

Colorimetric parameters as a stability indicative of banana alcoholic extract submitted to storage

Parâmetros colorimétricos como indicadores de estabilidade do extrato alcoólico de banana submetido ao armazenamento

Parámetros colorimétricos como indicativo de estabilidad del extracto alcohólico de banano sometido a almacenamiento

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Abstract

Studying the stability of the raw material as a function of the storage time is fundamental to establish the characteristics performance and to determine the period that it should be stored. The objective of the present study was to evaluate the stability of the alcoholic extract for 28 days of storage. It was performed in a completely randomized and split-plot design (3x5) with 3 repetitions and using the following formulation: 500 g of banana components (peel, pulp or peel plus pulp), 1000 mL of cereal alcohol 96 °GL and maceration process for fifteen days. Filtered alcoholic extracts were stored in a dark place at room temperature for analysis of colorimetric parameters Luminosity, hue, chroma, chromaticity a* and chromaticity b*. Results showed that storage period for 28 days significantly affected stability, promoting notable reduction in Luminosity, hue, chromaticity b* and chroma and also increased the

chromaticity value chromaticity a^* . It was observed that the banana pulp alcoholic extract showed the highest values for Luminosity and hue, and the banana peel alcoholic extract stood out in relation to the chromaticity chroma, chromaticity a^* and chromaticity b^* . The information obtained through colorimetric parameters can be used by the food industry to establish procedures that mitigate the effects of the storage period in the raw material, since the characteristics inherent to the raw material are significantly changed over time and result in changes in the quality of the final product.

Keywords: Alcoholic maceration; Colour; Storage; Colour degradation kinetics; Fruit peel; Agro-industrial residues.

Resumo

Estudar a estabilidade da matéria-prima em função do tempo de armazenamento é fundamental para estabelecer o desempenho das características e determinar o período que ela deve ser armazenada. O objetivo do presente estudo foi avaliar a estabilidade do extrato alcoólico por 28 dias de armazenamento. Foi realizado em delineamento inteiramente casualizado e subdividido (3x5) com 3 repetições e utilizando a seguinte formulação: 500 g dos componentes da banana (casca, polpa ou casca mais polpa), 1000 mL de álcool de cereais 96 °GL e processo de maceração por quinze dias. Os extratos alcoólicos filtrados foram armazenados em local escuro à temperatura ambiente para análise dos parâmetros colorimétricos Luminosidade, tonalidade, croma, cromaticidade a^* e cromaticidade b^* . Os resultados mostraram que o período de armazenamento por 28 dias afetou significativamente a estabilidade, promovendo notável redução na luminosidade, tonalidade, cromaticidade b^* e croma e também aumentou o valor de cromaticidade da cromaticidade a^* . Observou-se que o extrato alcoólico da polpa de banana apresentou os maiores valores para Luminosidade e tonalidade, e o extrato alcoólico da casca de banana se destacou em relação ao croma de cromaticidade, cromaticidade a^* e cromaticidade b^* . As informações obtidas por meio de parâmetros colorimétricos podem ser utilizadas pela indústria de alimentos para estabelecer procedimentos que mitiguem os efeitos do período de armazenamento na matéria-prima, uma vez que as características inerentes à matéria-prima mudam significativamente ao longo do tempo e resultam em mudanças na qualidade do produto final.

Palavras-chave: Maceração alcoólica; Cor; Armazenamento; Cinética de degradação da cor; Casca de fruta; Resíduos agroindustriais.

Resumen

Estudiar la estabilidad de la materia prima en función del tiempo de almacenamiento es fundamental para establecer las características de desempeño y determinar el período de almacenamiento. El objetivo del presente estudio fue evaluar la estabilidad del extracto alcohólico durante 28 días de almacenamiento. Se realizó en un diseño completamente aleatorizado y en parcelas divididas (3x5) con 3 repeticiones, utilizando la siguiente formulación: 500 g de componentes de plátano (piel, pulpa o piel más pulpa), 1000 mL de alcohol de cereal 96 °GL y proceso de maceración por quince días. Los extractos alcohólicos filtrados se almacenaron en un lugar oscuro a temperatura ambiente para el análisis de los parámetros colorimétricos Luminosidad, tono, croma, cromaticidad a* y cromaticidad b*. Los resultados mostraron que el período de almacenamiento de 28 días afectó significativamente la estabilidad, promoviendo una reducción notable en Luminosidad, tono, cromaticidad b* y croma y también aumentó el valor de cromaticidad a*. Se observó que el extracto alcohólico de pulpa de plátano presentó los valores más altos de Luminosidad y tono, y el extracto alcohólico de cáscara de plátano se destacó en relación a la cromaticidad croma, cromaticidad a* y cromaticidad b*. La información obtenida mediante parámetros colorimétricos puede ser utilizada por la industria alimentaria para establecer procedimientos que mitiguen los efectos del período de almacenamiento en la materia prima, ya que las características inherentes a la materia prima se modifican significativamente con el tiempo y resultan en cambios en la calidad del producto final.

Palabras clave: Maceración alcohólica; Color; Almacenamiento; Cinética de degradación del color; Piel de frutos; Residuos agroindustriales.

1. Introduction

Banana (*Musa* spp.) belongs to the Musaceae family and has its centre of origin on the Asian continent, where diploid, triploid and tetraploid banana trees can be found. It is one of the most consumed fruits in the world (Fioravanço, 2003) being grown by 107 countries (Silva et al., 2013). In 2017, the world banana production reached 125.3 million tons. The biggest producers were India with 30.5 million tons, China with 22.8 million tons, Indonesia with 7.2 million tons, Brazil with 6.7 million tons and Ecuador with 6.2 million tons. The world's largest consumer was China (FAOSTAT, 2017).

As an excellent source of calories, vitamins and minerals, bananas are a suitable food for all ages, mainly due to their source of potassium and carbohydrates (Siji & Nandini, 2017). For this reason, there are several studies that use bananas, or even green banana flour in food production (Silva et al., 2015) as breads (Silva et al., 2014; Oliveira et al., 2015), *brigadeiro* (chocolate truffle) (Moura et al., 2012; Silva Guterres & de Araújo, 2019), liqueur (Teixeira et al., 2007; Jesus Filho et al., 2018) and many others.

In view of the widespread use of bananas in food, the use of residues such as peel should be considered, mainly considering their great potential for use due to the presence of important chemical characteristics, for example bioactive compounds, which provide satisfactory sensory characteristics to products (Gastl Filho & Labegalini, 2017). In addition, the banana peel is already used in the production of cake (Bressiani et al., 2017), mariola type candy (Oliveira Neto et al., 2018), cereal bar (Santos et al., 2017), cupcake (Silva & Silva, 2018), among others. Fruit peels are also fundamental in the production of some liqueurs (Gastl Filho & Labegalini, 2017; Silva et al., 2017) when used together with grain alcohol for the purpose of maceration and extraction of the nutritional and sensory components from the peel.

According to Oriqui et al. (2013), the stability study has as main objective the search for evidences about products quality over time when they are exposed to different environmental factors as temperature, moisture and light to determine the shelf life, that is, the period of time in which the product maintains its quality characteristics according to the pre-established standards.

According to Sui et al. (Sui et al., 2016) one of the main parameters used by consumers as a quality indicator is the colour of the products. The colour influences issues of affinity and aesthetics of products and makes them more attractive or unattractive to consumers.

It is extremely important to know the stability of food products and raw materials during storage, such as alcoholic banana extracts, which are used as a raw material for the processing of various beverages and foods in Central and South America, bearing in mind that food industries often have to produce large volumes of extracts in periods that precede the shortage of banana fruits, in order to maintain the continuous supply to the consumer market during the off-season or due to other adversity.

Thus, for the use of alcoholic extract in the production of beverages or essences for bakery products, whether it is produced from the peel, pulp or even from the whole fruit it is necessary to ensure its stability. This stability can be assessed using colorimetric parameters.

The aim of the present study was to evaluate the stability of the alcoholic extract obtained from banana pulp, whole banana fruit (pulp plus the peel) and banana peel over 28 days of storage.

2. Materials and Methods

This study was carried out at the Food Laboratory and the Analytical Chemistry Laboratory from the Federal Institute of Education, Science and Technology of Triângulo Mineiro - IFTM, in Ituiutaba, Minas Gerais, Brazil, in 2017 and 2018.

The experiment was conducted as a completely randomized design, in a 3 x 5 split-plot design, with 3 replicates, in which the plot factor was the alcoholic extract (banana pulp alcoholic extract, whole banana alcoholic extract and banana peel alcoholic extract) and the subplot factor was the storage period (0, 7, 14, 21 and 28 days).

To obtain the alcoholic extract, the used fruit was the Cavendish banana (*Musa acuminata* 'Dwarf Cavendish'), acquired in local trade in Ituiutaba, Minas Gerais, Brazil. The alcoholic source used to obtain the banana alcoholic extract was cereal alcohol 96 °GL (°GL) acquired in a certified industry located in Uberlândia, Minas Gerais, Brazil.

The methodology used to get alcoholic extracts was the one recommended by the booklet of the Technological Institute of Pernambuco, Pernambuco, Brazil (1985) for the liqueurs production.

The chosen fruits were yellow with brown spots, corresponding to the note 7 on the Von Loesecke maturation scale (Von Loesecke, 1950), which is an indication that the fruits reached the maximum point of maturity, being ideal for the food products manufacture such as liqueurs. The fruits, free of injuries, were washed in running water and, subsequently, immersed in a 30 ppm solution of sodium hypochlorite for a period of fifteen minutes for sanitization.

To obtain the alcoholic extract of the banana pulp, the fruits were peeled and sliced about 1 cm thick. For the alcoholic extract of the whole banana fruit (pulp plus the peel) they were sliced about 1 cm thick. For the processing of the banana peel alcoholic extract, the obtained peels were sliced in thin strips.

The formulation used for all alcoholic extracts was 500 g of pulp, whole banana fruit or banana peel in 1000 mL of grain alcohol 96 °GL, the fruits were transferred to glass jars covered with laminated paper. The used process was alcoholic extraction and cold maceration, which components were left in a dark place at room temperature for fifteen days,

with daily agitation being performed in order to increase the specific surface area between the fruits and the grain alcohol to improve the efficiency of the bioactive and volatile compounds extraction.

At the end of the alcoholic maceration process, the hydro alcoholic mixture was filtered using cotton flannels. The alcoholic extracts were packed in glass bottles covered with laminated paper and then stored in a dark place at room temperature for the colorimetric parameters analysis.

The stability of alcoholic extracts was monitored for 28 days through the colorimetric parameters evaluation every 7 days using a portable digital colorimeter, model Delta Vista D8 - SN 7002000356, Delta Color, São Leopoldo, Brazil.

The obtained colour parameters were luminosity (L^*) that corresponds to the bright dark, which value 0.0 is black and the value 100.0 is white; chromaticity a^* , which positive values indicate red and negative values indicate green; chromaticity b^* , which positive values indicate yellow and negatives indicate blue; chroma (C^*) ranging from 0.0 to 60.0, the higher the value, the more saturated the colour will be; hue (h^*) expressed in rad. The alcoholic extracts were previously homogenized by inversion, with subsequent collection of samples at the central point of the container and carried out in triplicate analysis.

The obtained data were submitted to the Shapiro-Wilk test to verify the Residual Normality. The results were also submitted to analysis of variance (ANOVA). The means of alcoholic extracts were compared by the Tukey multiple comparison test at 5% of probability and the effects of the storage periods were evaluated by means of regression analysis adopting the criterion for choice of the model, the magnitude of the significant regression coefficients at 5% probability by the t-test. The used statistical program was R version 3.6.2 (Dark and Stormy Night) (R core Team, 2019).

3. Results and Discussion

Analysis of variance by the F-test showed that there were significant differences ($p < 0.05$) for the simple effects of alcoholic extract (AE) and storage period (SP) for all evaluated colorimetric parameters, although in relation to the interaction AE x SP, there were no significant differences ($p > 0.05$), except for the colorimetric parameter of L^* . The colorimetric parameters showed residues with normal distribution (Table 1).

Table 1. Summary of the analysis of variance for colorimetric parameters of three banana alcoholic extracts and five storage periods.

FV	GL	L*	a*	b*	C*	h*
Alcoholic extract (AE)	2	182.988*	127.547*	424.860*	448.720*	1298.250*
Residual a	6	0.031	0.013	0.060	0.060	0.090
Storage period (SP)	4	0.738*	1.189*	5.550*	5.830	21.170*
AE x SP	8	0.309*	0.041 ^{ns}	0.370 ^{ns}	0.410*	0.900 ^{ns}
Residual b	24	0.028	0.036	0.290	0.280 ^{ns}	0.560
Total	44					
CV 1 (%)		0.74	8.30	1.57	1.54	0.35
CV 2 (%)		0.70	13.74	3.42	3.34	0.86
SW		0.395 ^{ns}	0.365 ^{ns}	0.174 ^{ns}	0.195 ^{ns}	0.265 ^{ns}

Significant by the F-test at 5% probability. ^{ns}Not significant. Abbreviations: FV: Source of Variation; GL: Degrees of Freedom; L: luminosity; a*: chromaticity a*; b*: chromaticity b*; C*: chroma; h*: hue; CV: Coefficient of variation; SW: Normality of residues by the Shapiro-Wilk test, at a level of 5.0% probability of error. Source: by authors, (2020).

Significant differences ($p < 0.05$) were found in the interaction between AE x SP for the colorimetric parameter of L*. It was observed in all periods that the banana peel alcoholic extract showed the significantly lowest L*, that is, it was closer to absolute black than the other alcoholic extracts. Banana pulp alcoholic extract was the one that presented significantly higher L* than in relation to the other alcoholic extracts, being more distant from the absolute black (Table 2).

Table 2. Luminosity (L*) of three banana alcoholic extracts submitted to five storage periods.

Storage period (days)	Banana pulp	Whole banana	Banana peel
0	26.88 a ¹	24.28 b	20.79 c
7	26.52 a	23.96 b	19.77 c
14	27.17 a	24.51 b	19.77 c
21	26.68 a	24.35 b	19.53 c
28	26.42 a	24.12 b	19.34 c
Mean	26.73 a	24.24 b	19.84 c

¹Mean with different letters on the same line, differ statistically from each other, by the Tukey's test at 5% probability. Source: by authors, (2020).

Izidoro et al. (2008), performing the physical-chemical, colorimetric and sensory acceptance evaluation of emulsion stabilized with green banana pulp, found that the higher the pulp proportion, the lower the L* values. They also found that the formulations with the lowest pulp content of green bananas showed higher values of L*. This result is different from the present study, since it was observed that the higher the concentration of pulp in the formulation, the higher the L*. This difference is probably due to the fact that fruits were used at their maximum maturation point and Izidoro et al. (2008) made use of green fruits.

In an evaluation of the quality of bread with addition of flour and pureed green banana, Oliveira et al. (Oliveira et al., 2015) found that the breads, added with flour and pureed green banana, resulted in darker products in relation to the standard, both crust and crumb, a fact that is justified by the darker colour of the substitutes in relation to wheat flour. Such result was also verified by Mohamed et al. (2010), in their study with bread formulations with high banana powder content, where it was observed that the L* value decreased significantly, according to the increase in the banana powder content.

The difference in L* between the banana peel alcoholic extract and the banana pulp alcoholic extract may have occurred because of the difference in their compositions. In a study on the percentage of dry matter, mineral content and the capacity to supply minerals in the pulp and peel of green and ripe fruits of 15 banana cultivars showed that, for N, P, Fe, Zn and Cu, the peel showed twice the content observed in the pulp and the average levels of K and Mn in the peel were approximately four times higher than the contents of the pulp (Aquino et al., 2014).

There are also studies in the literature that report banana peel as a rich source of phenolic compounds and flavonoid compounds. Their concentrations are higher than the concentrations of the same compounds in banana pulp and highlight their importance in antioxidant activity (Rebello, 2013). Pereira (2015) also found a higher content of total phenols, total flavonoids and antioxidant activity in the banana peel than in the pulp. Thus, the elements probably contributed to the difference in L* between alcoholic extracts making them darker or lighter, depending on the composition of bioactive compounds and colour.

Mulas and Melis (2008) were studying the influence of the cultivation area, year, season and cultivar on the composition of leaves and alcoholic infusions of blueberries (*Myrtuscommunis* L.) when observed that the dark colour of the leaf's hydro alcoholic infusions (L*) seemed to be unrelated to the chlorophyll content of the leaf and that the negative correlations found between the infusion (L*) and the content of chlorophylls, tannins

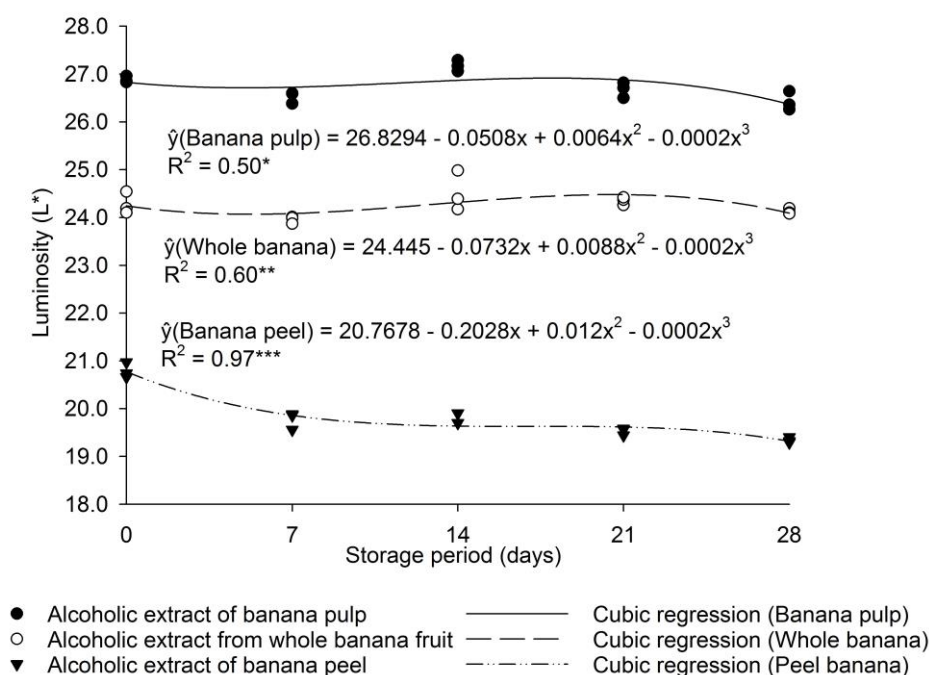
and polyphenols clearly indicate that these components are responsible for the pale brown colour of the blueberries infusion.

The colour parameters of the red wine samples indicated that the darkest samples had the lowest L* indexes, that is, they were the closest to absolute black, and the lightest sample presented the highest L* and pointed out that wines with a pH greater than 3.9 were more susceptible to the oxidation of phenolic compounds and, therefore, to the loss of their youthful colour (Oliveira et al., 2011).

It was verified that the L* of the banana pulp alcoholic extract showed a tendency ($p < 0.05$) of decrease due to the storage period from the 14th, that is, the longer the storage period of the banana pulp alcoholic extract was, the lower was its L*. The model adjusted to the cubic regression, with a maximum value of 26.84 for L*, was observed in a storage period of 16.06 days (Figure 1).

It was observed that the L* of the banana peel alcoholic extract showed a tendency to decrease ($p < 0.001$) as a function of the storage period, that is, the longer was the storage period, the lower was its L*. This alcoholic extract proved to be less stable in relation to L* than in relation to the other alcoholic extracts, bearing in mind that the presented trend was more accentuated than the others. The model adjusted to the cubic regression, observing the maximum value of 20.11 for L*, was in a storage period of 27,874 days (Figure 1).

Figure 1. Luminosity (L*) of three banana alcoholic extracts as a function of storage period.



Source: by authors, (2020).

For whole banana alcoholic extract, it was observed that the trend of L^* ($p < 0.01$) was decreasing from day 0 to day 7 and resumption of growth was from day 7 to day 21 of storage, tending to decrease from 21st to 28th day. In general, it is possible to see the trend curve, which values keep more or less stable depending on the storage period. The model fits the cubic regression with a maximum value of 24.99 for L^* being observed in a storage period of 24.32 days (Figure 1).

Teixeira et al. (2005), when carrying out the monitoring of alcoholic extraction in the processing of banana liqueur, identified that for all treatments the value of L^* was ascending until the time of 16 days and then declined. The authors also noted that the density increased from 16 days and justified that this probably occurred due to the extraction of sugars from the banana, which in turn overshadowed the L^* and contributed to the decrease in the L^* value. In addition, Teixeira et al. (2005) pointed out that, under the L^* point of view, the extraction of the ideal banana pulp would last 16 days.

Experiments on the influence of temperature on the physical, physical-chemical and chemical changes of silver banana peel jelly during storage showed that the L^* values were significantly altered as a function of time, which characterized the darkening of the jellies, a fact that can be explained by the oxidation of pigments such as phenolic compounds, chlorophyll and carotene (Dias et al., 2011). This result is similar to the present study, since alcoholic extracts showed a significant tendency to darken as a function of time.

When studying the effects of cold storage of blueberries under an atmosphere modified for liquor quality, Fadda et al. (Fadda et al., 2017) observed that since the first 10 days of storage, the colour of the blueberry changed from violet to dark red, that was one of the reasons for the decrease in L^* values. Tuberoso et al. (2008), when studying the effects of different technological processes on the chemical composition of the blueberry alcoholic extracts, found that the L^* of all samples decreased until the third week and then increased gradually.

Oliveira et al. (2015), when assessing the physical and chemical stability of soursop (*Annona muricata* L.) liqueurs during storage under environmental conditions, concluded that the L^* parameters were significantly reduced at the end of storage. According to the author, at the end of the processing the soursop liqueurs remained clear (time 0) with L^* ranging from 55.71 to 61.27 and later the L^* of the liqueurs decreased significantly ($p < 0.05$) during storage reaching values below 44.00 in all formulations. A fact is probably justified by the synthesis of dark compounds through the Maillard reaction, since soursop has a considerable amount of

protein in its composition, and the free amino acids from the pulp can react with reducing sugars synthesizing melanoidins.

A study on the physical-chemical and microbiological stability of organic dehydrated banana showed a significant difference for L* during storage, a decline from zero point was observed and characterized by browning and loss of brightness, which were due to non-enzymatic reactions (Batista et al., 2014).

Melo (2006), when studying the inhibition of enzymatic browning of minimally processed banana, observed a reduction in L* values during storage, regardless of the chemical treatment to avoid it. However, the authors identified 1% ascorbic acid + 1% calcium chloride + 1.5% cysteine as the most effective treatment in preventing changes in L* values associated with banana colour.

Significant differences ($p < 0.05$) were found in the simple effect of alcoholic extract for the colorimetric parameter of chromaticity a*. Banana pulp alcoholic extract showed significantly the lowest value for a*, that was negative and corresponding to the green colour. Whole banana alcoholic extract and the banana peel alcoholic extract showed positive values of a*, corresponding to the red colour, and the banana peel alcoholic extract showed the value significantly higher than the one in relation to the others (Table 3).

Table 3. Chromaticity a* and Chromaticity b* of three banana alcoholic extracts submitted to five storage periods.

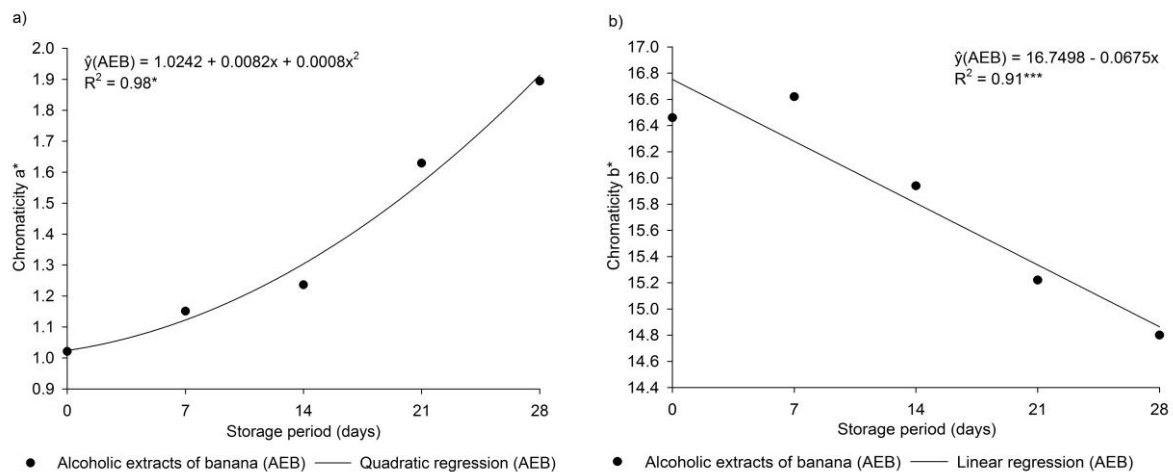
Storage period (days)	Chromaticity a*			Chromaticity b*		
	Banana pulp	Whole banana	Banana peel	Banana pulp	Whole banana	Banana peel
0	-1.313	0.237	4.140	10.31	17.89	21.18
7	-1.303	0.297	4.460	10.73	17.77	21.35
14	-1.030	0.353	4.383	9.84	16.97	21.00
21	-0.743	0.680	4.950	9.71	16.42	19.53
28	-0.490	0.880	5.293	9.43	15.71	19.25
Mean	-0.976 c ¹	0.489 b	5.645 a	10.00 c	16.95 b	20.46 a

¹Mean with different letters on the same line, differ statistically from each other, by the Tukey's test at 5% probability. Source: by authors, (2020).

It was found that the chromaticity a* of the three banana alcoholic extracts showed a growth trend ($p < 0.05$) as a function of the storage period, that is, the longer the storage period

for the alcoholic extracts, the greater the values of a^* , in other words, the colour of alcoholic extracts was redder. The model adjusted to the quadratic regression, with a maximum value of 1,087 for a^* , was observed in a storage period of 5.13 days (Figure 2a).

Figure 2. Chromaticity a^* (a) and chromaticity b^* (b) of three banana alcoholic extracts as a function of the storage period.



Source: by authors, (2020).

There were significant differences ($p < 0.05$) for the simple effect of alcoholic extract for the colorimetric parameter of chromaticity b^* . All alcoholic extracts showed positive values, corresponding to yellow, an expected fact, in view of the visible colouration of the fruits. The banana pulp alcoholic extract showed significantly the lowest value for b^* , that is, it was the least yellow extract compared to the others. Banana peel alcoholic extract showed a value significantly higher than the one in relation to the others, in other words, its colour was more yellow (Table 3).

It was found that the chromaticity b^* of the three banana alcoholic extracts tended to decrease ($p < 0.001$) as a function of the storage period, that is, the longer the storage period for the alcoholic extracts, the lower the values of b^* , in other words, less yellow were the extracts. The model adjusted to linear regression, with a maximum value of 16.75 for b^* was observed in a storage period of -0.07 days (Figure 2b).

Ortolan et al. (2010), in their study about the effect of storage at low temperature (-4 °C) on the colour and acidity content of wheat flour, concluded that as the storage time increased, from the initial time to six months, the flour became whiter due to the increase in the L^* of the flours and by the reduction of the chromaticity coordinates a^* and b^* .

Oliveira et al. (2015), when studying the physical and chemical stability of soursop liqueurs during storage under environmental conditions, found that soursop liqueurs in low density polyethylene packaging promoted, at the end of storage, significant increases in the total sugar values, total soluble solids and chromaticities a^* and b^* .

With the increase in the storage time of bocaiuva flour (*Acrocomiaaculeata* (Jacq.) Lood. ex. Mart) produced by artisanal and mechanized process, Galvani et al. (2016) observed a downward trend in the b^* chromaticity coordinate values for artisanal and mechanized flours; this was more evident in the chromaticity coordinate b^* , indicating a tendency to move away from yellow. For the chromaticity coordinate a^* there was an increase with the storage period, indicating a tendency to move away from green.

Fadda et al. (2017), in their study about the effects of cold storage of blueberries under atmosphere modified for liquor quality, observed that since the first 10 days of storage, the colour of the blueberry changed from violet to dark red, that was one of reasons for the decrease in b^* and hue angle associated with an increase in redness (a^*).

Dias et al. (2011), when studying the influence of temperature on the physical, physical-chemical and chemical changes of banana peel jelly cultivar Prata during storage, observed that at 75 days there was an increase in the red colour (a^*), tending to reduce to the end of storage. There was also a reduction in the yellow colour (b^*) and L^* over the 165 days.

Batista et al. (2014), studying the physical-chemical and microbiological stability of organic dehydrated banana, found a darkening of the product in the three analysed varieties. In addition to the significant loss of brightness, also occurred a decrease in the intensity of the yellow colour (b^*) and an increase in the intensity of the red colour (a^*) during storage.

Izidoro et al. (2008), in their physical-chemical, colorimetric evaluation and sensory acceptance of emulsion stabilized with green banana pulp, found that the higher was the proportion of pulp, the higher were the values of a^* and b^* , a result different from that of the present study, probably, because they had use of green fruits.

Significant differences ($p < 0.05$) were observed for the simple effect of alcoholic extract for the colorimetric parameter of C^* . Banana pulp alcoholic extract showed significantly the lowest value for C^* . Banana peel alcoholic extract showed a significantly higher value for C^* than in relation to the others, that is, its colour was more saturated (Table 4).

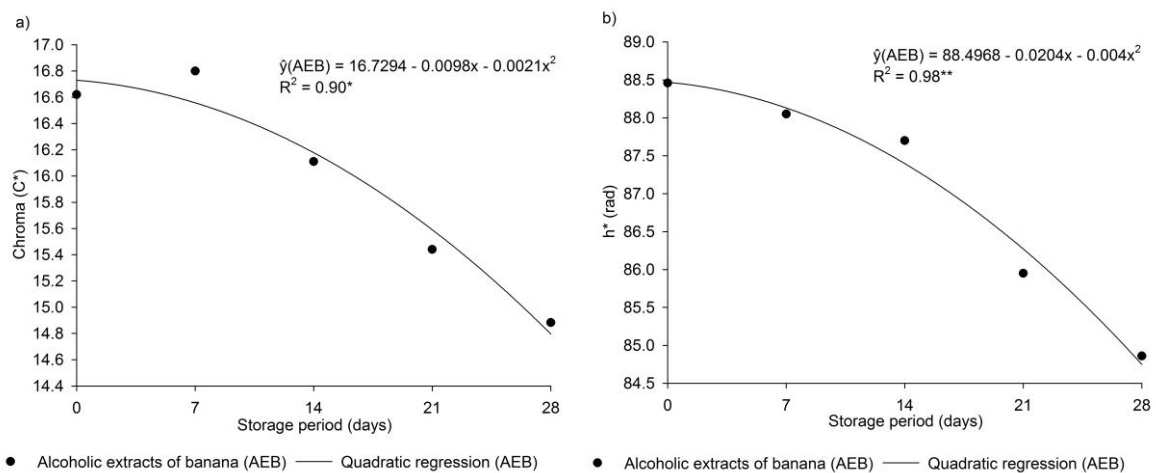
Table 4. Chroma (C*) and hue (h*) of three banana alcoholic extracts submitted to five storage periods.

Storage period (days)	C*			h* (rad)		
	Banana pulp	Whole banana	Banana peel	Banana pulp	Whole banana	Banana peel
0	10.390	17.890	21.580	97.27	89.23	78.89
7	10.810	17.770	21.817	96.94	89.01	78.19
14	9.897	16.977	21.457	96.00	88.89	78.20
21	9.740	16.437	20.143	94.38	87.73	75.75
28	9.543	15.697	19.410	93.11	87.04	74.41
Mean	10.076 c ¹	16.954 b	20.881 a	95.54 a	88.38 b	77.09 c

¹Mean with different letters on the same line, differ statistically from each other, by the Tukey's test at 5% probability. Source: by authors, (2020).

A decreasing trend ($p < 0.05$) C* was observed for the three banana alcoholic extracts as a function of the storage period, that is, the longer the storage period for the banana alcoholic extracts was, the lower was the colour saturation. The model adjusted to the quadratic regression, observing the maximum value of 16,695 for C*, in a storage period of 2.33 days (Figure 3a).

Figure 3. Chroma (C*) (A) and hue (h*) (B) of three banana alcoholic extracts as a function of storage period.



Source: by authors, (2020).

Fai et al. (2015), studying the production and application of edible coating based on minimally processed fruit and vegetable residues in carrots (*Daucuscarota* L.), observed a reduction in chromatic coordinates a^* and b^* as a function of time, which implied a consequent decrease in values of C^* . Thus, the evaluated samples showed a tendency to decrease the value of C^* throughout the experiment, ranging from 59.0 to 46.0 and from 52.0 to 48.0 for coated and uncoated samples, respectively.

Galvani et al. (2016) observed that C^* showed a higher value for artisanal flour on the first day of storage and declined in other periods. Barbosa et al. (2019), evaluating the post-harvest quality of banana 'Pacovan' under different storage conditions, observed that the fruits that were submitted to the temperature of 12 °C presented on the 3rd and 6th days of storage, with a value of C^* higher in relation to fruits that were stored at room temperature and, in addition, they remained between 45.93 and 48.24, respectively. At room temperature, after the 6th day, there was an increase, reaching 56.47.

Significant differences were observed ($p < 0.05$) for the simple effect of alcoholic extract for the colorimetric parameter of h^* . All alcoholic extracts showed a yellow colour trend (90°). Banana pulp alcoholic extract showed significantly the lowest value for the angle of h^* , its value corresponding to the shade of green pea. The value, obtained for the h^* angle of the whole banana alcoholic extract, corresponded to the shade of chartreuse green. Finally, the value of h^* , obtained for the banana peel alcoholic extract, corresponded to the shade of green grape, its value was the significantly higher (Table 4).

There was a tendency ($p < 0.01$) to decrease the h^* angle of the three banana alcoholic extracts as a function of the storage period, that is, the longer the storage period for the banana alcoholic extracts was, the smaller the h^* angle was, and the greater was the colour change. The extracts showed a tendency from yellow (90°) toward red (0°). The model adjusted to quadratic regression, with a maximum value of 88.42 for h^* was observed in a storage period of 2.55 days (Figure 3b).

Barbosa et al. (2019), when studying the post-harvest quality of Pacovan banana under different storage conditions by parameter h^* , observed the tendency of yellow colour (90°) over time at room temperature (25 ± 1 °C) and the proximity of green colour (180°) at a temperature of 12 ± 1 °C, and justified the change of green to yellow colour during the ripening of the fruits by the degradation of chlorophyll and the visibility of the carotenoids. This process, resulting from the breakdown of the chlorophyll structure, mainly due to changes in the pH, activation of chlorophylls and presence of oxidizing systems, was caused

by increased breathing in climacteric fruits. As breathing is closely linked to temperature, storage at 12 °C contributed to the reduction of chlorophyll degradation.

In an experiment on the stability of apple jellies and rose petals during storage, a linear increase in the values of the h^* angle of the jellies was observed, from 17.03° to 25.95° during 10 months of storage (Lourenço et al., 2020). The h^* angle of the jelly distanced from (0°) corresponding to the red colour, that is, there was a reduction of the red colour during storage (Barbosa et al, 2019).

Galvani et al. (2016), when carrying out the characterization and the study on the storage of bocaiuva flours produced by artisanal and mechanized process, found that the angle h^* presented greater value for artisanal flour on the first day of storage and decreased in the other periods, that was a similar result to the present study.

4. Final Considerations

The colorimetric parameters indicated that the storage of banana alcoholic extracts for 28 days significantly affected its stability, promoting a significant reduction in the values of L^* , angle h^* and chromaticities b^* and C^* . On the other hand, it promoted the increase in chromaticity values a^* . It was also observed that the banana pulp alcoholic extract showed the highest values for L^* and the angle of h^* , while the banana peel alcoholic extract stood out in relation to the chromaticity C^* , a^* and b^* . The information obtained through colorimetric parameters in relation to the stability of alcoholic banana extracts can be used by the food industry to establish procedures that mitigate the effects of the storage period in the raw material until its use in processing, since the characteristics inherent to the raw material are significantly changed over time and result in changes in the quality of the final product.

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