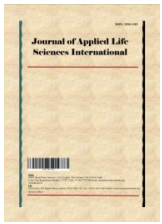

Journal of Applied Life Sciences International

22(1): 1-9, 2019; Article no.JALSI.51328
ISSN: 2394-1103

Physical and Chemical Parameters of "Cagaita" (*Eugenia dysenterica*) at Different Maturity Stages

Antônia M. Lima Alvarenga[1], Rodrigo E. Vassoler Silva[1], Patrícia M. Crivelari Costa[2*], Daniella Moreira Pinto[3] and Luiz José Rodrigues[1]

[1]Department of Food and Nutrition, Faculty of Nutrition, Federal University of Mato Grosso, Cuiabá, Mato Grosso, Brazil.
[2]Department of Tropical Agriculture, Federal University of Mato Grosso, Cuiabá, Mato Grosso, Brazil.
[3]Department of Food Engineering, Várzea Grande University Center, Várzea Grande, Mato Grosso, Brazil.

Authors' contributions

This work was carried out in collaboration among all authors. Authors AMLA and LJR conducted the experiment and wrote the first draft of the manuscript. Authors AMLA, DMP, REVS and LJR discussed the results. Author PMCC corrected and improved the final version of the manuscript in Portuguese and English versions. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JALSI/2019/v22i130118
Editor(s):
(1) Dr. Palanisamy Arulselvan, Institute of Bioscience, Universiti Putra Malaysia, Malaysia.
Reviewers:
(1) Ioana Stanciu, University of Bucharest, Romania.
(2) Valdir Florêncio da Veiga Junior, Military Institute of Engineering, Brazil.
(3) Sazelin Arif, Universiti Teknikal Malaysia Melaka, Malaysia.
Complete Peer review History: http://www.sdiarticle3.com/review-history/51328

Original Research Article

Received 08 July 2019
Accepted 10 September 2019
Published 17 September 2019

ABSTRACT

The cagaita fruit is widely distributed in the Brazilian Cerrado and is ideal for their sensory peculiarities, may be constituted in rich vehicle of vitamins and minerals, and its limited consumption to an essentially extractive process. This study aimed to evaluate the physical and chemical parameters of cagaita fruit (*Eugenia dysenterica*) from the Cerrado biome, especially of Mato Grosso State. The selection of fruits was made by their condition, at different maturity stages: Stage 1, fruits with greenish to yellowish hulls; Stage 2, fully yellowish hulls fruits attached to the mother plant; Stage 3, intense yellow hulls fruits with detachment from the mother plant. The fresh weight for cagaita fruit was 9.62 g; the longitudinal and transverse diameters were 20.75 mm and 243.09 mm, respectively. The fruit can be considered a perishable fruit due to its high moisture

**Corresponding author: E-mail: patriciacrivellari@gmail.com;*

content, around 88%, besides presenting significant protein (1.69%), compared to other fruits. Still has reduced lipid values (0.19%) and carbohydrates (7.4%), resulting in a fruit with low calorific value (36.6 kcal). The vitamin C index found was significant, around 55.02 mg.100g^{-1} in the ripe fruit. The cagaita fruit shows potential for industrialization due to low energy values and lipid and carbohydrate contents, as well as outstanding levels of vitamin C, which can contribute beneficially to health.

Keywords: Cerrado; native fruits; maturation; Brazilian biodiversity.

1. INTRODUCTION

Brazil is one of the most privileged countries in biodiversity worldwide. With distinct ecosystems distributed in its different regions, this country is one of the main centers of native and naturalized fruit species diversity, but almost all of them remain wild, little explored, integrating natural ecological formations, although many of them have potential to become competitive with domesticated fruit species [1].

Nevertheless, the Brazilian Savannah, or "Cerrado", the second largest Brazilian biome, occupies 23% of the national territory (206 million hectares), standing out for its biodiversity, with the richest flora among the savannas of the world. However, native species are relegated to the background despite the great potential for exploitation both domestically and abroad market. The vast majority of fruit species have their exploitation based almost exclusively on extractivism in naturally occurring areas [2].

In this context, *Eugenia dysenterica* is inserted, a native fruit of the Cerrado, of the *Myrtaceae* family, used by the local population for food and medicinal uses, whose fruits are popularly known as "cagaita", due to its laxative properties [3].

The species *E. dysenterica* occurs naturally in the States of Sao Paulo, Minas Gerais, Bahia, Tocantins, Mato Grosso, Mato Grosso do Sul, Pará, Maranhão, Piaui and Goiás, as well as the Federal District [4]. It occurs preferentially in the Cerrado biome with deep and well-drained soil.

It is a medium-sized tree, 4 to 10 m high, with a tortuous and cylindrical stem, 20 to 40 cm in diameter and a very characteristic suberose and cracked bark [5]. In the Cerrado, the flowering of the *E. dysenterica* occurs from August to September, usually synchronized with the beginning of or even before the first rains, lasting no more than a week. The fruit is a pale yellow globose-flat berry, 2 to 3 cm in diameter, containing 1 to 3 white seeds, wrapped in a slightly acidic pulp. It has a dry chalice attached to the fruit, bright membranous peel, succulent mesocarp and endocarp [6].

The socioeconomic exploitation and the demand for research on native fruit species reflect the offer of new alternatives of fresh fruits for *in natura* consumption and raw material for agribusiness, constituting a new source of food and wealth for the country [7].

Some native fruits of the Cerrado already have their fruits sold in fairs and with great popular acceptance, being excellent nutritional sources with high levels of sugars, proteins, vitamins and minerals, and can be consumed *in natura* or processed in the form of sweets, ice cream, juices, jams, jellies, among others. Today there are more than 58 native fruit species from the Cerrado known and used by the population of the region and other States [8].

Studying the chemical composition of native foods contributes to a better understanding of the relationship between nutrition and biodiversity, especially in terms of food production and food processing [9]. The fruits from Cerrado can contribute in considerable portions to the recommended dietary intake [10]. The Convention on Biological Diversity (CBD) recommends the sustainable use of biodiversity in programs related to food and nutritional security of the population, as well as encouraging the preservation and conservation of the natural biome [11].

In this sense and due to the lack of studies on the fruits of the Cerrado, the present work aims to characterize the physical parameters of the fruit of *Eugenia dysenterica* and the chemical composition of the pulp at different maturity stages.

2. MATERIALS AND METHODS

The experiment was carried out between August and December 2014, in a native pasture area

with typical Cerrado biome, located 34 km from the Cuiabá city, Mato Grosso State, Brazil, 144 masl, in the geographical coordinates 15º51'17" S and 56º4'13" W, with a mean precipitation of 1,500 mm and annual average temperature of 24,0°C [12].

Fifteen specimens of the species *E. dysenterica* were randomly selected, homogeneous in size, in which fruits were collected at three different stages of maturation during four weeks: Stage 1, fruits with greenish to yellowish hulls; Stage 2, fully yellowish hulls fruits attached to the mother plant; Stage 3, intense yellow hulls fruits with detachment from the mother plant. In the harvest of the specimens, we opted for the removed the fruits from the tree by a process called "combing", which was done manually, with shaking the branches; then, the yellowish fruits that did not detach from the mother plant were classified as stage 2 and collected manually; Those deep yellowish fruits, which were detached from the mother plant, were classified as stage 3, it was caught with a cloth.

The fruits were harvested in the morning, and at each maturity stage approximately eighty of them were collected, selected for color uniformity, health and absence of injuries and defects, divided into six equal lots, representing the repetitions.

The fruits were packed in low density polyethylene bags, placed in sanitized isothermal boxes and transported under environmental conditions to the Fruit and Vegetable Post Harvest Technology Laboratory of the Faculty of Nutrition of the Federal University of Mato Grosso (UFMT). The fruits were washed with neutral detergent and running water to remove surface dirt from the field and sanitized with 100 mg L^{-1} sodium hypochlorite solution for 15 minutes at 10°C.

The experiment was conducted in a completely randomized design, represented by three maturation stages, with six replications. The experimental plot consisted of twelve fruits.

The fruits were submitted to peel color analysis, fresh mass measurements, longitudinal and transverse diameters, firmness and vitamin C. The pulp was separated from the seeds manually with the help of knives and spoons. Afterwards, the samples, in the different maturity stages, were immediately placed in polyethylene bags and stored in a freezer at -18°C, for further analysis.

Fresh mass (g) was evaluated by weighing each fruit individually on a semi-analytical balance (Bioprecisa Modelo Electronic Scale - FA-2104N) and the l longitudinal and transverse diameters (cm) using a hand-held metal caliper from Somet®.

The peel color values of *E. dysenterica* fruits were determined with the aid of the Minolta CR-400 colorimeter with D_{65} illuminant and the CIE L*a*b* system. The readings of the values L*, a* and b* were taken at three random points of the fruit peel of each repetition.

The firmness was determined at three different points of the fruits with the aid of a Stable Micro System model TA.XT plus texturometer, using the P/2 probe, which measured the penetration force of the fruits at a speed of 1.5 mm s^{-1}, with the pre and post test speed 10.0 mm s^{-1}, and a penetration distance of 5 mm, using a HDP/90 platform as a base and the results expressed in Newton (N).

Analyzes of pH, titratable acidity (TA) and soluble solids (SS) were performed on filtered homogenate after grinding the fruit pulp in a 1:5 tissue homogenizer (20 g of the pulp diluted in 100 mL of distilled water). The determination of TA (% citric acid) was performed by titration with 0.1 N NaOH solution, using phenolphthalein as an indicator [13]. The pH was determined using a Tecnal pH meter (Tec 3MP) according to the AOAC [14]. The SS were determined by refractometry using a digital Pal-alpha model refractometer from ATAGO® with automatic temperature compensation at 25°C [14].

The proximate composition was performed on the whole fruit (pulp and peel) at the different maturity stages. The moisture content was determined according AOAC method (105°C, until constant weight was obtained) [14]. The ether extract (lipids and fat soluble substances) was extracted in the samples with organic solvent (petroleum ether), using the Soxhlet continuous extraction apparatus, according AOAC method [14]. Crude protein was determined by nitrogen content by distillation in a Microkjedahl apparatus, using factor 6.25 for the calculation [14]. Crude fiber was made by gravimetric method after acid hydrolysis [15]. The ash fraction, or fixed mineral residue, was determined gravimetrically by evaluating the weight loss of the material subjected to heating at 550°C in muffle furnace [14]. It was calculated the glycidic fraction by the difference of the

second equation 1, considering the entire material:

$$GF = 100 - (H + EE + P + F + A) \quad (1)$$

Where: GF is the glycidic fraction (%); H is the humidity (%); EE is the ether extract (%); P is the crude protein (%); F is the crude fiber (%) and A is the ashes fractions (%).

The total caloric value was estimated according to Atwater conversion factors, 4 kcal g^{-1} for proteins, 4 kcal g^{-1} for carbohydrates and 9 kcal g^{-1} for lipids [16]. Ascorbic acid content (after oxidation to dehydroascorbic acid) was determined in the pulp throughout its development by the colorimetric method using 2,4 dinitrophenylhydrazine [17].

Statistical analysis of the chemical and physical variables was performed with the support of SISVAR program [18]. After the analysis of variances of the results, it was noticed the significance level of the test F. The means of the treatments, when significant, were compared by the Scoott-Knott test at 5% probability.

3. RESULTS AND DISCUSSION

The results obtained from the physical and chemical analyzes of *Eugenia dysenterica*, which were not significantly affected by maturation stages ($p < 0.05$) are shown in Table 1.

Table 1. Proximate composition means values of *Eugenia dysenterica*

Parameters	Mean*
Fresh mass (g)	9.62 ± 2.4
Longitudinal diameter (mm)	20.75 ± 6.1
Transverse diameter (mm)	243.09 ± 5.1
Lipid (%)	0.19 ± 0.2
Protein (%)	1.69 ± 0.1
Crude fiber (%)	1.62 ± 0.1
Ash (%)	0.36 ± 0.1
Caloric value (kcal)	36.03 ± 6.5

**Mean ± Standard deviation (n= 6)*

The fresh mass for *E. dysenterica* was 9.62 g (Table 1), which was similar to that found in ripe fruits harvested in the Cerrado from Piauí, with an average value of 9.3 g [19].

The longitudinal and transverse diameters were 20.75 mm and 243.09 mm, respectively (Table 1). The values found are close to those described by Rocha [19], with 23.10 mm of longitudinal diameter and 271 mm of transversal diameter. According to Fonfría et al. [20], individual fruit size is inversely related to the number of fruits per tree, that is, adult plants produce more fruits, but these are smaller.

The lipids content in *E. dysenterica* of 0.19% (Table 1) was lower than the result obtained by Rocha [19], with 0.30%. Silva et al. [10], studying various native fruits from Cerrado biome, found average values of lipid content of 0.44% for *E. dysenterica* and 0.12% for *Campomanesia xanthocarpa*, the latter also being found by Santos et al. [21]. Nevertheless, most fruits contain low lipid values, around 1%, which are associated in the surface protective cuticle layers and cell membranes [22]. Aiming at healthier products for human consumption, the industry has been demanding low-lipid raw materials to pass on to consumers. Thus, the amount of lipids in industrialized food products has been decreasing. Thus, fruits with low lipid content deserve to be highlighted.

The protein content found was 1.69% in *E. dysenterica* (Table 1), a relevant value, given that most fruits are usually low in this constituent. Value below this was obtained by Silva et al. [10] in *E. dysenterica* fruits and by Santos et al. [21] in *C. xanthocarpa* fruits, with an average of 0.82% and 1.08%, respectively. Studies by Almeida et al. [5] obtained protein values of 0.98% for *E. dysenterica* fruits, while Cardoso et al. [23] report 0.63%. In general, most fruits are low in protein, averaging 1%, with peels and seeds richer than pulp [24].

The crude fiber presented by *E. dysenterica* was 1.62% (Table 1), however, no report was found on its crude fiber content at any maturity stage. Crude fiber has no nutritional value, although it plays a fundamental role in stimulating peristalsis, determining the food bolus speed through the gastrointestinal tract [25]. Poor diets of this component lead to constipation and increased risk of coronary heart disease and blood glucose and insulin levels [26].

The observed ash and caloric values for *E. dysenterica* were 0.36% and 36.03 kcal, respectively, which confirms the results obtained by Rocha [19] who found 0.30% ash and 36.60 kcal of caloric value in ripe fruits.

Tables 2 and 3 present data on the physical and chemical parameters obtained in *E. dysenterica*, whose results were significantly affected by the fruit ripening stages ($p < 0.05$).

Table 2. Color (L*, a* and b*), firmness (N) and moisture content (%) values of *E. dysenterica* at different maturity stages

Maturity stages	L*	a*	b*	Firmness (N)	Moisture (%)
Stage 1	42.04±4.3b	1.71±1,4b	24.98±2.5b	11.08±0.8a	89.10±0.1a
Stage 2	50.96±5.1b	4.02±1,6a	27.37±1.6b	8.05±0.6 b	88.20±0.1b
Stage 3	55.30±3.8a	4.00±0,8a	36.19±3.1a	7.43±0.3 b	87.48±0.2c
CV (%)	4.85	16.78	12.94	8.08	0.39

Means followed by the same letter represent statistical similarities at 5% probability by the Scoott-Knott test. Mean ± Standard deviation (n= 6)

Table 3. Carbohydrate (%), pH, titratable acidity-TA (% citric acid), soluble solids-SS (°Brix) and vitamin C (mg.100 g-1) values of *E. dysenterica* at different maturity stages

Maturity stages	Carbohydrate (%)	pH	TA (% citric ac.)	SS (ºBrix)	Vitamin C (mg100 g^{-1})
Stage 1	7.02±1.3 c	3.63±0.3 a	3.38±0.1 a	4.87±0.0 c	77.27±2.3 a
Stage 2	7.42±0.8 b	3.27±0.2 b	1.80±0.2 b	6.57±0.0 b	62.50±3.4 b
Stage 3	8.23±1.2 a	3.10±0.3 c	0.65±0.1 c	7.97±0.1 a	55.02±2.1 c
CV (%)	3.09	2.97	4.27	2.11	3.74

Means followed by the same letter represent statistical similarities at 5% probability by the Scoott-Knott test. Mean ± Standard deviation (n= 6)

The change from stage 1 to 2 and from stage 2 to 3 was observed within 8 days. The time it takes for changes to occur between maturity stages of a fruit is variable and dependent on soil and climate conditions. Gomes et al. [27] suggests for *Malpighia emarginata* fruits on average 22 days from the initial development of the fruit to maturation, which allows 6 to 7 flowerings per year or more.

The L* coordinate showed significant differences between the three maturity stages, with the highest value being observed at stage 3 (ripe fruit) (Table 2). The coordinates a* and b* presented similar behavior, with the highest values of these variables in stages 2 and 3, which did not differ from each other (Table 2). The L* coordinate represents brightness, how light or dark the sample is, with values ranging from 0 (all black) to 100 (all white); a* can assume values from -80 to +100, where the extremes correspond to green and red respectively, b* corresponds to the intensity from blue to yellow, which can range from -50 (all blue) to +70 (all yellow). Thus, the L* values between the maturity stages of the *E. dysenterica* indicate the increase of luminosity in the fruits, that is, the fruits became lighter, possibly due to the loss of green color.

The behavior of a* and b*, increasing their values with the maturity stage of the *E. dysenterica* and based on the color variations that these variables represent, have a green color loss and a yellow color change. As it ripens, the fruit gradually changes its color from dark green to light green; Then, yellow, orange and red pigments (carotenoids and anthocyanins) appear. These could be present together with the color green, being revealed only after chlorophyll degradation, or synthesized during maturation [28].

Changes in fruit color during the ripening process are due to both degradative and synthetic processes. They correspond to one of the main judgment criteria for identifying fruit ripening. The uniformity of the degree of ripeness can interfere with the color and appearance of processed products [29]. According to Rocha [19] he observed high values in the coefficients L*, a* and b*, which indicated luminous fruits, with greenish peel and yellowish coloration of the fruits, since the fruits analyzed by them were in the final maturity stage.

In the firmness evaluation, it is noticed the decrease in the value of this parameter with the ripeness process, however, with significant difference only between the stage 1 for the others. Data inherent to the firmness of *E. dysenterica* were not found in the literature. Firmness represents one of the most important physical characteristics, since fruits with high firmness suggest a longer postharvest shelf life. This feature is associated with the chemical components of the cell walls, notably the pectins present in the middle lamella, which act as

cementing material, maintaining cohesion between cells [25].

The moisture content was statistically different between maturity stages, decreasing with its ripeness process (Table 2). The moisture content in stage 3, of 87.48%, is close to the result obtained by Rocha [19] and Camilo et al. [30], which were 90.9% and 91.86% respectively. Almeida [6], Souza [31] and Silva et al. [10] found values for this variable of 95.00%, 90.70% and 94.34%, respectively, showing that the fruit is mostly composed of water; indicating one of the common characteristics of fruits of the *Myrtaceae* family, falling into the class of fleshy and juicy fruits. Thus, it is possible to conclude that the cagaita is one of the Cerrado fruits with the highest water content [5].

There were significant differences between the three stages regarding the percentage of carbohydrates, which increased according to the degree of ripeness (Table 3). In stage 3 the carbohydrate content found in fruits was 8.23%, a result different of 5.93%, found by Camilo [30]. Silva et al. [10] and Cardoso et al. [23] found an average of 3.08% and 5.54%, respectively, for carbohydrate content in *E. dysenterica*. In *C. xanthocarpa*, from the same family, these same authors found an average value of 10.57%.

The titratable acidity (% citric acid) decreases as the degree of maturation increases and consequently the pH drop occurs, and these variables presented statistical differences between the stages. The titratable acidity of the ripe fruit was 0.65% citric acid (Table 3); however, different values were found by Rocha [19] and Camilo [30], with 3.3% and 1.48%, respectively; and for the pH of the ripe fruit was 3.10, a value similar to that found by the above authors, 3.7 and 2.73, respectively. The pH result was also similar to those found by Almeida et al. [3], 2.95; and Almeida [6], 2.83; in *E. dysenterica* fruits. Organic acids, with few exceptions, tend to decrease with fruit ripening as a result of their use as a substrate in the respiratory process or their conversion to sugars [25]. Along with sugars, organic acids impart the characteristic fruit flavors, which vary by species.

The soluble solids content of the fruit was different between the maturity stages, with gradual increase in its values throughout the ripening process (Table 3). Soluble solids contents found for stages 1 and 2 were 4.87 °Brix and 6.57 °Brix, respectively, similar to those found by Silva et al. [32], about 4.1 °Brix and 6.2 °Brix. The SS content in the stage 3 was 7.97 ° Brix, close to the values found in the literature, exceeding the average found by Almeida [6], 5.6 °Brix, Rocha [19], 6.7 °Brix and Camilo [30], 7,18 ° Brix, however, lower than those found by Souza [31], about 8,19 °Brix.

From a commercial sense, for both fresh consumption and industrial processing, fruits with higher SS contents are preferred. For industry, higher levels imply higher yields and lower operating costs. However, according to Barros et al. [33], excess sugar in the fruit may be associated with rapid deterioration and fermentation and, consequently, a reduction in its postharvest period. The SS data found in *E. dysenterica* are consistent with the carbohydrate levels (Table 3), with the increase in their contents with maturation, indicating sugar synthesis. SS mainly comprise sugars, their content being dependent on the fruit's maturity stage, increasing during ripeness process by biosynthesis of mono and disaccharides, or polysaccharide degradation [28]. One of the main transformations that occur in fruit ripening is the accumulation of sugars, which can be derived directly from the sap imported by the fruit, before or concomitantly with starch degradation, having a direct effect on the development of the full edible quality of the fruit, especially with the increase in the degree of sweetness.

E. dysenterica pulp showed a significant difference in vitamin C content between the studied stages, with a considerable drop occurring as ripeness process increased (Table 3). In stages 1 and 2, with 77.27 mg $100g^{-1}$ and 62.50 mg 100 g^{-1}, respectively, were higher than those found by Silva et al. [32], 13.3 mg 100 g^{-1} for stage 1 and 26 mg 100 g^{-1} for stage 2. *E. dysenterica* at stage 3 presented 55.02 mg 100 g^{-1} of vitamin C (Table 3), lower than that found by Rocha [19] of 126.3 mg 100 g^{-1}. For the ascorbic acid index, the ripe fruits presented significantly lower averages when compared to the semi-mature and green fruits. This result corroborates several studies [34,35,36]. In general, the vitamin C content, expressed as ascorbic acid, decreases with the advancement of fruit maturation. The decrease in vitamin C during the fruit ripening process is due to the action of the enzyme ascorbic acid oxidase (ascorbate oxidase) as stated by Asenjo et al. [37], who found that enzymatic activity is higher in ripe fruits. There is wide variation in vitamin C content in fruits, which is generally associated

with factors such as environmental influence (soil conditions, climate, rainfall) and degree of ripeness, among other pre and postharvest factors. Vitamin C (ascorbic acid) participates in several metabolic processes, besides participating in oxide-reduction processes, increasing iron absorption and free radical inactivation, constituting an essential vitamin to the body [38]. Knowing that for adults the Recommended Daily Intake (RDI) of vitamin C is 45 mg day^{-1} [39], *E. dysenterica* pulp is an excellent source of vitamin C.

4. CONCLUSION

The cagaita fruits (*Eugenia dysenterica*) have high potential for industrialization due to low energy value and low lipids and carbohydrates content.

Eugenia dysenterica pulp presented high levels of vitamin C, what have a direct relationship with antioxidant activity and may contribute to beneficial health effects.

Due to the high moisture content in the cagaita fruit, it can become unviable for fresh marketing, as it has a short shelf life, however, it has pleasant sensory and nutritional characteristics, which stimulates the aggregation of commercial value as development of pulps fruits, which can be used for various purposes, thereby increasing their commercial stability.

Given the physical and chemical changes of the cagaita fruit, it is suggested that the fruit has inherent changes of climacteric fruits, so future studies can be performed to prove this feature.

ACKNOWLEDGEMENTS

The authors thank the Mato Grosso State Research Support Foundation (Fapemat) for their financial support (Process 157627/2014).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sampaio EVSB, Pareyn FGC, Figueirôa JM, Santos Júnior AG. Espécies da flora nordestina de importância econômica potencial. Recife: Associação Plantas do Nordeste. 2005;331. Portuguese
2. Rodrigues LJ, Vilas Boas EVB, Paula NRF, Pinto DM, Piccoli RH. Effect of cutting type and sanitizers on the browning of fresh cut peki fruit. Ciência e Agrotecnologia. 2011;35(3):560-567. Available:http://dx.doi.org/10.1590/S1413-70542011000300018
3. Almeida SP, Silva JÁ, Ribeiro JF. Aproveitamento alimentar de espécies nativas dos Cerrados: Araticum, baru, cagaita e jatobá. 2. Ed. Planaltina, DF: Embrapa-CPAC. 1987;83. Portuguese
4. Brito MA, Pereira EBC, Pereira AV, Ribeiro JF. Cagaita, Biologia e manejo. Planaltina, DF: Embrapa Cerrados. 2003;80. Portuguese
5. Almeida SP, Costa TS, Silva JA. Frutas nativas do cerrado: Caracterização físico-química e fonte potencial de nutrientes. In: Sano MS, Almeida SP, Ribeiro JF. Cerrado: Ecologia e flora. Brasília, DF: Embrapa Informação Tecnológica. 2008; 353-381. Portuguese
6. Almeida SP. Frutas nativas do cerrado: caracterização físico-química e fonte potencial de nutrientes. In: Sano MS, Almeida SP. Cerrado: Ambiente e flora. Planaltina, DF: Embrapa – CPAC. 1998; 247-285. Portuguese
7. Moraes VHF, Muller CH, Souza AGC, Antonio IC. Native fruit species of economic potential from the Brazilian Amazon. Angewandte Botanik, Goetting. 1994;68(1-2):47-52.
8. Ávidos MFD, Ferreira LT. Frutos dos Cerrados: Preservação gera muitos frutos. Revista Biotecnologia Ciência e Desenvolvimento, Brasília. 2000;3(15):36-41. Portuguese
9. Fernandes DC, Freitas JB, Czeder LP, Naves MM. Nutritional composition and protein value of the baru (*Dipteryx alata* Vog.) almond from the Brazilian Savannah. Journal of the Science of Food and Agriculture, London. 2010;90(10):1650-1655. Available:http://dx.doi.org/10.1002/jsfa.3997
10. Silva MR, Lacerda DBCL, Santos GG, Martins DMO. Chemical characterization of native species of fruits from savanna ecosystem. Ciência Rural, Santa Maria. 2008;38(6):1790-1793. Available:http://dx.doi.org/10.1590/S0103-84782008000600051

11. Esquinaz-Alcázar J. Science and society: Protecting crop genetic diversity for food security: Political, ethical and technical challenges. Nature Reviews Genetics, London. 2005;12(6):946-953.
Available:http://dx.doi.org/10.1038/nrg1729
12. INPE. Instituto Nacional de Pesquisas Espaciais.
Available:http://www.inpe.br/
(Access in Dec 16, 2014)
13. Instituto Adolfo Lutz. Normas Analíticas do Instituto Adolfo Lutz: Métodos químicos e físicos para análise de alimentos. 3. Ed. São Paulo. 1985;1:181.
14. AOAC. Official methods of the Association of the Agricultural Chemists. 17. Ed. Washington. 2005;1410.
15. Van de Kamer JH, Van Ginkel L. Rapid determination of crude fiber in cereais. Cereal Chemistry, Saint Paul. 1952;29(4): 239-251.
16. Osborne DR, Voogt P. The analysis in nutrient of foods. London: Academic. 1978;158.
17. Strohecker R, Henning HM. Analisis de vitaminas: Metodos comprobados. Madrid: Paz Montalvo. 1967;428. Spanish
18. Ferreira DF. Sisvar: Sistema de análise de variância. Versão 5.3. Lavras: UFLA; 2010. Portuguese
19. Rocha MS. Compostos bioativos e atividade antioxidante (*in vitro*) de frutos do cerrado piauiense. Dissertação [Mestrado em alimentos e nutrição] Universidade Federal do Piauí, Teresina, 93 f; 2011. Portuguese
20. Manica I, Manica FL, Fonfría MA, Orenga VA, Alcaina MA, Ferrer MJ, Romero VE. (Ed.). Citros: Desenvolvimento e tamanho final do fruto. Porto Alegre, RS: [s.n.]. 1996;102. Portuguese
21. Santos MS, Carneiro PIB, Wosiacki G, Petkowicz CLO, Carneiro EBB. Physicochemical characterization, extraction and analysis of pectins from fruit of *Campomanesia xanthocarpa* B. (Gabiroba). Sêmina: Ciências Agrárias, Londrina. 2009;30(1):101-106.
22. Kays SJ. Postharvest physiology of perishable plant products. Athens: Avi. 1997;532.
23. Cardoso LM, Martino HSD, Moreira AVB, Ribeiro SMR, Pinheiro-Sant'Ana HM. Cagaita (*Eugenia dysenterica* DC.) of the Cerrado of Minas Gerais, Brazil: Physical and chemical characterization, carotenoids and vitamins. Food Research International, Barking. 2011;44(7):2151-2154.
24. Gondim JAM, Moura MFV, Dantas AS, Medeiros RLS, Santos KM. Composição Centesimal e de minerais em cascas de frutas. Ciência e Tecnologia de Alimentos, Campinas. 2005;25(4):825-827. Portuguese
25. Vilas Boas EVB. Qualidade de alimentos vegetais. Lavras: UFLA/FAEPE. 2006;68. Portuguese
26. ADA. American Dietetic Association. Position of the American dietetic: Health implication of dietary fiber. Journal of the American Dietetic Association, Madison. 2008;108(10):1716-1731.
27. Gomes JE, Pavani MCMD, Perecin D, Martins ABG. Flower morphology and reproductive biology of West Indian cherry genotypes. Scientia Agrícola, Piracicaba. 2001;58(3):519-523.
28. Coombe BG. The development of fleshy fruits. Annual Review of Plant Physiology, Palo Alto. 1976;27(1):507-528.
29. Chitarra MIF, Chitarra AB. Pós-colheita de frutos e hortaliças: Fisiologia e manuseio. 2. Ed. Lavras: FAEPE. 2005;785. Portuguese
30. Camilo YMV, Souza ERB, Vera R, Naves RV. Fruit characterization and progeny selection of cagaita (*Eugenia dysenterica* DC.) Científica, Jaboticabal. 2011;42(1):1-10.
Available:http://dx.doi.org/10.15361/1984-5529.2014v42n1p1-10
31. Souza ERB. Fenologia, dados biométricos, nutrição de plantas e qualidade de frutos de cagaiteira (*Eugenia dysenterica* DC.) no Estado de Goiás. 2006. 114f. Tese [Doutorado em Agronomia: Produção Vegetal] - Escola de Agronomia e Engenharia de Alimentos, Universidade Federal de Goiás, Goiânia; 2006. Portuguese
32. Silva AML, Martins BA, Deus TN. Avaliação do teor de ácido ascórbico em frutos do cerrado durante o amadurecimento e congelamento. Pesquisa Agropecuária Tropical, Goiânia. 2009;36(11/12): 1159-1169. Portuguese
33. Barros RS, Finger FL, Magalhães MM. Changes in non-structural carbohydrates in developing fruit of *Myrciaria jaboticaba*. Scientia Horticulturae, Amsterdam. 1996;66:209-215.
34. Lima VLAG, Melo EA, Maciel MIS, Prazeres FG, Musser RS, Lima DES. Total

phenolic and carotenoid contents in acerola genotypes harvested at three ripening stages. Food Chemistry, London. 2005;90:565-568.
Available:http://dx.doi.org/10.1016/j.foodchem.2004.04.014

35. Nogueira RJMC, Moraes JAPV, Burity HA, Silva Júnior JF. Physicochemical characteristics of Barbados cherry influenced by fruit maturation stage. Pesquisa Agropecuária Brasileira, Brasília. 2002;37(4):463-470.
36. Vendramini AL, Trugo LC. Chemical composition of acerola fruit (*Malpighia punicifolia* L.) atthre estages of maturity. Food Chemistry, London. 2000;71:195-198.
37. Asenjo CF, Penaloza A, Medina P. Characterization of ascorbase present in the fruit of the *Malphigia punicifolia* L. Federation of America Societies for Experimental Biology. Federation Proceedings, Bethesda. 1960;19(1).
38. Barreto AG. Clarificação e concentração do suco de camu-camu por processos de separação com membranas. 2008;88. Dissertação [Mestrado em tecnologia de processos químicos e bioquímicos]. Universidade Federal do Rio de Janeiro, Rio de Janeiro; 2008. Portuguese
39. FAO. Human vitamin and mineral requirements. In: Report 7th Joint FAO/OMS Expert Consultation. Bangkok, Thailand. 2001;286.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/51328