Original Research Article

Characterization and Correlation Analysis of Physical and Physico-Chemical Properties of Cambucá Fruits (*Plinia edulis*)

.

ABSTRACT

Aims: This study was to characterize and correlate physical and physico-chemical properties of cambucá fruits (*Plinia edulis*).
Study design: Experimental design was completely randomized with fifteen samples of five fruits each.
Place and Duration of Study: Experimental orchard of the Department of Plant Science, Federal University of Viçosa (UFV), located in the municipality of Viçosa, Zona da Mata of Minas Gerais during the month of February 2015.
Methodology: Fruits were sampled when 100% of peels presented yellow-orange color. The following characteristics were evaluated: longitudinal and transverse diameter, total mass of both pulp and seed, pulp color, soluble solids, titratable acidity, soluble solids/titratable acidity ratio, ascorbic acid and carotenoids contents. To verify the degree of correlation between two physico-chemical variables, a Pearson analysis was performed.
Results: Cambucá fruits showed average values of longitudinal and transverse diameter of 37.76 and 44.36 mm, respectively. Fruits' average mass were 44,12 g and the percentage of pulp was 82,15 %. Both soluble solids and titratable acidity presented the respective average values: 10.53 ºBrix, 1.34 mg of citric acid and 100 mL^{-1} of pulp. Larger cambucá fruits presented higher pulp yield and lower acidity. The increase in ascorbic acid was positively correlated with the contents of soluble solids and carotenoids.
Conclusion: Fruits of cambucá have potential for commercialization, their characteristics are similar to those found in other fruit species native to the Myrtaceae family and already found in the fruit market.

Keywords: Analysis Pearson, carotenoids, exotic fruits, Myrtaceae, Plinia edulis.

1. INTRODUCTION

The species *Plinia edulis* is native from the Brazilian Atlantic forest, popularly known as "cambucazeiro" or "cambucá", growing from the State of Rio de Janeiro to Santa Catarina, being currently in danger of extinction [1]. It is a tree species, with height varying from 5 to 10 meters and belongs to the family Myrtaceae, which houses a great diversity of fruit species, such as jabuticaba (*Myrciaria jabuticaba*), pitanga (*Eugenia uniflora* L.), uvaia (*Eugenia pyriformis* Cambess.), guariroba (*Campomanesia xantocarpa* O. Berg.), cerejeira-do-mato (*Eugenia involucrate* DC.), among others [2,3].

The cambucazeiro is well known in local communities where the species is found, due to its fleshy and juicy fruits, widely used in folk medicine against stomach problems and sore throat [1]. Some important substances for the pharmaceutical industry are found in its leaves, such as flavonoids, terpenoids and tannin [1,4], while the fruits have acceptable sensory characteristics and nutritious properties of interest [5,6].

Although commonly used in local medicine, only a few scientific works were made with this species, justifying the need of more studies that may allow greater exploitation of the cambucá fruit [2,4,7]. Studies related to fruit's characterization are of great relevance to this exploitation, given new marketing possibilities for its potentialities. Native fruits from the Atlantic forest usually have good levels of vitamins, mineral salts and antioxidant composts [8,9,10,11].

Therefore, the lack of information that may enhance the potentiality of the cambucazeiro through fruits' characterization, thus allowing the exploitation and consequently the perpetuation of the species, since its currently endangered. The aim of the study was to characterize cambucazeiro fruits as the physical and physico-chemical properties and the correlation between these attributes.

2. MATERIAL AND METHODS

Seventy-five fruits were collected from the median part of cambucazeiro plants, of the native Mata Atlântica collection of the gy Department of Plant Science of the Federal University of Viçosa (UFV), in Viçosa, Minas Gerais, Brazil, at 20°45'S, 42°51'O and 649 m of altitude. Fruits were sampled in February 2015, when they reached full physiological maturation, i.e. with yellow-orange peel.

Right after collection, all fruits were taken to a post-harvest laboratory, where they were washed and sanitized. Then, fruits were characterized as the following physical attributes: longitudinal and transverse diameter, measured with a digital pachymeter; longitudinal/transverse ratio; total mass of pulp (epicarp + mesocarp + endocarp) and seed (g), weighted in a semi-analytical balance; pulp and seed percentage (%), obtained by the ratio between each part's mass by total fruit mass; pulp coloration (chromaticity, hueº angle and luminosity), determined by reflectometry utilizing the reflectometer Minolta (Color Reader CT-10).

The analyzed chemical properties were: soluble solids (ºBrix), obtained by means of the direct reading of a digital refractometer; titratable acidity (mg of citric acid per 100 mL^{-1} of juice), determined by the titration of 10 mL of homogenized juice with 90 mL of distilled water, using a 0.1N NaOH solution at as titrant and adding three drops of phenolphthalein as an indicator to the sample; soluble solids/acidity ratio; ascorbic acid content (mg of ascorbic acid in 100 g of pulp), determined by titration with Tillman reagent (2.6 dichlorophenolindophenol - sodic salt at 0.1 %) [12]; and the total carotenoids content (mg 100 g-1 of pulp), determined through the extraction of approximately 2 g of mashed pulp with the addition of 50 mL of acetone 80 % and kept for 48 h inside a refrigerator at 4 °C. Subsequently, the absorbance of the obtained extract was read in a spectrophotometer at the wavelength of 470.0 646.8 and 663.2 nm, and the carotenoids levels were determined [13].

Means were determined for all evaluated characteristics, as well as minimum and maximum values, standard deviation and variation coefficient. Then, all data underwent a Pearson's correlation analysis, among all variables. All statistical analysis was performed with the statistical program "GENES" [14].

3. RESULTS AND DISCUSSION

Average values of cambucá physical characteristics are presented in Table 1. Longitudinal and transverse fruits' diameter were 37.76 and 44.36 mm and the variation coefficient of 4.58 and 4.14% (considered low for these attributes), respectively, with the ratio longitudinal/transverse varying from 0.82 to 0.87, with average value of 0.85. These results indicate that this fruit has a flattened shape, due to a lower longitudinal diameter compared to the transverse, resulting in a ratio of these characteristics lower than 1. In "cagaita" (*Eugenia dysenterica* DC.), a species of the same family of the cambucá was observed lower average values of longitudinal (34.7 mm) and transverse (31.6 mm) diameter [10].

Fruits mass ranged from 35.21 to 55.42 g, with an average of 44.12 g, with a great homogeneity in evaluated data (VC = 13.24 % and σ = 5.88 g). For *Psidium friedrichsthalianum* an average mass observed was of 42.19 g, ranging from 18.02 to 83.82 g [15], while in *Campomanesia phaea*, the fruit mass ranging from 21.2 to 82.33 g, with an average of 42.19 g [8]. These results indicate that cambucazeiro fruits' average mass is similar to other species of the Myrtaceae family.

Pulp mass presented a variation from 28.92 to 45.34 g, with an average of 36.46 g, while seed mass was 7.94 g, ranging from 15.66 to 20.41 g (Table 1). Given these results, the higher pulp mass positively influenced on the increase in pulp percentage of fruits (Table 1). Pulp percentage was 82.15 %, while seed was 17.84 %. These values suggests that cambucazeiro fruits are fleshy, which is very interesting both for the industry and in natura consumption. Similar values to our results are observed in other Myrtaceae species, as in cagaita fruits, with pulp yield of 86.43 % [10] and, in jabuticabeira fruits with 62.54 % of the total fruits' mass corresponding to the pulp [3].

Table 1. Average values with respective minimum and maximum values, standard deviation (σ) and variation coefficient (VC) of the characteristics: longitudinal and transverse diameter, longitudinal/transverse ratio, total mass, pulp mass, seed mass, pulp and seed percentage of cambucá fruits (*Plinia edulis*).

Characteristics	Mean	Minimum	Maximum	σ	VC (%)
Longitudinal diameter (LD) (mm)	37.76	34.74	40.91	1,73	4.58
Transverse diameter (TD) (mm)	44.36	41.26	47.79	1,93	4.14
Ratio LD/TD	0.85	0.82	0.87	0,20	2.31
Total mass (g)	44.12	35.21	55.42	5,88	13.24
Pulp mass (g)	36.46	28.92	45.34	4,73	12.97
Seed mass (g)	7.94	6.18	11.31	1,43	18.03
Pulp percentage (%)	82.15	79.58	84.33	1,65	9.24
Seed percentage (%)	17.84	15.66	20.41	1,65	2.01

σ: standard deviation, VC: variation coefficient.

Color characterization variables such as chromaticity, hue angle and pulp luminosity are presented in Table 2. Mean values were 15.35(σ = 2.76 and VC = 18.01 %); 76,68˚ (σ = 3.15 and VC = 4.11) e 43,67 (σ= 2.38 and VC = 18.01 %), with low coefficients of variation. Based on these variables, cambucazeiro fruits were characterized with yellow-orange coloration, in both peel and pulp. In the literature the cambucá fruit is described as yellow-orange, with little intensity of color and brightness [1].

In native and exotic Amazon fruits was observed varying colors from yellow with slightly green to yellow with little orange (e.g. noni, murici, abiu, yellow mombin, cajarana, cashew, bacuri, cupuacu and soursop), with hue angle close to 70, indicating yellow shades [16].

Table 2. Average values with respective minimum and maximum values, standard deviation

(σ) and variation coefficient (VC) of the characteristics: chromaticity, hueº angle (HUE) and luminosity of the pulp of cambucá fruits (*Plinia edulis*).

Characteristics	Mean	Minimum	Maximum	σ	VC (%)
Chromaticity	15.35	11.36	20.06	2.76	18.01
HUE	76.68	72.50	83.03	3.15	4.11
Luminosity	43.67	39.26	47.60	2.38	18.01

σ: standard deviation, CV: variation coefficient.

Chemical properties of the cambucá fruits are presented in Table 3. Soluble solids variation ranged from 8.72 to 12.60, with an average of 10.53 °Brix, while the titratable acidity contents varied from 0.71 to 2.07%, with 1.34 % average of citric acid. Soluble solids content ranging from 7.3 to 13.30 ° Brix and titratable acidity of 0.65 to 3.48 % of citric acid are reported in the literature [8]. Due to the acidic character of the cambucá fruits, there is a possibility of use on fruits processing, such as concentrated juices and fermented beverages [17].

The average content of ascorbic acid in cambucá fruits was 7.84%, while the carotenoids was 0.21 mg.100 g^{-1} of pulp. Ascorbic acid and carotenoids are important for preventing and reducing lipids, proteins and nucleic acids' oxidative damage by reactive oxygen species, where free radicals are found [18].

Despite presenting antioxidative substance, determined by the contents of ascorbic acid and carotenoids, these values are below the observed for other native fruit species in Brazil, such as the mangaba (*Hancornia speciosa*), jabuticaba, caju (*Anacardium occidentale*) and umbu (*Phytolacca dioica*), all of which presents carotenoids varying from 0.3 to 1.0 mg.100g-1 of pulp and ascorbic acid contents of 18.4 to 23.8 % [11]. These contents are also below the levels found in traditional fruits, such as mango, banana, papaya and guava, being the last one of the same family as cambucá [19, 20, 21, 22].

Table 3. Average values with respective minimum and maximum values, standard deviation (σ) and variation coefficient (VC) of the characteristics: soluble solids, titratable acidity, soluble solids/titratable acidity ratio, ascorbic acid and carotenoid levels of the pulp of cambucá fruits (*Plinia edulis*).

Characteristics	Mean	Minimum	Maximum	σ	VC (%)
Soluble solids (ºBrix)	10.53	8.72	12.60	1.00	9.54
Titratable acidity (% of citric acid)	1.34	0.71	2.07	0.48	35.58
Soluble solids/titratable acidity ratio	8.82	4.74	13.22	3.12	35.35
Ascorbic acid levels (% of ascorbic acid)	7.84	6.16	9.91	1.22	15.63
Carotenoid (mg 100 g^{-1} of pulp)	0.21	0.13	0.29	0.04	21.72

σ: standard deviation, CV: variation coefficient.

Pearson's correlation values for physical and physico-chemical characteristics of cambucá fruits are presented in Table 4. Is was verified that the total mass has high positive correlation with the following variables: longitudinal diameter (0.94), transverse diameter (0.94), pulp mass (0.99) and seed mass (0.85). On the other hand, negative correlations were verified with titratable acidity (0.71) at 1% significance, fruits with higher mass presented lower citric acid contents, represented by titratable acidity, contributing to the increase in the ratio SS/TA (0.66).

This results of positive correlation between total mass, longitudinal and transverse diameter, seed mass, and mass pulp, were similar of the ones verified for cagaita fruits [24]. Para *Psidium friedrichsthalianum* also verified high positive correlation between fruit mass and physical properties of the [15]. These correlations are important, since they indicate that plants selection with fruits of higher mass may be performed from the measurement of the diameter still in the field, without the need of weighting the fruits [10].

The variable chromaticity correlated negatively with most of the physical variables, beyond hue angle, vitamin C and ratio AT/SS of cambucá fruits, and positively with (although low) luminosity (-0.53) and titratable acidity (-0.77). The hue angle associated only with the acidity, demonstrating that the higher the pulp's angle, the lower is the acidity. The variables chromaticity, luminosity and hue° angle are used to describe the color of fruits, which directly influences consumer's choice.

Titratable acidity negatively correlated with the observed physical characteristics, except for pulp yield, which was not influenced by this variable. It was also observed a positive correlation between ascorbic acid content and the chemical variables, soluble solids and carotenoids. These results indicate that fruits with higher levels of ascorbic acid tend to present increased soluble solids and carotenoids. The ratio soluble solids/titratable acidity was positively correlated with total mass, longitudinal and transverse diameter, pulp and seed mass, while negatively with titratable acidity.

Positive correlations between soluble solids, ascorbic acid levels and carotenoids and the ratio soluble solids/titratable acidity was observed im papaya fruits. Significant associations of these variables are interesting because they allow genotype selection with greater levels of soluble solids and carotenoids [21].

Table 4. Estimates of Pearson's correlation coefficients between the characteristics: total mass (TM), longitudinal diameter (LD), transverse diameter (TD), pulp mass (PM), seed mass (SM), pulp yield (PY), longitudinal/transverse diameter ratio (DL/DT), soluble solids (SS), chromaticity (CRO), luminosity (LUM), hueº angle (HUE), titratable acidity (TA), ascorbic acid content (AA), carotenoids (CT) and soluble solids/titratable acidity ratio (SS/TA) of cambucá fruits (*Plinia edulis*).

	LD	TD	PM	SC	PY	LD/TD	SS	CRO	LUM	HUE	TA	AA	CT	SS/TA
TM	0.94 **	0.94 **	0.99 **	0.85 **	-0.22 ns	0.17 ns	-0.32 ns	-0.63 *	-0.48 ns	0.41 ns	-0.71 **	0.33 ns	-0.29 ns	0.66 **
LD		0.87 **	0.91 **	0.86 **	-0.32 ns	0.44 ns	-0.31 ns	-0.68 **	-0.45 ns	0.34 ns	-0.72 **	0.47 ns	-0.41 ns	0.80 **
TD			0.92 **	0.83 **	-0.26 ns	-0.07 ns	-0.33 ns	-0.50 **	-0.30 ns	0.33 ns	-0.52 *	0.19 ns	-0.21 ns	0.53 *
PM				0.75 **	-0.06 ns	0.15 ns	-0.26 ns	-0.64 **	-0.53 *	0.38 ns	-0.68 **	0.35 ns	-0.28 ns	0.62 *
SM					-0.70 **	0.22 ns	-0.43 ns	-0.46 ns	-0.24 ns	0.44 ns	-0.64 **	0.20 ns	-0.26 ns	0.65 **
PY						-0.18 ns	0.39 ns	0.00 ns	-0.20 ns	-0.24 ns	0.25 ns	0.07 ns	0.04 ns	-0.34 ns
LD/TD							-0.03 ns	-0.46 ns	-0.36 ns	0.07 ns	-0.51 *	0.59 *	-0.45 ns	0.64 *
SS								-0.27 ns	-0.04 ns	0.05 ns	0.16 ns	0.52 *	-0.10 ns	-0.50 ns
CRO									0.53 *	-0.47 ns	0.77 **	-0.82 **	0.48 ns	-0.56 *
LUM										-0.14 ns	0.47 ns	-0.49 ns	0.32 ns	-0.43 ns
HUE											-0.52 *	0.14 ns	-0.05 ns	0.11 ns
TA												-0.44 ns	0.32 ns	-0.65 **
AA													-0.55 *	0.48 ns
CT														-0.46 ns

The superscript indexes *, ** and ns indicate correlation coefficients significant at 5 %, at 1 % and non-significant respectively.

The results obtained in fruits' characterization studies provide the establishment of important techniques of production for fruits, allowing the implantation of technified native fruit trees, where a difficulty of crops establishment exists, due to lack of information [15]. Thus, scientific information is important to establish cambucazeiro crops, enabling commercial exploitation of its fruits and reducing the extinction risk of this species.

4. CONCLUSION

Fruits of cambucá have potential for commercialization, their characteristics are similar to those found in other fruit species native to the Myrtaceae family and already found in the fruit market. Its physico-chemical characteristics present significant correlations for most variables.

In relation to their nutraceutical properties, antioxidant compounds (ascorbic acid and carotenoids) were found in considerable amounts, but below those found in other species.

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