Physical and chemical characterization of cajá-manga in Northern Minas Gerais

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ABSTRACT

A fruit native to the Polynesian islands, the cajá-manga belongs to the Anacadiaceae family. This species plays a prominent role in fruit growing in the northeast region of the country. The growing demand for its fruits has provided a larger cultivation area. Therefore, it is necessary to advance research that studies all stages of the cultivation and physiological system for the commercial production of this fruit plant. The objective of this work was to evaluate the physical and chemical characteristics of cajá-manga in the north of Minas Gerais. The experiment was carried out in a completely randomized experimental design, and consisted of ten replications and five fruits per experimental unit. The evaluations carried out were physical characteristics (length, diameter, fruit mass, pulp yield, fruit skin color, luminosity, hue angle and chromaticity), chemical characteristics (soluble solids, pH, titratable acidity and soluble solids/titratable acidity ratio).). The mean values and standard deviation of each variable were determined for the data. The cajá-manga fruit had a diameter and length of 55.16 ± 3.91 mm and 39.43 ± 3.17 mm, respectively. As for the mass, it was 54.16 ± 4.77 g, while the pulp yield was greater than 50% (79.37% ± 1.02). The fruits had pH levels (2.90 ± 0.15), soluble solids 16.04 oBrix ± 1.70, titratable

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acidity (0.90% ± 0.10). In relation to brightness (58.12 ± 2.19), hue angle (70.85 ± 1.44) and chromaticity (54.18 ± 2.48). Similar to those described in the literature for other fruits of the same botanical genus, it demonstrated that the fruit is within commercial standards.

Keywords: Fruit, Pattern, Species.

INTRODUCTION

Originally from the Polynesian islands, the mango tree (*Spondias dulcis*) belongs to the Anacardiaceae family, of the genus Spondias, as well as other fruit trees: the umbu (Spondias tuberosa), the ciriguela (*Spondias purpu*rea), the cajazeira (*Spondias mombin*) and the umbucajazeira (*Spondias* sp.) (KOHATSU, et al., 2011). This species is found in the native areas of America, Asia, Africa and Brazil. The cajá-mango is distributed in all Brazilian regions, and the Northeast and Southeast are the main regions of cultivation of this fruit, due to the edaphoclimatic conditions favorable to its development. In the north of Minas Gerais, cajá is grown mainly in backyards or in small areas. It is not a typical fruit of the Cerrado, but it adapts well and has high production in this biome, being then popularly known as a fruit of the Cerrado, from which several by-products originate. (SATURNINO, 2008). The growing demand for fruits and processed products such as cajá-mango has increased the interest of agroindustries and fruit growers for commercial exploitation, but production, for the most part, is still carried out in an extractive way (RIBEIRO et al., 2019).

The fruit has its double ellipsoid shape, when ripe it has an intense yellow color, its skin is thin and smooth, it has a fibrous pulp with a bittersweet flavor, its seed has a white color with rigid fibers, which partially extend inside the pulp. This species occurs spontaneously on the coast up to the Brazilian semi-arid region, and these fruits are well accepted by consumers in the area of occurrence during the harvest, due to the presence of compounds that provide benefits (NETO, 2018).

This fruit is composed of magnesium, potassium, zinc, copper, calcium, phosphorus and iron in large quantities, it also has vitamins such as A, B1, B6 and C, rich in fiber, it can be used for the production of juices, cocktails, liqueurs, ice cream, among others, but the highest consumption is in natura (NETO and SILVA, 2019). For fresh consumption, those that meet the quality requirements of different consumer segments are preferable, such as flavor (sugar content and acidity), good pulp yield, and good appearance, are characteristics associated with the standardization parameters of the fruit and are generally used as a criterion by consumers to evaluate the quality of the fruits (ABREU et al., 2009).

Therefore, the physical and chemical characterization of fruits is of great importance, because through this characterization it is possible to determine if the fruits produced and marketed in a given region meet the quality parameters required by consumers who consume fresh fruits and by the industry.

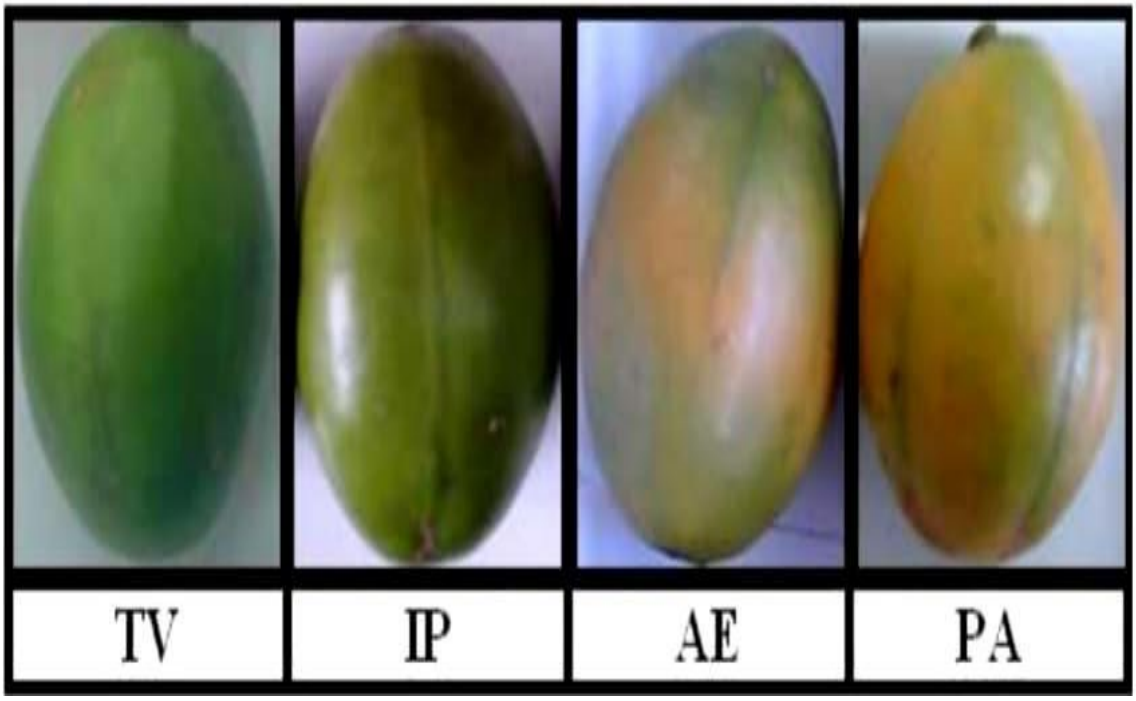
OBJECTIVE

The general objective of this work is to evaluate the physical and chemical characteristics of cajá-manga in the north of Minas Gerais.

MATERIAL AND METHODS

The study was carried out at the Laboratory of Postharvest Physiology of the State University of Montes Claros - Campus Janaúba-MG. Cajá - mango fruits from natural vegetation were used, without organized planting in the Janaúba region (15° 47'50" S and 43° 18'31" W), were harvested manually in the May 2020 harvest, at the predominant yellow maturation stage, according to the degree of skin color, as shown in figure 1. The fruits were immersed in washing tanks containing water and neutral detergent to eliminate impurities and allowed to dry in the shade. After drying the fruits, they were transferred to expanded polystyrene trays in groups of five fruits per tray.

Figure 1 Evolution of the maturation of mango tree (*Spondias dulcis) fruits*, TV - Totally Green; PI - Onset of Yellow Pigmentation; AE - Greenish Yellow and PA - Predominantly Yellow.



VARIABLES EVALUATED

Physical Characteristics

Bark color

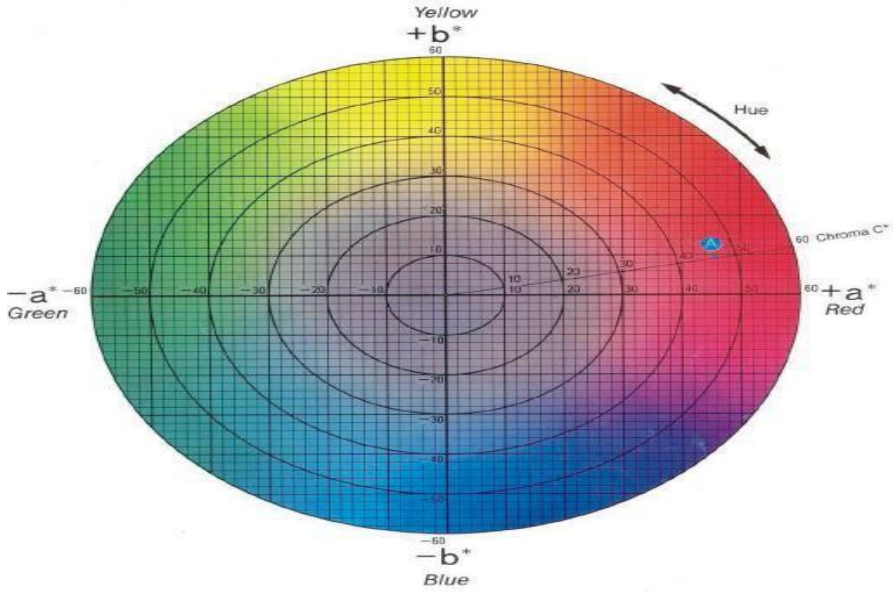
The analysis of the bark color was performed using a colorimeter Color Flex 45/0(2200), stdzMode:45/0 with direct reflectance reading of the coordinates L* (luminosity), a* (red or green hue) and b* (yellow and blue hue), from the Hunterlab Universal Software system (Figure 2), using the CIELAB scale using the 10°/D65 illuminant.

Through the values of a* and b*, the following values were obtained: Hue angle: obtained by relating through the formula: Hue = tg-1 b/a. The Hue angle is defined as starting on the + a axis and is expressed in degrees, where 0° corresponds to +a (red), 90° corresponds to +b (yellow), 180° corresponds to –a (green) and 270° corresponds to –b (blue).

Chromaticity: This value defines the intensity of the color, assuming lower values for more neutral colors (gray) and higher values for vivid colors. This variable was obtained using the formula:

$$C= (a2+b2)^{0.5}$$

Figure 2 L, a, b Color Solid representation of the Hunterlab Universal Software system and description of hue angle (ºh*) and chroma saturation index (C*).



Fresh Pasta

The fruits of each replication were weighed individually with the aid of an analytical balance and the result was expressed in grams (g).

Pulp Yield

The seeds of the fruits were removed by hand extraction and then weighed.

Fruit Dimensions

The dimensions of the fruit were estimated using a caliper, measuring the length (from the base of the peduncle to the other end) and the width (larger transverse diameter). The result was expressed in millimeters (mm).

Firmness

Firmness was measured by the penetration force required for a 4 mm diameter tip to penetrate the equatorial region of the peeled fruit at a depth of 8 mm. The results were expressed in Newton (N).

Chemical Characteristics

Soluble Solids Content

The determination of soluble solids was made after crushing the pure pulp in a mixer. An aliquot was removed for direct reading in an ATAGO benchtop refractometer, model N1. The result was expressed in °Brix, which corresponds to grams of sucrose per 100 g of solution and can generally be used as grams of soluble solids per 100 g of solution.

Titratable Acidity

The titratable acidity was determined according to the technique recommended by the AOAC (1992), titrating the juice of the fruit set from each tray under agitation after extracting, crushing and homogenizing 10g of the pulp of the central region of each fruit in 90 mL of distilled water, with 0.1N NaOH, using 1% phenolphthalein as an indicator. The result was expressed in eq. mg citric acid, 100mL-1 juice.

Soluble Solids / Titratable Acidity Ratio

The soluble solids/titratable acidity ratio was obtained by dividing the percentage of soluble solids by the titratable acidity.

ph

The pH determination was made directly in the juice using a Digital pH of the brand DIGIMED, model DM20, after the preparation of the samples as in the analysis of the titratable acidity.

Experimental Design and Statistical Analysis

The experiment was carried out in a completely randomized design, consisting of ten replications and five fruits per experimental unit. The results were submitted to analysis of variance using the statistical program SISVAR version 5.6.

RESULTS AND DISCUSSION

PHYSICAL CHARACTERISTICS

The fruits acquired in the present study obtained averages for length and width of 55.16 ± 3.90 mm and 39.43 ± 3.76 mm, respectively (Table 1). Ishak et al. (2005) described the results of length and diameter 66.80 mm and 50.20 mm respectively, which are higher than the data obtained in this study, while the results obtained by Silva et al. (2009), the fruit length was lower (41.70 mm) and the diameter result was 43.90 mm higher when compared to the values obtained in this study. According to Viana et al. (2017), there are some important characteristics for the agroindustry, such as the length and diameter of *fresh fruits* , as they directly interfere with the drying time when these fruits are destined for processing, and consequently with the cost of production due to energy demand.

The physical and physicochemical characteristics of the fruits are dependent on some factors, for example, genetic constitution, cultural management, time of harvest of the fruits and their stage of maturation (CARVALHO et al., 2013). Characterization is important for the commercialization of fruits and also for their use in the elaboration of new products (CHITARRA and CHITARRA, 2005; NASCIMENTO et al., 2014).

The fresh weight of the fruits was 54.16 g (Table 1), lower than the value observed by Neto e Silva (2019), for Brejo Paraibano-PB and João Pessoa-PB it was 99.82 and 97.47 g, respectively. According to Silva et al. (2009), for the evaluation of the weight of the cajá-mango fruits, the average weight was 28.90g, thus being lower than the result obtained in this study.

Determining the firmness of the fruits is essential to establish techniques and containers for transport and storage, in order to reduce as much as possible the damage caused by mechanical shocks, allowing greater longevity on shelves (FAGUNDES; YAMANISHI, 2001; JACOMINO et al., 2003).

As for firmness, which is a texture characteristic and corresponds to the degree of resistance of plant tissues to compression (CHITARRA and CHITARRA, 2005), the average obtained was 30.91 N (Table 2), a value close to that found by Neto and Silva (2019), which ranged from 23.83 to 50.63 N. The firmness of the pulp and fruit can be influenced by the cultivar, harvest time, cultural treatments and environmental conditions (FAGUNDES and YAMANISHI, 2001).

According to Jacomino et al. (2003), during this process the firmness can decrease from 20 to 30 times, indicating that the further the advance, the lower the firmness. This physical characteristic is correlated with the increase in enzymes responsible for structural changes in pectin, hemicellulose, and cellulose, which is the main substance that forms the primary and secondary walls of plant cells (PAULL et al., 1999; CHITARRA and CHITARRA, 2005).

According to the percentage yield of fruit pulp, the average yield was 79.37 ± 1.02% (Table

1). The value obtained in this study was higher than that found by Silva et al. (2009) and Damiani et al. (2011), in which the average yield of cajá-mango pulp was 73.58 and 61.02%, respectively. The pulp yield evaluated in this study was higher than the minimum acceptable (40%) indicated by the Ministry of Agriculture, Livestock and Supply (MAPA) and the Identity and Quality Standard (PIQ) of fruits (BRASIL, 2016).

Table 1 - Physical characteristics of mango tree (*Spondias dulcis*) *in natura*.

Evaluated Characteristics	Length (mm)	Diameter (mm)	Fresh mass (g)	Firmness (N)	Pulp yield (%)
Average/SD	55.16 ± 3.91	39.43 ± 3.17	54.16 ± 4.77	30.91 ± 3.94	79.37 ± 1.02
C.V. (%)	7.08	9.55	8.80	12.75	1.02

Mean values, standard deviations (SD) and coefficients of variation (CV) of the characteristics length (mm), diameter (mm), fresh mass (g), firmness (N) and pulp yield (%).

Table 2 shows the characteristics of the fruit peel color based on the parameters, luminosity, hue angle and chromaticity. According to Álvares et al. (2003), the determination of fruit color by colorimeter analyzes differences in skin color that spectrally approximate the pattern observed by the eyes, with the advantage of being three-dimensional, excluding evaluations of each observer (when it is done only visually).

Considering that the parameter L* (luminosity or brightness) of the shell ranges from 0 to 100, and that low values indicate opaque/dull bark and high values are equivalent to maximum brightness, this study presented an average value. An average of 58.12 ± 2.19 was observed, a value close to that found by Ribeiro et al. (2019), in the work on the greening of the cajá-manga with the use of ethylene, the fruit without the application of ethylene obtained a result 56,39, therefore, the present study obtained a mean result in terms of fruit luminosity. Chromaticity, on the other hand, demonstrates the intensity of the color, i.e., the saturation in terms of pigments according to Mendonça et al., (2003), being considered lower values for more neutral colors and higher values for vivid colors. The fruit of the present work has had the result 54.18 ± 2.48, i.e. average color saturation.

The color shade, represented by the ºhue parameter (Table 2), of the fruits was within the angular range of yellow color (90°). According to Ramos and Gomide (2007), the ºHue angle can vary from green (100º to 200º) to yellow (70º to 100º), which would simulate the ripening of the fruits.

The mean value of the Hue angle was 70.85 ± 1.44 (Table 2). According to the preference of the consumers interviewed by Matsuura et al. (2004), the preferred bark colors were medium yellow and dark yellow, totaling 74.6% of the preference. According to the CIELAB system (Figure 2), if

the angle is between 0° and 90°, the higher it is, the yellower the fruit, and the smaller it is, the redder the fruit.

The yellowing or change in color of the bark of the cajá has as its main event the degradation of chlorophyll (green color), and the synthesis of other pigments is carried out at relatively low levels. During this process, the pre-existence of carotenoid pigments (yellow to orange color) is visible (SARMENTO et al., 2015). According to Castricini et al. (2015), during fruit ripening, chlorophyll degradation occurs, such as the synthesis of carotenoids, which are processes articulated by ethylene gas, and according to them, the Hue angle allows us to observe the change in pigments from green to yellow.

Table 2 - Characteristics and color of the peel of mango tree (*Spondias dulcis*) *in natura*.

Evaluated Characteristics	**Luminosity**	**Hue Angle**	**Chromaticity**
Average/SD	58.12 ± 2.19	70.85 ± 1.44	54.18 ± 2.48
C.V. (%)	3.94	2.04	4.57

Mean values, standard deviations (SD) and coefficients of variation (CV) of the characteristics luminosity, hue angle and chromaticity.

CHEMICAL CHARACTERISTICS

The result of the physicochemical characterization of the pulp of the mango tree was considered an acid pulp, with an average pH of 2.90 and titratable acidity of 0.9 eq. mg citric acid. 100mL-1 of juice (Table 3).

Neto and Silva (2019) observed similar values, with an average of 2.28 for pH in fruits from different microregions of the state of Paraíba. Silva et al., (2019) found values higher than those of this study (3.47) in a species of cajarana S. (*S. cytherea* Sonn), from the state of Rio Grande do Norte.

According to Benevides et al. (2008) in which they describe that in fruit processing, low pH values are ideal to favor the preservation of products, and disfavor the development of microorganisms. However, higher pH values are appreciated in the fresh fruit market (GONDIM et al., 2005).

As for soluble solids, the average was 16.04 º Brix. Neto and Silva (2019) reported lower levels of soluble solids (15.40 and 14.61) ºBrix. According to the MAPA Normative Instruction (BRASIL, 2016), which aims to establish throughout the Brazilian territory the standards of identity and quality (PIQ) of the pulp of cajá *(Spondias lutea* L.*),* a fruit pulp of the same genus as cajá-manga, the minimum content of soluble solids for commercialization is 9.0 oBrix. In this way, the fruits marketed and produced in Janaúba are a good alternative for the fresh fruit market and agribusiness.

The soluble solids/titratable acidity ratio (SS/TA) or ratio is the ratio that determines the

flavor of the fruits between the soluble sugars, the higher this ratio, the sweeter the fruits will be, therefore, it indicates that these fruits are very tasty, having potential for fresh consumption. The observed ratio of this study showed a mean value of 18.03 ± 2.51ºBrix, close to that found by Silva et al. (2009), which was 15.03 ºBrix. The SS/TA ratio is a more representative index than the isolated measurement of sugars or acidity (CHITARRA and CHITARRA, 2005).

The mean values of pH, soluble solids content, and titratable acidity found in this study for the fruits of cajá-mango were higher than the minimum values (SS 9.0%, pH 2.2 and TA of 0.9g of citric acid 100g-1) established by the Identity and Quality Standard (PIQ) of the Ministry of Agriculture, Livestock and Supply (MAPA) (BRASIL, 2016), for the fruit pulp of *Spondias lutea* L, fruiting species of the same genus as the one studied in this work.

Table 3 - Chemical characteristics of mango (*Spondias dulcis*) pulp *in natura*.

Characteristics Evaluated	**ph**	**SS**	**AT**	**RATIO**
Average/SD	2.90 ± 0.15	16.04 ± 1.70	0.90 ± 0.10	18.03 ± 2.51
C.V. (%)	5.27	10.60	11.16	13.93

Mean values, standard deviations (SD), and coefficients of variation (CV) of the characteristics pH, SS: soluble solids (ºBrix), AT: titratable acidity (eq. mg citric acid/100mL of juice) and RATIO: soluble solids/titratable acidity ratio.

CONCLUSION

The results obtained in the evaluation of the physical and chemical characterization of the cajá-mango from the north of Minas Gerais, demonstrate that the fruit is within the commercial standards.

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