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Effect of gellan gum concentration on the physicochemical, rheological and sensory properties of acerola smoothie

Amanda Rodrigues LEAL[1], Luiz Eduardo Oliveira HOLANDA[2], Fernanda Clara Moreira SOARES[2], Juliana Nascimento da COSTA[3], Luís Gustavo Lima NASCIMENTO[4], Jessica Silva do CARMO[3], Wende Carla da SILVA[5], Luciana Façanha MARQUES[5], Paulo Henrique Machado de SOUSA[1,2*]

Abstract

This study aimed to develop an acerola smoothie using gellan gum (GG) as a texture modifier. Samples were developed with three concentrations of GG (0.1%, 0.2%, 0.3% w/v) and a control sample (without GG). Physicochemical, rheological, and sensory properties were evaluated. The smoothie samples showed increased color intensity than the control, with a tendency to yellow and red colors. However, the hydrocolloid concentration did not affect the samples' pH values (4.13 to 4.17). GG presence favored an increase in the samples' viscosity, classified as pseudoplastic fluid. There was a reduction in vitamin C in samples with GG (422.18 to 430.49 mg/100 g), however, the values remained close to the control (448.89 mg/100 g). There was greater sensory acceptance by the sample with intermediate texture (0.2% GG), which obtained a higher frequency for the attributes "homogeneous" and "acerola flavor".

Keywords: hydrocolloid; fruit drink; low acylation; fluid gel.

Practical Application: Smoothie with acerola and gellan gum appear as a drink option with nutritional and sensory appeal.

1 Introduction

Smoothies are non-alcoholic creamy drink beverages consisting of a mixture of fruits or vegetables and crushed ice, added with yogurt or milk, with high creaminess and semi-liquid consistency. They can be additive-free and without added sugar, fulfilling all the current demands of consumers (Teleszko & Wojdyło, 2014; Cano-Lamadrid et al., 2018; Fernandez et al., 2019).

The consumer is more aware of the health problems associated with the diet. Therefore, there is a high demand for quality products with simple compositions, which provides health benefits. Thus, there is growing pressure on industries to develop foods that can supply this demand, and in this scenario, smoothies occupy a prominent place (Keenan et al., 2010; Young; Mills & Norton, 2020).

Various fruits, such as orange, banana, or apple, are widely used to produce commercial smoothies. Besides, other fruits with a high content of nutrients and sensory acceptance can also be incorporated in preparing these products, for example, red fruits (Hurtado et al., 2017). Recent studies have reported the development of smoothie drinks with different types of fruits and vegetables. Cano-Lamadrid et al. (2018) evaluated the storage conditions in the quality of pomegranate smoothies and fruit puree. Ribeiro et al. (2020) elaborated juçara, banana, and strawberry smoothies, which showed high sensory acceptability and contents of phenolic compounds. Camargo et al. (2020) analyzed the sensory acceptance of smoothie-type drinks based on oats associated with strawberries and bananas.

The acerola (*Malpighia emarginata* D.C.), a fruit originally from the tropical Americas, also called cherry from the Antilles or cherry from Barbados, shows an increasing expansion and economic importance, mainly due to the high content of vitamin C (1000-4000 mg/100 g in the fresh pulp), high antioxidant activity (90.41 μM TE/g for ABTS), carotenoids (371–1881 μg/100 g), phenolic compounds (256.22-2631.34 mg GAE/100 g), minerals and dietary fibers (Souza et al., 2014; Leffa et al., 2015; Jaeschke, Marczak, & Mercali, 2016; Lemos et al., 2019; Xu et al., 2020). As it has a reduced shelf life after harvest, part of the fruit is frozen and exported for processing in a variety of products, and another part is processed into pulp and clarified juice, nectars, among others (Albuquerque & Silva, 2008; Belwal et al., 2018). Thus, acerola has great potential for making smoothie-type beverages, associating the nutritional benefits of the fruit, with its acid flavor, aroma, and color characteristics.

The creamy consistency of smoothies can be achieved by elaborating a fluid gel and incorporating hydrocolloids in low concentrations. Fluid gels can be defined as a suspension of soft gelled particles dispersed in a continuous non-gelled phase,

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[1] *Departamento de Engenharia de Alimentos, Universidade Federal do Ceará, Fortaleza, CE, Brasil*
[2] *Instituto de Cultura e Arte, Universidade Federal do Ceará, Fortaleza, CE, Brasil*
[3] *Instituto Federal de Educação, Ciência e Tecnologia, Campus Sobral, Sobral, CE, Brasil*
[4] *Departamento de Tecnologia de Alimentos, Universidade Federal de Viçosa, Viçosa, MG, Brazil*
[5] *Instituto Federal de Educação, Ciência e Tecnologia do Sertão Pernambucano, Campus Salgueiro, Salgueiro, PE, Brasil*
*Corresponding author: phmachado@ufc.br.

functioning as excellent suspending agents (Phillips & Williams, 2009; Young et al., 2020).

Among the used hydrocolloids, gellan gum (GG) is widely used in beverage systems as an emulsifier and stabilizer (Xu et al., 2019). It is an extracellular polysaccharide produced by *Sphingomonas elodea* during aerobic fermentation and consists of tetrasaccharide repetition composed of (1–3)-β D-glucose, (1–4)-β-D-glucuronic, (1–4)-β-D-glucose and (1–4)-α-l-laminose. Two forms of GG differ by their degree of acylation: the native form, known as high acyl gellan gum (HAG), and low acyl gellan gum (LAG) which is produced by alkaline treatment of HAG (Funami, 2011; Morris et al., 2012). GG has gelling functions and its gels are firm, translucent, brittle, and stable at low pH (Zia et al., 2018).

No studies have been found on smoothies based on acerola and GG, formulated as a fluid gel. In this way, the proposal to associate LAG with acerola pulp will contribute to the optimization of the formulation of this type of drink, aiming the development of a product that is easy to prepare with taste and texture characteristics that are attractive to the consumer.

Thus, the study's objective was to develop an acerola smoothie through fluid gels' production using gellan gum to provide a creamy texture and evaluate the effect of this hydrocolloid concentration on the physicochemical, rheological, and sensory characteristics of the elaborated product.

2 Material and methods

2.1 Raw material

The acerola pulp (*Malpighia emarginata DC*), unpasteurized, without preservatives, was purchased directly from the manufacturer, a fruit pulp processing company located in Fortaleza, CE, Brazil. The pulp was received frozen in 100 g packs and was stored at −18 °C. The hydrocolloid used was low acylation gellan gum (LAG) (CP Kelco®, Atlanta, GA, USA). In addition, UHT whole milk (Nestlé®) and refined sugar (União®) were purchased in the local market. All the standards reagents and analytical chemicals were purchased from Sigma-Aldrich (St. Louis, Missouri).

2.2 Elaboration of acerola smoothie formulations

Smoothie formulations were made from the combination of acerola pulp (45% v/v) (6.4% (m/m dry matter), milk (45% v/v), sugar (10% w/v), and GG in three different concentrations (0.1%, 0.2% and 0.3% w/v) to define the best formulation. Besides, a control sample (without GG) was created. GG and sugar were added to the milk, and this mixture was heated to approximately 90 ± 2 °C for 20 s in a food processor (Termomix, PMS-018, Yammi). These conditions of GG proportion, formulation, and temperature were based on Sherafati et al. (2013) and Xu et al. (2019), with adaptations. After thermal processing, the homogenized acerola pulp was added with the aid of a glass stick. Subsequently, the mixture was poured into a plastic container and stored under refrigeration at 5 °C for 12 h to complete the maturation of the gel. After that time, the formed gel was broken with the aid of a mixer for 60 s to form the fluid gel. The control sample was composed of acerola pulp (45% v/v), milk (45% v/v), and sugar (10% w/v) and, for its production, these ingredients were manually homogenized. All smoothie samples were stored at 5 °C until further analysis.

2.3 Color properties

Color coordinates were determined using a colorimeter (ColorQuest XE, Hunterlab, Virginia, EUA), using the coordinate CIELab/CIELch system of L*, a*, b*, chroma (c*) and Hue angle (h°) according to the methodology described by the Association of Official Analytical Chemists (2005), which was calibrated with a white standard before being used.

2.4 Physicochemical analysis

The pH analysis was performed using a digital potentiometer (Modelo 3505-Jenway, UK); the Total Soluble Solids (TSS) were analyzed using a digital refractometer (Modelo Pal-1, Atago-Tokyo, Japan); Titratable Acidity (TA) was evaluated by titrating the samples with standard NaOH solution at 0.1000 mol.L^{-1}, using phenolphthalein as an indicator, and the results were expressed as a percentage of citric acid (Association of Official Analytical Chemists, 2005).

The evaluation of ascorbic acid (AA) was carried out by the titrimetric method, based on the reduction of the indicator 2.6-dichlorophenolindophenol (DFI) to 0.02% until a permanent light pink color. The sample (1 g) was diluted in 50 mL of oxalic acid 0.5% (m/m) and homogenized. Then, 5 mL of this suspension was diluted to 25 mL with distilled water and titrated (Strohecker & Henning, 1967; Association of Official Analytical Chemists, 2005). The results were expressed in mg of ascorbic acid per 100 g of sample.

2.5 Rheology

The rheological analysis was performed on rheometer equipment (Brookfield R/S Plus- SST, EUA), with the spindle sensor (V3 40/20 model), with an upward rotation rate of 0 to 60 s, and downward of 60 to 120 s, accelerating for one minute and decelerating for another minute, collecting 50 measurement points, 25 per minute. The tests were carried out at a constant temperature of 25 °C (Moura et al., 2017). The results of shear stress were obtained for each applied strain rate. The Power Law model (Equation 1) was adjusted to the experimental data by applying the linear regression technique, with the aid of the KaleidaGraph v 4.5.4 program.

$$\tau = k.\gamma^{n} \quad (1)$$

where: τ is the shear stress (Pa),

k is the consistency index (Pa.s^{n}),

γ is the strain rate (s^{-1}) and n is the behavior index.

2.6 Sensory analysis

Sensory tests were performed only with samples with hydrocolloid (GG - 0.1, 0.2, and 0.3%) to select the ideal concentration of GG for the acerola smoothies and to analyze its effect on the properties of flavor, aroma, color, and texture of this product.

For acceptance tests and Check-All-That-Apply (CATA), 100 untrained panelists of both sexes, aged 18 to 65 years were recruited according to their interest in participating and their consumption habits of acerola. The panelists evaluated approximately 10 mL (7 ± 1 °C) of each smoothie. The tests were performed in individual booths and the samples were served monadically to the tasters in plastic cups encoded with random three-digit numbers. A glass of natural water also was provided to eliminate the residual taste in the mouth between the samples. The panelists evaluated the sensory attributes through the 9-point hedonic scale, associated with a numerical value (1: "Dislike extremely" to 9: "Like extremely") (Stone & Sidel, 2004). This scale indicated how much the tasters liked or disliked the samples concerning the attributes of color, appearance, aroma, flavor, texture (softness), and overall impression. A 5-point structured scale was adopted for consumption intention, where 1 represents the minimum score (I would never drink it) and 5 the highest score (I would always drink it).

Then, the panelists filled out the CATA test, which presented a list of 28 terms related to the smoothie samples, in which the panelists should indicate which of these best described each formulation. The terms were selected based on preliminary tests made with possible panelists. The study was approved by the Research Ethics Committee (CEP), under opinion no. 1.829.642

2.7 Statistical analysis

The study was conducted in a completely randomized design, with three repetitions of each of the experiments, and the data were treated with the aid of the SAS 2020 1.3. The results obtained were submitted to analysis of variance (ANOVA) and compared using the Tukey (samples with GG) and Dunnett (for comparisons with the control) test at the level of 5% probability. The results were expressed as means followed by standard deviations. For the rheology test, data were analyzed using the KaleidaGraph v 4.5.4 program. The data from the CATA test were processed by the XLSTAT- 2019 program version 0.7. The frequency of use of each sensory attribute was determined by counting the number of consumers who used this term to describe each sample, following standard procedures, according to Meyners et al. (2013). The Cochran Q test was used to identify significant differences between smoothie formulations (Silva et al., 2012).

3 Results and discussion

3.1 Color coordinates

The results obtained in the evaluation of the color properties of smoothie formulations are shown in Table 1. There was a significant difference ($p \leq 0.05$) between the control and the formulations with GG in all evaluated properties, however, there was no difference among the samples with GG ($p > 0.05$). Therefore, there was no interference of the hydrocolloid concentration in the color of the smoothies.

For the luminosity variable (L *), the control showed a relatively higher value than formulations with GG (0.1, 0.2 and 0.3%), indicating that this gum made the samples darker. Possibly, the presence of GG may have increased the stability of acerola pigments, such as anthocyanins and carotenoids, during heating, retaining the color, which resulted in darker samples (Xu et al., 2019). On the other hand, it is suggested that in the control sample the pigments were partially degraded during heating (Andrés et al., 2016) and possibly resulted in a lighter colored sample. Zhao et al. (2020) analyzed red rice drinks with the presence of xanthan gum and vitamin C. They observed that xanthan gum increased the color stability of the samples when compared to the control. A similar phenomenon may have occurred in this study with the use of gellan gum in smoothie samples.

For the variables a* (red to green color) and b* (yellow to blue color), the GG samples resulted in values higher than the control, located in the red and yellow color bands, which indicates that there was better maintenance of red color, possibly associated with the concentration of anthocyanin in the acerola pulp (Jaeschke et al., 2016). Leal et al. (2020) elaborated mango-acerola bars with hydrocolloids addition and reported that the samples with GG show an intense red color, demonstrating that the hydrocolloid may interfere with the color of the products.

For the chroma (c*), which represents the color purity, and hue angle (intensity of the color) it was observed that the samples GG presented values higher than the control, indicating that the presence of GG, regardless of the concentration, intensified the color of the samples, with the predominance of the yellow color (°h closest to 90°, + b *). The intensity of pigments is linked to complex biochemical changes involving the compounds, such as carotenoids, vitamin C, thiamine, riboflavin, niacin, calcium, and phosphorus (Malegori et al., 2017).

Table 1. Characterization of the color properties (L *, a*, b*, c* and °h) e of the acerola smoothie samples with different concentrations of gellan gum.

Samples	L*	a*	b*	c*	°h
Control	64.60 ± 0.19	15.39 ± 15.39	18.80 ± 0.14	24.30 ± 0.21	50.68 ± 0.27
GG 0.1%	61.14 ± 1.22^{a*}	17.40 ± 17.40^{a*}	23.00 ± 0.22^{a*}	28.84 ± 0.38^{a*}	52.90 ± 0.30^{a*}
GG 0.2%	62.49 ± 0.19^{a*}	17.25 ± 17.25^{a*}	23.07 ± 0.19^{a*}	28.81 ± 0.27^{a*}	53.21 ± 0.20^{a*}
GG 0.3%	60.96 ± 0.35^{a*}	17.84 ± 17.84^{a*}	23.46 ± 0.12^{a*}	29.46 ± 0.21^{a*}	52.76 ± 0.19^{a*}

*Represents a verages in the same column present a significant difference in comparison to the control at the 5% probability level by the Dunnett test ($p \leq 0.05$). Means followed by equal letters do not differ significantly at the 5% probability level by the Tukey test. GG = Gellan Gum.

These findings are in agreement with the studies by Xu et al. (2019), who stated that the addition of GG in beverages containing anthocyanins in the presence of ascorbic acid promoted the reduction of color loss caused by heat treatment, improving its stability. These results infer that the hydrocolloid utilized probably favored color intensification of smoothies, which can contribute to the product becoming more sensorially attractive.

3.2 Physico-chemical analysis

The results of the physical-chemical properties of the acerola smoothies with and without GG are available in Table 2. The average values of pH and TA did not show a significant difference at 5% significance between the samples and the control, in contrast to the AA and TSS in which the control differed statistically ($p \leq 0.05$) comparing to the formulations (0.1%, 0.2% and 0.3%). The samples containing GG did not differ among them in all the evaluated properties.

For AA, the control sample showed slightly higher mean values (448.89 mg/100 g) compared to the other formulations, suggesting that the use of GG between 0.1 and 0.3% in acerola smoothie did not result in large AA losses. Lower AA values for formulations with GG may be due to the entrapment of the AA in GG gel networks (Xu et al., 2019. On the other hand, even with lower values of vitamin C comparing to the control, smoothies containing GG still showed high values of this nutrient, since the recommended intake of this nutrient is 45 mg per day for healthy adults (Brasil, 2005).

For soluble solids content found that all smoothie formulations containing GG showed statistically higher values ($p \leq 0.05$) than the control sample. The result can be justified due to the interaction of sucrose with the LAG during the formation of the gel network, promoting the suspension of this disaccharide (Morris et al., 2012).

According to Sancho et al. (2007), the variability of this parameter can be explained, in principle, by the variation of the °Brix of the raw material itself and the friction between the sample particles and the surface of the processing site, resulting in a greater breakdown of the pulp and polysaccharides and thus, promoting an increase in the content of soluble solids. For pH and total acidity, the samples with GG were shown to be the same as the control formulation, which implies that the use of this hydrocolloid does not influence the concentration of organic acids in beverages like acerola smoothies. The high acidity characteristic of the acerola pulp, with pH between 2.9 to 3.68 (Maciel et al., 2010; Souza et al., 2014) contributed for this parameter to remain low in smoothie samples, which contributes to its conservation, and act as a barrier for the growth of pathogenic microorganisms (Ribeiro et al., 2018).

3.3 Rheology

In Figure 1, it can be seen that there is no linear relationship between the shear stress and the strain rate of the samples, indicating the non-Newtonian behavior of the product (Wei et al., 2001). Table 3 presents the values of the samples' consistency index and behavior after adjusting to the Power Law model of the shear stress results as a function of the change in the strain rate.

Table 2. Physico-chemical characterization of acerola smoothie samples with different concentrations of gellan gum.

Samples	Ascorbic Acid (AA)	TSS (°Brix)	Titratable Acidity (AT)	pH
Control	448.89 ± 2.56	16.03 ± 0.06	0.56 ± 0.02	4.15 ± 0.01
GG 0.1%	425.99 ± 0.88[a*]	17.10 ± 0.10[a*]	0.56 ± 0.02[a]	4.17 ± 0.03[a]
GG 0.2%	422.18 ± 2.37[a*]	17.07 ± 0.15[a*]	0.56 ± 0.01[a]	4.15 ± 0.03[a]
GG 0.3%	430.49 ± 3.70[a*]	17.23 ± 0.06[a*]	0.56 ± 0.01[a]	4.13 ± 0.02[a]

*Averages in the same column present a significant difference in comparison to the control at the 5% probability level by the Dunnett test ($p \leq 0.05$). Means followed by equal letters do not differ significantly at the 5% probability level by the Tukey test. GG = Gellan Gum. AA = mg ascorbic acid / 100 g sample; AT = g citric acid / 100 g sample.

Table 3. Consistency index (k) and behavior index (n) of smoothies with different levels of gellan gum.

Samples	k	n
Controle	0.20 ± 0.02[a]	0.83 ± 0.06[a]
GG 0.1%	1.43 ± 0.09[b]	0.44 ± 0.03[b]
GG 0.2%	6.96 ± 0.48[c]	0.25 ± 0.01[c]
GG 0.3%	14.72 ± 1.18[d]	0.19 ± 0.01[d]

Means followed by at least one equal letter in the same column, do not differ significantly at the level of 5% probability by the Tukey test. GG = Gellan Gum.

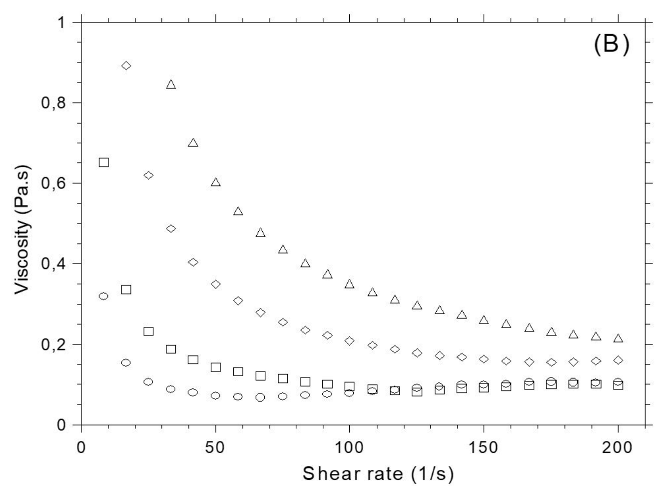

Figure 1. (A) Flow curve of smoothies with different concentrations of gellan. (B) Viscosity as a function of the shear rate of smoothies with different concentrations of GG. Control (○), GG 0.1% (□), GG 0.2% (◊) e GG 0.3% (△).

The data were well fitted to the power-law model for all samples ($R^2 > 0.98$) and the values of "n" (behavior index) were less than 1, showing that all formulations have their rheological behavior classified as being of a pseudoplastic fluid (Steffe, 1996). It can be seen that the behavior index decreases as the hydrocolloid concentration increases, showing an increase in the pseudoplastic behavior of the samples (Mitsoulis, 2010). The present study showed results similar to those reported by Ribeiro et al. (2019) who studied the rheological behavior of juçara, banana and strawberry smoothies, where all systems presented $n < 1.0$ indicating pseudoplastic behavior and good adjustment to the Power Law. The consistency index (k) increased as the GG concentration increased, that is, the higher the concentration of that hydrocolloid, the greater the sample consistency index (k). It is explained by the higher concentration of GG, which forms a more structured network, once more interaction between the polymeric chains occurs (Phillips & Williams, 2009).

The apparent viscosities of all samples showed similar behavior as the strain rate increased, characterized by a rapid decrease in viscosity at lower strain rates followed by a slower decrease in higher strain rates. This behavior is typical of pseudoplastic fluids (Kaur & Kaur, 2020) and is explained by the rearrangement of polymeric gellan chains that occurs at higher shear rates. The results were similar to those found by Sherafati et al. (2013); when evaluating the rheological aspects of carrot juice with different proportions (0.02, 0.025 and 0.03%) of low and high acylation GG (LA and HA), they also observed pseudoplastic behavior in the evaluated drink, and that the concentration of GG, heat treatment and carrot juice had a good potential to alter the flow index and the coefficient of consistency of the drink.

3.4 Sensory analysis

Acceptance test

The averages for the acceptance test of the smoothie samples are available in Table 4. It can be observed that there was no significant difference ($p > 0.05$) for the appearance and aroma attributes, with averages corresponding to the hedonic term "Liked moderately". For the other attributes evaluated, the samples were statistically different ($p \leq 0.05$).

For the color attribute, the averages were between the terms "Liked slightly" and "Liked moderately", with a statistical difference ($p \leq 0.05$) between the samples 0.1% and 0.3%. Regarding the texture, it can be seen that the 0.2% sample obtained a higher average acceptance, corresponding to the term "Liked moderately", and the other formulations were placed between the terms "Neither like nor dislike" and "Like slightly". Therefore, it is observed that the tasters showed greater acceptance of the sample with an intermediate texture (0.2%). This can be explained by the increase of GG concentration, which promoted an increase in the samples' viscosity (Banerjee et al., 2013). Regarding the attributes of flavor and global impression, the samples showed averages that varied between the terms "Neither like nor dislike" and "Liked moderately", with the formulation 0.3% being less accepted for these attributes. The lower acceptance of this formulation in the flavor parameter may be related to the higher intensity of acid taste in higher concentrations of low acyl gellan gum, since it is less associated as an ideal characteristic, according to Leal et al. (2021). In addition, the increase in the hydrocolloid concentration increased the viscosity of the drinks and, consequently, the intensity of flavor was less perceived by the tasters, since high viscosity levels can reduce or eliminate the taste of food products (Wagoner et al., 2020). For consumption intention, it is observed that the averages were classified according to the terms of the hedonic scale "I would rarely drink it" and "I would drink it occasionally". Of the three formulations, the 0.2% sample obtained the highest average (3.29), therefore, more accepted by the tasters. Guazi et al. (2019) observed low acceptance for smoothies made with banana/apple pulps, the authors justified it by the novelty of the product and its low sugar content.

Table 4. Averages of the sensory acceptance test for acerola smoothies made with gellan gum.

Attributes	Gellan Gum Concentration		
	0.1%	0.2%	0.3%
Appearance	6.65 ± 1.67 [a]	7.08 ± 1.62 [a]	6.72 ± 1.61 [a]
Color	6.71 ± 1.66 [b]	7.12 ± 1.45 [ab]	7.28 ± 1.25 [a]
Aroma	6.77 ± 1.63 [a]	6.91± 1.60 [a]	6.73 ± 1.69 [a]
Texture	6.21 ± 1.71 [b]	7.01 ± 1.51 [a]	5.69 ± 2.18 [b]
Flavor	6.15 ± 2.05 [ab]	6.73 ± 2.03 [a]	5.58 ± 1.93 [b]
Global Impression	6.19 ± 1.85 [ab]	6.78 ± 1.69 [a]	5.95 ± 1.85 [b]
Consumption intention	2.78 ± 1.12 [b]	3.29 ± 1.16 [a]	2.65 ± 1.06 [b]

Means with the same letter on the same line do not differ at the 5% level of significance for the Tukey test.

Check-all-that-apply (CATA)

Significant differences ($p \leq 0.05$) were found in 14 of the 28 attributes used to describe the acerola smoothie samples, being the terms "homogeneous", "yellowish color", "soft", "acerola flavor" and "acerola aroma" those that presented higher frequencies (Table 5).

Table 5. Frequency of Check-All-That-Apply (CATA) using the Cochran Q test to compare samples of acerola smoothie.

	Gellan Gum Concentration		
Attributes	0.1%	0.2%	0.3%
Homogeneous	35 [b]	49 [a]	36 [ab]
Bright	14 [b]	20 [b]	43 [a]
Pale color	22 [a]	8 [b]	9 [b]
Pinkish red color	2 [b]	0 [b]	75 [a]
Yellowish color	66 [a]	77 [a]	5 [b]
Presence of liquid	2 [ab]	0 [b]	1[a]
Firm	4 [b]	22 [a]	28 [a]
Soft	44 [a]	37 [a]	42 [a]
Presence of foam	20 [b]	13 [b]	41 [a]
Gelatinous	5 [b]	26 [a]	3 [b]
Astringent	1 [a]	2 [a]	7 [a]
Sandy	11 [a]	5 [a]	12 [a]
Liquid	77 [a]	36 [b]	26 [b]
Juicy	11 [a]	18 [a]	16 [a]
Fruit aroma	32 [a]	40 [a]	33 [a]
Acid aroma	23 [a]	21 [a]	18 [a]
Sweet aroma	33 [a]	26 [ab]	14 [b]
Acerola aroma	52 [a]	54 [a]	49 [a]
Cooked acerola aroma	7 [a]	6 [a]	6 [a]
Acidic taste	22 [b]	23 [b]	46 [a]
Sweet taste	22 [a]	19 [a]	10 [a]
Fruit flavor	37 [a]	38 [a]	19 [b]
Acerola flavor	65 [a]	63 [a]	34 [b]
Milk flavor	33 [a]	26 [a]	22 [a]
Yogurt flavor	7 [a]	13 [a]	8 [a]
Fresh acerola flavor	6 [a]	9 [a]	7 [a]
Strange taste	14 [a]	16 [a]	19 [a]

Means with the same letters, in the same line, do not differ at the 5% level of significance for the Cochran Q test ($p > 0.05$).

The 0.1% formulation showed higher frequencies of the attributes "pale color", "liquid" and "sweet aroma". The most liquid texture of the formulation containing the lowest hydrocolloid concentration occurred, according to Banerjee et al. (2013), when the hardness of the gel increases as the hydrocolloid concentration is increased. The "homogeneous" attribute was more related to the 0.2% formulation. In turn, the 0.3% sample was more characterized by the keywords "bright", "pinkish-red color" and "acidic taste", being less associated with the attributes "yellowish color", "fruit flavor" and "acerola flavor". Based on this result, it was observed that the use of a higher concentration of hydrocolloid resulted in stronger gels, which possibly contributed to making the product brighter and enhanced the intensity of the red color of the acerola. However, a higher concentration of hydrocolloid resulted in reduced taste, which is expected in rigid and firm gels with less flavor release, in addition to a grainy appearance (Bayarri et al., 2007; Morris et al., 2012). This corroborates with the results of hedonic tests, which showed a lower average of acceptance in the flavor attribute for a sample of 0.3%. In the supplementary material (Figure S1), principal coordinate analysis is available for the global impression attributes according to CATA terms.

4 Conclusion

The use of GG for the production of acerola smoothie allowed the development of a drink with a fluid gel aspect, with pseudoplastic behavior, higher viscosity, and intense red color. The different concentrations of GG (0.1, 0.2, and 0.3%) did not interfere in the physical-chemical properties of the samples and the levels of ascorbic acid, although they have reduced, remained high when compared to the control. The concentration of 0.2% presented higher acceptance averages for appearance and flavor, being the most attractive for consumers. GG can be an ally in the production of smoothies or similar drinks, making it possible to use the fluid gel production technique with other fruits or vegetables and thereby make combinations that may result in products with nutritional quality and standardized textures.

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Supplementary Material

Supplementary material accompanies this paper.

Figure S1. Principal Coordinate Analysis for the global impression attributes according to the CATA terms.

This material is available as part of the online article from https://www.scielo.br/j/CTA.