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Cagaita (*Eugenia dysenterica*) jams with paste and dough textures: physical, chemical, and antioxidant evaluation

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Abstract

Jams with paste and dough textures were developed from cagaita (*Eugenia dysenterica* DC), in which the physicochemical parameters, proximal analysis, and antioxidant activity during storage were characterized. The jams were stored, and the analyses were carried out every 2 months so that possible variations during 8-month storage time were observed. The values were significant ($p < 0.05$) for most of the variables studied when comparing the two products concerning time. The main variations were humidity, pH, and total titratable acidity. The storage and conditioning of the products influenced the proximal and antioxidant composition values. The production, commercialization, and consumption of cagaita jams are recommended to contribute to income generation and improvement of nutritional support, especially for individuals living in the Cerrado region.

Keywords: fruits; food preservations and processing; shelf life.

Practical Application: Storage time influences the physicochemical parameters and antioxidant composition of cagaita jam.

1 INTRODUCTION

The Cerrado is the second largest biome in Brazil, occupying about 22% of the national territory, with many fruit species, and having great agricultural potential that is still less explored (Brazil, 2020). The native fruits of the Cerrado have important sensorial particularities and high nutritional value, as well as an essential role in the local economy (Reis & Schmiele, 2019; Santos et al., 2022).

In this context, the cagaita (*Eugenia dysenterica*) belongs to the Myrtaceae family, comprising 14 genera, and is represented by 211 species that naturally occur in the Cerrado. The Myrtaceae family has great economic potential, as many of its species, such as *Psidium guajava* L., guava, and *Eugenia uniflora* L., "pitanga," are used in the food products like juices, jams, jellies, and ice cream (Cardoso et al., 2021; Lorenzi et al., 2006; Santos et al., 2022), and another species is the "camu-camu" (*Myrciaria dubia* (Kunth) Mc Vaugh), which has a high vitamin C content, according to ethnopharmacological information (Albuquerque et al., 2015). Cagaita fruits are globose, bacaceous, light yellow, slightly acid, and membranous epicarp, with 14–20 g weight, 3–4 cm length, and 3–5 cm diameter, an average of 3–4 seeds, and great potential for use in agricultural systems. Also, the pulp of cagaita and other fruits of the same species can be used to manufacture food products (e.g., jams, juices, liqueurs, and jellies) for fresh consumption (Silva et al., 2015). The appreciation of Cerrado fruits in the market gained space mainly due to the use of fruits to prepare jams and other products.

According to CTA Normative Resolution no. 9/78, jams with paste and dough textures are the products resulting from the proper processing of the disintegrated edible parts of fruits with sugars, with or without the addition of water, pectin, pH adjuster, and other ingredients and additives permitted by food legislation, up to appropriate consistency (Garrido et al., 2015). Finally, it is packaged to ensure its perfect conservation (Jackix, 1988).

The intrinsic factors, such as the degree of pectin esterification and the pH of the jam, and extrinsic factors, such as pre-processing of the fruit, cooking temperature, package size, time, and temperature of gelling, besides the order in which the ingredients are placed, affect the manufacturing process of jams and jellies, and therefore the quality of the final product (Albuquerque, 1997; Souza et al., 2018). From a microbiological point of view, artisanal jams, depending on the packaging, processing, and storage conditions, have a shelf life ranging from 6 months to 1 year (Borges, 2012; Tfouni & Toledo, 2002). Given the above, the objective was to elaborate and evaluate both physically and chemically the cagaita jams (*Eugenia dysenterica*) with paste and dough textures for 8 months.

2 MATERIALS AND METHODS

Cagaita fruits were collected in a native area, with typical Cerrado formation, located in the municipality of Abadia-GO, at a latitude of -16°45'26" and a longitude of -49°26'15". After harvesting, they were examined for physical integrity and the absence of mechanical and pathogenic damage.

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2.1 Development of the jams

Figure 1 shows the flowchart for preparing the jams with paste and dough texture, obtaining the fruits, and preparing the sweets. The fruits were chosen, classified, washed, and sanitized using 200 mg.L^{-1} of sodium hypochlorite for 15 min, and then the pulp was extracted. For the dough jam preparation, 1,500 g of pulp, 841.5 g of sugar, and 6.0 g of industrial pectin were used. For the paste jam preparation, 1,000 g of pulp, 561 of sugar, and 4.0 g of industrial pectin were used. Both were cooked for approximately 20 min until they reached the desired soluble solids content (68 ºBrix for dough and 78º Brix for paste). After determining the endpoint, the paste jam was placed in sanitized glass containers and the dough jam in low-density polyethylene packaging, followed by storage at room temperature (± 25°C) for 8 months. The packaging of polypropylene because of its low gas permeability and light is appropriate and economical for a short time to make it available in market as fruit jams, maintaining acceptable products in terms of sensory and microbiological changes (Borges, 2012).

2.2 Physical and chemical aspects

Physical and chemical analyses were carried out every 2 months for 8 months, in the Laboratory of Physical-Chemical Analysis of Food, Department of Food Engineering of the School of Agronomy, Federal University of Goiás, so that possible variations were observed during the storage time.

The color was determined at three different points of jam preparation by reading three parameters using the CIE L * a * b * mode, provided by the colorimeter (Hunterlab, ColorQuest II). The water activity was performed at room temperature (± 25°C), using an Aqualab device (Aqualab CX-2), through a direct reading of the sample. According to AOAC (2012), the content of soluble solids, pH, and total titratable acidity were determined in triplicate.

2.3 Antioxidant activity

2.3.1 Obtaining extracts

The extracts were prepared in the following order: ethereal, alcoholic, and aqueous, where 2.5 g of the sample was placed in beaker glasses duly covered with foil to avoid contact with the light. Then 50 mL of ethyl ether was added, and the solution was stirred for 1 h with the help of magnetic ions in the container. The extract was filtered through a Buckner funnel, using a 50-mL beaker filter paper, which was also covered with aluminum foil. After all filtration, the volume was made up to 50 mL with ethyl ether. The remaining residue was subjected to drying to be used in the extraction of the alcoholic extract. The filtered extract was placed in an amber flask and stored in the freezer at -18°C. In the same filter paper that contained the dry residue from the ether extract, 1:20 ethyl alcohol was added and the mixture was stirred for 1 h to obtain the ethanolic extract. It was filtered with the same care taken for the ether extract. The volume was completed, according to the initial volume of ethyl alcohol, and it was stored in an amber bottle in the freezer at -18°C. For the aqueous extract, 1:20 distilled water was added to the filter paper that contained the dry residue, the same as used in the ethereal and ethanolic extracts, and stirred for 1 h. Then, the filtration was performed, and the volume was completed according to the initial volume of distilled water used. The filtered extract was placed in an amber flask and stored in the freezer at -18°C.

2.3.2 DPPH radical sequestration method and Vitamin C

From the extract obtained in earlier step, at least three different triplicate dilutions were prepared in test tubes. In a dark environment, an aliquot of 0.1 mL of each dilution of the extract was transferred to test tubes with 3.9 mL of the DPPH radical and homogenized in a tube shaker. A 750 μL aliquot of the BHT solution was taken and placed in a cuvette, and 1.5 mL of the DPPH solution was added to it. The absorbance readings were taken after 20 min. For the sample blank, 750 μL of the sample and 1.5 mL of methanol were used. The control was prepared with 750 μL of methanol containing 1.5 mL of DPPH. For the sample, a 750 μL aliquot was removed, and 1.5 mL of DPPH was added to the cuvette. According to Rufino et al. (2007), the absorbance readings of the samples were taken after 20 min at a wavelength of 517 nm in a Rayleigh UV-1800 spectrophotometer. The antioxidant activity was expressed according to Mensor et al. (2001).

The vitamin C content was determined by the colorimetric method. Vitamin C was extracted with 0.5% oxalic acid under

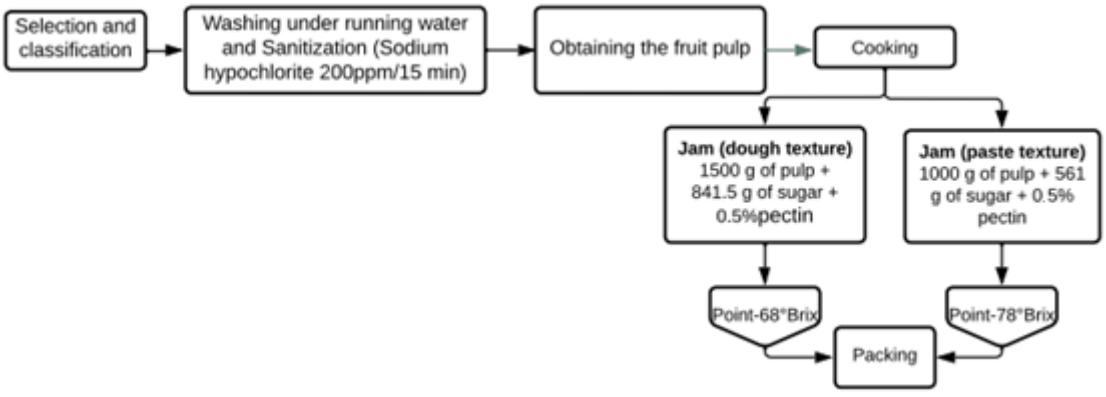

Figure 1. Flowchart for the preparation of jams with paste and dough textures.

agitation, and, after filtration, the extract was assayed using 2,4-dinitrophenylhydrazine and using ascorbic acid as a standard. The reading was performed on a Rayleigh UV-1800 spectrophotometer at 520 nm, and the results were expressed in mg of ascorbic acid/100 g of sample (Strohecker & Henining, 1967).

2.4 Proximal composition

Moisture was obtained using the gravimetric technique, in a ventilated oven at a temperature of 105°C, until constant weight was reached. The samples were subjected to heating in a muffle at 550–600°C to determine the ash values. The protein was determined by the Kjeldahl method, which was based on the determination of total nitrogen. The protein content was calculated by multiplying the total nitrogen by a factor of 5.75 (AOAC, 2012). The ether extract was determined by extracting organic solvent (ethyl ether) in three replications, with the help of the Soxhlet extractor.

2.5 Statistical analysis

The experiment was conducted in a simple factorial design using the Statistica software, observing two types of sweets and five storage times (2 × 5), consisting of the months of evaluation in triplicate. The means were submitted to polynomial regression, where the models were selected according to the significance of the t-test and the coefficient of determination.

3 RESULTS AND DISCUSSION

3.1 Physical and chemical aspects

Figure 2 presents the results of water activity (aw) and total soluble solids of cagaita jams with dough and paste textures. The water activity results ranged from 0.73 to 0.78 for paste jam and 0.56 to 0.57 for dough jam. During the 8 months of storage, no significant differences were observed ($p > 0.05$) for the jams with both dough and paste textures. The relatively low values for the dough jam inhibited the growth of most bacteria, with yeasts and molds being the microorganisms capable of developing more easily. In contrast, the paste jam, which obtained relatively high values, became more susceptible to the development of molds and yeasts because of more viscosity and water content.

A study carried out to evaluate the stability of blackberry jams during their storage showed a different result, with the water activity decreased over the storage time (Carneiro et al., 2016). The authors attributed this fact to the hydrolysis of non-reducing sugars to reducers, which are more hygroscopic and depressants of water activity. In the physicochemical and microbiological alterations of the umbu jams study, it was observed that the water activity decreased over the storage time (Martins et al., 2010). Umbu jams (prepared with sugar) had a shorter cooking time than cagaita jams, which needed a longer time to concentrate the broth.

Regarding soluble solids, significant differences were observed ($p > 0.05$) for both dough and paste textures. It is noted that the content of soluble solids decreased for the paste jam, whereas it increased for the dough jam. Studies on blackberry jams showed an increase in the content of soluble solids stored in polypropylene packaging for 120 days (Carneiro et al., 2016). On the contrary, a report found in the literature observed a gradual reduction in the content of soluble solids during the storage of cagaita jams. This decrease was associated with a reduction in the content of organic acids and vitamin C, generating other compounds through degradation/conversion, which may have less solubility in water (Santos et al., 2012). The same might have happened with the jelly. On the contrary, there was an increase in soluble solids in the jam, probably due to the water evaporation during storage at a relatively high temperature (30°C) and the concentration of these solids.

The jam water activity had only a slight change over time for both textures. When comparing both methods, in terms of conservation, the dough jam is more promising than the paste jam, as it has less water content. One of the most striking differences in the jams studied was their consistency (texture) and soluble solids content. Sweets in the paste can be classified according to their consistency: creamy (homogeneous paste and soft consistency) and dough (homogeneous mass and consistency that allows cutting), which are strongly linked to pectin and sugar concentrations (Silva, 2000; Souza et al., 2018).

In addition to pectic substances and acid, sugar is another necessary component for the formation of the gel. The sugar that is most frequently used in the manufacturing of jam is sucrose, which is derived from sugar cane or beet. Its quantities, together with pectin and acid, determine the formation of the gel responsible for the jam texture (Curi et al., 2017; Silva, 2000).

Regarding the pH and total titratable acidity (Figure 2), significant differences were observed ($p > 0.05$) for both jam textures. The pH in paste jam had a marked increase at time zero, ranging from 3.30 to 3.90 in the second month of storage and remaining at 3.85 until the eighth month. The dough jam continued to increase steadily; at time zero, it reached pH 3.50, and after 8 months of storage, pH was 3.95. In terms of food security, all jams had a pH below 4, that is, no sporulated bacteria would be able to develop, and most vegetative bacteria are unable to multiply (Ordoñez et al., 2005).

Based on the significance of the test, the paste jam presented better conditions concerning pH, as it remained constant until the last month of analysis. For the two jams studied, the pH showed a tendency to increase during the storage period. Similar behavior was observed in the green umbu jam, while it remained stable in the ripe umbu jam during storage (Martins et al., 2010). This fact was also observed in the pH of acerola jelly until 120 days of storage (Caetano, 2010).

There was also a difference ($p < 0.05$) in the total titratable acidity for both jams during storage. There was a tendency for a rapid decrease in acidity in the period evaluated for both products. Considering the amount of pulp and its acidity, the main difference between the jams evaluated for this variable is predominant in the amount of sugar present in each. As it is an acidic fruit, it would be recommended to correct its pH. Wille et al. (2004) developed a technology for manufacturing jam with very acidic fruit araça-pêra, and it was needed to correct the pH with low acid fruits to values from 3.1 to 3.6 in order to

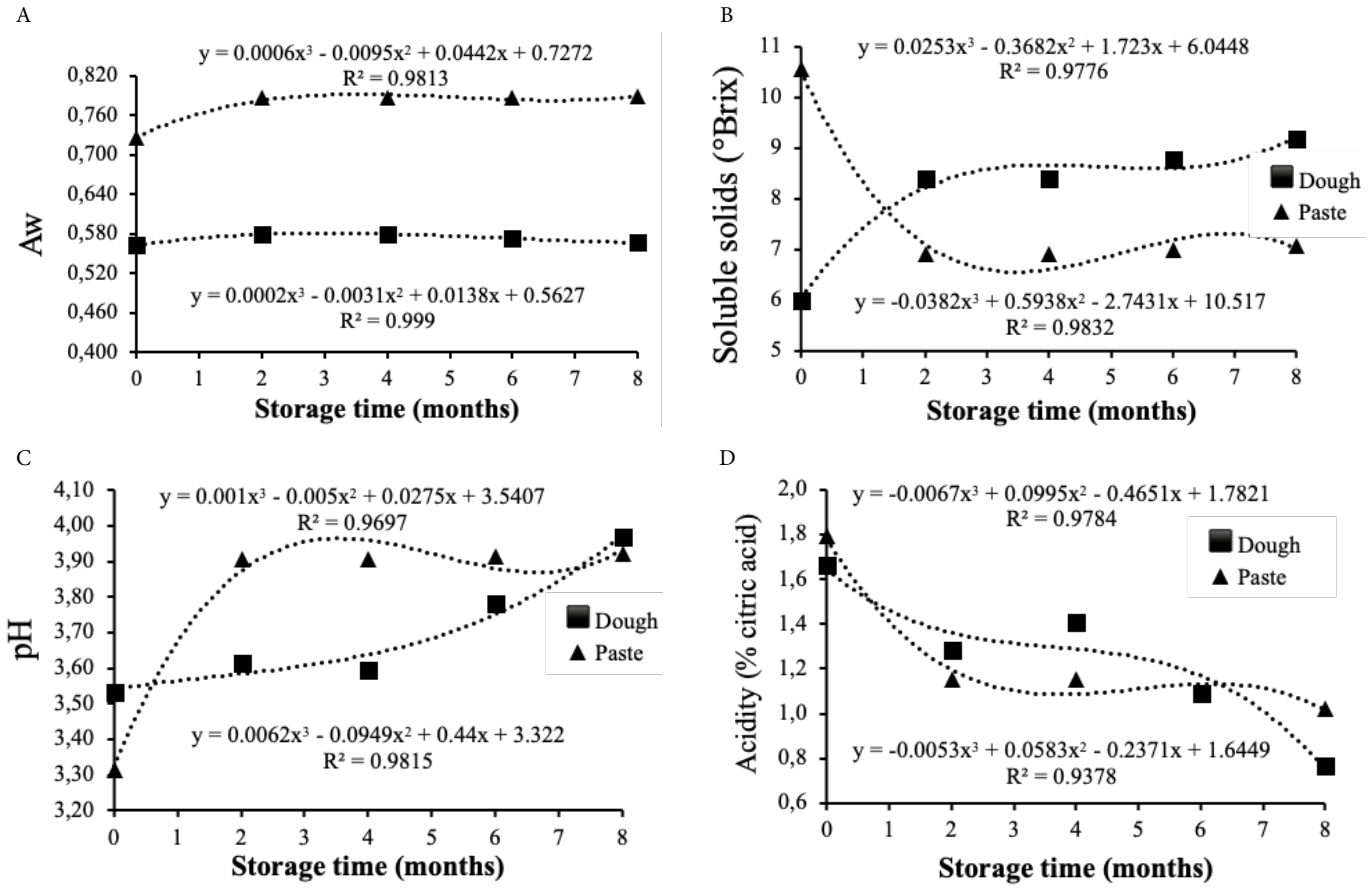

Figure 2. Medium values, regression equations, and determination coefficients of the values of (A) water activity (aw), (B) total soluble solids, (C) pH, and (D) titratable acidity in cagaita (*Eugenia dysenterica*) jams with dough and paste textures by the t-test.

obtain a good-consistency gel. Menezes et al. (2009) observed an increase in the pulp/sugar ratio in different formulations of guava jam (*Psidium guajava* L.), that is, the increase in the addition of pulp also had a positive effect concerning the titratable acidity of the jams. Similar results were found in the analysis of the shelf life of cagaita jellies (Santos et al., 2012). According to Santos et al. (2012), the reduction in the acidity content in cagaita jam was already expected as its storage was carried out at room temperature and susceptible to the presence of light, as observed in this study.

Food color is one of the first attributes that consumers analyze, exerting significant influence on their choice. In Figure 3, the effect of storage time on color variables is observed. Note that the L * and a * variables were significantly affected ($p > 0.05$) with average values between 33.45 and 23.64 for paste jam and 23.56 and 9.51 for dough jam.

Luminosity is a variable that evaluates the color scale between black (0) and white (100), which is used in food analysis to describe color changes and monitor product stability (Monteiro & Pires, 2016). The luminosity values tended to decrease with the storage time for both jams, indicating that the product darkened over the days of storage. Similar results were found in the murici jam, noting that the luminosity was influenced by the storage time, with a drop in values over the days (Monteiro & Pires, 2016).

The values of the variable a*, which have a color range between green and red, were significantly influenced by the storage time. For the dough jam, the change in the value of a* occurred in reverse manner: it increased from time zero to the second month and from the sixth to the eighth month of storage, whereas for the paste jam, the value of a* decreased only during the 8 months of storage. The chroma values and b* were similar as the b* value is the chromaticity coordinate that defines yellow for positive values and blue for negative values. In this parameter, the positive values of the coordinate b* and chroma ranged between 28.57 and 36.29 and 29.65 and 37.45, respectively, for the paste jam and 12.08 and 10.42 and 15.08 and 11.67 for the dough jam.

During the storage period, the hue angle values were stable in the paste jam, while in the dough jam, there was a considerable increase in the first 2 months and a slight variation until the end of the storage. The hue values depend on the relative amounts of red and yellow colors (Monteiro & Pires, 2016). The sweet that was most affected by the 8 months of storage time, concerning the color, was the jam dough, which showed a more accentuated darkening because its luminosity and chroma values decreased during that period, making the jam darker and with less noticeable colors. The possible explanation for this fact may be due to pigment degradation and/or oxidation (Cunha et al., 2020).

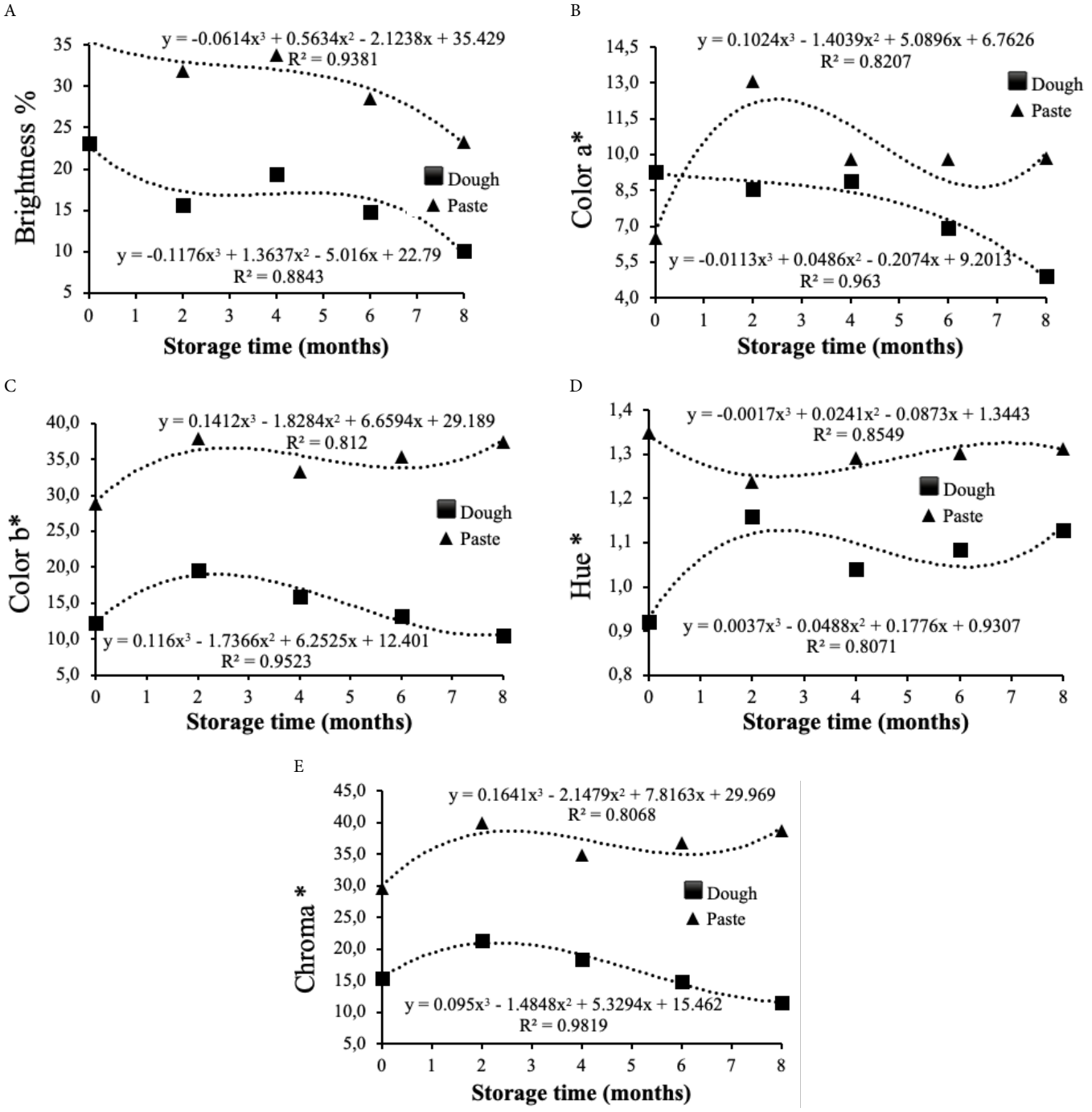

Figure 3. Mean values, regression equations, and determination coefficients of values of (A) L*, (B) coordinate a*, (C) coordinate b*, (D) Hue*, and I Chroma* of cagaita (*Eugenia dysenterica*) jams with dough and paste textures by the t-test.

3.2 Proximal composition

Figure 4 shows the average results of the proximal composition of the cagaita jam with paste and dough texture. The results indicated approximate moisture content, comparing the two types of jams. However, it is possible to verify the stability of this parameter for the paste jam and a slight increase with 6 months of storage for the dough jam, and at the end of the period, there was also a decrease. This parameter varied during storage from 92.43 to 90.80 g/100 g and from 71.16 to 65.84 g/100 g for paste jam and dough jam confectionery, respectively. It was found that the dough jam showed a significant difference ($P \leq 0.05$) concerning the moisture content during the storage period, differently from the paste jam. It is observed that the moisture content of the paste jam is higher than that of the dough jam. This is due to the lower soluble solids content in the paste jam and shorter processing time.

The decrease in moisture content was also observed in the study on the technological processing of acerola jam in

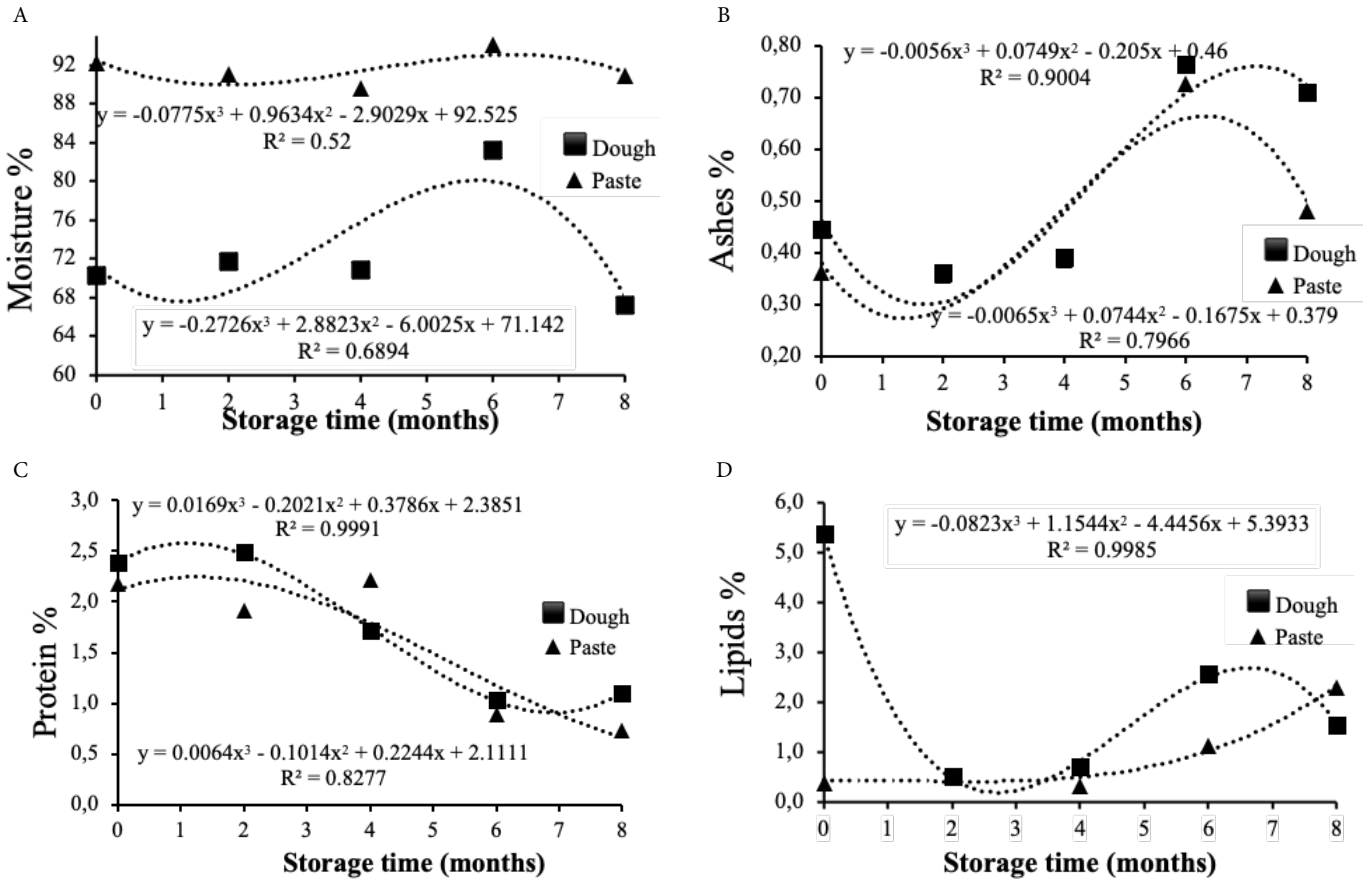

Figure 4. Mean values, regression equations, and determination coefficients of values of the proximal composition of cagaita (*Eugenia dysenterica*) jams with dough and paste textures by the t-test.

glass containers. According to the author, this loss of moisture may occur due to the incorrect closure of the metallic lid of the packaging (Caetano, 2010). Possibly, the dough jam had evaporation of water due to the permeability of the packaging used, which also provided an increase in soluble solids. This loss of moisture can be explained by the exchange of moisture between the inside and outside of the glass by desorption. Other causes for the decrease in humidity are the super junction chains forming the gel, trapping free water, and making it unavailable in the center (Ordoñez et al., 2005), the presence of fungi such as *Byssochlamys fulva*, which synthesizes pectinases that degrade pectin (Evangelista, 2000), leaving galacturonic acid free to bind water molecules, and, to a lesser extent, the Maillard reaction, which occurs at high temperatures in products with high sugar content and low pH values using the water-free environment.

Regarding the ash content, it was observed that the two jams had similar behaviors and that they differed significantly ($P \leq 0.05$) during the 8 months of storage. The decrease in humidity suggests that the ash content should have increased in this period due to the concentration of substances in the samples. However, this was observed only in the fourth and sixth months of storage, where the jams had higher ash contents than in the previous periods. In the literature, ash contents were found around 0.21% for acerola jams, which remained stable over 180 days, with a non-significant increase in the fourth month, unlike this study (Caetano, 2010).

Regarding the protein content, a decrease in the behavior of the curves was observed for both jams, with a decrease in the protein content during storage. The raw material used has a relatively low concentration of proteins, 1.3 g/100 g (Lima, 2006), which resulted in a low concentration of this substance in all jams, unlike reports in the literature that found a slight increase in protein levels up to 180 days of acerola j'ms' storage (Caetano, 2010).

The levels of lipids in both evaluated jams were signi'icant with very different behaviors. The dough jam had a sharp drop in the first 2 months of storage. This is possibly due to the hydrolytic oxidation occurred by the low average pH value (Araujo, 1995). Between the third and sixth months, there was an increase in the lipid content, while the paste jam had a slight increase during the entire storage process, probably due to the nutrient concentration because of the decreased humidity. In the eighth month, the detection of lipids for paste jam and dough jam was 2.14 and 1.54%, respectively. Due to the low concentration of this macronutrient in the raw material, part of it may still have been degraded during cooking. Santos et al. (2012) studied cagaita jelly and observed a high moisture content and reduced content of proteins, lipids, and ash.

3.3 Antioxidant and vitamin C results

The results of antioxidant potential and vitamin C are shown in Figure 5. Using the DPPH radical capture method, the antioxidant potential of cagaita jams showed significant variation

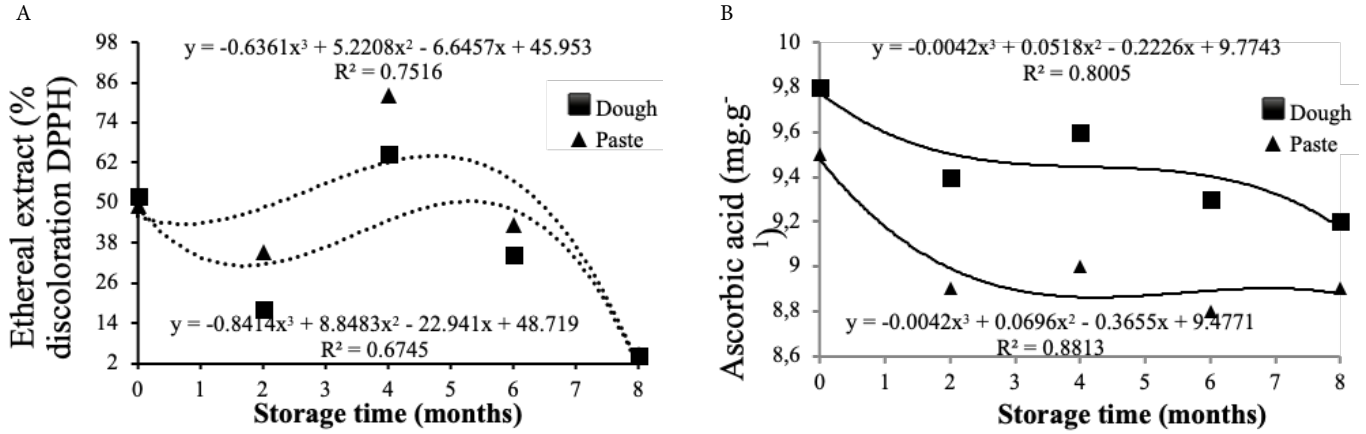

Figure 5. Mean values, regression equations, and determination coefficients of values of (A) DPPH and (B) ascorbic acid of cagaita (*Eugenia dysenterica*) jams with dough and paste textures by the t-test.

($p > 0.05$) over time, with high antioxidant capacity during the 8-month storage period, especially reaching 62.16% of discoloration of the DPPH radical in the fourth month of storage in jam. However, due to the behavior of the curves, it is noted that the percentage of discoloration increased at the beginning of storage, with a decrease after the sixth month of storage.

This antioxidant capacity is high compared with fruit pulps, such as sapota (Carvalho et al., 2012) and araçá (Damiani et al., 2011), which showed, respectively, 27.85 and 12.75% of DPPH radical discoloration. The other extractors used (ethanolic and aqueous) did not show as much efficiency in determining the antioxidant activity of the analyzed sweets.

The results for vitamin C were significant, indicating that there were changes in its contents. Due to the behavior of the curve (Figure 5), it can be observed that the contents suffered a sharp drop in the dough jam, with a slight increase in the fourth month, and after this period, there was a reduction until the eighth month of storage. Similar behavior was observed in the paste jam, which also suffered a decrease in its vitamin C content until the eighth month of storage. According to reports, the levels of vitamin C and antioxidant activity are significantly influenced by the storage time in blackberry jams, with a reduction in their levels (Carneiro et al., 2016).

Concerning the paste jam, there was a marked drop from zero to the fourth month of storage, reaching 9.5 mg/100 g of ascorbic acid, possibly due to the effect of cooking for the manufacture of jams, followed by a slight increase in the eighth month (8.9 mg/100 g). The incidence of light is one of the causes of vitamin C oxidation, as it accelerates the reaction of ascorbic acid with amino groups, producing dark pigments through polymerization and also causing color degradation and loss of some sensory characteristics in fruit jams. This may be related to the reduction in the ascorbic acid content of this study because the jams were not stored in the absence of brightness and a tendency toward their darkening was also observed (Alves & Garcia, 1993). In general, mainly for the variables of the proximal composition, antioxidant activity, and vitamin C, their values were influenced by the storage conditions, such as exposure to excess light and oxygen, the permeability of the packaging for the dough jam, sealing of the glass jars for the paste jam, and period of evaluation of the samples.

In general, when comparing the two jams with paste and dough textures, it is noted that the paste jam is more viscous and has more water, which the production demands less cooking time. During the storage period, the parameters of pH, color, and humidity, showed better stability. On the contrary, the dough jam is more promising when considering the raw parameters and the proximate composition of the product.

4 CONCLUSION

This study made it possible to prepare jams with dough and paste texture using fruits from the Brazilian Cerrado, obtaining a shelf life of at least 8 months and meeting the physical and chemical characteristics of the jams, besides promoting the aggregation of value to this fruit as well as its commercialization.

Based on the results, considering both physical and chemical parameters, the ones that showed the most variations were humidity, pH, and total titratable acidity during the 8-month storage period. It is important to note that storage is essential for any type of food product and the use of adequate packaging, which, in this study, had a direct influence on the results of the two products developed.

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