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Chemistry

Optimizing genipap (*Genipa americana*) blue dye extraction using glutamic acid

Otimizando a extração do corante azul de jenipapo (*Genipa americana*) usando ácido glutâmico

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ABSTRACT

Dyes are highly important to the food industry. Because of this, natural dyes have great potential, both due to their bioactive compounds and the harm that artificial dyes cause in humans. Genipin, responsible structure for the blue pigment extracted from genipap (*Genipa americana*), was studied in relation to its stability. Among the natural dyes investigated, genipin exhibited the highest stability of its pigments against changes caused by variations in pH, exposure to light and temperature fluctuations. However, this dye requires methods that enhance its stability for potential application in food. Therefore, this work aims to improve the blue dye extraction procedure by using glutamic acid, an amino acid present in genipap that participates in the formation of blue pigments. Analyses of four different dye formulations were conducted, covering quantification of blue pigment and stability over the 408-hour period, pH, antioxidant activity and colour determination. The dyes that used the addition of glutamic acid in their extraction obtained better results for concentration of blue pigments and stability, proving their effectiveness in optimizing this process.

Keywords: Natural dyes; Amino acid; Efficiency; Enhancement; Pigment stability

RESUMO

Os corantes são altamente importantes para à indústria de alimentos. Devido a isso, os corantes naturais têm grande potencial, tanto devido aos seus compostos bioativos quanto ao dano que os corantes artificiais causam aos seres humanos. O genipina, estrutura responsável pelo pigmento azul extraído do jenipapo (*Genipa americana*), foi estudado em relação à sua estabilidade. Entre os corantes naturais investigados, a genipina apresentou a maior estabilidade de seus pigmentos contra

as alterações causadas por variações de pH, exposição à luz e flutuações de temperatura. No entanto, esse corante requer métodos que melhorem a sua estabilidade para uma potencial aplicação em alimentos. Portanto, este trabalho tem como objetivo aprimorar o procedimento de extração do corante azul usando o ácido glutâmico, um aminoácido presente no jenipapo que participa da formação de pigmentos azuis. Foram realizadas análises de quatro formulações diferentes de corantes, abrangendo a quantificação do pigmento azul e a estabilidade ao longo de um período de 408 horas, pH, atividade antioxidante e determinação da cor. Os corantes que utilizaram a adição de ácido glutâmico em sua extração obtiveram melhores resultados quanto à concentração de pigmentos azuis e estabilidade, comprovando sua eficácia na otimização desse processo.

Palavras-chave: Corantes naturais; Aminoácidos; Eficiência; Aprimoramento; Estabilidade de pigmentos

1 INTRODUCTION

Dyes are present in most food products, ensuring greater sensory acceptability due to their main attribute: colour (Neves & Meireles, 2018). However, there is increasing concern about the amount of consumption of foods containing synthetic dyes, because although they are regulated by ANVISA and other responsible agencies, there is no assessment of the total substances consumed daily, which over time can cause numerous health problems (Pereira et al. 2015). An alternative to reduce the intake of synthetic dyes is the use and availability of natural dyes on the market.

Natural dyes have functional characteristics, which generates a nutritional increase in the product that is added. The consumption of products with natural and functional characteristics has increased, driving the food industry to produce them in order to ensure healthier products. One of the main challenges is the difficulty of a natural source of blue dye. According to Bechtold and Mussak (2009), the dyes that are marketed as blue are extracted from fruits of Gardenia (*Gardenia jasminoides*), algae and the green fruit of genipap (*Genipa americana*).

Currently, natural dyes are presenting significant technological potential. There are an increasing number of studies on their applications in both solid and liquid food products. Thus, new ways of increasing concentration, yield, and applicability are constantly being developed with optimization of technological and toxicological

characteristics. The market for natural dyes is also expanding because of consumers' tendency to choose healthy products (Luzardo-Ocampo et al., 2021).

The beneficial effects of natural dyes are commonly explained because of their antioxidant and anti-inflammatory capacity derived from their bioactive compounds. According to Pereira, Vidal, and Constant (2009), the antioxidant power of natural dyes acts against free radicals, which, when reacting in the body, promote the development of diseases. The ingestion of these antioxidant compounds is the main way to achieve their effect in the body. Fukumoto and Mazza (2000) conducted studies that identified anthocyanins with a greater and more effective antioxidant effect than BHA and vitamin E. Bergmann et al. (2021) describes carotenoids as precursors of vitamin A, as well as presenting studies that confirm the relationship between consumption and the prevention of diseases such as head, neck, stomach, and colorectal cancer, cardiovascular diseases, and muscular diseases. The potential of turmeric with mechanisms resembling chemotherapeutic agents and not harming normal cells is also reported (Park and Conteas, 2010).

According to some studies found, jenipapo has a remarkable amount of geniposide, an iridoid. Iridoids are bioactive compounds of the monoterpene class. It is through the hydrolysis reaction of this iridoid that another structure called genipin is formed, being an iriroid-glycoside, which is responsible for the pigment obtained from jenipapo. This pigment is the dye most used by indigenous people due to its durability in body paintings (Bolzani, 2016).

For the formation of the blue pigment, in addition to oxygen being one of the indispensable factors, primary amines play a very important role in this reaction. The fruit itself has primary amines, but during its maturation stage, its quantification may be decreased and the colour of the dye obtained may not be as intensely blue. Secondary and tertiary amines do not contribute to this reaction (Touyama et al. 1994). Thus, this work aims to verify the influence of glutamic acid in the process of optimizing the extraction and stability of the blue dye of the jenipapo obtained.

2 MATERIAL AND METHODS

The present work was conducted in the laboratories of Food Chemistry and Biochemistry of the Department of Food Technology (DTA) of the Federal University of Sergipe. The raw material used was genipap in a green ripening stage, obtained between November and December 2022 in the municipality of Laranjeiras – SE, and stored in ultrafreezing until their use. Before use, the fruits were cleaned, sanitized in 0.1% sodium hypochlorite solution for 15 minutes, and washed with running water.

2.1 Physical characterization of the jenipapo

Of the fruits used in the work, 40 samples were weighed on an analytical scale and the longitudinal and transverse diameters were measured with a Pantec digital caliper. The instrumental colour of the fruits was determined through analysis with the Konica Minolta CR-10 colourimeter. The analysis was performed in triplicate.

2.2 Extraction of the dye from jenipapo

The colouring extract was obtained from the use of the mesocarp and endocarp of jenipapo in a green maturation stage, using two solvents and four conditions.

The extraction process was performed according to the methodology proposed by Renhe et al. (2009) with adaptations. Where the pulp wrapper and the seeds were crushed in distilled water and 50% ethanol, in the ratio (1:2) of (fruit/solvent), at temperatures of 55 °C and 75 °C, respectively, for 30 minutes, under constant stirring. Samples extracted with 50% ethanol were rotary evaporated until complete elimination of solvent. After the extractions, Glutamic Acid additions were performed on the two samples extracted with different solvents to aid in the intensity and stability of the blue pigment. Both samples were subjected to 55º heating for 30 min under constant stirring. Storage was carried out in amber flasks and at refrigeration temperature.

2.3 Quantification of the blue pigment in the obtained dyes

The quantification of the blue pigment present in the 4 dyes was determined using the equation model proposed by Bentes (2015), which relates the determination of the concentration of the blue pigment resulting from the calibration curve of the reaction of genipin and glutamic acid. Where the wavelength used was 605nm and the specific absorptivity for the blue pigment was 10.7936 L g-1cm-1. The absorbance reading of the dyes was performed at 8 points with a total time of 408 hours.

$$A = 10{,}7936c - 0{,}0039 \quad (1)$$

Where:
A = Absorbance of the solution (dimensionless); c = Concentration of the solution (g/L)

2.4 Stability in the obtained dyes

To evaluate stability according to the methodology adapted from Stringheta (1991), 10 mL transparent vials were used, at a controlled temperature of 25 °C and in two conditions, in the presence of light with fluorescent lamps of 40W, 2,500 lux, c, corresponding to the incidence of daylight, and in the absence of light, where the vials were stored in a box wrapped in aluminum foil. The pH 4 phosphate buffer solution was used, in the ratio of 20 mL of solution to 1.5 mL of dye, with the addition of 0.01% potassium sorbate to prevent fungal growth. Each sample was prepared with three replicates, totaling 192 samples for absorbance reading at wavelength 605 nm, at 8 points with intervals for 408 hours.

2.5 pH in the obtained dyes

The samples of the dyes obtained were measured for pH, in triplicate, in a digital pH meter, according to the Analytical Standards of the Adolfo Lutz Institute.

2.6 Antioxidant capability

The dyes were analyzed by two methods: ABTS and DPPH. To study the antioxidant capacity by the ABTS method of the dye extracted under different conditions, the methodology described by Rufino et al. (2007a) was used. Where ABTS solution was prepared 16h before use. The results were presented in terms of TEAC (Trolox Equivalent Antioxidant Capacity), which represents the equivalent antioxidant capacity to Trolox (6-hydroxy-2,5,7,8-tetramethylchromo-2-carboxylic acid), expressed in μmol of TEAC per gram of sample. For quantification by the DPPH method, the methodology used was Rufino et al., (2007b). The rationale for this method lies in the reduction of the DPPH • radical by removing an H•, obtained from the antioxidant under analysis, causing a decrease in absorbance (Brand-Wyllians et al. 1995). The results were also presented in TEAC, which is the unit of measurement used to express the antioxidant capacity equivalent to Trolox, in μmol TEAC per gram of sample.

2.7 Colour Determination

The colour of the four dye samples were qualified by direct reflectance reading of the coordinate “L”, “a”, and “b”, using the Cielab scale in a Konica Minolta colourimeter, model CM-700d (Renhe *et al*. 2009).

3 RESULTS AND DISCUSSION

3.1 Physical Analysis of Jenipapo

After the analysis of 40 samples used in this study, Table 1 was obtained. The average weight of the green fruits was 127.01 g, with a minimum and maximum analyzed weight of 99.80 g and 151.40 g, respectively. When comparing this result with values found by Hansen et al. (2007), it is observed that the average fruit weight is significantly lower. However, the maturation stage of the fruit analyzed by it differs

from the maturation stage of jenipapo verde. As you can also see the geographical influence on the physical characteristics of the fruits.

Table 1 – Means and standard deviations of the physical characteristics of the genipap fruits used

Weight (g)	Longitudinal diameter (mm)	Transverse diameter (mm)	Colour (L, a, b)		
127,01 ± 16,7009	68,28 ± 4,3108	59,73 ± 2,61058	16,32 ± 4,5744	5,41 ± 3,7788	18,17 ± 10,5565

Source: Author's own elaboration, 2023

The jenipapos presented longitudinal and transverse diameters of 68.28 mm and 59.73 mm, respectively. Values found by Hansen et al. (2007), in relation to diameters were 80.15 mm for longitudinal and 76.9 mm cross-sectional, higher than those analyzed in this study. It is important to highlight, in addition to the diversity that this fruit can present, the external influences in view of its characterization as the harvest period. The harvest period carried out by Hansen et al. (2007), was from May to June, while that carried out in this study was from November to December.

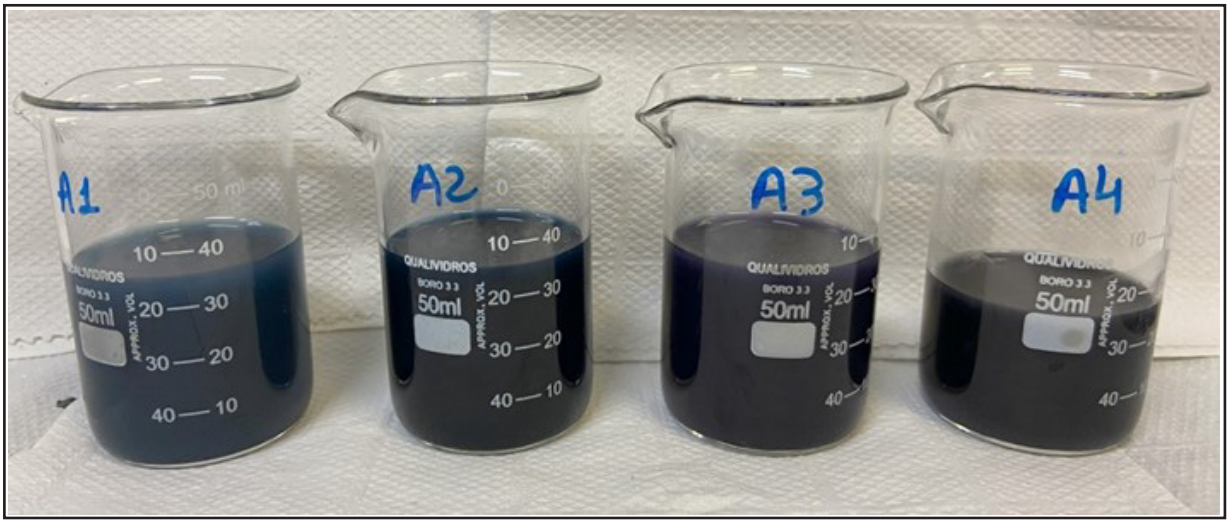
The instrumental colour analysis performed only on the outside of the fruit gave mean values for the L*, a * and b* coordinates of 16.32, +5.41, +18.17, respectively. Through CIELAB the values of L* represent the luminosity, a * describes the intensity of red and green and b* intensity of yellow and blue. Through the positive values of the results, the instrumental colour of the peel of the jenipapo presents intensity of shades of red and yellow, which confers this brownish colour of the fruit (Minolta, 2007).

3.2 Obtaining the dye

The dyes were obtained by extraction with two different types of solvents, distilled water and 50% ethanol pH 4.0, for Renhe et al. (2009) and confirmed by (Figure 1), the samples extracted in ethanol (A3 and A4) obtain a more intense and darker colouration than those extracted in distilled water. However, glutamic acid was added to aid in the

stabilization of the blue pigment in samples A2 and A4, where it is possible to notice that the intensity of the pigment increases, resembling the dye extracted with etanol.

Figure 1 – Concentrated dyes obtained under different conditions



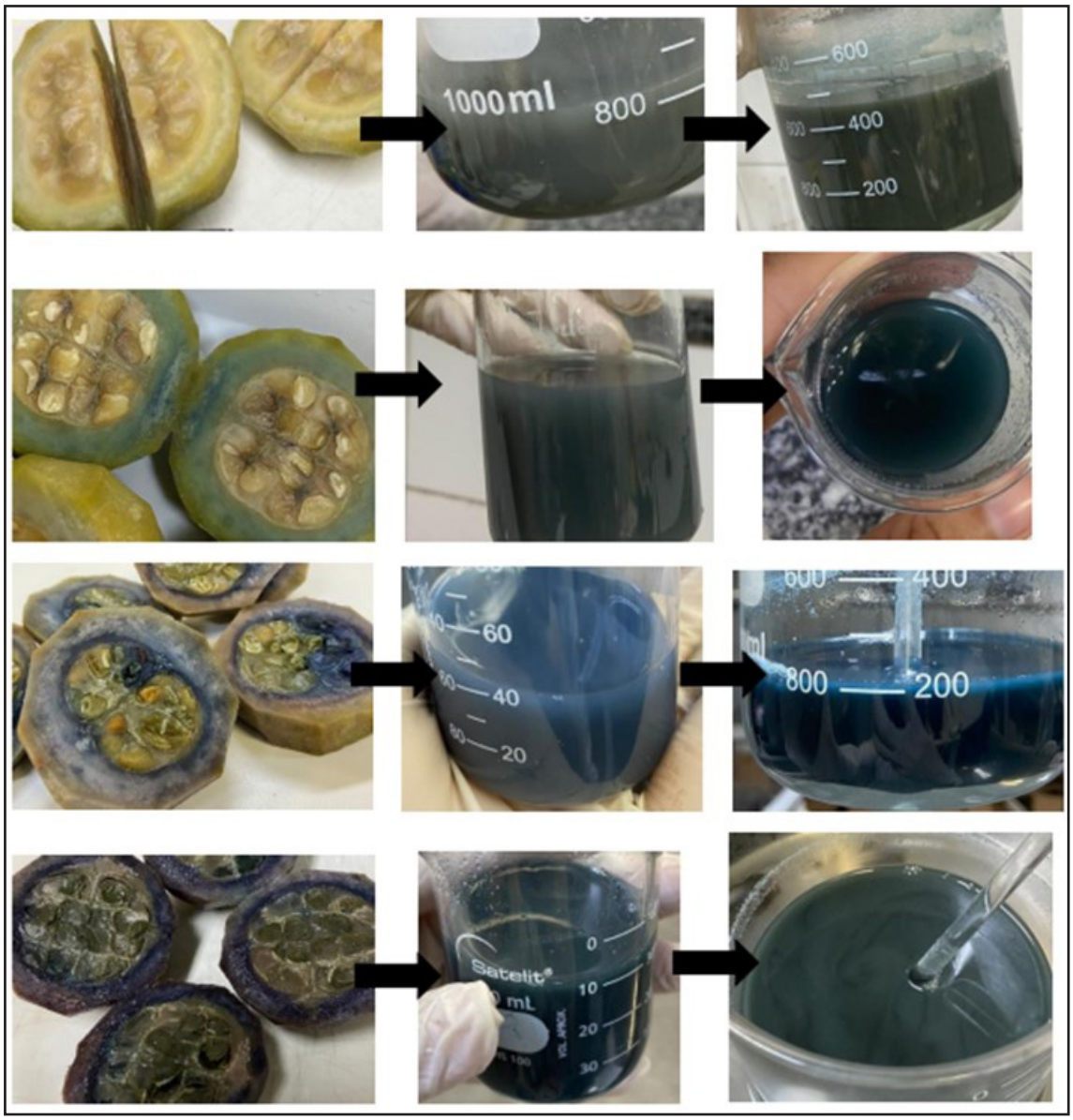
Source: Author's own elaboration, 2023
*Sample A1: water; Sample A2: water + glutamic acid; Sample A3: ethanol; Sample A4: ethanol + glutamic acid

Genipin reacts in various ways with the very free amino acids present in jenipapo. According to Bentes et al. (2015), the largest amino acid quantified in jenipapo is glutamic acid, present mainly in the endocarp, also found in large proportion in the mesocarp. The choice of glutamic acid use refers to the main blue pigment formation reaction in jenipapo.

It was observed during the dye extractions using water as a solvent that the jenipapos that presented a low formation of blue pigment as soon as they oxidized, when the glutamic acid addition step was performed, the dye pigmentation intensified to the blue shade. However, with some green jenipapos it was not possible to revert the colour to the desired tone, which can be justified due to the amount of genipin available for reaction in the fruit. These dyes that did not acquire a colour shade for the blue shade were not used in the study.

It is important to highlight the difficulty in the uniformity of the blue tone in water extractions. It was observed in this study that the degree of oxidation of the fruit as soon as it breaks has a direct influence on the colour of the dye obtained, even with the addition of glutamic acid (Figure 2).

Figure 2 – Influence of the degree of oxidation of jenipapo on the hue of the dye extracted in water



Source: Author's own elaboration, 2023

Through visual evaluation, it is noted that the addition of glutamic acid in a dye obtained from a fruit with high oxidation results in the change to green. This suggests that the enzymes present in the fruit, responsible for releasing genipin for reaction, may no longer be active, as well as there may be interference between the amount of compounds present in the fruit itself.

3.3 Analyses of Stability

By analyzing the behavior of the different samples of the jenipapo dye, table 2 was obtained, which describes the means of the absorbances of each sample, submitted to both exposure and light deprivation over a period of 408 hours.

Table 2 – Means of absorbances of stability analysis of jenipapo dyes

Hours	A1L	A1A	A2L	A2A	A3L	A3A	A4L	A4A
0	0.5400^{a}	0.5400^{a}	1.0260^{b}	1.0260^{b}	0.9507^{c}	0.9507^{c}	0.8387^{d}	0.8387^{d}
24	0.4187^{a}	0.3957^{a}	0.9300^{b}	0,9247^{b}	0,7663^{c}	0,7333^{c}	0,7183^{c}	1,0503^{d}
48	0,2057^{a}	0,2120^{a}	0,7697^{b}	0,7630^{b}	0,5600^{c}	0,5293^{c}	0,5237^{c}	0,9327^{d}
72	0,3313^{a}	0,2817^{a}	0,9767^{b}	0,9447^{b}	0,6077^{c}	0,5933^{c}	0,6183^{c}	1,0637^{d}
168	0,0707^{a}	0,0980^{a}	0,9410^{b}	0,8533^{b}	0,5370^{c}	0,4053^{c}	0,4610^{c}	1,0030^{b}
216	0,2917^{a}	0,2853^{a}	1,3360^{bc}	1,2910^{b}	0,5397^{d}	0,5243^{d}	0,7797^{e}	1,3560^{c}
312	0,0470^{a}	0,0567^{a}	1,4383^{b}	1,4137^{bc}	0,3310^{d}	0,2923^{d}	0,8213^{e}	1,3620^{c}
408	0,2477^{a}	0,2570^{a}	1,8613^{b}	1,7130^{c}	0,5430^{d}	0,4863^{d}	1,0623^{e}	1,4980^{f}

Source: Author's own elaboration, 2023

*A1L- Sample 1 in the presence of light; A1A- Sample 1 in the absence of light. A2L- Sample 2 in the presence of light; A2A- Sample 2 in the absence of light. A3L- Sample 3 in the presence of light; A3A- Sample 3 in the absence of light. A4L- Sample 4 in the presence of light; A4A- Sample 4 in the absence of light. **Sample 1- Water. Sample 2- Water and glutamic acid. Sample 3: Ethanol 50%. Sample 4- Ethanol 50% and glutamic acid * **Means followed by the same letter in the rows of the table do not differ significantly by Tukey's test at the 5% probability level

It is noted that samples A1 and A3 showed a reduction in their absorbance values, while samples A2 and A4 were able to increase their absorbance over the analyzed hours. Through the Tukey test, it is observed that the samples did not differ significantly from each other in relation to light exposure, which proves that light does not influence the degradation of jenipapo dyes. However, sample 4 showed a significant difference between its two conditions, and the sample was subjected to the absence of light, which resulted in a greater increase in absorbance.

When compared comprehensively, samples A1 were the only ones to reveal a significant difference in relation to the other samples. In the range of 24 hours to 168 hours, samples A3L, A3A, and A4L demonstrated similar performance and exhibited

no discrepancies in the values analyzed at each hour. Both samples were extracted using the same solvent. However, such a relationship is not observed in sample A4a. During the 168 to 312 hour period, samples A2L, A2A, and A4A exhibited similar behavior and values. However, samples A2 and A4 diverge in the use of solvent. The addition of glutamic acid may have an influence on these results.

According to the behavior presented by the samples, it is noted that the degradation of the dye is not influenced by light, as reported in previous studies by Renhe et al. (2009). However, it is necessary to investigate the difference observed in the A4 samples, which, despite following a pattern in relation to the hours, presented divergent absorbance values throughout the analysis.

3.4 Quantification of blue pigment

In the study carried out by Bentes et al. (2015), an equation was proposed that allowed the quantification of the blue pigment present in the dyes extracted from jenipapo. This equation was developed with the objective of determining the precise concentration of the blue pigment, avoiding any possible errors. Being used in the present study to quantify the concentration of blue pigments in jenipapo dyes with different extraction methods.

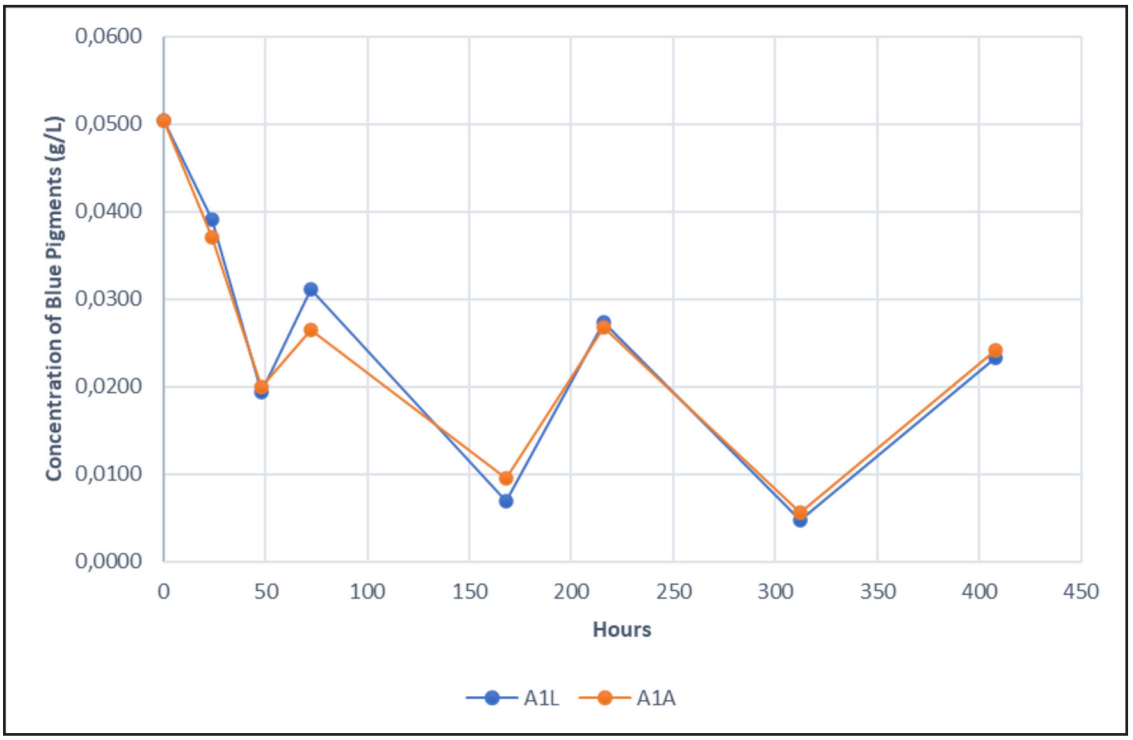
Through the data obtained, the positive influence of the action of glutamic acid in samples A2 and A4 is observed. In addition to acting on colour stability, there was an increase in blue pigments of 181% and 166% for samples 2, and 126% and 178% for samples 4, over the time elapsed of 408 hours.

For samples without addition of glutamic acid, A1 and A3, there was a reduction in the concentration of blue pigments by 46% and 48% for sample 1, and 57% and 51% for sample 3. This further characterizes the feasibility of using glutamic acid to ensure the colour stability of the jenipapo dye.

Figure 3 shows the behavior of the samples of the jenipapo blue dye extracted in distilled water in the presence of light (A1L) and in the absence of light (A1a). It is observed as previously mentioned that the jenipapo dye does not follow a first-order kinetics, that

is, there is no direct decline in its concentration over the analysis time. In addition, it is possible to observe the similarity in the behavior of the samples in relation to both light exposure and its absence, presenting an initial behavior of loss of concentration of blue pigments in a few hours, followed by a subsequent partial recovery.

Figure 3 – Blue pigment concentration in sample 1 for 408 hours under two conditions

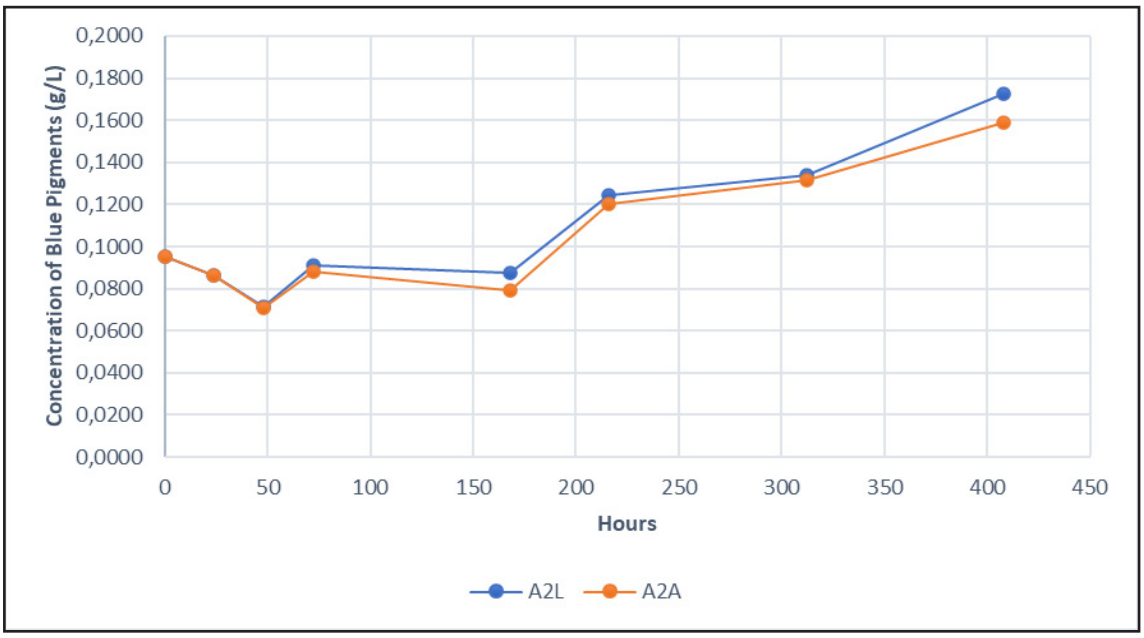


Source: Author's own elaboration, 2023
*A1L- Sample 1 in the presence of light; A1A- Sample 1 in the absence of light

Figure 4 illustrates the behavior of sample 2 regarding the concentration of its blue pigments. When comparing sample 1, which has the same solvent used in its extraction, it is noted that there is a relevant difference due to the use of glutamic acid.

Sample 2, in both conditions, shows a small loss of concentration in the first 50 hours. However, soon after, there is a recovery that exceeds the initial value. After 168 hours of analysis, there is a slight phase of loss of concentration, followed by a continuous increase in the concentration of the pigments. This increase represents approximately double the initial value of the sample.

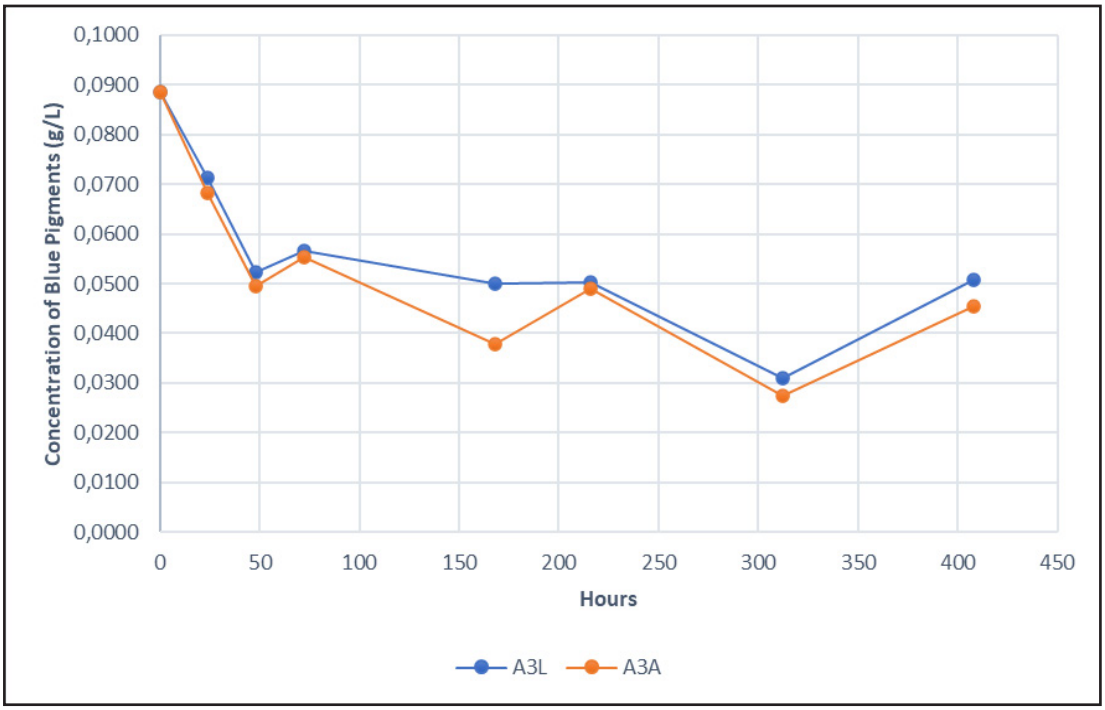
Figure 4 – Blue pigment concentration in sample 2 for 408 hours under two conditions



Source: Author's own elaboration, 2023
*A2L- Sample 2 in the presence of light; A2A- Sample 2 in the absence of light

Sample 3, extracted in 50% ethanol, has a similar behavior to sample 1 (Fig. 5).

Figure 5 – Blue pigment concentration in sample 3 for 408 hours under two conditions

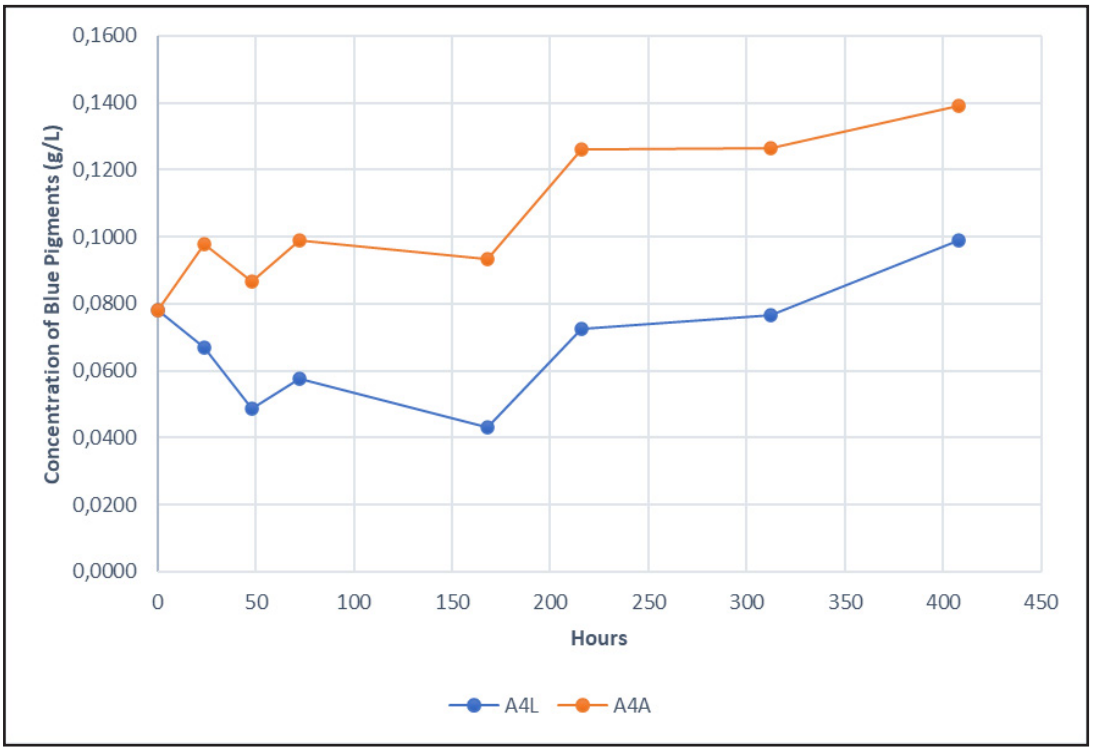


Source: Author's own elaboration, 2023
*A3L- Sample 3 in the presence of light; A3A- Sample 3 in the absence of light

The similarity of the behavior of both conditions regarding exposure to light also remains in sample 3. With its phases marked by loss of concentration and followed by partial recovery. However, the final concentration of the blue pigments in this sample showed a reduction of approximately 52% from the initial value.

Sample 4 obtained from extraction in 50% ethanol and addition of glutamic acid was the only one that demonstrated a difference in relation to light exposure when compared to samples 1, 2 and 3 (Figure 6). The sample was kept in the absence of light (A4a) with a greater recovery in the concentration of blue pigments.

Figure 6 – Blue pigment concentration in sample 4 for 408 hours under two conditions



Source: Author's own elaboration, 2023
*A4L- Sample 4 in the presence of light; A4A- Sample 4 in the absence of light

Samples packaged in the absence of light in the first 24 hours obtained an increase in their concentration, followed by a reduction. On the other hand, the sample exposed to light during the first 48 hours showed an initial reduction, followed by an increase. From 48 hours, the behavior was similar for both samples, but the sample subjected to light showed reduced values compared to the sample maintained in the absence of light.

3.5 pH

The pH values correspond to the means and standard deviation obtained from each sample of the dye extracted from jenipapo.

According to Hoffmann (2001), the jenipapo mesocarp has pH values between 4.0 and 4.5, while the endocarp has a pH above 4.0. As in the samples studied, both the mesocarp and the endocarp were used, and with the use of ethanol with pH 4.0 in part of the samples, the pH obtained in the dye is within the range reported in the literature. However, with the addition of glutamic acid, samples A2 and A4 acquire a more acidic pH compared to the others and do not differ significantly from each other through the Tukey test. Sample A2, when compared to A1, which uses the same solvent but without addition of acid, has a reduced pH. The same occurs with samples A4 and A3, and sample A4 presents a pH reduction of greater magnitude.

3.6 Antioxidant capability

Samples of the dyes obtained from jenipapo in 4 different conditions were analyzed when the antioxidant capacity by ABTS and DPPH methods. The antioxidant capacity of fruits is extremely important due to their ability to inhibit oxidative processes, as well as their role in protecting against diseases from their daily consumption (Dickson, 2021).

For jenipapo in natura, Souza et al. (2008) obtained a value of 7.31 µmol TEs/g of fruit through the ABTS method. For the dry extract analyzed by Vedana et al. (2008), the values for the ABTS and DPPH methods were 0.40 ± 0.00 mmol TE/g of fruit and 10.17 ± 0.36%, respectively. These values differ from those found in this study (ABTS: A1: 13,35a ± 2,15; A2: 17,09b ± 2,99; A3: 11,87a ± 2,00; A4: 12,50a ± 1,84) (DPPH: A1: 2,01a ± 0,36; A2: 1,39b ± 0,29; A3: 1,31b ± 0,41 A4: 2,94c ± 0,20), one of the factors being the extraction methods.

For the abt method, sample 2 has a higher antioxidant capacity, followed by sample 1. Sample 4 had a similar behavior to sample 2, being larger than sample 3. However, it is important to highlight that samples extracted in 50% ethanol showed lower values compared to those extracted in water. In addition, statistical analysis

using the Tukey test revealed significant differences only for sample 2, which suggests the influence of glutamic acid in relation to the extraction method.

The results by the DPPH method showed a different behavior in relation to the samples, when compared to the ABTS method. Sample 4 had the highest antioxidant content, followed by sample 1. The behavior of the influence of the addition of glutamic acid on the increase in antioxidant capacity is only observed in samples extracted in 50% ethanol. In this method, extraction in water resulted in a reduction of antioxidant capacity when glutamic acid was added. However, samples 2 and 3 showed no significant difference through the statistical analysis of the Tukey test, which suggests that the addition of glutamic acid did not interfere with the antioxidant capacity values by this method.

Santos et al. (2008) quantified the antioxidant capacity of grape extracts using the ABTS and DPPH methods, in which similar values were found for both methods. The grape extracts in the study showed a value of 4.31 μmolTrolox/g fruit. When comparing this value with the antioxidant activity of the jenipapo colouring extracts obtained by the ABTS method, it is observed that the samples analyzed have an antioxidant content approximately 3 times higher than that of the grape. Similar values are also reported by Moura et al. (2009) for açaí pulps of different brands analyzed, with variations in results between 10.21 and 52.47 μM trolox/g of sample.

When compared to fruit extracts known for their high antioxidant content such as Jamelão, which has 927.27 μM trolox/g fruit (ethanolic extract); 8465.65 μM trolox/g fruit (concentrated extract) and Jabuticaba, which has 116 μM trolox/g fruit (aqueous extract); 723 μM trolox/g fruit (ethanolic extract), the values obtained are considered low (Resende et al. 2022).

3.7 Colour Determination

The colourimetry measurement of the dyes obtained through the four different formulations showed similarity in their coordinates. Although noticeably the addition of glutamic acid in samples 2 and 4 show a stronger shade of blue

(Fig. 1), through the cielab colour solid, it is noted that all samples are in the same colour space of the diagram. The luminosity and the b* coordinate showed no significant difference when the Tukey test was applied. Only the a* coordinate of sample 1 showed a significant difference in relation to samples 3 and 4. This suggests that the solvent influenced this result; however, sample 2, which has the same solvent as sample 1, but has the addition of glutamic acid in the extraction step, showed no significant difference in relation to the other samples.

4 CONCLUSIONS

The use of glutamic acid in the extraction process of the blue dye from jenipapo proved to be efficient for both solvents used (water and ethanol 50%). The concentration of blue pigments in samples 2 and 4 increased significantly during the 408 hours of analysis, with increases of 181% (A2L), 166% (A2A) and 126% (A4L), 178% (A4a). Samples 2 and 4 also showed similar behavior regarding stability. As for pH, the samples with addition of glutamic acid reduced their values and, even with different solvents, did not differ significantly from each other. Regarding the antioxidant capacity by the ABTS method, sample 2 obtained the best result, while by the DPPH method, sample 4 obtained the most significant result. However, glutamic acid showed no significant influence on colour determination. Since genipap is a primitive fruit, with enormous variability and geographical influence, in addition to there being no genetic improvement, the addition of glutamic acid contributes to solving the problems related to the lack of uniformity of the fruit.

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