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STABILITY OF POTENTIALLY BIOACTIVE COMPOUNDS IN RED STRAWBERRY GUAVA (PSIDIUM CATTLEIANUM SABINE) AND RED BRAZILIAN CHERRY (EUGENIA UNIFLORA L.) JAMS

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Red strawberry guava (*Psidium cattleianum* Sabine) and Brazilian cherry (*Eugenia uniflora* L.) are endemic Brazilian species with commercial potential for fresh and/or processed fruits. From the processing perspective, were prepared conventional and *diet* jams and evaluated the stability of potentially bioactive compounds, antioxidant activity, microbiological stability and sensory acceptability of the products. At the end of four months (red strawberry guava jams) and six months (Brazilian cherry jams) there was a significant decrease at all concentrations of all compounds as well as in antioxidant activity. Diet formulations presented higher concentration of the evaluated compounds, being also the formulations that presented greater acceptability. Contamination by molds and yeasts during storage was not verified. From this study, it turns out that diet jams were the most accepted. Red strawberry guava jam with the highest acceptability index (81.44%) was elaborated with sodium saccharin and sodium cyclamate. Among the Brazilian cherry jams, the most accepted formulation (82.89%) was that containing acesulfame potassium and sucralose. However, at the end of four (red strawberry guava jams) and six months of storage (Brazilian cherry jams), there is loss of antioxidant potential (9.1-33.1%) and total phenols (5.6-27.0%), total anthocyanins (1.0-57.9%), total carotenoids (22.3-55.1%) and L-ascorbic acid (3.4-15.0%).

Keywords: Storage, Processing, Phytochemicals, Antioxidant, Red brazilian cherry, Red strawberry guava

INTRODUCTION

Brazil is a country with great flora biodiversity, with approximately 55,000-60,000 species of higher plants. Among this diversity there are many fruit tree species, with the Atlantic forest and the Cerrado being considered, among the Brazilian biomes, the richest in endemic species (Myers *et al.*, 2000; and Fiaschi and Pirani, 2009). The strawberry guava tree (*Psidium cattleianum* Sabine) and the Brazilian cherry tree (*Eugenia uniflora* L.), two representatives of this diversity, although presenting potential for exploitation, are still little used and valued commercially, mainly due to the lack of agronomic

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information and high perishability of its fruits (Haminiuk *et al.*, 2006; and Medina *et al.*, 2011).

Strawberry guava is a globose berry fruit, of yellow or red color, with juicy pulp and very sweet-acid flavor. The distribution of these species occurs in several regions of the country, from subtropical to temperate biome (Biegelmeyer *et al.*, 2011; Ribeiro *et al.*, 2014; Denardin *et al.*, 2015; and Teixeira *et al.*, 2016). The Brazilian cherry, when ripe, presents a coloring of the epidermis that varies of orange, red or purple, being its *in natura* consumption much appreciated. This fruit is also known as *pitanga* or *Surinam Cherry*, and is widely distributed throughout the different regions of Brazil and in other countries of South America, such as Argentina, Paraguay and Uruguay (Weyerstahl *et al.*, 1988; Griffis *et al.*, 2012; Victoria *et al.*, 2012; and Denardin *et al.*, 2015).

Both strawberry guava and Brazilian cherry are rich in secondary metabolites (such as phenolic compounds, carotenoids and L-ascorbic acid), and several studies have already demonstrated their potential biological effects. A number of studies point to the antioxidant, anti-inflammatory, antiproliferative and antimicrobial effects of fruit and leaf extracts from strawberry guava tree (Jun *et al.*, 2011; Moon *et al.*, 2011; Brighenti *et al.*, 2012; and McCook-Russel *et al.*, 2012) and Brazilian cherry tree (Bagetti *et al.*, 2011; and Santos *et al.*, 2012).

Strawberry guava and Brazilian cherry are very perishable fruits and their processing in the form of jam is an alternative to provide a greater variety of products to the consumer, to avoid the waste of the fruits and to favor the consumption of products in the periods in which the fruit *in natura* is not available. Besides jam in its traditional presentation, produced with fruit pulp and sucrose, it is possible to make jams without addition or with reduced sugar content. In this type of product there is a need to add substances that can replace sucrose. Thickeners and sweeteners are widely used to improve the texture and sweet taste of these products (van Buul *et al.*, 2014). *Diet* jams are in great demand by people who have dietary sugar restrictions due to chronic-degenerative diseases like diabetes mellitus and also by those who associate reducing sugar intake to a healthier diet. In addition to the interest in nutritional intake of food, consumers are interested in non-nutritive components, such as potentially bioactive compounds, which may act to prevent chronic non-transmittable diseases such as cardiovascular diseases, cancer and diabetes mellitus (Chang *et al.*, 2016).

Many compounds derived from plant secondary metabolism are sensitive to processing and storage. The processing of conventional, *diet* and *light* jams of the same vegetable raw material, as well as the storage period, can promote variations in the chemical composition and antioxidant potential of the product, as already observed in different studies with jams of another species of strawberry guava (*P. guinnensis* Sw), black carrot (*Daucus carota*), and the and strawberry (Fragaria x ananassa Duch.)(Damiani *et al.*, 2012; Holzwarth *et al.*, 2013; Kamiloglu *et al.*, 2015; and Kamiloglu *et al.*, 2015). To date, few studies have been carried out on the effect of processing and storage of products made with strawberry guava and Brazilian cherry, and this knowledge is important to elucidate the alterations due to these factors in the physical-chemical, phytochemical, microbiological and sensorial characteristics of the processed product.

Thus, the present study aimed to elaborate conventional and *diet* jams of strawberry guava and Brazilian cherry, and to evaluate the stability of potentially bioactive compounds, antioxidant activity, microbiological stability and sensorial acceptability immediately after the processing and during the storage period.

MATERIAL AND METHODS

Plant Material and Preparation of Jams

It was used mature red strawberry guava and Brazilian cherry fruits, harvested in the first quarter of 2014 of plants kept in the collection of works of strawberry guava and Brazilian cherry of Embrapa Clima Temperado - Pelotas/RS (geographic coordinates: 31º40'47"S and 52º26'24"W: 60m altitude). In convencional jams was used (% m/m): red strawberry guava and Brazilian cherry pulp (50), commercial sucrose (50), distilled water (40), pectin HM (0.7 for red strawberry guava jam and 1.0 for Brazilian cherry jam), citric acid (0.2), sodium benzoate (0.05) and sodium erythorbate (0.25). In the jams with no added sugars were used (% m/m): red strawberry guava or red Brazilian cherry pulp (50), distilled water (40), pectin LM (2.5), calcium chloride (50 mg/g of BTM pectin), sorbitol (65), specific sweeteners for each formulation (A: aspartame - 0.13, S + C: sodium saccharin and sodium cyclamate - 0.03 and 0.07, respectively: A + S: acesulfame potassium and sucralose - 0.06 and 0.07, respectively), citric acid (0.2), sodium benzoate (0.05) and sodium erythorbate (0.25). The final percentage of pulp in processed products was 43% for strawberry guava and Brazilian cherry *diet* jams, and 41% for conventional jams.

Processing of the jams was carried out in a stainless steel vessel (simulating open pan processing), at atmospheric pressure and under constant manual stirring. The processing temperature of the jams was 82.5 °C (± 2.5), being raised to 90 °C just before the packaging. The processing time for conventional jams took 1 hour and 15 minutes. The *diet* jams were processed in two hours. The final concentration, in ºBrix, of conventional and *diet* strawberry guava jams with aspartame, saccharin + cyclamate and acesulfame + sucralose was 68, 46, 48 and 47, respectively. For conventional and *diet* Brazilian cherry jams with aspartame, saccharin + cyclamate and acesulfame + sucralose it was 64, 47, 48 and 47, respectively. The jams were packed in 248 mL glass containers and tinplate lids. Right after processing, the jams were stored at room temperature (20-22 °C). For the physico-chemical analyzes the samples were collected from the original containers at appropriated period for analyzes (0, 60, 120 and 180 days) and stored at -18 ºC. With the exception of sensory and microbiological analysis, all the others were performed in triplicate.

Color Attributes

The color determination was performed through a Minolta CR-300 colorimeter by the CIE system (L * a * b *), by direct reading of the L * values (brightness) ranging from 0 (black) to 100 (white); a*, from green (-) to red (+); b*, from blue (-) to yellow (+). The color parameters were used to calculate the angle Hue (ºHue = tan -1b */a *).

Total Anthocyanins

The determination of total anthocyanins was performed according to the methodology described by Lees and Francis (1972). For the preparation of the extract 2 g of sample and methanol pH 1.0 were used. Absorbance was determined by spectrophotometer reading (Jenway, 6700 UV-Vis) at a wavelength of 520 nm. The results were expressed as mg cyanidin-3-glucoside per 100 g wet sample.

Total Phenols

For the determination of total phenolic compounds, a methodology adapted from Singleton and Rossi (Singleton and Rossi, 1965) was used. To obtain the extract, 2 g of sample was weighed and diluted in 20 ml of methanol. It was homogenized in Ultra Turrax® (IKA®, T18 digital) at 7500 rpm for one minute and centrifuged (Eppendorf Centrifuge, 5430) at 7000 rpm for 15 minutes, cooled to 4 °C. For the colorimetric reaction, 250 µL of the extract, 4 mL of ultrapure water and 250 µL of 0.25 N Folin-Ciocalteau solution were pipetted. After 3 minutes was added 500 µL of 1 N sodium carbonate. After two hours of reaction, the absorbance of the sample was measured in a spectrophotometer (Jenway, 6700) through the wavelength of 725 nm. The results were expressed in mg equivalent of gallic acid in 100 g wet sample.

Total Carotenoids

The total carotenoids of the samples were determined by AOAC modified method 970.64 (AOAC Int, 2005). Initially, 2.5 g of sample was weighed into 50 ml falcon tubes. Was added 15 mL of extractive solution (hexane: acetone: ethyl alcohol: toluene in the ratio of 10: 7: 6: 7) and stirred for 30 seconds in vortex (Phoenix, AP-56). Then, 1 mL of 10% potassium hydroxide in methanol (m/v) was added, the mixture was stirred in vortex (Phoenix, AP-56) for one minute and and then it was hot saponified (the falcons were kept for 20 minutes in a water bath at 56 ºC). After 20 minutes in the water bath, the samples were left at room temperature for one hour. 15 ml of petroleum ether was added to the tubes and the volume of the falcon was filled with 10% sodium sulfate solution in water (m/v). After one hour stand, the supernatant was read in a spectrophotometer (Jenway, 6700 UV-Vis) at the wavelength of 450 nm. The results were expressed in ìg of β-carotene per gram of wet sample.

Total Antioxidant Capacity

Two different methods were used to determine the total antioxidant capacity, DPPH and ABTS radical method.

A method adapted from Brand-Williams, Cuvelier and Berset (Brand-Willians *et al.*, 1995) was used to determine the antioxidant activity through the use of the free radical 2,2-diphenyl-1-picryl-hydrazila (DPPH). For this analysis the same extract prepared for the determination of the total phenolic compounds was used. In a 15 mL falcon, 100 ìL of extract and 3.9 mL of DPPH solution in methanol were added. The solution was homogenized in vortex (Phoenix, AP-56) and held in the dark for 24 hours. After this time, it was measured in spectrophotometer (Jenway, 6700 UV-Vis) at a wavelength of 517 nm. The results were expressed as mg trolox equivalent per 100 g of sample.

The antioxidant activity using the free radical 2,2-azino-bis-3-ethylbenzthiazoline-6-sulfonic acid (ABTS) was determined by the method adapted from Rufino *et al.* (2007). The ABTS radical was prepared from 5 mL of ABTS solution (7 mM) and 88 µL of 140 mM potassium persulfate solution. The mixture was kept in the dark at room temperature for 16 hours. 1 ml of this mixture was diluted in methanol until an

absorbance of 0.700 nm ± 0.05 nm at 734 nm. A 30 μL aliquot of the same extract used for quantification of total phenolic compounds was transferred into falcon tubes (15 mL) with 3 mL of the ABTS radical. It was homogenized in vortex (Phoenix, AP-56) and read in spectrophotometer (Jenway, 6700 UV-Vis) at a length of 734 nm after six minutes of reaction. The results were expressed in mg trolox equivalent per 100 g of sample.

L-Ascorbic Acid

The determination of L-ascorbic acid was performed using a methodology proposed by Vinci, Botre and Ruggieri (Vinci *et al.*, 1995), with adaptations. The extraction was carried out with 5 g of sample, where 15 ml of 4.5% (m/v) metaphosphoric acid was added. It was kept in the dark at ambient temperature for 1 h, stirring every 15 minutes. The sample was filtered into a 25 mL flask and the volume was made up with ultrapure water. Before the chromatographic run the filtrate was centrifuged at 13000 rpm for 10 minutes, the supernatant from that centrifugation was added in vials, and 10 μL was injected into the chromatograph. The ascorbic acid was quantified by High Performance Liquid Chromatography (HPLC) using the Shimadzu HPLC system, equipped with automatic injector and UV-visible detector (254 nm). The elution was performed using a gradient system initially containing the mobile phases A (99.9: 0.1% v/v, ultra-pure water: acetic acid p.a) and B (100% methanol), at 25 °C and flow rate of 0.8 mL per minute. The results were obtained from standard L-ascorbic acid curve and expressed as mg per 100 g of fresh sample.

Molds and Yeasts Analysis

The analysis of mold and yeast in conventional and *diet* strawberry guava and Brazilian cherry jams was carried out at all storage times, as recommended by Anvisa's RDC nº 12 of 2001 (BRASIL, 2001). For the analysis, 25 g of sample was weighed and diluted into 225 ml of 0.1% buffered peptone water. From the initial dilution, two more were made by taking 1 part of the previous dilution for 10 parts of diluent. The plates were pre-prepared with 15 mL of molten potato dextrose agar, cooled to 44-46 °C and acidified with 10% (m/v) tartaric acid. 0.1 ml of each dilution was inoculated in the surface of plates prepared previously and, using Drigalski's loop, the inoculum was spread over the entire surface of the medium until all excess liquid was absorbed. Plates were incubated at 25 °C for five days. The analyzes were done in duplicate and the results were expressed in $CFU.g^{-1}$ (Silva *et al.*, 2007).

Sensory Analysis

For the acceptance test, a nine-point hedonic scale was used, anchored in the extremes by the terms "I liked it very much" and "I disliked it very much". The Acceptability Index (AI) was calculated by the global quality through the mean of the answers, multiplied by 100, divided by the maximum value of the scale (9). To be considered accepted, the product had to obtain an AI of 70% or greater (ABNT, 1993; and Gularte, 2009). Fifty untrained testers, predominantly between 14-19 years old and female, participated in the test. Each tester performed the test in individual cabin, with white artificial lighting, in air conditioned environment (20-22 ºC). The vehicle used was salty cracker and together it was served mineral water for cleansing the palate. Approximately 10 g of each formulation was served at room temperature (20-22 °C). This study was part of the research project on the technological potential of native fruits, from the Graduate Program in Food Science and Technology - UFPel, and was approved by the ethics committee for conducting the sensory analysis (CAAE: 38484814.0.0000.5317). All participants in the sensory analysis also signed a free and informed consent form.

Experimental Design and Statistical Analysis

All treatments and all physicochemical analyzes were performed in triplicate. Data were expressed as mean ± standard deviation. Data on the physicochemical analyzes were submitted to analysis of variance (ANOVA) and comparison of means by Tukey's test ($p \leq 0.05$). The Pearson (r) correlation between the analyzed phytochemicals and the antioxidant activity was performed. The STATISTICA 7.0 program was used (STATSOFT, 2004).

RESULTS AND DISCUSSION

Diet red strawberry guava jams, shortly after processing, presented higher luminosity compared to the conventional formulation (Table 1). This behavior was also observed in kiwifruit jams (García-Martínes *et al.*, 2002), where the *diet* formulation presented greater luminosity compared to the conventional one, being this result attributed to the higher concentration of water of the *diet* product. However, this kind of response does not always occur. This was verified in the red strawberry guava jams, 60 and 120 days after processing (Table 1), and in the Brazilian cherry jams (Table 2), in which there was no significant difference in luminosity ($p \leq 0.05$) between conventional and *diet* formulations. In the last storage period, all the jams, both of strawberry guava

Table 1: Total Phenols (TP), Total Anthocyanins (TA), Total Carotenoids (TC), Vitamin C and Color Atributes (L* and Hue°) of Convencional and Diet Red Strawberry Guava Jams During Four Months (120 Days) of Storage

Determinations	Storage Period (Days)	F1	F2	F3	F4
L[1]	0	27,19±0,4^{cC}	36,28±0,7^{aB}	36,68±0,4^{aB}	34,50±0,2^{bB}
	60	34,62±0,6^{aB}	34,38±0,5^{aB}	34,34±0,5^{aC}	34,30±1,9^{aB}
	120	50,88±1,4^{bA}	59,77±1,8^{aA}	53,94±0,7^{bA}	51,05±0,4^{bA}
°Hue[2]	0	28,19±0,1^{bA}	51,06±1,1^{aB}	50,33±0,3^{aB}	50,37±1,2^{aB}
	60	31,44±12,3^{bA}	57,80±1,0^{aA}	62,44±2,2^{aA}	57,39±2,7^{aA}
	120	28,58±5,7^{bA}	60,16±2,0^{aA}	65,15±1,2^{aA}	61,57±0,6^{aA}
TP[3]	0	117,59±1,7^{bA}	120,31±0,8^{abA}	123,31±2,1^{aA}	120,31±3,1^{abA}
	60	110,96±1,4^{bB}	113,96±0,6^{abB}	112,04±3,3^{aB}	117,28±0,5^{abAB}
	120	108,24±1,4^{bB}	112,90±1,7^{aB}	113,30±1,4^{aB}	113,52±1,3^{aB}
TA[4]	0	2,47±0,1^{abA}	2,38±0,1^{bA}	2,59±0,1^{aA}	2,38±0,1^{bA}
	60	2,18±0,1^{aB}	1,70±0,1^{cB}	1,89±0,1^{bB}	1,84±0,1^{bB}
	120	1,04±0,1^{bC}	1,57±0,1^{aB}	1,49±0,1^{aC}	1,45±0,1^{aC}
TC[5]	0	26,00±0,2^{cA}	27,10±0,1^{aA}	26,47±0,3^{bcA}	26,93±0,2^{abA}
	60	23,20±0,4^{bB}	23,98±0,4^{abB}	24,65±0,1^{aB}	24,79±0,3^{aB}
	120	11,67±0,3^{bC}	18,01±0,4^{aC}	17,90±0,1^{aC}	17,96±0,4^{aC}
Vit. C[6]	0	2,67±0,4^{aA}	2,09±0,1^{aA}	2,32±0,1^{aA}	2,29±0,1^{aA}
	60	2,62±0,3^{aA}	2,26±0,1^{aA}	2,20±0,2^{aA}	2,25±0,1^{aA}
	120	2,27±0,1^{abA}	2,16±0,1^{abA}	2,06±0,1^{bA}	2,14±0,1^{abA}

Note: [1] L - brightness (white to black). [2] °Hue – color tone. [3] mg of gallic acid 100g^{-1} wet basis. [4] mg of cyanidin 3-glycoside 100 g^{-1} wet basis. [5] µg of β-carotene g^{-1} wet basis. [6] mg 100 g^{-1} of L-ascorbic wet basis. Means followed by the same lowercase letter in the line do not differ by Tukey test ($p \leq 0.05$). Means followed by the same capital letter in the column, within each analyzed treatment, did not differ by Tukey test ($p \leq 0.05$). F1 = convencional; F2 = aspartame; F3 = saccharin + cyclamate; F4 = acesulfame + sucralose.

and Brazilian cherry, presented higher luminosity compared to the one found in the initial period.

Regarding the color tone (ºHue) of strawberry guava jams (Table 1), the conventional formulation showed the lowest value soon after processing. However, there was no significant difference between *diet* formulations. The closer to the 0ºHue, the greater the tendency to reddish color. In this way, conventional jam showed a more reddish color than jams without added sugar. During storage there was no significant difference ($p \leq 0.05$) in the color shade of conventional jams. Yet, in *diet* jams, there was an increase in color tone during storage, demonstrating a decrease in red color tone.

As in strawberry guava jam, conventional Brazilian cherry jam (Table 2) obtained the lowest value for ºHue when compared to *diet* jams. During storage, only the formulation F4 (acesulfame + sucralose) showed a significant decrease ($p \leq 0.05$) in the ºHue. In studies with conventional apricot jam, there was no significant decrease in the value of ºHue during 60 days of storage at 25 ºC (Touati *et al.*, 2014). It was expected, both for strawberry guava and Brazilian cherry jams, that *diet* formulations would be more reddish than conventional, due to the higher concentration of phytochemical compounds promoting reddish coloring, in addition to the fact that there may be copigmentation with BTM pectins. Melgarejo *et al.* (2011)

Table 2: Total Phenols (TP), Total Anthocyanins (TA), Total Carotenoids (TC), Vitamin C and Color Atributes (L* and Hue°) of Convencional and Diet Brazilian Cherry Jams During Six Months (180 Days) of Storage

Determinations	Storage Period (Days)	F1	F2	F3	F4
L[1]	0	29,65±0,1^{aB}	30,09±0,4^{aB}	29,77±0,3^{aB}	30,44±0,3^{aB}
	60	24,32±0,2^{bC}	27,63±0,2^{aC}	27,39±0,3^{aC}	27,74±0,1^{aC}
	120	24,54±2,4^{aC}	26,44±0,2^{aC}	26,68±1,4^{aC}	23,62±1,1^{aD}
	180	40,03±2,4^{aA}	40,55±1,2^{aA}	38,98±0,4^{aA}	39,27±0,2^{aA}
°Hue[2]	0	30,99±0,6^{bA}	33,98±0,6^{aA}	34,17±0,4^{aA}	33,57±0,8^{aBC}
	60	21,03±0,6^{cB}	33,13±0,6^{bA}	35,75±1,1^{aA}	34,31±0,3^{abB}
	120	27,45±1,4^{bA}	35,04±4,4^{aA}	35,91±3,5^{aA}	32,00±0,8^{aC}
	180	28,85±2,9^{bA}	36,40±0,1^{aA}	35,34±0,6^{aA}	38,23±0,5^{aA}
TP[3]	0	141,19±3,9^{bA}	148,48±1,0^{aA}	152,25±2,8^{aA}	152,67±0,9^{aA}
	60	115,66±0,6^{bB}	122,17±2,6^{aB}	119,40±2,0^{abB}	117,58±1,4^{abB}
	120	109,93±1,0^{aC}	112,76±0,7^{aC}	112,02±2,5^{aC}	110,42±1,9^{aC}
	180	106,69±1,4^{cC}	113,40±1,8^{abC}	111,09±1,5^{bC}	115,80±1,6^{aB}
TA[4]	0	3,70±0,1^{dA}	4,21±0,1^{aA}	4,17±0,1^{bA}	3,96±0,1^{cB}
	60	3,31±0,1^{bB}	4,01±0,3^{aA}	3,71±0,1^{abB}	3,97±0,1^{aB}
	120	3,09±0,2^{bB}	4,22±0,1^{aA}	3,31±0,2^{bC}	4,16±0,1^{aA}
	180	3,15±0,1^{cB}	4,07±0,1^{aA}	3,47±0,1^{bBC}	3,92±0,1^{aB}
TC[5]	0	57,91±1,1^{cA}	99,17±6,0^{bA}	120,71±5,8^{aA}	113,89±5,2^{aA}
	60	48,35±1,2^{bB}	87,48±1,0^{aB}	87,48±3,3^{aB}	87,59±1,7^{aB}
	120	49,91±0,5^{cB}	83,84±1,2^{aBC}	85,41±0,2^{aBC}	80,93±0,2^{bBC}
	180	30,44±0,5^{bC}	77,01±1,2^{aC}	77,14±0,2^{aC}	78,74±1,3^{aC}
Vit. C[6]	0	4,95±0,2^{cA}	5,28±0,5^{bcA}	6,14±0,2^{aA}	5,89±0,2^{abA}
	60	4,86±0,4^{bA}	5,57±0,1^{aA}	5,94±0,2^{aA}	5,79±0,2^{aA}
	120	4,85±0,5^{abA}	4,92±0,4^{bA}	5,81±0,1^{aA}	5,78±0,4^{aA}
	180	4,78±0,4^{aA}	4,65±0,6^{aA}	5,34±0,1^{aB}	5,58±0,2^{aB}

Note: [1] L - brightness (white to black). [2] °Hue – color tone. [3] mg of gallic acid 100 g^{-1} wet basis. [4] mg of cyanidin 3-glycoside 100 g^{-1} wet basis. [5] µg of β-carotene g^{-1} wet basis. [6] mg 100 g^{-1} of L-ascorbic wet basis. Means followed by the same lowercase letter in the line do not differ by Tukey test ($p \leq 0.05$). Means followed by the same capital letter in the column, within each analyzed treatment, did not differ by Tukey test ($p \leq 0.05$). F1 = convencional; F2 = aspartame; F3 = saccharin + cyclamate; F4 = acesulfame + sucralose.

found similar results, both with the use of BTM and ATM pectins.

A higher retention of total phenols was observed in strawberry guava and Brazilian cherry jams soon after processing in *diet* formulations. In physalis *light* jam (4.69%) the concentration of phenols was also higher when compared to the conventional formulation (Rutz *et al.*, 2012). Phenols have several biological functions, one of which is

to prevent damage caused by oxidative stress. In plants, they confer resistance to predators and pesticides, in addition to making the leaves, flowers and fruits more attractive, due to the coloration provided by molecules of phenolic nature (Dicko *et al.*, 2006; and da Silva *et al.*, 2016). Like most compounds with antioxidant properties, phenols are highly unstable and reactive, providing enzymatic and chemical reactions during processing and storage. The temperature, processing time, oxygen, pH, enzymes and the presence of other phytochemicals and/or other substances that interact with the phenols in the food matrix are examples of factors related to the degradation of these molecules (Ioannou *et al.*, 2012; and Shahidi and Ambigaipalan, 2015). For the strawberry guava jams (Table 1), the reduction was observed in the order of 7.95% for conventional, 6.16% for F2 (aspartame), 8.12% for F3 (saccharin + cyclamate) and 5.64% for F4 (acesulfame + sucralose). For the Brazilian cherry jams (Table 2), after six months of storage, a reduction in the total phenol concentration of 24.44% was observed for the conventional formulation, 23.63% for F2 (aspartame), 27.03% for F3 (saccharin + cyclamate) and 24.15% for F4 (acesulfame + sucralose). In black carrot jams and marmalades, samples stored at 25 ºC presented a decrease of 26.4 to 48.0% in the concentration of phenolic compounds, which was slightly higher than in those stored at 4 ºC (21.0 to 42, 5% loss), demonstrating that storage at room temperature, with consequent exposure to light, are the main factors that may have promoted a decrease in the concentration of these compounds.

Concerning to anthocyanins in strawberry guava jams, there was no significant difference between the conventional and *diet* formulations shortly after processing (Table 1). Among *diet* formulations, F3 (saccharin + cyclamate) presented the highest concentration of total anthocyanins. A higher concentration of total anthocyanins in *diet* jams was expected, since the use of pectin BTM may promote a hyperchromic effect and bathochromic displacement in the absorption spectrum of anthocyanins, where pigments (such as anthocyanins) and copigments (such as pectins) may form molecular associations and alter the color intensity of the food system (Boulton, 2001; and Castañeda-Ovando *et al.*, 2009).

Differently from the results observed in strawberry guava jams, in the conventional Brazilian cherry jam (Table 2) a higher concentration of total anthocyanins in relation to the formulations *diet* was observed. These different results may be explained by the differences in the food matrix of the pulps used, because the preparation process was similar for strawberry guava and Brazilian cherry jams. During storage there were considerable losses in the concentration of anthocyanins in almost all formulations (34.0 to 57.9% in strawberry guava jams and 1.0 to 16.8% in Brazilian cherry jams). Only in the F2 (aspartame) and F4 (acesulfame + sucralose) formulations of Brazilian cherry jam there was no significant decrease ($p \leq 0.05$) during the storage period. Like phenols in general, the stability of anthocyanins is affected by several factors, such as pH, light, storage temperature, presence of enzymes, oxygen and metal ions, among other factors. Their stability is also influenced by the substituents present on the B ring of the molecule and by the presence of hydroxyl and methoxy groups. The presence of sugars bound to anthocyanins plays an important role, making them more stable than their aglycone form (Fleschhut *et al.*, 2006; and Castañeda-Ovando *et al.*, 2009).

The concentration of carotenoids was significantly higher ($p \leq 0.05$) in *diet* jam formulations, except for strawberry guava F3 (saccharin + cyclamate) (Table 1), which did not differ significantly from the conventional formulation. Higher concentration of carotenoids was also found in *light* physalis jam formulation (8.23 μg β-carotene g^{-1}) compared to conventional (3.94 μg β-carotene g^{-1}). Carotenoids perform essential functions for the photosynthetic activity of plants, being a photoprotective molecule of the photosynthetic apparatus. In addition, they provide essential intermediates for the biosynthesis of phytonutrients and bioactive compounds. For humans, they are important because they are sources of vitamin A precursors and also because of their molecules have antioxidant capacity, which promotes several health benefits (Fernádez-García *et al.*, 2012; and Esteban *et al.*, 2015). Food processing may promote severe losses in carotenoid composition of the food. The temperature, presence of oxygen, light intensity during storage and water activity are examples of factors that may affect the stability of these compounds. The high amount of unsaturated bonds present in these compounds favors the isomerization and oxidation of the molecules, leading to loss of antioxidant activity, product color and pro-vitamin A activity (Rodriguez-Amaya *et al.*, 2008; and Saini *et al.*, 2015).

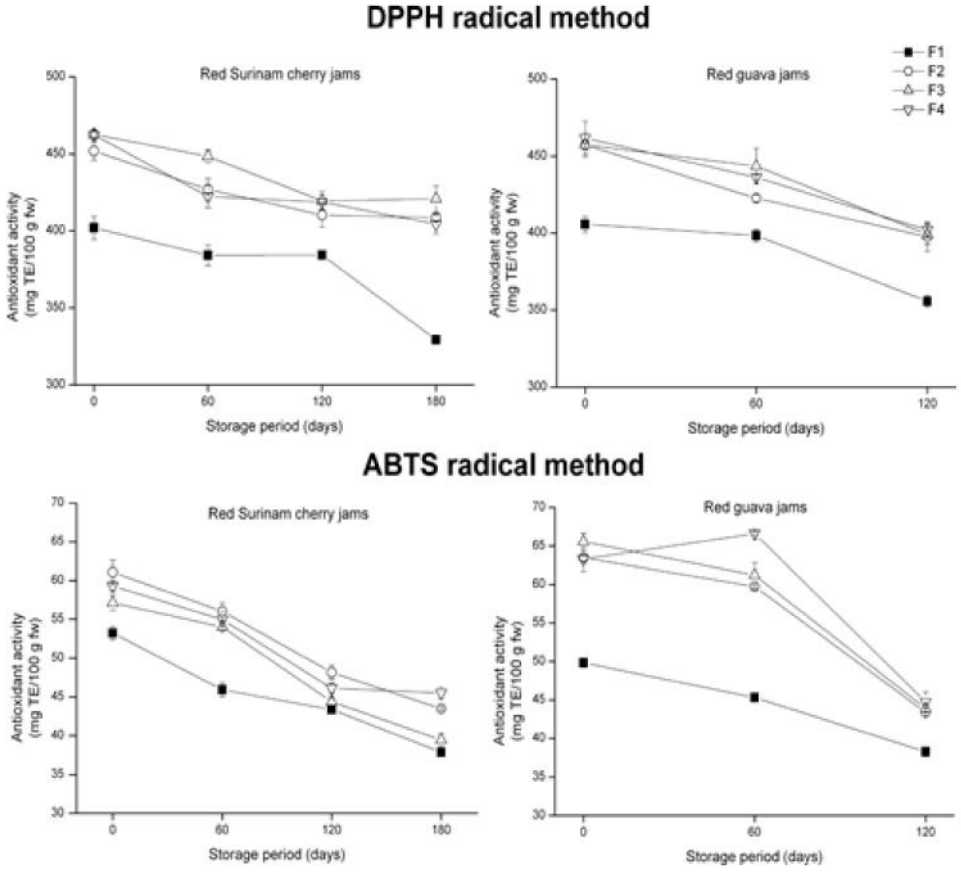
During the storage period there was a decrease in total carotenoid concentration in all formulations, ranging from 32.4 to 55.1% in strawberry guava jams and 22.3 to 47.4% in Brazilian cherry jams. In a study carried out with grape jams stored for 90 days, there was a 33.6% reduction in the

concentration of β-carotene (mg β-carotene 100 g^{-1}) in jams prepared by the conventional method (Igual *et al.*, 2013).

For L-ascorbic acid levels, there was no significant difference ($p \leq 0.05$) between the conventional and *diet* formulations of strawberry guava jams (Table 1). For the Brazilian cherry jams (Table 2), the conventional formulation presented the lowest concentration, with the formulations F3 (saccharine + cyclamate) and F4 (acesulfame + sucralose) having the highest concentrations of this compound, after processing. L-ascorbic acid is a hydrosoluble vitamin that participates in the biosynthesis of collagen and hormones, besides presenting bioactive characteristics related to the prevention of chronic-degenerative diseases. It is a vitamin very susceptible to degradation during food processing and storage, and its retention is considered an indicator of the nutritional quality of the products (Marfil *et al.*, 2008; and Rodríguez-Roque *et al.*, 2015). At the end of 120 days of storage there was a decrease in the concentration of L-ascorbic acid, between 6.6 and 15.0% in the strawberry guava jam formulations, with conventional jam having the highest loss. For Brazilian cherry jams, the decrease was between 3.3 and 13.0% at the end of 180 days of storage, and, unlike the strawberry guava formulation, the conventional Brazilian cherry jam was the one with the lowest decrease in the concentration of L-ascorbic acid at the end of the storage period.

The antioxidant activity (Figure 1), both by capture of the DPPH radical and by the capture of the ABTS radical, was superior in the *diet* formulations of strawberry guava and Brazilian cherry jams. As the concentration of phytochemicals was higher in *diet* formulations, the higher antioxidant activity of these jams is understandable. There

Figure 1: Antioxidant Activity of Red Strawberry Guava and Brazilian Cherry Jams During Three (120 Days) and Four (180 Days) Periods of Storage, Determined by the DPPH and ABTS Radical Capture Methods, Data are Presented as Means ± Standard Deviation, F1 = Convencional; F2 = Aspartame; F3 = Saccharin + Cyclamate; F4 = Acesulfame + Sucralose



was a significant reduction ($p \leq 0.05$) in the antioxidant activity during the storage of all the formulations. Only in the F4 (acesulfame + sucralose) formulation of strawberry guava jam there was an increase in antioxidant activity in the second storage period, with a subsequent decline in antioxidant activity in the third storage period. Similar results were found in black carrot jams, where in both sugar formulation and sweetener formulation there was a decrease in antioxidant activity during five months of storage, and losses of 12.8 to 60.9% were observed at 25 ºC. In the present work, losses in antioxidant capacity were observed between 12.3 and 33.1% for strawberry guava jams and 9.1 and 30.9% for Brazilian cherry jams.

When performed correlation of the analyzed phytochemicals with the antioxidant activity, in strawberry guava jams, a positive correlation of the phenolic compounds with the antioxidant activity by DPPH was observed (r = 0.95 for the formulations F2, F3 and F4, r = 0.81 For F1). In relation to carotenoids, a correlation was observed between the capture of the DPPH radical (r = 0.98 for F1, r = 0.96 for F3, r = 0.95 for F2 and F4), and for the capture of the ABTS radical (R = 0.97 for F1, r = 0.93 for F4, r = 0.99 for F2 and F3). For the Brazilian cherry jam formulations, it was observed that the carotenoids had the highest correlations. By the DPPH method correlations were obtained r = 0.98 for F1 and r = 0.95 for the three *diet* formulations, indicating a strong correlation. Using the ABTS method, r = 0.91 for F1, r = 0.90 for F2 and F3 and r = 0.93 for F4.

With respect to the microbiological analysis, no formulation showed contamination by molds and yeasts. In this way, elaborated jams comply with the Brazilian sanitary standards established by RDC No. 12/2001. The intrinsic factors of jams, such as acid pH, high soluble solids concentration and low water activity, associated with thermal treatment and potting in the absence of oxygen, limit the growth of microorganisms, making them products with good microbiological stability (Assis *et al.*, 2007).

The acceptability index (IA) of red strawberry guava jams at 120 days of storage was 77.8%, 71.4%, 81.4% and 76.2% for formulations F1, F2, F3 and F4, respectively. Regarding to Brazilian cherry jams, at 180 days of storage, the acceptability indexes were 78.9%, 78.2%, 75.8% and 82.9% for the formulations F1, F2, F3 and F4 respectively. Considering these results, the strawberry guava jams that presented the highest acceptability index were those elaborated with saccharin and cyclamate, whereas for Brazilian cherry jams the formulation with acesulfame and sucralose was the one with the highest acceptance. The conventional formulation was the second best evaluated by the judges, for both Brazilian cherry and strawberry guava jams. It is worth mentioning that all the formulations presented AI greater than 70%, demonstrating that all were well accepted by the judges. The results obtained demonstrate that the products elaborated with the *diet* formulations are of high quality, both sensorial and alimentary, since generally the conventional jams present a greater acceptance index, due to the greater presence of sugar, which is important for the sweet taste and texture of product.

CONCLUSION

Storage of strawberry guava and Brazilian cherry jams at room temperature for four and six months, respectively, results in losses in most potentially bioactive compounds and in antioxidant capacity, with anthocyanins and total carotenoids being the compounds that suffered the highest losses. *Diet* jams had the highest concentrations of potentially bioactive compounds when compared to their conventional version. The use of native fruits, such as strawberry guava and Brazilian cherry, through the elaboration of jams, proved to be a good alternative. The processing used was safe from a microbiological perspective, and all the formulations presented good index (above 70%) of sensorial acceptance. In *diet* products, the formulations with sodium saccharin/sodium cyclamate for strawberry guava jams, and sucralose/acesulfame potassium for Brazilian cherry jams were highlighted.

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REFERENCES

- ABNT (1993), Associação Brasileira de Normas Técnicas, Análise sensorial de alimentos e bebidas – NBR 12806, ABNT, Rio de Janeiro.
- AOAC Int (2005), *Official Methods of Analysis of the Association of Official Analytical Chemists*, 18th Edition, AOAC International, AOAC Int., Gaithersburg, MD.

- Assis M M M, Maia G A, Figueiredo E A T, Figueiredo R W and Monteiro J C S (2007), "Processamento e estabilidade de geleia de caju", *Rev. Cienc. Agron.*, Vol. 38, No. 1, pp. 46-51.
- Bagetti M, Facco E M P, Piccolo J, Hirsch G E, Rodriguez-Amaya D, Kobori C N, Vizzotto M and Emanuelli T (2011), "Physicochemical Characterization and Antioxidant Capacity of Pitanga Fruits (*Eugenia uniflora* L.)", *Cienc. Tecn. Alim.*, Vol. 31, No. 1, pp. 147-154.
- Biegelmeyer R, Andrade J M M, Aboy A L, Apel M A, Dresch R R, Marin R, Raseira M C and Henriques A T (2011), "Comparative Analysis of the Chemical Composition and Antioxidant Activity of Red (*Psidium cattleianum*) and Yellow (*Psidium cattleianum* var. Lucidum) Strawberry Guava Fruit", *J. Food Sci.*, Vol. 76, No. 7, pp. 991-996.
- Boulton R (2001), "The Copigmentation of Anthocyanins and its Role in the Color of Red Wine: A Critical Review", *Am. J. Enol. Vitic.*, Vol. 52, No. 2, pp. 67-87.
- Brand-Willians W, Cuvelier M E and Berset C (1995), "Use of a Free Radical Method to Evaluate Antioxidant Activity ", *Food Sci. Technol (Campinas)*, Vol. 28, No. 1, pp. 25-30.
- BRASIL (2001), *Ministério da Saúde. Agência Nacional de Vigilância Sanitária. Resolução RDC nº 12 de 02 de janeiro de*, Regulamento Técnico sobre padrões microbiológicos para alimentos [cited 2016 July 18], available from: http://portal.anvisa.gov.br/wps/wcm/connect/a47bab8047458b909541d53fbc4c6735/RDC_12_2001.pdf?MOD=AJPERES
- Brighenti F L, Gaetti-Jardim E Jr, Danelon M, Evangelista G V and Delbem A C (2012), "Effect of *Psidium cattleianum* Leaf Extract on Enamel Demineralisation and Dental Biofilm Composition in Situ", *Arch. Oral Biol.*, Vol. 57, No. 8, pp. 1034-1040.
- Castañeda-Ovando A, Pacheco-Hernández M L, Páez-Hernández M E, Rodríguez J A and Galán-Vidal C A (2009), "Chemical Studies of Anthocyanins: A Review", *Food Chem.*, Vol. 113, No. 4, pp. 859-871.
- Chang S K, Alasalvar C and Shahidi F (2016), "Review of Dried Fruits: Phytochemicals, Antioxidant Efficacies, and Health Benefits", *J. Funct. Foods*, Vol. 21, pp. 113-132.
- da Silva B V, Barreira J C M and Oliveira M B P P (2016), "Natural Phytochemicals and Probiotics as Bioactive Ingredients for Functional Foods: Extration, Biochemistry and Protected-Delivery Technologies", *Trends Food Sci. Tech.*, Vol. 50, pp. 144-158.
- Damiani C, Silva F A, Asquieri E R, Lage M E, de Vilas Boas E V B (2012), "Antioxidant Potential of *Psidium guinnensis* sw. Jam During Storage", *Pesq. Agropec. Trop.*, Vol. 42, No. 1, pp. 90-98.
- Denardin C C, Hirsch G E, da Rocha R F, Vizzotto M, Henriques A T, Moreira J C F, Guma F T C R and Emanuelli T (2015), "Antioxidant Capacity and Bioactive Compounds of Four Brazilian Native Fruits", *J. Food Drug Anal.*, Vol. 23, pp. 387-398.
- Dicko M H, Gruppen H, Traoré A S, Voragen A G J and Berkel W J H (2006), "Phenolic Compounds and Related Enzymes as Determinants of Sorghum for Food Use", *Biotechnol. Mol. Biol. Rev.*, Vol. 1, No. 1, pp. 21-38.
- Esteban R, Moran J F, Becerril J M and García-Plazaola J I (2015), "Versatility of Carotenoids: An Integrated View on Diversity, Evolution, Functional Roles and Environmental Interactions", *Environ. Exp. Bot.*, Vol. 119, pp. 63-75.
- Fernádez-García E, Carvajal-Lérida I, Jarén-Galán M, Garrido-Fernández J, Pérez-Gálvez A and Hornero-Méndez D (2012), "Carotenoids Bioavailabitily from Foods: From Plant Pigments to Efficient Biological Activities", *Food Res. Int.*, Vol. 46, pp. 438-450.
- Fiaschi P and Pirani J R (2009), "Review of Plant Biogeographic Studies in Brazil", *J. Syst. Evol.*, Vol. 47, No. 5, pp. 477-496.
- Fleschhut J, Kratzer F, Rechkemmer G and Kulling S E (2006), "Stability and Biotransformation of Various Dietary Anthocyanins *in vitro", Eur. J. Nutr.*, Vol. 45, No. 1, pp. 7-18.
- García-Martínes E, Ruiz-Diaz G, Martínez-Monzó J, Camacho M M, Martínez-Navarrete N and Chiralt A (2002), "Jam Manufacture with Osmodehydrated Fruit", *Food Res. Int.*, Vol. 35, pp. 301-306.
- Griffis Jr J L, Sams C E, Manners M M, McDonald T G and Radovich T J K (2012), "Purple-Fruited Pitanga – Antioxidant Levels and Flavors of Mature Fruits Vary Considerably Among Closely Related Cultivars", *Acta Hort.*, Vol. 959, pp. 209-216.

- Gularte M A (2009), Manual de análise sensorial de alimentos, Pelotas: Ed. da Universidade Federal de Pelotas, p. 106.
- Haminiuk C W I, Sierakowski M R, Vidal J R M B and Masson M L (2006), "Influence of Temperature on the Rheological Behavior of Whole Araça Pulp (*Psidium cattleianum* Sabine)", *LWT Food Sci. Technol.*, Vol. 39, pp. 426-430.
- Holzwarth M, Korhummel S, Carle R and Kammerer D R (2013), "Influence of Different Pectins, Process and Storage Conditions on Anthocyanin and Colour Retention in Strawberry Jams and Spreads", *LWT Food Sci. Technol.*, Vol. 52, No. 2, pp. 131-138.
- Igual M, García-Martínez E, Camacho M M and Martínez-Navarrete N (2013), "Jam Processing and Storage Effects on b-Carotene and Flavonoids Content in Grapefruit", *J. Funct. Foods.*, Vol. 5, No. 2, pp. 736-744.
- Ioannou I, Hafsa I, Hamdi S, Charbonnel C and Ghoul M (2012), "Review of the Effects of Food Processing and Formulation on Flavonol and Anthocyanin Behavior", *J. Food Eng.*, Vol. 111, No. 2, pp. 208-217.
- Jun N J, Mosaddik A, Moon J-Y, Jang K-C, Lee D-S, Ahn K S and Cho S K (2011), "Cytotoxic Activity of b-Caryophyllene Oxide Isolated from Jeju Guava (*Psidium cattleianum* Sabine) Leaf", *Rec. Nat. Prod.*, Vol. 5, No. 3, pp. 242-246.
- Kamiloglu S, Pasli A A, Ozcelik B, Camp J V and Capanoglu E (2015), "Colour Retention, Anthocyanin Stability and Antioxidant Capacity in Black Carrot *(Daucus carota)* Jams and Marmalades: Effect of Processing, Storage Conditions and *in vitro* Gastrointestinal Digestion", *J. Funct. Foods*, Vol. 13, pp. 1-10.
- Kamiloglu S, Pasli A A, Ozcelik B, Camp J V and Capanoglu E (2015), "Influence of Different Processing and Storage Conditions on *in vitro* Bioaccessibility of Polyphenols in Black Carrot Jams and Marmalades", *Food Chem.*, Vol. 186, pp. 74-82.
- Lees D H and Francis F J (1972), "Standardization of Pigment Analyses in Cranberries", *Hort Science*, Vol. 7, No. 1, pp. 83-84.
- Marfil P H M, Santos E M and Telis V R N (2008), "Ascorbic Acid Degradation Kinetics in Tomatoes at Diferente Drying Conditions", *LWT-Food Sci. Technol.*, Vol. 41, No. 9, pp. 1642-1647.
- McCook-Russel K P, Nair M G, Facey P C and Bowen-Forbes C S (2012), "Nutritional and Nutraceutical Comparison of Jamaican *Psidium cattleianum* (Strawberry Guava) and *Psidium guajava* (Common Guava) Fruits", *Food Chem.*, Vol. 134, No. 2, pp. 1069-1073.
- Medina A L, Haas L I R, Chaves F C, Salvador M, Zambiazi R C, da Silva W P, Nora L and Rombaldi C V (2011), "Araçá (*Psidium cattleianum* Sabine) Fruit Extracts with Antioxidant and Antimicrobial Activities and Antiproliferative Effect on Human Cancer Cells", *Food Chem.*, Vol. 128, No. 4, pp. 916-922.
- Melgarejo P, Martínez R, Hernández Fca, Martínez J J and Legua P (2011), "Anthocyanin Content and Colour Development of Pomegranate Jam", *Food Bioprod. Process.*, Vol. 89, No. 4, pp. 477-448.
- Moon J Y, Mosaddik A, Kim H, Cho M, Choi H K, Kim Y S and Cho S K (2011), "The Chloroform Fraction of Guava (*Psidium cattleianum* Sabine) Leaf Extract Inhibits Human Gastric Cell Proliferation via Induction of Apoptosis", *Food Chem.*, Vol. 125, No. 2, pp. 369-375.
- Myers N, Mittermeier R A, Mittermeier C G, Fonseca G A B and Kents J (2000), "Biodiversity Hotspots for Conservation Priorities", *Nature*, Vol. 403, pp. 853-858.
- Ribeiro A B, Chisté R C, Freitas M, da Silva A F, Visentainer J V and Fernades E (2014), "*Psidium cattleianum* Fruit Extracts are Efficient *in vitro* Scavengers of Physiologically Relevant Reactive Oxygen and Nitrogen Species", *Food Chem.*, Vol. 165, pp. 140-148.
- Rodriguez-Amaya D B, Kimura M, Godoy H T and Amaya-Farfan J (2008), "Updated Brazilian Database on Food Carotenoids: Factors Affecting Carotenoid Composition", *J. Food Comp. Anal.*, Vol. 21, No. 6, pp. 445-463.
- Rodríguez-Roque M J, de Ancos B, Sánchez-Moreno C, Cano M P, Elez-Martínez P and Martín-Belloso O (2015), "Impact of Food Matrix and Processing on the *in vitro* Bioaccessibility of Vitamin C, Phenolic Compounds, and Hydrophilic Antioxidant Activity from Fruit Juice-Based Beverages", *J. Funct. Foods*, Vol. 14, pp. 23-43.

- Rufino M S M, Alves R E, Brito E S, Morais S M, Sampaio C G, Pérez-Jiménez J and Saura-Calixto F D (2007), "Metodologia científica: Determinação da atividade antioxidante total em frutas pela captura do radical livre ABTS.+", *Comunicado Técnico.*, Embrapa, Ceará.
- Rutz J K, Voss G B, Jacques A C, Pertuzatti P B, Barcia M T and Zambiazi R C (2012), "*Geleia de physalis peruviana L.: Caracterização bioativa, antioxidante e sensorial*", *Alim. Nutr*., Vol. 23, No. 3, pp. 369-375.
- Saini R K, Nile S H and Park S W (2015), "Carotenoids from Fruits and Vegetables: Chemistry, Analysis, Occurrence, Bioavailability and Biological Activities", *Food Res. Int.*, Vol. 76, No. 3, pp. 735-750.
- Santos K K A, Matias E F F, Tintino S R, Souza C E S, Braga M F B M, Guedes G M M, Rolón M, Vega C, de Arias A R, Costa J G M, Menezes I R A and Coutinho H D M (2012), "Anti-Trypanosoma Cruzi and Cytotoxic Activities of Eugenia Uniflora L", *Exp. Parasitol*., Vol. 131, No. 1, pp. 130-132.
- Shahidi F and Ambigaipalan P (2015), "Phenolics and Poliphenolics in Foods, Beverages, and Spices: Antioxidant Activity and Health Effects—A Review", *J. Funct. Foods*., Vol. 18, pp. 820-897.
- Silva N, Junqueira V C A, Silveira N F A, Taniwaki M H, Santos R F S, Gomes R A R and Okazaki M M (2007), *Manual de métodos de análise microbiológica em alimentos*, 3rd Edition, Varela, São Paulo.
- Singleton V L and Rossi J A J R (1965), "Colorimetry of Total Phenolics with Phosphomolybdic-Phosphotungstic Acid Reagents", *Am. J. Enol. Viticult*., Vol. 16, No. 3, pp. 144-158.
- STATSOFT (2004), INC. Programa computacional Statistica 7.0. E.A.U.
- Teixeira A M, Chaves F C, Franzon R C and Rombaldi C V (2016), "Influence of Genotype and Harvest Season on the Phytochemical Composition of Araçá (*Psidium Cattleianum* Sabine) Fruit", *IJFANS*, Vol. 3, pp. 1-7.
- Touati N, Tarazona-Díaz M P, Aguayo E and Louaileche H (2014), "Effect of Storage Time and Temperature on the Physicochemical and Sensory Characteristics of Commercial Apricot Jam", *Food Chem*., Vol. 145, pp. 23-27.
- van Buul V J, Tappy L and Brouns F J P H (2014), "Misconceptions about Fructose-Containing Sugars and their Role in the Obesity Epidemic", *Nutr. Res*., Vol. 27, No. 1, pp. 119-1130.
- Victoria F N, Lenardão E J, Savegnago L, Perin G, Jacob R G, Alves D, Silva W P, Motta A S and Nascente P S (2012), "Essential Oil of the Leaves of *Eugenia uniflora* L.: Antioxidant and Antimicrobial Properties", *Food Chem. Toxicol*., Vol. 50, No. 8, pp. 2668-2674.
- Vinci G, Botre F and Ruggieri G (1995), "Ascorbic Acid in Exotic Fruits: A Liquid Chromatographic Investigation", *Food Chem*., Vol. 53, No. 2, pp. 211-214.
- Weyerstahl P, Marschall-Weyerstahl H, Christiansen C, Oguntimein O and Adeoye A O (1988), "Volatile Constituents of Eugenia Uniflora Leaf Oil", *Planta Med*., Vol. 54, No. 6, pp. 546-549.


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