Morphological characteristics and yield of red rose apple pulp from public roads in the municipality of Inhumas/GO, Brazil

Características morfológicas e rendimento da polpa de jambo vermelho de via públicas do município de Inhumas/GO, Brasil

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ABSTRACT
The aim of this research was to determine the physical and physicochemical characteristics of the red rose apple fruits, that have great economic potential, and will be able to subsidize the cultivation and the appropriate selection, aiming at their use in the production of new products. For the harvest, selected 3 regions of the city of Inhumas Goiás. An average of 5 kg of fruits from each region was collected. Volume, density, height, diameter, pulp yield, physicochemical characterization by determination of pH, total acidity (TA) and total soluble solids (SS) and color by digital image were determined. Considering the results found, the physicochemical characteristics of the red rose apple fruits present considerable pulp yield, reasonable values of total soluble solids and acidity. The properties of the fruits are presented in the desirable standards for the production industrialized products, satisfactory characteristics for industrialization. The informed ones show that the fruit of the red rose apple fruits corresponds to a potential alternative to be used in the industries in the manufacture of jams.

Key Words: *Syzygium malaccense*, color, total acidity, fruit quality

RESUMO
O objetivo desta pesquisa foi determinar as características físicas e físico-químicas dos frutos de jambo vermelho, que apresentam grande potencial econômico, e poderão subsidiar o cultivo e a seleção adequada, visando sua utilização na produção de novos produtos. Para a colheita, foram selecionadas 3 regiões do município de Inhumas Goiás. Foram coletados em média 5 kg de frutas de cada região. Foram determinados o volume, densidade, altura, diâmetro, rendimento de polpa, caracterização físico-química por determinação de pH, acidez total (AT) e sólidos solúveis totais (SS) e cor por imagem digital. Diante dos resultados encontrados, as características físico-químicas dos frutos do jambo vermelho apresentam considerável rendimento de polpa, valores razoáveis de sólidos solúveis totais e acidez. As propriedades dos frutos apresentam-se nos padrões desejáveis para a produção de produtos industrializados, características satisfatórias para a industrialização. As informações mostram que o fruto do jambo vermelho corresponde a uma alternativa potencial a ser utilizada nas indústrias de fabricação de geleias.

Palavras chaves: *Syzygium malaccense*, cor, acidez total, qualidade do fruto.

1 INTRODUCTION

The fruits of rose apple tree have dark red, slightly sweet, exuding scent of roses, persistent and very pleasant to smell. The physical characteristics of the fruit such as color, size, number of seeds, pulp and the amount of water content can influence the consumption, both natural and industry.

Physical and chemical characterization is important for quality assessment, technological classification of the fruit, providing reliable information for assessing the nutritional value, yield, processing operations and product life [1]. It is a fruit that has been cultivated for many decades in tropical regions, and whose first native species appear to have appeared between Southeast Asia and Oceania. In Brazil, it is found in the states of the North, Northeast and hot regions of the Southeast.

The epicarp is thin smooth and colored, varying with the stage of maturation (pink, red, dark red to very dark red); the mesocarp and endocarp are whitish and succulent, constituting the pulp [2]. The trees of this fruit are grown in orchards, gardens and streets, for their beauty, as well as for their fruits that are appreciated by the population, being consumed *in nature*, or in the form of sweets, jams, jellies, soft drinks and liquors, or used in animal feed. In Indonesia, the fruits are used in salads and are also preserved as “pickles”. Both leaves and roots are traditionally used in home medicine in Thailand [3]. In Goiás it is widely used as ornamentation on public roads.

Research related to biometric description of fruits and seeds can provide important information for differentiation of species of the same genus [4]. The fruits are evaluated by size, measured over the circumference or cross-sectional diameter, width, weight volume. Products with similar characteristics and standardized are easier to be handled in large quantities, since they have lower losses faster production and better quality [5].

The fruit has an attractive appearance due to the intense red color and form, is appreciated for its taste and exotic aroma and has interesting aromatic properties that favors as flavoring agent in foods and beverages. Red rose apple occurs a great waste of the time of harvest, due to the high yield per tree, the short harvest period and reduced life of the fruit in nature [6].

In the context, the aim of this research was to determine the physical-chemical characteristics of the red rose apple fruits (*Syzygium malaccense*), that have great economic potential, and will be able to subsidize the cultivation and the appropriate selection, aiming at their use in the production of new products.

2 MATERIAL AND METHODS

The fruits of (*Syzygium malaccense*) were harvested at the stage of maturation suitable for consumption, of trees planted in the city of Inhumas-Go in the 2018 harvest. For the harvest, 3 regions of the city of Inhumas-Go, were selected and the coordinates of each genotype were defined by GPS (Global Position System) with their respective directions in the city of Inhumas-GO.

An average of 5 kg of fruits from each region was collected and taken to the plant processing laboratory of IFG Campus Inhumas. Before seed removal, 20 fruits were randomly selected for the analysis of morphological (biometric) and physicochemical characteristics.

2.1 VOLUME, DENSITY, HEIGHT, DIAMETER, PULP YIELD

The volume of the fruit was obtained by displacement of water in a test tube [7] and the weight of the whole fruit was recorded in a digital precision scale [8], and it was possible to calculate the density of the fruit. The length or height of the fruits and diameters were obtained with the aid of a digital caliper in the equatorial or median position of the fruit. The seed of the fruit was removed by manual extraction and thus it was possible to calculate the weight of the seed, obtaining the pulp yield.

Fruit density (g ml^{-1}) = $\frac{Fruit\ mass}{Fruit\ volume}$

Pulp yield = ($\frac{Fruit\ mass - Seed\ mass}{Fruit\ mass}$) *100

Pulp thickness = (mm) = $(D_1 - d_1)/2)$

Being D_1 = larger diameter of the fruit d_1 = Seed greater diameter.

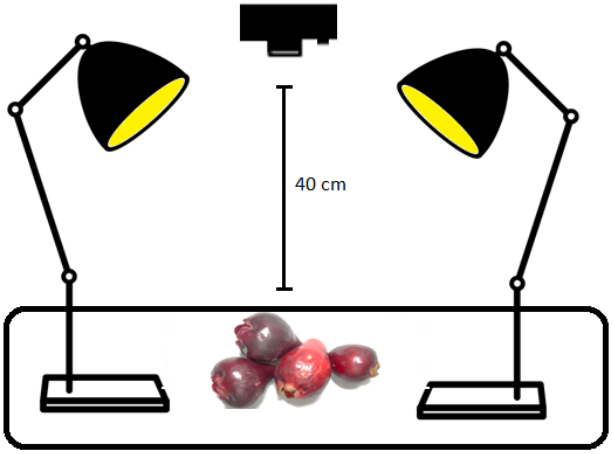
2.2 PHYSICOCHEMICAL ANALYSIS

Total acidity (TA) was determined using approximately 10 g of fresh pulp homogenized in 100 mL of distilled water, added of three drops of alcoholic solution of phenolphthalein and titrating with 0,1N NaOH until the turning point (red purple color). The results were expressed as percentage of citric acid. Water-soluble solids (SS) was obtained using about 10 g of homogenized pulp. About 50µL of macerated was transferred to a prism of a portable refractometer (Instrutherm, RT-30 ATC, São Paulo, Brazil). Maturation index was calculated by the ratio SS/TA. The pH was obtained in 10 mL of homogenized pulp, added to 100 mL of distilled water. The solution was taken to a digital potentiometer (Analion, PM 608, São Paulo, Brazil), calibrated with pH 4.0 and 7.0 buffer solutions, according to the methodologies recommended by [9].

2.3 COLOR BY DIGITAL IMAGE

To determine the color of the fruits was employing digital camera (Samsung WB100, Manaus, Brazil), with resolution of 12.2 megapixels. The fruit was placed on a watch glass on a white surface; photos were taken shortly after the fruit collection, under controlled lighting (Philips, white color, 20 W), with a slope of 45º, and the illuminator D65, which corresponds to the midday lighting. The chamber lens was positioned perpendicular to the surface of the fruit at distance of 40 cm from the white surface (Figure 1). By the Microsoft Paint Program were selected in the central area of the digital image of the fruits, approximately 1 x 1 cm, still in Paint, clicked on the color picker and then edited the colors, converting the fragment of the photo into average values of RGB using pixel by pixel. The RGB values were converted into the CieLab scale using the Easy RGB platform, obtaining the values of Luminosity, chroma a* and chroma b*.

FIGURE 1: Layout of the digital image acquisition system for red rose apple (*Syzygium malaccense*).



2.4 STATISTICAL ANALYSIS

All the physical and physicochemical properties were determined in triplicate, according to the methods recommended by the Instituto Adolfo Lutz (2008) [10], each sample composed one parcel. Data were subjected to ANOVA, using a free software Assistat 7.7 [11], and the averages were compared by Tukey test at 5% significance.

3 RESULTS AND DISCUSSIONS

The physical properties (fruit and seed mass, volume fruit, longitudinal and transverse diameter of the fruit, fruit density, pulp yield) are shown in Table 1. There was no difference in these parameters in the fruits collected in the three collection regions in the city of Inhumas Goiás, Brazil. The physical characteristics found in this fruit are identic to apple, pear and peach, mainly in relation to shape and size [12].

Table 1. Average and standard deviation of physical properties, fruit mass (M_F), seed mass (M_S), fruit volume (V_F), longitudinal fruit diameter (DL_F), transversal fruit diameter (DT_F), density of the fruit (D_F g cm^{-3}) pulp yield (R_P) (%) in red rose apple fruits in regions 1, 2 and 3 (R1, R2 e R3) in Inhumas Goiás, Brazil

Fruit dimensions	Regions			
	R1	R2	R3	CV%[2]
M_F [1]	68,34a±19,43	65,96a±17,24	65,71a±19,78	27,09
M_S	13,82a±3,28	13,58a±1,55	12,11a±2,31	19,35
V_F	70,55a±20,71	73,75a±19,32	80,00a±15,99	25,68
DL_F	60,02a±6,89	58,60a±7,66	56,64a±7,21	13,47
DT_F	46,71a±5,13	47,94a±4,86	48,20a±5,00	10,00
D_F	0,94a±0,11	0,89a±0,13	0,87a±0,19	16,73
R_P	77,29a±5,71	79,24a±5,11	79,20a±5,07	6,85

[1]Means followed by different letters on the same line differ by the Tukey test at 5% probability. [2]Variation coefficient (%).

The mean value for fruit mass (65.71 to 68.34 g) found was lower than that found by Batista et al. (2016) [13] and Gibbert (2017) [14], who analyzed red rose apple in São Paulo, and Morretes in Paraná, these authors found 75.86 g and 94.26 g, respectively. Seed mass ranged from 12.11 to 13.82 g. Carvalho and Nakagawa (2012) [15] state that seed size is very related to their physiological quality. Within the same batch of seeds, those with larger size have greater vigor and germination when compared to those of small size.

In the present study, the longitudinal diameter of the fruits ranged from 56.64 to 60.02 (mm) or 5.664 to 6.002 (cm) in the three collection regions, values below the Gibbert (2017) [14], which found values for this parameter of 6.46 (cm). The width ranged from 46.71 (mm) to 48.20 (mm). According to Gibbert (2017) [14], the average length (longitudinal diameter) of the red rose apple indicates that

the fruit has a similar appearance to jambolan (*Syzygium cumini*), both of which belong to the same family. Regarding the maximum and minimum dimensions, the variation was 1.80 – 5.57 cm, indicating that the fruit has a slightly elliptical or oval shape [1], characteristic of this botanical species. For the manufacture of sweets in syrup or glaciers, in which the appearance of the final product is paramount, preference is usually given to fruits with uniformity of slightly rounded or oblong shape [16]. Although it does not present an oblong form, red rose apple has an exotic shape that, associated with intense red color, makes it very attractive in the eyes of the consumer, favoring its use for the production of glaciated sweets and jam [1].

The transverse and longitudinal diameters are related to the size and shape of the fruit, while the mass of fruits, peels and seeds is related to the yield of the product, becoming important factors in the establishment of the maturation point, economic viability for industrialization, and packaging sizing [17, 18].

The density of 0.87 to 0.94 g cm-3 of the fruits of the three red rose apple collection regions, higher values for fruit density are desirable, as they benefit from increased yield, and resistance against kneading during harvesting and transport operations, because they have a more compact form, with lower internal volume of cavities [19], aspects not observed in the present study.

Pulp yield with red rose apple peel in % ranged from 77.29 to 79.24% among the collected fruits (Table 1). Pulp yield, obtained by the relationship between pulp, peel and stone is an important attribute for the commercialization of fruits [20]. The yield of edible parts of fruits directly implies the efficiency of industrial processes [15]. Pulp yield can be decreased during fruit maturation due to the consumption of organic substances in the respiratory process, also by transpiration. Borges et al. (2010) [21] reports the reduction in pulp yield of cerrado cherry (*E. calycina*) during the last maturation stages, especially when it passes from the red to the purple stage. Gouveia et al. (2003) [22] also found a decrease in pulp yield in guavas (*Psidium guajava*) during maturation. The accumulation of mass in gabiroba was attributed to the formation of proteins, sugars and other substances that accumulate throughout its development [23].

The mean values of pH, acidity, total soluble solids and ratio of total soluble solids and acidity are presented in Table 2. There was no significant difference in the parameters evaluated. The pH ranged from 3.40 to 3.57, and the pH is not altered by the degree of maturation and soluble solids when mature [24].

Table 2. Mean and standard deviation of pH, acidity (TA), total soluble solids (SS), ratio of total soluble solids and total acidity (SS/TA) of red rose apple in regions 1, 2 and 3 in Inhumas Goiás, Brazil

Region	Physicochemical characteristics			
	pH	TA[1]	SS[2]	SS/TA
R1[3]	3,57a±0,06	0,76a±0,003	8,33a±0,35	114,41a±8,20
R2	3,53a±0,10	0,73a±0,008	8,23a±0,17	113,62a±13,71
R3	3,40a±0,05	0,70a±0,005	7,90a±0,06	110,61a±7,15
CV%[4]	2,13	8,12	2,98	8,95

[1]g $_{acid}$ 100g^{-1} sample; [2] ºBrix; [3]Means followed by different letters in the same column differ by the Tukey test at 5% probability. [4]Coefficient of variation (%).

The hydrogen potential (pH) values in this range are very favorable to industrialization processes in the form of sweets jellies and juices. Being possible its use in the manufacture of jams as a form of acidification to obtain adequate gels and for the enrichment of the product and juices, since in the juice industry, the high acidity content causes high dilution of the product and, consequently, higher final yield [16]. The pH of the red rose apple found in the present study is within the range stipulated for fruits of the Family Myrtaceae from 2.54 to 4.09 for pear from the field and jambolan, respectively [18, 25]. The acidity in the fruit pulp varied from 0.70 to 0.761g 100g-1 acid, in general, with fruit ripening, titratable acidity tends to decrease.

The values of total soluble solids (SS) of fruits with peel ranged from 7.90 to 8.33 ºBrix, the values found in the present study corroborate with Santos (2013) [26], which characterized red rose apple fruits from the state of Pará, and verified mean values of soluble solid, obtained from the pulp of ripe fruits with bark of 7.80 ºBrix. Total soluble solids attest to the degree of fruit maturation [27] and are used to determine the ideal point of fruit harvest [28]. However, although the soluble solids content indicates the fruit maturation point, one should consider the potential that the fruit has to achieve great values of this measure.

The ratio of total soluble solids/titratable acidity ranged from 110.61 to 114.41 with no significant difference between the fruits of the three collection regions. The highest value was found for regions 1. Although the SS/TA ratio is more useful in determining maturation stages, as this relationship tends to increase with the advance of the fruit maturation stage [29], this comparison would be more important within the same region, because the differences are linked to the potential that the fruits have, which are not valid to consider significant differences.

In Figure 2, ripe red rose apple fruits are presented, taking account the coloration of the intense red skin, from the collections carried out in Inhumas, Goiás Brazil (2018).

Figure 2: Color red rose apple (*Syzygium malaccense* (L) Meer & Perry) during maturation collected in the city of Inhumas, Goiás, Brazil 2018. Rodriguez da Silva Source Kauana.

The mean values for the color coordinates L*, a* and b* obtained from digital images are shown in Table 3. For luminosity there was no significant difference between the fruits of the three regions of collection. The lowest luminosity (L*) was observed in the fruits of region 1 (21.18) and the highest in the fruits of region 3. Low luminosity values indicate that the coordinate is closer to the shade of black, which is confirmed by the characteristic color of the fruits that are colored between purple to blue, due to the presence of anthocyanin pigments [30].

Table 3. Mean and standard deviation of the coordinates of L*, a* and b* using a digital image of red rose apple in regions 1, 2 and 3 in Inhumas, Goiás, Brazil

Region	Hue		
	L*	a*	b*
R1[1]	21,18a±3,05	20,68b±9,00	6,73b±
R2	25,66a±3,92	27,28ab±8,30	9,84ab±
R3	32,15a±9,94	39,63a±9,94	19,07a±
CV%[2]	24,36	25,04	40,96

[1]Averages followed by different letters in the same column differ from each other by the Tukey test at 5% probability. [2]Coefficient of variation (%).

The a* coordinate ranged from 20.68 to 39.63, with a significant difference in the level of 5% probability between the fruits of the three regions. It can be affirmed that when the a* coordinate is positive, the fruit has a tone closer to the red and when negative it has the tone closest to the green. The fruits of region 3 presented the highest value for the a* coordinate, however, this did not differ from region 2. The increase in the a* coordinate is explained by the maturation stage of the fruit, changing the pigment content.

The results obtained show that the color of the skin has a red tint, due to a* having a positive value, which exceeds the yellow tone expressed by the coordinate b* with a positive value.

4 CONCLUSIONS

Considering the results found the physicochemical characteristics of red rose apple fruits present considerable pulp yield, reasonable values of total soluble solids and acidity. These fruit properties are presented in the desirable patterns for production of agro-industrialized products.

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To the Federal Institute of Goiás / IFG

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