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Stability of bioactive compounds in conventional and low-calorie sweet chewable candies prepared with red and yellow strawberry guava pulps

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Abstract

Processing and storage may influence the bioactive compound content of red and yellow strawberry guava (*Psidium cattleianum* Sabine) chewable candies. The aim of the present work was to develop conventional and low-calorie chewable candies prepared with red and yellow strawberry guava pulp, and assess the stability of the potentially bioactive compounds present in them, during storage. Two formulations of chewable candies were prepared: conventional and low calorie. Physicochemical parameters, bioactive compound content, and antioxidant activity at 0, 60, 120, and 180 d of storage were evaluated. It was observed that the processing and storage of chewable candies influenced the concentrations of the bioactive compounds in the candies. The low-calorie formulation yielded the highest carotenoid content, and at the end of the storage period, a reduction in its concentration to 46.83 and 12.5% in the candies formulated with red and yellow strawberry guava pulp, respectively, was noted. Further, red strawberry guava of conventional and low-calorie candies featured the highest phenolic content. Meanwhile, candies prepared with yellow strawberry guava pulp had greater monomeric anthocyanin content by the end of the storage. Even with respect to the phenolic and anthocyanin content, it was found that there was very low antioxidant activity in the candies at the end of the storage period. The present work demonstrated that the use of native Brazilian fruits in the formulation of chewable candies are associated with health benefits as it allows for desired products to be obtained without adding artificial flavouring or colouring agents.

Introduction

Chewable candy is a product obtained from the cooking of sugars, characterised by being chewable (gummy), and dissolving in the mouth relatively slowly, with colour, taste, aroma, and texture derived from chemical agents. Chewable candy differs from hard candy owing to the use of fat in the formulation, lower cooking temperatures, and a higher percentage of moisture (Marcelino and Marcelino, 2012). Brazil is the third largest producer of candies and confectioneries after United States and Germany (ABICAB, 2019).

The food industry is challenged to find innovative strategies to meet growing consumer demand for nutritionally balanced, healthy, natural, and additive-free products while retaining their desired characteristics (Silva *et al.,* 2016). Candies are products much appreciated by children and young people; so, research has been directed at replacing artificial with natural food colours so that there is not only a pleasant appearance to the product but it may also offer benefits to consumers.

To date, few studies are available that report the use of native fruits in the formulation of chewable candies. The incorporation of native fruits will limit the need for the addition of artificial flavours and colours, and consequently improve the health appeal of the product. However, it is important to first evaluate the effect of processing on bioactive compounds present in fruit pulps, as well as the physicochemical and colour characteristics of the candies incorporating

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the fruit extracts.

Among native fruits, the strawberry guava (*Psidium cattleianum* Sabine) from the Mirtaceae family is characterised by being a globose berry fruit, yellow or red, with juicy pulp and a sweet-acid taste. It is a fruit widely cultivated in domestic orchards, being widely distributed in various regions of the country, ranging from Rio Grande do Sul to Bahia. The fruit has a pleasant taste, high vitamin C content, and significant amounts of phenolic compounds. These compounds are considered potentially bioactive and may contribute to the reduction of disease risk, particularly by their ability to minimise the action of or altogether sequester free radicals (Lorenzi *et al.,* 2006; Franzon, 2009; Coradin *et al.,* 2011).

Previous studies have shown that storage influences the content of bioactive compounds as well as antioxidant activity in products prepared with strawberry guava. Storage of red strawberry guava jam for four months led to anthocyanin, carotenoid, and antioxidant activity losses (Reissig *et al.,* 2016; 2018; Vergara *et al.,* 2018). Therefore, the objective of the present work was to assess the physicochemical characteristics, mainly of potentially bioactive compounds, in conventional and low-calorie chewable candies formulated with yellow and red strawberry guava pulps over 180 d of storage.

Materials and methods

Fruit sampling and pulp preparation

Yellow and red strawberry guava (Figure 1) were harvested ripe (based on the criteria of uniform red and yellow peel colourings) in the first quarter of 2015 from trees cultivated in the strawberry guava collection of Embrapa Temperate Climate, Pelotas - RS - Brazil (geographic coordinates: 31° 40' 47"S and 52° 26' 24" W; 60 m altitude). A mix of genotypes was used for each type of strawberry guava (yellow and red).

Figure 1. Yellow and red strawberry guava (*Psidium cattleianum* Sabine) fruit.

The strawberry guava were selected, washed with water, sanitised in a 200 mg L^{-1} chlorinated solution, and pulped in a horizontal pulping machine with a 2-mm mesh (Kirchfeld® POB 4626, Switzerland) in a dark room. To prevent pulp oxidation, 1% (w/w) L-ascorbic acid was added. Right after yellow and red strawberry guava pulp preparation, two chewable candy formulations were developed: conventional and low calorie.

Production of chewable candies

The chewable candies were prepared following the procedure described by Fadini (2003) with minor modifications. The formulations were made in quadruplicate.

For conventional chewable candy preparation, the following was used: fruit pulp 7.2%, potable water 18.30%, commercial crystal sugar 36.01% (Caravelas®), glucose syrup (dextrose equivalent 38.0 - 40.0%, Glucosul®) 33.01%, commercial vegetable fat 4.91% (Qualy®), commercial emulsifier 0.33% (Emustab®), sodium chloride 0.029% (Diana®), commercial unflavoured gelatine 0.18% (Royal®), and citric acid 0.033% (Synth®).

For low-calorie chewable candy preparation, the following was used: fruit pulp 6.43%, potable water 16.34%, commercial refined sugar 10.72% (União®), commercial light sugar 16.07% (Magro®), sorbitol (70.0%, Synth®) 16.07%, glucose syrup (dextrose equivalent 38.0 - 40.0%, Glucosul®) 29.47%, commercial vegetable fat 4.38% (Qualy®), commercial emulsifier 0.29% (Emustab®), sodium chloride 0.026% (Diana®), flavourless gelatine 0.16% (Royal®), and citric acid 0.029% (Synth®). All ingredients were purchased locally.

The preparation of conventional chewable candies began with the dissolution of sugar and glucose in water in a stainless steel container. The mixture was heated to 50°C at atmospheric pressure, and with constant manual stirring to form syrup to which the fruit pulp, fat, emulsifier, and sodium chloride were added. When the mass reached 116°C (Vissoto and Lucas, 1999), gelatine was added. After the mass was concentrated at the process completion temperature of 123°C, citric acid was added. The processing time was 8 min. Afterwards, tempering was performed by arranging the mass on a marble stone. Then, the candies were manually shaped into a spherical shape with an average unit weight of 4 g, and individually wrapped with bioriented polypropylene. The preparation of the low-calorie candies followed the same steps described for the conventional candies. The processing time was 10 min. At the end, the candies were stored at room temperature between 22 ± 2°C for 180 d. Samples for analysis were collected at 0, 60, 120, and 180 d after processing.

Chemicals

The chemicals and reagents used in the physicochemical analysis were sodium hydroxide (Synth®), sodium sulphate (Synth®), copper sulphate (Synth®), sulphuric acid (Synth®), boric acid (Synth®), methylene blue (Dinâmica®), hydrochloric acid (Vetec®), methanol (Synth®), Folin-Ciocalteu reagent (Sigma Aldrich®), sodium carbonate (Synth®), gallic acid (Sigma Aldrich®), potassium chloride (Synth®), sodium acetate (Synth®), hexane (Synth®), acetone (Synth®), ethyl alcohol (Synth®), toluene (Synth®), potassium hydroxide (Dinâmica®), petroleum ether (Dinâmica®), sodium sulphate (Synth®), potassium persulfate (Synth®), 2,2-diphenyl-1-picrylhydrazyl (DPPH, Sigma Aldrich®), and 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS, Sigma Aldrich®).

Physicochemical analysis

The total titratable acidity, pH (potentiometer, Hanna Instruments® - HI2221 Calibration Check pH/ORP Meter, Brazil), total soluble solids (digital refractometer, Atago®, PR-32α, Japan), moisture (drying equipment Nova ética®), ashes (muffle, Quimis®, model Q 318.24, Brazil), lipids, proteins (nitrogen distiller, Tecnal® TE-03-63, Brazil), reducing sugars, and total sugars were determined following the Instituto Adolfo Lutz, standards (IAL, 2008). The amount of carbohydrates was calculated by the difference between the sum of moisture, ashes, lipids, and proteins, and by subtracting that figure from 100 (ANVISA, 2005). The caloric value was calculated based on the guidelines of ANVISA (2005). The colour was evaluated with the CIELAB system using the parameters L*, a*, and b* using a Minolta CR-300® colorimeter (Mahawar *et al.,* 2018). The colour tone parameter was based on Hue angle calculation (Hue° = tan – 1b*/a*).

Phytochemical compounds

Total phenolics were determined spectrophotometrically following the methodology proposed by Singleton and Rossi (1965). The absorbance of the sample was read at 725 nm (Jenway®, 6700, Spain), and the results were expressed in milligram equivalents of gallic acid at 100 g fresh weight.

Monomeric anthocyanin amounts were determined spectrophotometrically following the methodology proposed by Rodriguez-Saona and Wrolstad (2001). The extract was prepared following the methodology proposed by Lees and Francis (1972). The samples were read spectrophotometrically at 520 nm (Jenway® 6700, Spain). The anthocyanin concentration was obtained through the differential pH (Eqs. 1 and 2). The results were expressed in mg cyanidine3-glycoside per 100 g fresh weight.

Total carotenoids were determined following the method 970.64 (AOAC, 2005). The supernatant was read spectrophotometrically at 450 nm (Jenway® 6700, Spain). Results were expressed as mg β-carotene in 100 g fresh weight.

$$A = (A520 - A700)\, pH1.0 - (A520 - A700)\, pH4.5 \quad \text{(Eq. 1)}$$

$$Monomeric\ anthocyanins\ (mg/100\ g) = \frac{A \times MW \times DF \times 100}{(\varepsilon \times 1)} \quad \text{(Eq. 2)}$$

where, A = absorbance (Eq. 1); MW = molecular weight of cyanidine-3-glycoside (449.2); DF = dilution factor; and ε = molar absorption coefficient of cyanidine-3-glycoside (26.900 $M^{-1}cm^{-1}$).

Radical-scavenging activity

The radical-scavenging activity from the capture of the DPPH radical (2,2-diphenyl-1-picrylhydrazyl) was assessed using a spectrophotometer following the methodology proposed by Brand-Williams *et al.* (1995). The absorbance was read spectrophotometrically at 517 nm (Jenway® 6700, Spain).

Radical-scavenging activity by the capture of the ABTS radical (2,2′- azino-bis[3-ethylbenzothiazoline-6-sulfonic acid]) was also established using a spectrophotometer employing methods described by Rufino *et al.* (2007). The absorbance was read spectrophotometrically at 734 nm (Jenway® 6700, Spain).

Both results were expressed as percentage (%) DPPH and ABTS radical remaining using Eq. 3:

$$\%\ inhibition = \frac{(Acontrol - Asample)}{Acontrol} \times 100 \quad \text{(Eq. 3)}$$

Experimental design and statistical analysis

The experiment was conducted in a randomised block design based on a factorial scheme, with treatments arranged in three replications. All variables analysed were performed in triplicate. The obtained data were submitted to the diagnosis of the normalities and homogeneities of the residual variances, as well as additivity of the statistical model. First, the analysis of variance was evidenced considering the effects of the type of strawberry guava × type of candy interaction at a 5%

probability. When these variables showed significant interaction, they were dismembered to the simple effects of the variation factors using the Tukey probability matrix. Subsequently, similar trends were observed for the type of strawberry guava × type of candy × storage interaction at a 5% probability. When these variables showed significant interaction, the simple effects of the variation factors were dismembered (type of strawberry guava and type of candy) based on the Tukey probability matrix. Regarding quantitative effects of storage, there was a specific breakdown for each level of qualitative factors, proceeding with a linear regression with adjustment of the highest significant degree of the polynomial, its significance being based on a 5% probability by the Student's *t*-test.

Results and discussion

Strawberry guava types × types of candies

The variance analysis showed significant interaction between strawberry guava types × types of candies for pH, reducing sugars, total sugars, and carotenoids. The pH values were lower in the low-calorie candies with red strawberry guava pulp than in those made with yellow pulp, and not differing statistically between the other formulations. Reissig *et al.* (2016) reported lower pH values in conventional and low-calorie red strawberry guava jelly. The content of reducing sugars was higher for conventional candies with red guava pulp. As expected, conventional candies had greater reducing and total sugar content than low-calorie candies owing to the higher amount of glucose in the formulation. The lower sugar content resulted in a significant reduction ($p \leq 0.05$) in energy values in low-calorie candies (23.97% in the red strawberry guava candy and 18.87% in the yellow strawberry guava candy). Further, there was a significant reduction ($p \leq 0.05$) in the lipid content of the low-calorie candies as compared to conventional candies (91.71% in the candies with red strawberry guava and 59.28% in the candies with yellow strawberry guava), which makes it possible to categorise them as light candies, following Anvisa's Technical Regulation No. 54 (ANVISA, 2012).

The carotenoid content in the conventional red strawberry guava candy was higher as compared to those with yellow strawberry guava. In candies with yellow strawberry guava pulp, a higher carotenoid content was observed in those with low caloric value as compared to conventional ones. However, the opposite was observed for candies with red strawberry guava pulp. This behaviour may be associated with the higher fat percentage (4.91%) in the conventional candies with red strawberry guava pulp, which could lead to a higher retention of carotenoids.

Several authors have reported that the carotenoid content in strawberry guava could vary considerably, with values ranging from 389.0 – 1,084.0 and 364.4 – 11,34.0 μg of β-carotene equivalents in 100 g fresh weight, respectively, for yellow and red strawberry guava (Medina *et al.,* 2011; Denardin *et al.,* 2015; Vinholes *et al.,* 2017). The maturation stage and extraction method are also factors that may lead to differences in the quantification of these compounds.

The variables that did not reveal a significant interaction between strawberry guava types × type of candy were moisture, protein, lipids, ashes, caloric value, and total carbohydrates.

Candies with different pulps exhibited similarities in moisture content. However, candies with reduced caloric values had more moisture than conventional formulations. The low-calorie chewable candies feature a moisture percentage close to that reported by Vissoto and Luccas (1999) (6.0 - 9.0%). The low-moisture content found in conventional candy does not categorise it as hard candy, which is defined as a vitreous state by the amorphous conformation of sucrose molecules, while chewable candy is considered an emulsion because its formulation contains fat. It is likely that the processing time (10 min) may have resulted in the decrease in moisture of the conventional candies. The same authors explain that moisture content is an important factor in the storage of sweets in general, being directly related to its shelf life. If proper packaging of the product is not adhered to, moisture gain or loss may cause undesirable changes in the texture of the products.

The protein content was higher in the candies with yellow strawberry guava pulp. Regarding the types of candies, low-calorie candies had higher protein content than conventional candies. The main source of protein in candies is the gelatine added in the formulation, which is responsible for the product's structure, rigidity, and/or softness (Vicente *et al.,* 2013).

The lipid content was similar between the candies made with either yellow or red strawberry guava pulp. Regarding the types of candies, the conventional formulation had higher lipid content. Specifically, they had higher lipid content when compared to those with low caloric values owing to the higher percentage of fat added to the formulation.

Regarding ashes, the candies of both pulps had a similar amount. Between the types of candies, ash content was higher in the low-calorie candies. The caloric value of the candies with red strawberry

guava pulp was higher (44.42 kcal for red strawberry guava pulp, and 41.97 kcal for yellow strawberry guava pulp). In terms of the type of candies, the conventional formulation had the highest caloric values (48.74 kcal conventional, and 37.66 kcal low-calorie candy). The total carbohydrate content, both with respect to yellow and red strawberry guava pulps as well as types of candies, was similar.

Strawberry guava type × type of candies × storage

Analysis of variance revealed a triple interaction between strawberry guava types × types of candies × storage for total soluble solids, luminosity, monomeric anthocyanins, ABTS°, and DPPH°.

The total soluble solid content in both red and yellow strawberry guava candies did not change during the storage (Figure 2). At 0 and 60 d of storage, a higher total soluble solid content was observed in the candies with yellow strawberry guava pulp. Between the types of candies, conventional candies had greater contents owing to the higher percentage of sucrose added in the formulation. At 120 and 180 d of storage, no differences were observed between conventional candies. Yellow strawberry guava low-calorie candies presented higher values. Regarding the types of candies, conventional candies with red strawberry guava pulp had the highest values at 0 and 60 d.

The low-calorie candies were clearer (brightness near 100) than conventional candies soon after processing (Figure 2). Similar results were observed by Reissig *et al.* (2018) in diet strawberry guava jam. However, both types of candies became darker during storage. This diminution in brightness is because of storage time, which promotes the darkening of candies owing to the oxidation of certain pigments (carotenoids, anthocyanins, and phenolic compounds), thus generating a dark colour, as explained by Castañeda-Ovando *et al.* (2009). It is probable that the type of packaging used also influenced the brightness reduction, which in the present work was transparent polypropylene.

Conventional candies exhibited similarities in luminosity on day 0 of storage. For the candies of reduced caloric value, those with red strawberry guava pulp presented higher values. Related to the

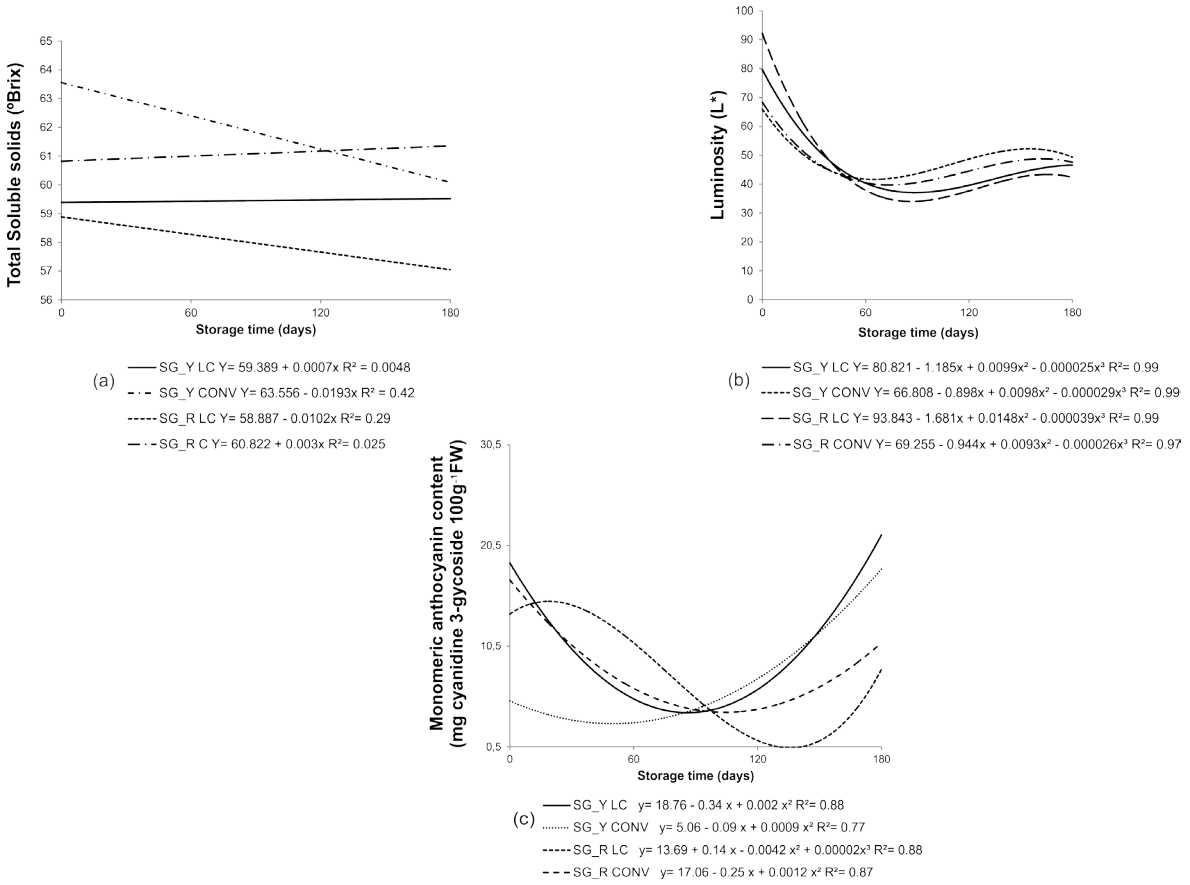

Figure 2. Regression equation and mean variation (n = 3) of the triple interaction of total soluble solids content (a), luminosity (b), and monomeric anthocyanins (c) in conventional and low-calorie strawberry guava candies during 180 d of storage. The degree of the polynomial and the equations were tested by Student's t-test at 5% probability. SG_Y = yellow strawberry guava; SG_R = red strawberry guava.

type of candies, those with reduced caloric values presented higher values.

At 60 d of storage, the luminosity variable was similar in the conventional candies of both pulps. However, low-calorie candies formulated with yellow strawberry guava pulp presented higher values. The candies with yellow strawberry guava pulp had intermediate brightness, and were slightly lighter than that observed by Mutlu *et al.* (2018), specifically jelly candy made with honey (48.63 of brightness). Regarding the types of candies, similarities were noted between formulations.

At 120 d of storage, conventional candies with yellow strawberry guava pulp had higher luminosity. For candies with lower numbers of calories, both formulations were similar. Regarding the types of candies, the conventional formulation presented higher values.

The luminosity was similar at 180 d of storage in conventional candies with either yellow or red strawberry guava pulp. Regarding low-calorie candies, the yellow pulp formulation presented higher values. Between the types of candies, regardless of the type of strawberry guava used, they featured similarities.

Overall, there was a peak in monomeric anthocyanin content at 180 d of storage (Figure 2), which probably occurred because more unstable anthocyanin compounds were lost during the cooking step. With the storage of chewable candies, certain groups of naturally occurring anthocyanidin polyphenolic cofactors in guava may have added additional stability to the remaining anthocyanins by intermolecular co-pigmentation reactions between these compounds (Pacheco-Palencia and Talcott, 2010).

At day 0 of storage, the monomeric anthocyanin content in the conventional candies with red strawberry guava pulp was higher. In the low-calorie formulations, no differences were observed. Vinholes et al. (2017) evaluated the anthocyanin content in red and yellow strawberry guava fruit, and determined that the concentration in the red fruit was almost 21-fold higher than in the yellow fruit. Owing to the red coloration of the epicarp, the red strawberry guava had a higher anthocyanin concentration than the yellow. However, these amounts were relatively low as compared to other fruits with more intense red colour (Pereira *et al.,* 2017).

When relating to the types of candies, regardless of the type of pulp used, those with reduced caloric values presented higher values. We expected a lower concentration of monomeric anthocyanins in the low-calorie candies. The formulation requires a longer processing time, and, in addition, considering the sum of the ingredients, the relative amount of pulp was lower. Silva *et al.* (2016) assessed the anthocyanin content in *açaí* chewable candies without sugar addition and observed that the content remained constant during storage with 99.21% retention.

At 60 d of storage, it was observed that the monomeric anthocyanin content in conventional candies with red strawberry guava pulp was higher. In candies with low caloric values, there was no difference, and this was independent of the pulp employed. Relating the types of candies and yellow strawberry guava pulp, it was seen that the candies with reduced caloric values presented the highest values. No differences were observed for the candies with red strawberry guava pulp.

At 120 d of storage, the conventional candies with yellow strawberry guava pulp had higher monomeric anthocyanin content than those with red strawberry guava pulp. In the candies with a low number of calories, no differences were observed. The anthocyanin content found in the present work was higher than that established by Medina *et al.* (2011) in accessions of yellow strawberry guava fruit. Fetter *et al.* (2010) reported higher values (10.69 in mg cyanidine-3-glycoside equivalent 100 g^{-1} fresh sample). As with the other physicochemical parameters, many factors may influence anthocyanin content and composition. The degree of maturation may cause a pigment increase (Boyles and Wrolstad, 1993; Baldi *et al.,* 1995). Regarding the types of candies, both yellow and red strawberry guava pulp showed similarity with respect to anthocyanin content.

At 180 d of storage, the monomeric anthocyanin content in both conventional and low-calorie candies with yellow strawberry guava pulp continued to feature higher values than candies with red strawberry guava pulp. Regarding the types of candies, independent of the type of strawberry guava used, we observed a similarity in anthocyanin content.

On day 0, the antioxidant activity was higher for conventional and low-calorie candies prepared with red strawberry guava pulp. This can be explained by the presence of anthocyanins, which contribute to antioxidant potential, being present in larger amounts in red strawberry guava (He and Giusti, 2010). Regarding the types of candies, those made with yellow strawberry guava pulp had similarities in terms of the results. For candies prepared with red strawberry guava pulp, the conventional formulation had the most antioxidant activity. As the bioactive content was higher in the conventional formulation, the greater antioxidant activity of these candies is understandable and possibly expected.

At 60 d of storage, the candies prepared with red strawberry guava pulp presented higher values of antioxidant activity (ABTS° radical method), both for conventional and low-calorie candies. Regarding the types of candies, regardless of the pulp used, those with reduced caloric values were greater in numbers.

The antioxidant activity (DPPH° radical method) of conventional and low-calorie candies prepared with yellow and red strawberry guava exhibited a significant decrease over the course of the storage period (Figure 3).

On day 0, no difference was observed between conventional and low-calorie candies. With respect to the type of candies, it was shown that regardless of the pulp used, the conventional candies presented higher activity. The same was observed on day 0 for antioxidant activity measured by the ABTS° radical method.

Further, the antioxidant activity was similar between conventional candies formulated with yellow and red strawberry guava at 60 d of storage. Low-calorie candies prepared with red strawberry guava pulp had more pronounced activity. Irrespective of the candy types, we observed similarities in antioxidant activity.

The antioxidant activity (ABTS° and DPPH° methods) in both conventional and low-calorie candies reached 0 at the end of the storage period. At this point, it was possible the compounds were degraded or converted to other chemical species that do not act as antioxidants.

Storage × type of candies

The variance analyses showed a double interaction between storage × type of candies for carotenoid content and Hue°.

Overall, there was an increase in carotenoid content at 60 d of storage for both candy formulations (Figure 4). Harakotr *et al.* (2014) observed that heat treatment does not always imply the complete destruction of bioactive compounds, and that cooking can lead to the generation of new compounds, including enhancing antioxidant properties.

On day 0, low-calorie candies had higher carotenoid content than conventional candies. The candies had similarities in carotenoid content at 60 and 120 d of storage. At 180 d of storage, the carotenoid content in conventional candies was higher. This behaviour can be explained by the higher fat percentage (4.91%) in these as it provides greater retention of carotenoid content.

Strawberry guava candies showed an increase in the variable that expresses colour tone (Hue° angle) during storage (Figure 4). On day 0, the conventional candies presented higher Hue° values than the low-calorie candies. This was probably because of the sugar caramelisation reaction during processing that was less intense in the conventional candy, which has a shorter processing time. At 60, 120, and 180 d of storage, the values were similar.

Strawberry guava type × storage

The variance analysis showed a double interaction between the types of strawberry guava × storage for the phenolic and carotenoid content.

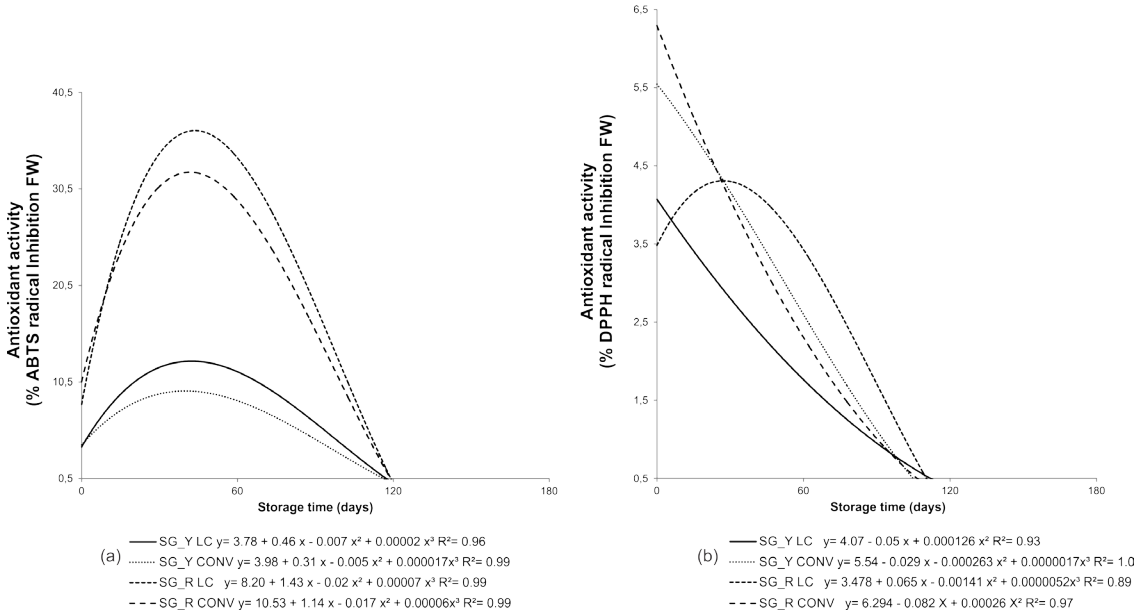

Figure 3. Regression equation and mean variation ($n = 3$) of the triple interaction of ABTS° (a), and DPPH° (b) in conventional and low-calorie strawberry guava candies during 180 d of storage. The degree of the polynomial and the equations were tested by Student's *t*-test at 5% probability. SG_Y = yellow strawberry guava; SG_R = red strawberry guava.

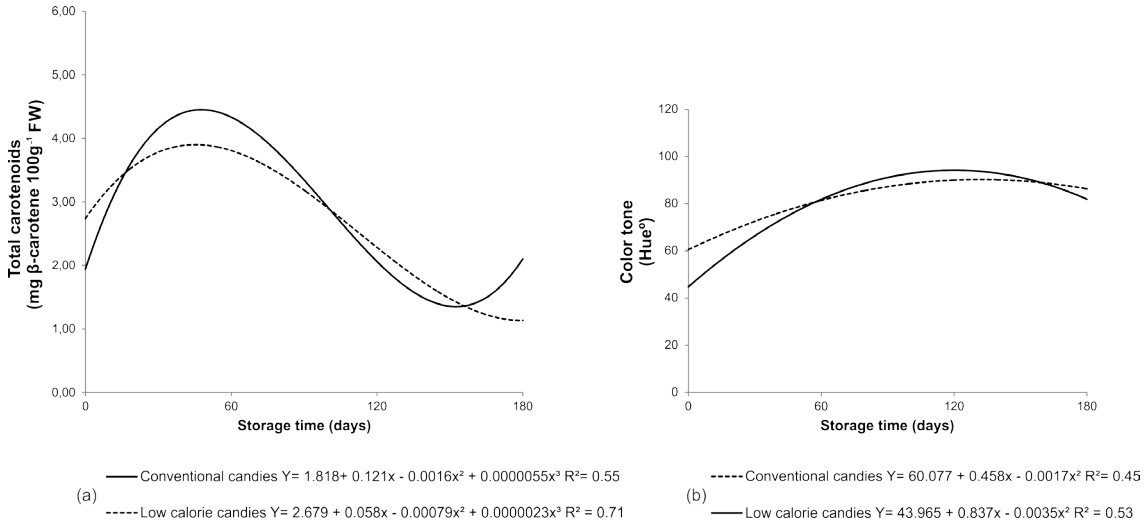

Figure 4. Regression equation and mean variation ($n = 3$) of the double interaction (storage × candy type) of the carotenoid content (a), and Hue° (b) in conventional and low-calorie strawberry guava (yellow and red, respectively) candies during 180 d of storage. The degree of the polynomial and the equations were tested by Student's *t*-test at 5% probability.

Candies prepared with strawberry guava pulps exhibited an increase in phenolic compound content during storage (Figure 5).

Red strawberry guava candies had higher phenolic compound content across all storage days evaluated. The phenolic compound content in fruit depends on the species, variety, environment, physiological state, climatic conditions, and extraction method (Scalbert and Williamson, 2000), as well as the selectivity of polyphenol oxidases for anthocyanins (Zhang *et al.,* 2005). These factors may have contributed to the differences in phenolic compound values found by the authors.

In general, there was a decrease in carotenoid content during storage in the candies prepared with either of the strawberry guava pulps (Figure 5). Moreover, at 0, 120, and 180 d of storage, there was a similarity in carotenoid content between candies prepared with either strawberry guava pulp. At 60 d of storage, the candies prepared with red strawberry guava pulp had higher carotenoid content. Carotenoids consist of a family of lipophilic pigments found in nature, being responsible for the yellow to red colour of most fruits and vegetables (Cozzolino, 2009). Although candies with red strawberry guava pulp had greater carotenoid content as compared to candies prepared with yellow strawberry guava pulp, at 60 d of storage, low amounts of this compound were observed in both candies.

Conclusion

It was observed that the use of red and yellow strawberry guava fruit pulps in chewable

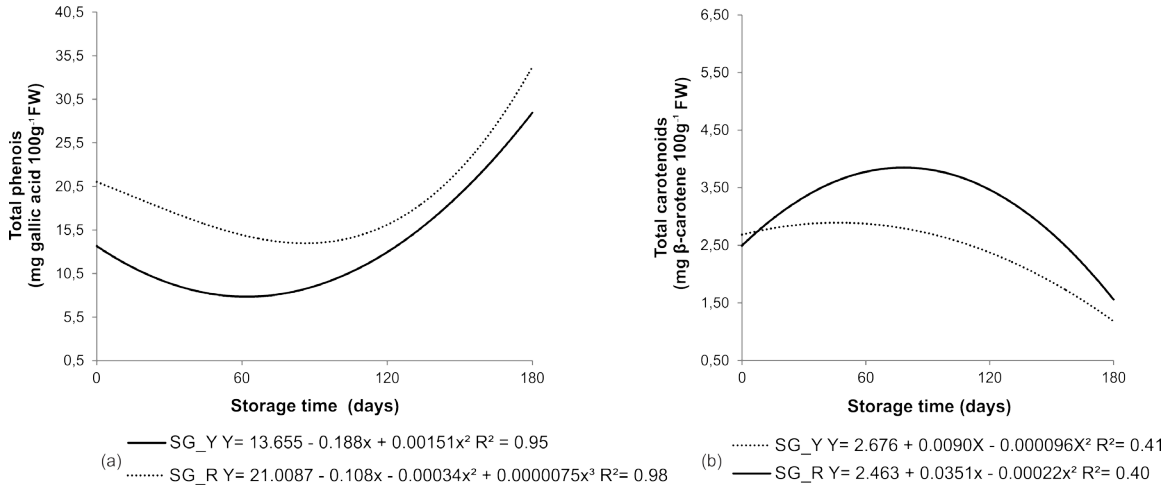

Figure 5. Regression equation and mean variation ($n = 3$) of the double interaction (strawberry guava type × storage) of the phenolic compounds (a), and carotenoid content (b) in conventional and low-calorie strawberry guava candies during 180 d of storage. The degree of the polynomial and the equations were tested by Student's *t*-test at 5% probability. SG_Y = yellow strawberry guava; SG_R = red strawberry guava.

candies influenced physicochemical parameters and the retention of bioactive compounds (phenolic compounds, monomeric anthocyanins, and carotenoids) and antioxidant activity, owing to the effects of the processing and storage of the products. Conventional formulations lost a higher amount of carotenoids and monomeric anthocyanins shortly after processing as compared to those with reduced caloric values. The red pulp strawberry guava pulp, regardless of the candy type, featured higher phenolic compound across all evaluated storage durations. Furthermore, the present work showed that the use of Brazilian native fruit is a natural and innovative option as it is an ingredient that has merit to be utilised by the confectionery industry, and as highlighted by our demonstration that the production of chewable candies with different nutritional characteristics is possible. The present work also demonstrated that fruits could contribute colour and flavour to products that allow for the replacement of artificial additives (colouring and flavouring agents) frequently employed in traditional confectionery products.

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