

Full Length Research Paper

Physico-chemical characterization of prickly pear (*Opuntia Ficus indica*) in the semi-arid region of Bahia State, Brazil

Valtânia Xavier Nunes^{1*}, Núbia Xavier Nunes², Luciana Nogueira Londe³, Carlinne Guimarães de Oliveira², Natália Akemi Medina Inoue², Selma Silva Rocha⁴ and Jéssica Guerra Calaes⁵

¹Fitotecnia, Universidade Federal de Viçosa, Avenida Peter Henry Rolfs, s/n - Campus Universitário, Viçosa - MG, 36570-900, Brazil.

²Agronomy, University in Montes Claros Unimontes (UNIMONTES), Janaúba-MG, Brazil.

³Biologist, D.Sc., Pesq. Epamig Norte De Minas - Janaúba, Minas Gerais, Brazil.

⁴Teacher of IF-BAIANO he Instituto Federal de Educação, Ciência e Tecnologia Baiano, Brazil.

⁵Agronomy of Universidade Federal De Minas gerais (UFMG), Janaúba-MG, Brazil.

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In Brazil, prickly pear has gained increasing attention, mainly due to its nutritional benefits of health promotion, however, its postharvest conservation is still incipient and has to be evaluated. The objective of this work was to evaluate the physical and physico-chemical characteristics of prickly pear from three municipalities in the semi-arid region of the state of Bahia-Brazil. The fruits were harvested at random at the commercial harvest point stage, when the bark began to show a change of color from green to yellowish green. Data were subjected to analysis of variance, using the software GENES software, and the averages were compared using the Tukey test at the 5% probability level. The physical and chemical characteristics of the fruits were evaluated. Evaluating the effect of the place of cultivation on these characteristics, it is verified that the municipality of Guanambi presented the lowest value of acidity and higher pH, proving that there is climatic influence on the physico-chemical characteristics of the fruits. It was verified that the values found for the different variables studied, cactus pear, from the municipalities of Guanambi and Riacho de Santana present commercial properties more interesting for *in natura* consumption and agroindustrial use.

Key words: *Opuntia ficus, indica*, post-harvest quality, cultivation site.

INTRODUCTION

The cactus pear (*Opuntia ficus-indica*) is a plant of the cactus family, which supports conditions of lack of water,

high temperatures, poor soils, and is easy to handle in planting. This is the reason why it is cultivated in the arid

*Corresponding author. E-mail: tania_chavier@yahoo.com.br. Tel: (38) 99192-6857.

and semi-arid regions with the purpose of being used to feed livestock during periods of drought (Almeida et al., 2013).

In the northeast of Brazil, the cactus pear is mainly cultivated for feeding of animals. In the meantime, this cactus is the fruit known as the prickly pear, whose fruit is an oval berry with sweet and juicy pulp. It has high nutritional value, presenting in its composition fibers, soluble carbohydrates, vitamins (mainly A and C), calcium and magnesium (Yahia and Jacobo, 2011). In addition, it has the possibility of being explored for its medicinal properties, demonstrating several activities, including antioxidant (Zhong et al., 2010) and anti-inflammatory (Galati et al., 2003), and is a promising fruit with respect to the production of functional foods and nutraceuticals, because it has important compounds for humans. Based on this, prickly pear stands as one of the resources with great potential to add value and increase income and quality of life for the population of the Brazilian semi-arid region.

Although, the cactus pear is commonly cultivated for animal feed, its fruit is still little explored and valued, perhaps because it is considered as exotic fruit and with small spines. This fruit has not yet gained great space in the Brazilian market, due to the lack of knowledge on its potentialities (Almeida et al., 2013). Thus, the realization and dissemination of studies may serve for future research and stimulation of the production and consumption of still-consumed prickly pear in the country.

The physical and physicochemical characteristics of the fruits are influenced by soil and climatic conditions, cultural practices, harvesting period, genetic constitution, stage of maturation and postharvest treatment, among others (Nascimento et al., 2014). These characteristics are factors of quality and fundamental importance for subsidies related to the handling and packaging and for the elaboration of industrialized products (Chitarra and Chitarra, 2005). On the other hand, the physical characterization of the fruits has great importance with determination of the genetic variability of a species that can subsidize genetic breeding programs, as well as its relation with the environmental factors (Carvalho et al., 2003).

Thus, the objective of this work was to evaluate the physical and physicochemical characteristics of prickly pear from three municipalities in the semi-arid region of the state of Bahia.

MATERIALS AND METHODS

The fruits used in this work were *Opuntia ficus indica*, 3-year-old "Gigante" Cv, in properties of small farmers located in three municipalities in the semi-arid region of the state of Bahia, Guanambi, located in the Southwest region of Bahia, totally covered by the drought polygon, semi-arid climatic type, with geographic coordinates of south latitude 14° 13' 24" and longitude 42° 46' 53" W, altitude 530 m; annual average temperature of

23.6°C and 720 mm annual average rainfall. Pindaí is located in the southwestern region of Bahia, with semi-arid climatic type, geographical coordinates with south latitude of 14° 29' 33" and longitude 42° 41' 14" W, altitude 610 m. The average annual temperature in Pindaí is 23.1°C. The average annual rainfall is 688 mm. And Riacho de Santana, is located in the southwestern region of Bahia, semi-arid climatic type, with geographical coordinates: south latitude 13°36' 33" and longitude: 42° 56' 20" W, altitude 627 m, with average temperature of 23.3°C and 852 mm of annual average rainfall.

The fruits were harvested in the month of March 2012, at random, at the commercial harvest point stage, when the bark began to show color change, from green to yellowish green. After being harvested, they were taken to the Food Analysis Laboratory of the Federal Institute of Bahia, Guanambi Campus for physical and chemical analysis. In the laboratory, the spines were removed with the aid of a soft sponge, washed and selected, those that presented some types of injury were discarded. Afterwards they were separated into 10 lots of 5 fruits each, totaling 50 fruits per municipality.

Separation of the bark, pulp and seeds was performed manually using knife, spoon and fine mesh stainless steel sieve. The fruits were submitted for physical determinations: length, diameter, flesh firmness, peel color, bark thickness, number of seeds, fruit weight, bark weight, pulp weight and pulp/bark ratio. Measurements of longitudinal length and diameter (cm), was determined by means of direct measurements, with the aid of a caliper, placing it in a perpendicular position and parallel to the axes of the fruit; the mass (g) was determined by individual weighing of each fruit on a digital analytical scale; firmness of the whole fruit with bark, was determined individually in two distinct points of the equatorial region in the whole fruit with digital dynamometer (N), the coloration was realized by means of a Color Flex 45/0 (2200) colorimeter, stdzMode: 45/0 with reading direct reflectance of the coordinates L* (brightness) a* (red or green tint) and b* (yellow or blue tint) of the Hunterlab Universal Software system. From the values of L*, a* and b*, the angle hue (°h*), number of seeds by individual counting in each fruit and the fruit pulp/peel ratio were calculated by direct weighing in an analytical balance for the average evaluation of fruit weight, as well as the proportions of pulp and peel.

The pulp was analyzed for the physico-chemical characteristics: pH, titratable acidity, soluble solids and SS/AT ratio following the methodologies described in the Adolfo Lutz Institute's Manual of Analyzes (IAL, 2008). The pH was measured by direct measurement in potentiometer of bench, with glass membrane electrode calibrated with pH 4.0 and 7.0 solutions; titratable acidity was determined by titration with 0.1 N sodium hydroxide using 1% phenolphthalein as indicator, and the results were expressed as % citric acid; soluble solids was determined by direct reading in digital refractometer and the results expressed in °Brix, the SS/AT ratio is the soluble solids value divided by the titratable acidity and the result expressed in pure number with two decimal places.

The experiment was conducted using a completely randomized design, with ten replicates and five fruits per experimental unit, three treatments (municipalities). The data were subjected to analysis of variance using the software GENES software, and the averages were compared using the Tukey test at the 5% probability level (Cruz, 2001).

RESULTS AND DISCUSSION

The values of the physical and physico-chemical components of the fruits from the municipalities of Guanambi, Pindaí and Riacho de Santana are presented

Table 1. Values of the physicochemical analyses of prickly pear from the municipalities of Guanambi, Pindaí and Riacho de Santana.

Characteristic	Municipality			Medium	CV (%)
	Guanambi	Pindaí	Riacho de Santana		
Length (cm)	9.38 ^a	7.65 ^c	8.9 ^b	8.64	7.5
Diameter (cm)	5.73 ^a	5.83 ^a	5.86 ^a	5.81	7.7
Fruit weight (g)	180.68 ^b	143.65 ^c	190.43 ^a	171.59	11.5
Pulp weight (g)	106.42 ^a	72.62 ^c	96.21 ^b	91.75	15.4
Shell weight (g)	72.52 ^b	68.74 ^b	86.25 ^a	75.83	16.3
Pulp/shell ratio	1.55 ^a	1.08 ^b	1.12 ^b	1.25	29.1
Number of seeds	308.12 ^a	277.72 ^c	288.24 ^b	291.36	6.3
Shell thickness (cm)	0.50 ^b	0.55 ^{ab}	0.57 ^a	0.546	21.5
Firmness (N)	27.29 ^a	27.13 ^{ab}	26.78 ^b	27.06	3.02
Angle HUE°	60.28 ^c	80.18 ^a	79.16 ^b	73.21	2.3
Soluble solids	14.19 ^a	7.59 ^c	13.33 ^b	11.70	6.2
pH	6.02 ^a	5.65 ^b	5.08 ^c	5.58	6.3
Titrateable acidity	0.241 ^b	0.153 ^c	1.12 ^a	0.507	13.3
Relation SS/AT	59.19 ^a	57.83 ^a	11.90 ^b	42.97	30.5

*Averages followed by the same letter in the rows do not differ from each other by Tukey test at 5% probability.

in Table 1. According to data analysis, it was observed that there was a significant difference in fruit length in the three municipalities evaluated. The fruits from Guanambi presented a 9.38 cm length significantly higher than the values obtained in prickly pear of the other localities: 7.65 (Pindaí) and 8.9 cm (Riacho de Santana). Similar results are demonstrated by Almeida et al. (2013) (9.24 cm) and Silva Junior et al. (2007) (9.18 cm). As for the diameter characteristic, there was no significant difference between the evaluated municipalities, presenting an average of 5.81 cm, this is within the values obtained by Silva Junior et al. (2007) from 4.2 to 5.9 cm, similar to those found by Almeida et al. (2013) (5.73 cm) and higher than that found by Oliveira et al. (2011) (5.1 cm) and Chougui et al. (2013) (4.45 cm).

The fresh fruit weight varied from 143.65 to 190.43 g, the municipality of Riacho de Santana presented the highest fresh fruit weight of 190.43 g, followed by the municipalities of Guanambi (180.68 g) and Pindaí (143.65 g). It is known that several factors can influence the average weight of the fruits, such as irrigation, fertilization, harvesting time, stage of maturation, cultural treatments and climate (Nascimento et al., 2014). This work shows that the region of production had a significant influence on the average weight of the fruits, since the municipalities with the highest annual rainfall presented fruits with higher average weights. As for pulp and bark mass, the municipality of Riacho de Santana also presented higher values than the other municipalities (96.21 g and 86.25, respectively). It is observed that prickly pear have a large amount of pulp when compared with other cactus, and this characteristic may be interesting both for the *in natura* consumption and for processing of the fruit.

The average values found in this work for fresh fruit, pulp and peel (171.59, 91.75 and 75.83 g) were higher than those reported by Almeida et al. (2013) (154.62, 66.49 and 66.19 g, respectively). Such divergences are probably due to differences in the soil-climatic conditions of the growing sites. Brunini et al. (2004) also observed differences in acerola from different growing regions.

The fruit pulp/peel ratio ranged from 1.12 to 1.55, and the highest values were found in fruits from Guanambi. These values are similar to those reported by Rojas et al. (2008) and Chiacchio et al. (2006). Regarding the quantity of seeds, the importance of this component is related to the size of the fruit and therefore, related to the yield and also quality of the product. The number of seeds ranged from 277.72 to 308.12, the fruits from Guanambi had the highest amount of seeds. These values are higher than those found by Almeida (2011) (257).

For thickness of the bark, the values ranged from 0.50 to 0.57 cm, where the fruits from Guanambi presented the lowest values (0.50 cm) and Riacho de Santana had 0.57 cm, while the fruits of Pindaí presented intermediate values of 0.55 cm. The thickness of the shell is of great importance in the yield, because the smaller the thickness, the greater the pulp yield of the product. Prickly pear showed firmness values of 26.78, 27.13 and 27.29 N for the municipalities of Riacho de Santana, Pindaí and Guanambi, respectively. The fruits from Guanambi were firmer, proving to be more resistant to the mechanical damages. These results are consistent with those found by Zegbe and Covarrubias (2010) (27.3).

The color of the bark, evaluated through the hue angle, presented significant differences among the evaluated

municipalities. The fruits from Pindaí and Riacho de Santana had a yellow coloration of 79.16 and 80.18, while fruits harvested in Guanambi showed a reddish orange coloration of 60.28. These differences were probably due to the effect of different environmental conditions. Brito Primo (2008) also observed color differences when evaluating fruits of *Opuntia ficus indica* cv Gigante in different locations in the state of Paraíba.

The soluble solids contents varied between the different localities, ranging from 7.59 to 14.19 °Brix. Fruits harvested in Guanambi present the highest soluble solids contents, differing from other localities. It is shown to be more attractive for *in natura* consumption, because they present a higher content of soluble solids and thus a better palatability. Similar results were found by Brito Primo (2008), evaluating fruits in different locations in the state of Paraíba, and by Chougui et al. (2013), which found values of 12 to 15 °brix in varieties grown in northern Algeria.

The pH and acidity values can be observed to vary from 5.08 to 6.02 and 0.153 to 1.12, respectively. These values make the prickly pear flavored moderately and are well accepted for consumption as fresh fruit since, together with a high soluble solid content, it gives the product a bittersweet flavor. The values of pH and acidity found in this work are consistent with those found by Zegbe and Covarrubias (2010). However, Chougui et al. (2013) verified that prickly pear have high pH (6.2-6.6) and low acidity (0.04 to 0.07%). Almeida et al. (2013), also found low acidity for prickly pear of 0.08 in fruits grown in the state of Bahia.

Evaluating the effect of the place of cultivation on these characteristics, it was verified that the municipality of Guanambi presented the lowest value of acidity and higher pH, proving that there is climatic influence on the physico-chemical characteristics of the fruits. Nascimento et al. (2014) evaluating the physical and physico-chemical characteristics of mangabeira fruits also verified significant differences for the values of pH and acidity in the different cultivation sites.

The SS/AT ratio ranged from 11.90 to 59.19, and fruits from the municipalities of Guanambi and Pindaí presented the highest values for the SS/AT ratio (59.19 and 57.83, respectively), while fruits in the municipality of Riacho de Santana presented the lowest values. The SS/AT ratio is widely used as a subjective taste assessment criterion because it expresses the sweet-acid balance of foods. It is interesting that this relation presents high values, since it indicates there are more sugars than fruit acids. Thus, the fruits from the municipality of Riacho de Santana contain more acids than sugars.

Conclusion

The physical and physico-chemical characteristics of

prickly pear are strongly influenced by the growing site, especially in relation to color, fruit mass and soluble solids contents. Factors such as genetic variability, edaphoclimatic conditions and crop management may be determinants of the oscillations recorded for the variables studied in the different orchards.

Considering the values found for the different variables studied, prickly pear from the municipalities of Guanambi and Riacho de Santana present commercial properties more facilitating for *in natura* consumption and agroindustrial use.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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