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Influence of the type of packaging and the hydrocolloid addition on the physico-chemical and sensory quality of soursop (*Annona muricata*) juice

Influencia del tipo de envase y la adición de hidrocoloides sobre la calidad físicoquímica y sensorial del jugo de guanábana (*Annona muricata*)

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ABSTRACT

Soursop is a tropical fruit valued for its unique flavor and beneficial health properties. Due to its pleasant taste and nutritional profile, it is used in the food industry to produce juices and nectars. However, during processing, it can present challenges due to the need to maintain suspension stability and the desired viscosity. This research evaluated the influence of packaging type and the addition of hydrocolloids on the physicochemical and sensory quality of soursop (*Annona muricata*) juice. A completely randomized factorial design A*B*C was used, where factor A = Type of stabilizer (xanthan gum, guar gum), Factor B =Percentage of fruit (14 -15 %), and Factor C = Type of container (glass or plastic). For the analysis of variance (ANDEVA), the free software InfoStat was used. The physicochemical results show that using gums does not affect the evaluated parameters such as pH, soluble solids, acidity, and density over time. Regarding sensory profile, treatment 3, which corresponds to xanthan gum, 14% pulp, and glass packaging, stood out in each organoleptic profile. In general terms, both Xanthan gum and Guar gum are beneficial for increasing stability and improving the sensory quality of soursop juice.

Keywords: Food products; Food analysis; Tropical fruit; Food preservation; Fruit processing

RESUMEN

La guanábana es una fruta tropical valorada por su sabor único con propiedades beneficiosas para la salud, por ende, en la industria alimentaria es utilizada en la producción de jugos y néctares debido a su agradable sabor y perfil nutricional. Sin embargo, su procesamiento puede presentar desafíos debido a la necesidad de mantener la estabilidad de la suspensión y la viscosidad deseada. Esta investigación evaluó la influencia del tipo de envase y la adición de hidrocoloides sobre la calidad fisicoquímica y sensorial del jugo de guanábana (*Annona muricata*). Se empleó un diseño factorial completamente al azar A*B*C; donde factor A= tipo de estabilizante (goma xantana, goma guar), Factor B= porcentaje de fruta (14 -15 %) y Factor C= tipo de envase (vidrio o plástico). Para el análisis de varianza (ANDEVA), se utilizó el software libre InfoStat. Los resultados fisicoquímicos demuestran que el uso de las gomas no afecta los parámetros evaluados como pH, sólidos solubles, acidez y densidad al transcurrir el tiempo. En cuanto al perfil sensorial el tratamiento 3, el cual corresponde a goma xantana, 14 % de pulpa y envase de vidrio se destacó en cada uno de los perfiles organolépticos. En términos generales, tanto la goma xantana y goma guar resultan beneficiosas para incrementar la estabilidad y mejorar la calidad sensorial del jugo de guanábana.

Palabras clave: Análisis de alimentos; Conservación de alimentos; Fruta tropical; Productos alimenticios; Procesamiento de frutas

INTRODUCTION

The international market has driven the evolution of a dynamic system in the production and consumption of fresh fruits, influenced by current demands and requirements (Lima Santos *et al.* 2023). This transformation is attributed to the physicochemical and nutritional properties of various tropical horticultural products, as well as to the bioactive compounds they have, which make them multifunctional foods with benefits for human health and, at the same time, attractive commercial characteristics (Casco Guerrero *et al.* 2024).

Worldwide, soursop (*Annona muricata* L.) is known as a fruit with a unique and pleasant flavor, making it ideal for juices, ice creams, and jellies. Additionally, soursop pulp does not undergo organoleptic changes when exposed to high temperatures (Ávila de Hernández *et al.* 2018). Due to the senescence process of the fruit, about 83.12-85.85% is marketed fresh (Coria-Téllez *et al.* 2018).

To improve the quality and extend the life of juices prepared from fruits such as soursop, stabilizers can be added such as xanthan gum, which is a natural polysaccharide produced by the fermentation of sugars, used in the food industry as a thickener and stabilizer, its aggregating effect in juices allows obtaining a consistent texture and avoiding the separation of liquids and solids (Castulovich & Franco, 2018). Moreover, the addition of guar gum to juices helps to maintain adequate viscosity and prevent sedimentation of suspended solids (Yen-Nhi *et al.* 2020).

In addition, the choice of the right packaging is fundamental in the juice industry, because it directly influences quality and life. The materials commonly used include plastic and glass materials (Matche, 2018). Among the plastic containers, those made of polyethylene terephthalate (PET) or high-density polyethylene (HDPE) offer lightness, durability, and flexibility in design. However, a drawback is its permeability to oxygen and its susceptibility to the migration of compounds into the container (Epure *et al.* 2023). In contrast, glass containers stand out for their barrier against gases, and their ability to preserve the sensory and nutritional quality of foods (Romero *et al.* 2021).

For this reason, the objective of this research was to evaluate the influence of the type of container and the addition of hydrocolloids on the physicochemical and sensory quality of soursop (*Annona muricata*) juice.

MATERIALS AND METHODS

The raw material used was purchased at the local market in the canton of Quevedo, located in the province of Los Ríos, Ecuador. The fruit was selected based on a visual analysis that indicated an adequate maturity index, thus guaranteeing its optimum quality for subsequent analysis, which was carried out in the Biotechnology laboratory, located at the "La María" Campus of the Universidad Técnica Estatal de Quevedo, Quevedo, Ecuador.

Experimental Design and Statistical Analysis. A completely randomized design (CRD) with factorial arrangement A*B*C was used in this research, where factor A was the type of stabilizer (xanthan gum, guar gum), factor B was the percentage of fruit (14%, 15%), and factor C was the type of container (glass, plastic). The final product was evaluated in three periods at 15, 30, and 45 days.

For the analysis of variance (ANDEVA), the free software InfoStat was used to compare the means obtained in the treatments. Subsequently, a Tukey multiple range test with a $p \leq 0.05$ probability was applied to determine the significant differences between groups.

Process for the Preparation of Soursop Juice with the Addition of Xanthan Gum and Guar Gum. The pulping of the soursop was carried out by selecting ripe fruits with fleshy, white pulp, a pH of 4, and a sweet flavor, indicating an optimal state of maturity. Once the pulp was obtained, the main additives, such as stabilizers xanthan gum (0.008 g), guar gum (0.008 g), sugar (30.6 g), and soursop pulp (60.10 g) were received. After mixing the ingredients, the pasteurization process was carried out by heating the mixture at 63°C for 15 minutes to eliminate any pathogenic microorganisms present without altering its flavor or quality. Subsequently, it was packaged following the methodology established in the Ecuadorian Technical Standard INEN 2337 (2008) as requirements for the packaging of juices. The beverage was cooled to 30°C and finally stored at 9°C to preserve its freshness, flavor, and quality for a longer period.

Physicochemical Parameters of the Soursop Juice

<u>pH determination.</u> The pH content was determined in each of the three replicates, following the methodology established by the Ecuadorian Technical Standard INEN 0389 (1986a).

<u>Determination of soluble solids.</u> Soluble solids were measured by using a refractometer, placing a small sample of the juice in the lens (AOAC, 2012).

<u>Acidity determination.</u> The acidity of the soursop juice was determined by titration according to Ecuadorian Technical Standard NTE 0013 (1984), introducing 50 mL of distilled water and 10 mL of the sample in an Erlenmeyer flask and diluting the contents. Subsequently, a phenolphthalein solution (C2H14O4) was added as an indicator, and the sample was then titrated with 0.1 N sodium hydroxide (NaOH). The final results were obtained by the following equation:

$$A = \frac{V(NaOH) * N(NaOH) * 0{,}067(\text{ácido málico})}{\text{Volumen de la muestra}}$$

where:

A: titratable acidity of the sample (malic acid as the predominant acid).

V(NaOH): volume of sodium hydroxide, in cm^3.

N(NaOH): normality of sodium hydroxide (0.1 N).

Obtaining density. The density of the juice was determined by the pycnometer method, where the empty and dry pycnometer was weighed. Then, the pycnometer was filled with distilled water and the weight was recorded. Subsequently, the pycnometer was emptied and filled with the juice sample, and the weight was recorded again (NTE INEN 0391, 1986b).

Once the mass values were obtained, the density was calculated using the following equation:

$$\rho = \frac{m(picnómetro + líquido) - m(picnómetro\ vacío)}{m(picnómetro + agua) - m(picnómetro\ vacío)} * \rho(agua)$$

Sensory characterization. The established treatments were evaluated by a total of 30 semi-trained panelists, who received a 10 ml sample for evaluation. The sensory evaluation was carried out using two tasting cards: one for the juices containing xanthan gum and the other for those containing guar gum. For the evaluation of sensory parameters, a 5-point hedonic scale was used for each profile: aroma, flavor, viscosity, and acceptability. A Friedman test was also applied (Ramírez-Navas, 2012).

RESULTS AND DISCUSSION

Physicochemical Characterization of Soursop Juice over Storage Time. Figure 1a shows the variability of the pH values evaluated at 15, 30, and 45 days. It can be seen that treatment 5 stood out with values of 4.20 and 4.28 at 15 and 30 days, respectively. However, treatment 6 showed the highest value at day 45. The treatments with guar gum showed pH values higher than 4, indicating that the juice has sufficient acidity to prevent the growth of microorganisms that can affect the product quality.

Based on the results obtained, it was observed that the treatments presented a slight, but not significant, decrease in pH as the days of storage elapsed. The authors Laz Mero *et al.* (2018) point out that hydrocolloids significantly affect pH, causing its decrease. This response was attributed to the encapsulating properties of hydrocolloids, which allow them to retain organic acids and other acidic substances, thus masking the beverage pH. As for other research on soursop pulp, Ojeda de Rodriguez *et al.* (2007) obtained average pH values of 4.1, which is similar to the value found in this research. It is important to indicate that pH, being a measure of the intensity of acid taste, is very important in controlling the development of microorganism populations. Previous studies such as those by Taiwo & Gift (2013) agree that the addition of hydrocolloids to juices, nectars, and fruit concentrates does not generate significant alterations.

Figure 1b shows the results of the soluble solids analyzed on days 15, 30, and 45, showing that the highest total solids content was obtained by treatment 5 on day 45 of storage with 10.60, while at the beginning of day 15, treatment 6 obtained the highest result with 9.25. In general, all treatments showed values above 9, except treatments 3 and 4 with 8.80 and 8.85, respectively. It can be observed that the type of stabilizer influences the total solids, as does the type of container, with the glass container being more effective in preserving total solids. These values are related to the data obtained by Castulovich & Franco (2018) who reported a value of 8.0 in total solids in their study on the effect of stabilizers, and also noted no variability in total soluble solids during the evaluation period. Thus, it is possible to indicate that the use of xanthan gum and guar gum allows maintaining stable total soluble solids.

The acidity of the juice on day 15 was similar in treatments 2, 3, 4, and 5, and the treatments containing guar gum showed a slight increase on days 30 and 45 with values ranging between 0.21 and 0.25 (Figure 1c). The values found are related to those reported by Chuproski *et al.* (2020). Besides, these authors mention that the inclusion of stabilizers significantly influences acidity. Authors such as Macías Andrade *et al.* (2022) in their study on stability in orange and mandarin pulp established that by implementing 50% pulp plus xanthan gum, acidity remained favorable during the time evaluated.

Regarding the type of container, the acidity of the juice showed greater stability in the glass container, which was also reported by Crivelari-Da Cunha *et al.* (2020) who found that this characteristic was preserved in the glass containers for up to 12 months.

Density values are shown in Figure 1d, where it can be observed that by day 15, treatment 4 obtained a value of 1.06, which is higher than the other treatments. On the other hand, treatment 2 had a value of 1.10 on day 30 of storage, while on day 45, treatment 8 showed an increase of 1.10 on day 45. It is worth mentioning that the stabilizer Xanthan gum maintained the best results in the first 30 days. As described by Macías-Andrade *et al.* (2022), density can be influenced by a variety of factors in the pulp, such as acids, amino acids, enzymes, dissolved metals, and salts present in the pulp. In other research, such as that of Gutierrez Casiano *et al.* (2016), where they used the stabilizers carboxymethylcellulose (CMC) and xanthan gum, they mention that the density parameter remained stable during the storage period, which is consistent with the findings of this study.

Sensory Characterization of Soursop Juice. Table 1 shows the results of sensory evaluation of soursop juice, considering sensory categories such as aroma, flavor, viscosity, and acceptability.

Regarding the sensory category of aroma, significant differences were observed. The highest value was found in treatment 3, while the lowest values were observed in treatments 4 and 6. In the study by Contreras-Lozano *et al.* (2019) on the use of hydrocolloids as stabilizers in sweet corn and aloe vera gel beverages, they found that the sensory evaluation of aroma and flavor showed no significant differences with respect to the concentrations of xanthan gum and CMC, indicating that the predominant flavor and aroma in the beverage without stabilizers were characteristic of sweet corn.

Table 1. Sensory characterization of the evaluated treatments of soursop juice.

Treatments	Aroma	Flavor	Viscosity	Acceptance
T1	4.7±0.06 C	4.7 ± 0.06 D	4.2 ± 0.06 C	4.1 ± 0.06 CD
T2	4.2 ± 0.06 ABC	4.3 ± 0.05 BCD	4.7 ± 0.06 D	3.9 ± 0.06 BC
T3	4.8±0.06 C	4.4 ± 0.06 CD	5.0 ± 0.00 E	4.3 ± 0.25 D
T4	3.7 ± 0.06 A	3.7 ± 0.06 A	4.7 ± 0.15 D	3.8 ± 0.06 B
T5	4.0 ± 0.00 AB	4.3 ± 0.25 BCD	3.3 ± 0.06 A	4.1 ± 0.06 CD
T6	4.7±0.06 C	4.3 ± 0.06 BCD	4.3 ± 0.06 C	3.8 ± 0.06 B
T7	3.7 ± 0.06 A	4.0 ± 0.06 AB	3.9 ± 0.06 B	3.4 ± 0.06 A
T8	4.3 ± 0.15 ABC	4.0 ± 0.06 AB	4.2 ± 0.15 C	4.2 ± 0.06 D
p-value	0.004	0.001	0.001	0.001

Different letters show significant differences according to Tukey's test (p<0,05).
T1: xanthan gum + 15 % pulp + glass container; T2: xanthan gum + 15 % pulp + plastic container; T3: xanthan gum + 14 % pulp + glass container; T4: xanthan gum + 14 % pulp + plastic container; T5: guar gum + 15 % pulp + glass container; T6: guar gum + 15 % pulp + plastic container; T7: guar gum + 14 % pulp + glass container; T8: guar gum + 14 % pulp + plastic container.

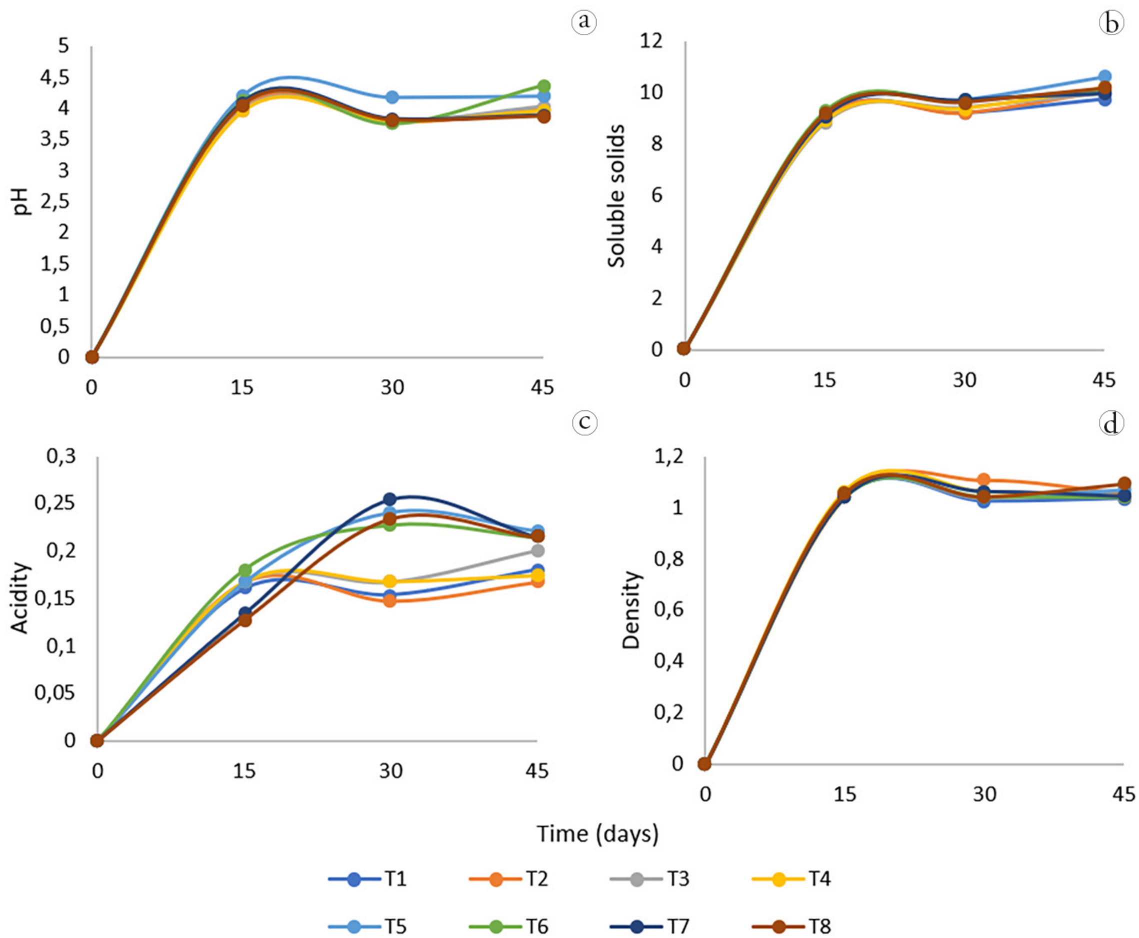

Figure 1. Results of the physicochemical analysis of soursop juice with the addition of different hydrocolloids and the use of different containers at 15, 30, and 45 days of storage. a) pH; b) total soluble solids; c) acidity; d) density.
T1: xanthan gum + 15 % pulp + glass container; T2: xanthan gum + 15 % pulp + plastic container; T3: xanthan gum + 14 % pulp + glass container; T4: xanthan gum + 14 % pulp + plastic container; T5: guar gum + 15 % pulp + glass container; T6: guar gum + 15 % pulp + plastic container; T7: guar gum + 14 % pulp + glass container; T8: guar gum + 14 % pulp + plastic container.

In the flavor category, a significant difference was found ($p<0.05$), where treatment 1 showed the highest valuation, while treatment 4 had the lowest valuation. Some authors such as Abedi *et al.* (2012) mentioned that hydrocolloids in concentrations no higher than 0.35% do not influence sensory properties, except for viscosity, which can be influenced. Thus, it can be noted that these types of hydrocolloids do not alter the flavor of soursop juice.

As for the viscosity parameter, a significant difference was observed ($p<0.05$), with treatment 3 obtaining the most representative value and treatment 5 the lowest score. This response has also been demonstrated in previous studies such as Contreras-Lozano *et al.* (2018) who indicated that hydrocolloids affect viscosity in beverages, indicating a rheological change in the product, due to its isotropic structure.

In terms of acceptability, a statistical difference ($p<0.05$) was found between treatments, where treatment 3 had the highest acceptance by tasters compared to treatment 7, which obtained the lowest score.

On the other hand, the glass container contributes favorably to a better preservation of beverages, which is due to the barrier generated and the compatibility with the juice which allows preserving the juices in a safe and stable way (Matche, 2018).

It is concluded that xanthan gum and guar gum generated significant improvements on the physicochemical stability and density uniformity of soursop juice. The guar gum treatments showed an adequate pH to prevent microbial growth, especially treatment 5.

In addition, an increase in soluble solids in the soursop juice was observed over time with the use of hydrocolloids, where treatment 5 reached the highest concentration at day 45. On the other hand, acidity varied between treatments and periods, with a tendency to higher values in the guar gum treatments.

It was also observed that both hydrocolloids are effective in the formulation of soursop juice without negatively altering the sensory characteristics of aroma, flavor, color, and acceptability. Therefore, xanthan gum and guar gum are recommended to improve the stability and sensory quality of soursop juice with different impacts depending on the formulation conditions employed.

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