species for the strategies of food and nutritional security of family groups whose eating habits are directly related to the consumption of this species.

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