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PHYSICAL AND PHYSICAL-CHEMICAL CHARACTERIZATION OF *EUGENIA DYSENTERICA* FRUITS FROM WESTERN BAHIA

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ABSTRACT

Among the different species of native Cerrado stands out cagaiteira the wide use of its fruits in the manufacture of sweets, liqueurs, ice cream, jam and other products. This work aimed to study the physical and physical-chemical characteristics of the cagaita fruit in Western region of Bahia. 270 fruits were sampled from nine matrices, which were collected in an area of the municipalities of Angical - BA and Barreiras – BA. It was considered for the physical assessments, the fruit weight, longitudinal and transversal diameters of the fruit, total seed weight per fruit, the weight of the pulp and peel, the yield of pulp and peel. As for the physicochemical evaluations, the fruit pulp was subjected to the determinations of potential hydrogen (pH), soluble solids content (SS), titratable acidity (TA) and the relation soluble solids and titratable acidity. For the variables, longitudinal and transversal diameters, the weight of pulp and peel, seed weight, fruit weight and the yield of pulp and peel, the averages were, respectively, 26.77 and 29.23 mm, 10.60 g, 2.02 g, 12.53g and 83.35%. However, with regard to pH, SS, AT and SS/AT, means were 3.59, 8.40 Brix, 0.84 and 10.49. The results indicate that there are statistically significant differences between all variables evaluated.

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INTRODUÇÃO

Fruit plants native of the Cerrado biome have great potential for exploration in the Brazilian agribusiness sector through consumption as fresh fruit or as processed products (Santos *et al*., 2012; Hansen *et al*., 2013; Gatti *et al*., 2014). Such plants provide fruits with their own sensory characteristics and high levels of vitamins, minerals and sugars (Cardoso *et al*., 2011; Oliveira *et al*., 2012), but are exploited in an extractive manner. Among the fruit species native to the Cerrado, the cagaiteira (*Eugenia dysenterica DC.),* a perennial plant belonging to the Myrtaceae family, deserves special mention (Assumpção *et al*., 2013). It blooms during the months of August and September, and the fruits ripen between the months of October and November (Silva *et al*., 1994). It presents high fruit production, between 500 and 2,000 fruits per plant, which are characterized by yellow color and flavor acidulated (Silva *et al*., 1994). These fruits are widely used in the manufacture of sweets, liquors, ice cream and jellies (Oliveira *et al*., 2011). The physical characteristics which correspond to the external appearance, such as the size, shape and color of the fruit's peel, associated with the physical-chemical characteristics, such as taste and nutritional value of the fruits, are quality attributes necessary for the use and commercialization of the fruit and its pulp and for the elaboration of industrialized products (Chitarra and Chitarrra, 2005; Silva *et al*., 2013). These quality attributes are responsible for the acceptance of fruits in the food market. In addition, they are attributes that act as an important factor to detect the genetic variability of the species and its relationship with environmental factors, as well as assisting genetic improvement programs (Carvalho *et al*., 2003; Gonçalves *et al*., 2013). These studies are also important for obtaining information on the handling and packaging of the fruits. The chemical and physical characteristics are influenced by factors such as edaphoclimatic conditions, cultural treatments, genetic constitution and post-harvest treatment (Lira Júnior, 2005). Based on exposed facts, there are numerous genotypes of cagaiteira in nature with the potential to be explored economically in commercial plantations and not just in an extractive manner, as long as research and development of technologies enable their use and market entry. Therefore, the aim of this work was to determine the physical and physical-chemical characteristics of cagaiteira fruits in Western Bahia, in order to subsidize the commercial exploitation of the fruits.

MATERIALS AND METHODS

Fruit collections were carried out in two areas in the municipalities of Barreiras and Angical, located in the western region of Bahia. The

climate of the region is characterized, according to Thornthwaite and Mather, as dry sub-humid - C1d'A '- presenting rainy summer and extremely dry winter with an annual rainfall of 700 to 2000 mm (AIBA, 2004) concentrated between the months of October and April showing, however, a high probability of summery during the rainy season. The climatic conditions of this region has much variation, however, the West region presents a very severe climate, low annual capacity distributed in a short period of the year and hot and rainy summers. The minimum and maximum temperatures are respectively 14 and 34° C. The relative humidity of normal air in Barreiras varies from 47.1% in September to 80.3% in March, reaching a normal annual average equivalent to 68% .The region has a luminance equivalent to 3000 h year-1 (AIBA, 2004), cerrado vegetation and sandy soil. The fruits were collected from plants with an average height of 7.0 meters. Nine matrices were chosen (Table 1), from which the fruits were removed at the ripe stage of maturation, yellow color, packed in polyethylene bags and taken to the laboratory.

The hydrogenionic potential (pH) was determined by the potentiometric method in pH meter with the aid of a digital meter calibrating the potenciometer through buffer solutions (pH 4.0 and 7.0). The content of soluble solids (SS) was determined by direct reading on a digital refractometer and expressed in ° Brix (AOAC 2016). The titratable acidity (AT) was determined by means of titration in the presence of phenolphthalein with standardized sodium hydroxide solution (NaOH) 0.1 N, expressing the final results as a percentage of citric acid (IAL, 1985). The soluble solids and titratable acidity ratio (SS / AT - Ratio) was also determined.

Statistical analysis of the study

A completely randomized design was used and the data obtained in physical and physical-chemical analyzes were subjected to analysis of variance and the means compared by the Tukey test at 5% probability.

Table 1. Coordinates and places of collection of the fruits of the cagaiteira matrices

PLANT	LOCATION	COORDINATES
1	Barreiras	12° 10' 07,8" / 44° 51' 42,4" / 699m
2	Barreiras	12° 10' 08,1" / 44° 51' 42,4" / 696m
3	Barreiras	12° 10' 07,8" / 44° 51' 42,4" / 699m
4	Barreiras	12° 10' 08,1" / 44° 51' 42,4" / 696m
5	Barreiras	12° 10' 07,9" / 44° 51' 42,6" / 693m
6	Barreiras	12° 11' 38,0" / 45° 12' 41,3" / 544m
7	Angical	11° 46' 38,5" / 44° 35' 91,1" / 409m
8	Angical	11° 46' 38,4" / 44° 35' 89,9" / 397m
9	Angical	11° 46' 38,5" / 44° 35' 91,1" / 405m

Table 2. Physical characteristics of fruits of cagaiteira matrices

Number		Diameter (mm)		Weight (g)			Yield (%)
Matrice	Fruits	Longitudinal	Transversal	Pulp and peel	Fruit	Seeds	Pulp and peel
1	30	23,55 de	26,91 d	6,64 e	9,35 de	2,57 b	71,28 e
2	30	26,27 c	29,48 bc	11,24 c	12,69 b	1,45 d	88,51 ab
3	30	33,86 a	30,00 b	15,48 a	17,29 a	1,80 cd	89,53 ab
4	30	29,90 b	33,41 a	12,85 b	17,21 a	4,36 a	75,59 d
5	30	26,35 c	23,17 e	6,76 e	8,11 e	1,35 d	83,51 c
6	30	24,52 d	27,46 d	7,18 e	9,37 de	2,19 bc	76,65 d
7	30	22,84 e	27,99 cd	9,23 d	10,67 cd	1,45 d	86,53 bc
8	30	26,53 c	32,13 a	10,77 c	12,23 bc	1,46 d	88,12 ab
9	30	27,15 c	32,49 a	14,33 a	15,85 a	1,52 d	90,45 a
MG		26,77	29,23	10,60	12,53	2,02	83,35
CV (%)		6,20	7,25	15,33	16,96	15,48	4,66

MG - general average. CV - coefficient of variation. Means followed by different letters in the columns differ by the Tukey test at the 5% level of significance.

Physical analysis of fruits: Two hundred seventy ripe, morphologically perfect fruits were randomly selected and sent to the laboratory, where individualized physical analyzes by fruit were performed. The weight of the fruit (FP) in grams was determined using a precision digital scale; longitudinal and transverse diameters (DL / DT) of the fruit, in millimeters, measured with a digital caliper; the total weight of seeds per fruit (PTS) and the weight of the pulp and peel (PPC), in grams, on a precision digital scale; the number of seeds per fruit and pulp and peel yield (RPC), in percentage, that is, division between the weight of the pulp and the weight of the fruit multiplied by 100 (AOAC, 2000).

Physico-chemical analysis of fruits: For physicochemical evaluations 30 fruits were randomly collected from the four quadrants of a single matrix in a total of 270 fruits and then were transported to the laboratory in styrofoam boxes. The fruits were collected manually, immediately after leaving the plant and morphologically perfect. To obtain the pulp, the fruits were macerated in a sieve, individually and later the pulp was packed in polyethylene bags, identified and stored under refrigeration in a freezer (- 18° C). The pulp of each matrix was divided into ten equal lots and each lot was composed of the pulp of three fruits. The lots represented the repetitions and the matrices were considered as treatments. The physicochemical analyzes were performed after thawing the pulp.

RESULTS AND DISCUSSION

The results referring to the physical characteristics of the cagaiteiras fruits are shown in Table 2. The results show that there was a statistically significant difference between all the physical variables evaluated ($p \leq 0.05$). The longitudinal and transversal diameter of the fruits of the cagaiteiras differed in some evaluated levels. For the longitudinal diameter the maximum value was 33.86 mm and the minimum value 22.84 mm in relation to the transverse diameter. Such characteristics presented the following values, 33.41 mm and 23.17 mm, respectively. The averages of the longitudinal and transverse diameters of the fruits were 26.77 mm and 29.23 mm which gives cagaiteira fruits a flattened appearance. Most fruits had a longitudinal diameter smaller than the transversal diameter as found in a study by Silva et al. (2001) in the state of Goiás,in which the mean values for the longitudinal and transversal diameter of the cagaiteira fruits were 24.05 and 28.88 mm, respectively. According to Chitarra and Chitarra (2005), the diameter and length of fruits are physical attributes that are seldom used in products intended for processing, unlike fruits intended for *in natura* consumption where these characteristics are important. The shape of the fruit influences its commercial value, therefore, fruits with deformities are little accepted by the consumer and have a lower price.

The weight of the fruits was different in all the evaluated plants, varying between 8.11 g, and 17.29 g, general average of 12.53 g. The fruit weight values found in this study corroborated the values obtained by Silva et al. (2001) in which the values vary from 8.80 g to 17.09 g. The variations in the weight of the fruits may be due to genetic variability or environmental variations due to different geographical locations. Therefore, plants 3, 4 and 9 deserve to be highlighted because they have the highest values of fruit weight, since for the fresh fruit market, heavier or larger fruits are more attractive to consumers. In addition, fruits that have standardized size and weight are easier to handle in large quantities, according to Chitarra and Chitarra, (2005). The variation in fruit weight data that occurred between the matrices was already expected, as these are plants that have not yet been domesticated (Nascimento et al., 2011). It was also found that for the variable weight of pulp and peel of the fruits there was a difference with values varying between 6.64 g and 15.48 g, an average of 10.60 g. In the evaluated fruits, the pulp and peel yield varied from 71.28% to 90.45% of the fruit mass. The mean value of the pulp and peel variable was equivalent to 10.61 g, found by Silva et al. (2001), working with characterization of cagaiteiras fruits in the state of Goiás. Cardoso et al. (2011) in a study with cagaiteiras fruits in Minas Gerais found an average pulp weight of 21.72 g, ranging from 10.73 g to 31.30 g. Among all the physical characteristics of the fruit, the weight of pulp and peel is the most important for economic exploitation, especially in relation to fruit processing since this is the usable part of the fruit (Carvalho et al., 2003). Regarding this characteristic, plants 3, 4 and 9 stand out, since the values observed in the yield of pulp and peel of the fruits of these matrices indicate the possibility of selecting fruits with high pulp yield for industry. The weight of seeds per fruit varied from 1.35 g to 4.36 g with a general average of 2.02 g. The number of seeds per fruit was quite variable, as mentioned by Silva et al. (1992), presenting a variation of 1 to 3 seeds / fruit. It was also found the presence of 1 fruit with 4 seeds (Figure 1).

In this work, the fruits that presented the lowest weight of seeds also had greater weight of pulp and peel, an important characteristic for economic exploration and industrialization. The lower weight of seeds per fruit directly influences the percentage of yield, mainly for the fruits destined for the elaboration of products, whose minimum value required by the processing industries is 40%, according to Chitarra and Chitarra (2005). Therefore, this characteristic was observed in plants 2, 5, 7, 8 and 9 which had the lowest seed weights.
A positive correlation was observed for most of the physical variables of the cagaiteira fruits, all of which are statistically significant, with the exception of the variables Fruit Weight x Number of Seeds / Fruits, Number of Seeds / Fruits x Longitudinal Diameter and Number of Seeds / Fruits x Transverse diameter. Negative correlations were observed only for the variables Pulp and Peel x Number of Seeds / Fruits (-0.1486) and Number of Seeds / Fruits x Transverse Diameter (-0.0830). The highest value observed was for fruit weight x pulp weight (0.9528) (Table 3).

The higher correlation value observed indicates that the larger the fruit size, the higher the pulp yield, therefore, the value of one variable is directly proportional to the value of the other. Nascimento et al. (2011) when studying murici in the Angical region - BA also observed a proportionality between the mass of the fruit and the pulp mass. According to the results (Table 4), it was found that there was a statistically significant difference between all the physical-chemical variables evaluated ($p \leq 0.05$). Thus, the cagaiteira fruits had a hydroxygenic potential varying between 2.77 and 3.21, with an average value of 2.98. The average pH value found in the present study was similar to that found by Almeida et al. (1998), whose general mean pH was 2.83, as well as that found by Silva et al. (2008) who obtained a value of 2.96 for the pH of cagaiteira fruits in the mature stage of maturity. Fruits with a pH below 4.50 are classified as very acidic, being that pH below 4.50 is desirable to prevent the proliferation of microorganisms.

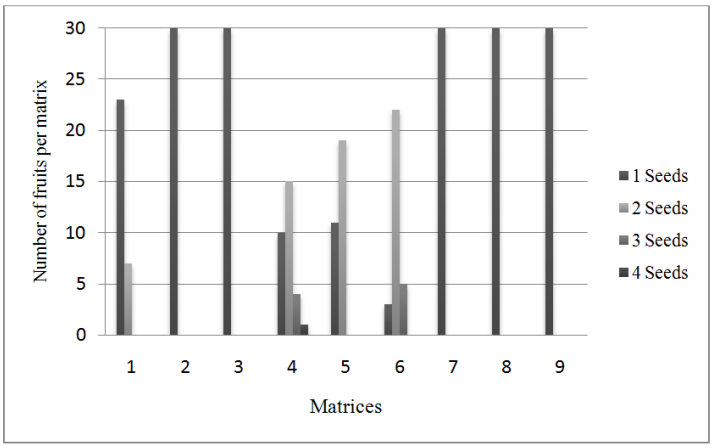

Figure 1. Number of seeds per fruit, according to each cagaiteira matrix

Table 3. Correlation for the physical variables of the fruits of the cagaiteira matrices

Correlation	Coeficient Correlation (r)	Significance
Fruit Weight x Average Seeds/Fruit	0,5011	**
Fruit Weight x Pulp and Peel	0,9528	**
Fruit Weight x Number of Seeds/Fruits	0,0753	ns
Fruit Weight x Longitudinal Diam.	0,6404	**
Fruit Weight x Transversal Diam.	0,6293	**
Average Seeds/Fruit x Pulp and Peel	0,2186	**
Average Seeds/Fruit x Number of Seeds/Fruits	0,6862	**
Average Seeds/Fruit x Longitudinal Diam.	0,2329	**
Average Seeds/Fruit x Transversal Diam.	0,3076	**
Pulp and Peel x Number of Seeds/Fruits	-0,1486	*
Pulp and e Peel x Longitudinal Diam.	0,6407	**
Pulp and e Peel x Transversal Diam.	0,6004	**
Number of Seeds/Fruits x Longitudinal Diam.	0,0169	ns
Number of Seeds/Frutos x Transversal Diam.	-0,0830	ns
Longitudinal Diam. l x . Transversal Diam	0,4426	**

** significant at the 1% probability level (p <.01); * significant at the 5% probability level (.01 = <p <.05); ns: non-significant.

Table 4. Physico-chemical characteristics of cagaiteira fruits

Matrice	pH	Soluble Solids (SS) (ºBrix)	Titratable acidity (AT) (% citric acid)	SS/AT - Ratio
1	2,77 c	10,50 a	0,95 ab	11,09 cd
2	3,08 ab	10,36 ab	0,60 f	17,43a
3	2,73 c	8,50 c	0,95 ab	8,92 e
4	2,87 c	10,31 ab	0,87 bc	11,95 c
5	3,15 ab	9,95 b	0,71 de	14,19 b
6	3,03 b	6,03 e	0,99 a	6,12 f
7	3,21 a	7,04 d	0,70 ef	10,05de
8	2,83 c	7,08 d	0,82 cd	8,79 e
9	3,17 ab	5,80 e	0,99 a	5,89 f
MG	2,98	8,40	0,84	10,49
CV %	3,59	3,95	9,34	10,15

MG - general average. CV - coefficient of variation. Means followed by different letters in the columns differ by the Tukey test, at the level of 5% significance.

Table 5. Correlation for the physicochemical characteristics of the fruits of the cagaiteiras matrices

.Correlation	Coeficient Correlation (r)	Significance
pH x Brix	-0,2751	**
pH x Acidity	-0,3248	**
Brix x Acidity	-0,3564	**

** significant at the 1% probability level (p <.01).

In addition, according to the current Brazilian legislation, the pH in fruit pulp can vary from 2.2 to 4.6, therefore, all matrices are within the allowed variation. In the analysis of processed foods based on fruits, the pH measurement is important for the analysis of food deterioration caused by the growth of microorganisms, jelly texture, flavor and odor retention, stability of artificial colors and verification of the degree of fruit ripeness . The higher the ripeness of the fruit, the lower the pH and acidity levels (Cecchi, 2003; Damodaran et al., 2010). In this study, there was a variation in the SS values from 5.80 to 10.50 ºBrix and a general average of 8.40 ºBrix. The SS values were higher than those reported by Almeida et al. (1998), whose value for this characteristic was 5.6 ºBrix. However, the value of the general average was close to those obtained by Silva et al. (2008) in a study with cagaiteira in the state of Goiás in which they obtained the value of 8.00 ° Brix for fruits in the stage of ripe maturation. The content of soluble solids may be indicative of the levels of sugars contained in the fruit, because as the soluble solids increase, so does the sugar content (Chitarra and Chitarra, 2005). However, the soluble solids content varies according to the stage of maturation and the climate (Matias et al., 2014). Fruits with higher levels of soluble solids are preferred for fresh consumption due to the excellent degree of sweetness. As for the industry, the higher the content of soluble solids contained in the fruit pulp, the less sugar will be added, resulting in higher yield of the final product and less time spent evaporating water during processing, and, consequently, reducing costs in production (Santos et al., 2018). Considering this characteristic, matrices 1, 2 and 4 should be highlighted.

Regarding total titratable acidity, the average was 0.84 with a range from 0.60 to 0.99. A fruit with citric acid content between 0.08 to 1.95% can be classified as of moderate flavor and well accepted for consumption as fresh fruit (Sacramento et al., 2007). The flavor, odor and color attributes are directly influenced by the organic acids present in the fruits. On the other hand, the industry has a preference for fruits with greater acidity, because during the processing of jams and sweets less acid addition is necessary. Therefore, these fruits are suitable for consumption in natura, due to the differentiated flavor and for processing, justified by not needing to add acidulants to reduce the pH when higher than 4.5, which can favor the growth of *Clostridium botulinum*, bacterium that causes botulism (Nascimento et al., 2011). Thus, for fruits intended for the production of products such as juices, sweets, popsicles and ice cream, the physical-chemical parameters related to the titratable acidity and the soluble solids content are more relevant. The results obtained for the SS / AT ratio ranged from 5.89 to 17.43. The SS / AT ratio provides a good evaluation of the fruit's flavor, becoming more representative than the isolated measurement of sugars and acidity.

A lower ratio indicates acidic flavor in the fruit and a higher ratio indicates greater sweetness (Chitarra and Chitarra, 2005) and is also an indicator of the fruit's ripeness point (Krumreich et al., 2015). The SS / AT ratio, which relates the quality of the fruit in terms of ripeness and flavor, showed that the cagaita had a very high average value. This indicates that the pulp of this fruit is indicated for the industrialization of sweet products, such as sweets, jellies, popsicles and ice cream. However, the value was due to the low acidity and the high content of soluble solids, according to Nascimento et al. (2011).
All the correlations of the physical-chemical variables were statistically significant (Table 5). It was observed that the variables pH x Brix (-0.2751), pH x Acidity (-0.3248) and Brix x Acidity (-0.3564) showed a negative correlation. The physicochemical characteristics of the cagaiteira fruits showed a negative correlation, which means that the increase in pH and Brix are inversely proportional to the increase in acidity, as well as the increase in pH is inversely proportional to the increase in Brix. Nascimento et al. (2014) and Nascimento and Cocozza (2015) also found negative values for the correlation of pH x Brix and pH x Acidity in mangabeiras and pequizeiro fruits, indicating that the pH increase is inversely proportional to the increased acidity and soluble solids content., as occurred for cagaiteira fruits.

CONCLUSIONS

1. The physical and physicochemical evaluations show that the studied plants present great variations in all the evaluated variables, due to the high variability that this species presents.
2. The fluctuation in physical variables results from the lack of uniformity of the fruits, which requires a pre-classification of them by size or weight to serve the consumer market.
3. The physicochemical aspects of cagaiteira fruits are attractive for consumption as fresh fruit as well as for industrialization. Therefore, this species has the potential to be exploited commercially, since the results showed that such matrices are promising for future genetic improvements in the species, aiming at the installation of commercial plantations.

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