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Research Article

Kinetic and sensory analysis of ginger beer produced by diversified fermentation methods

Análise cinética e sensorial de ginger beer elaborada por métodos diversificados de fermentação

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ABSTRACT

This study investigates the production of ginger beer flavored with soursop, highlighting its viability in the fermented beverage market and its connection to Brazilian biodiversity. The research focused on the physicochemical, microbiological, and sensory characterization of the beverage, comparing induced and natural fermentation, with and without the use of ginger bug. The results indicate that the addition of ginger bug increased the alcohol content of the fermented beverage to 0.71 °GL, while fermentation without ginger bug showed no detectable alcohol. On the other hand, induced fermentation resulted in an alcohol content of 4.32 °GL. Microbiological analyses confirmed the absence of coliforms and pathogens, ensuring compliance with quality standards. In sensory evaluation, the fermented beverage with 20% soursop received the highest flavor ratings (above seven), while the same concentration in natural fermentation had the lowest acceptance in purchase intent. These data suggest that ginger beer can be a viable and healthy alternative in the market for fermented beverages, leveraging the richness of Brazilian biodiversity.

KEYWORDS: Fermented beverage. Sustainable product development. Kinetic parameters.

RESUMO

Este estudo investiga a produção de *ginger beer* saborizada com graviola, destacando sua viabilidade no mercado de bebidas fermentadas e sua relação com a biodiversidade brasileira. A pesquisa focou na caracterização físico-química, microbiológica e sensorial da bebida, comparando fermentação induzida e natural, com e sem o uso de *ginger bug*. Os resultados indicam que a adição de *ginger bug* aumentou o teor alcoólico da bebida fermentada para 0,71 °GL, enquanto a fermentação sem *ginger bug* não apresentou álcool detectável. Por outro lado, a fermentação induzida resultou em um teor alcoólico de 4,32 °GL. As análises microbiológicas confirmaram a ausência de coliformes e patógenos, garantindo conformidade com os padrões de qualidade. Na avaliação sensorial, a bebida fermentada com 20% de graviola obteve as melhores notas de sabor (acima de sete), enquanto a mesma concentração na fermentação natural teve a menor aceitação em intenção de compra. Esses dados sugerem que a *ginger beer* pode ser uma alternativa viável e saudável no mercado de bebidas fermentadas, aproveitando a riqueza da biodiversidade brasileira.

PALAVRAS-CHAVE: Bebida fermentada. Desenvolvimento de produto sustentável. Parâmetros cinéticos.

INTRODUCTION

The preservation of Brazilian biodiversity is a central concern, and the Brazilian Development Bank (BNDES) emphasizes the importance of developing products that promote bioeconomic growth. Such products should not only contribute to economic and environmental value, but also support economic activities in a sustainable way, encouraging technological innovations (PAMPLONA et al. 2021).

One industry that has played a significant role in the market and in job creation is the alcoholic beverage industry, an ancient practice throughout the world (VIANA 2023). However, this industry is also evolving to become more sustainable, exploring new technologies and raw materials that reduce its environmental impact (SANTOS et al. 2020).

At the same time, the fruit production sector has grown globally due to technological advances, resulting in a wide variety of fruits available to the food industry (SANTOS et al. 2021). Brazil, due to its diversity of climates and soils, is particularly rich in fruits, which makes it an ideal candidate for the production of fermented alcoholic beverages from these resources (SANTOS & SOUZA 2020). This scenario also contributes significantly to reducing waste in fruit production (NEVES et al. 2020).

The production of fermented alcoholic beverages is no longer limited to the traditional use of grapes, as various raw materials are now being explored (MORENO 2022). Ginger (*Zingiber officinale*) is a remarkable plant not only for its characteristic flavor and aroma, but also for its therapeutic properties and rich nutrient composition (SACOOR 2020).

Ginger has been widely used in the food industry, especially in the production of beverages such as soft drinks (BAG 2018). Globally, there is a growing demand for natural products, and the use of ginger as a raw material for high value-added alcoholic beverages is a promising trend (NUTAKOR et al. 2020).

Ginger beer, originating from England and Switzerland, is a notable example of a fermented beverage based on ginger. It is produced by fermenting a sugary solution with ginger, resulting in a drink with a relatively low alcohol content (NUTAKOR et al. 2020). Furthermore, ginger beer can be produced through cascade fermentation using "ginger bug" as the initial culture, which is a fermented culture of microorganisms native to ginger. This method has been associated with a more homogeneous final product, with better carbonation and improved nutritional profile and sensory characteristics (OLIVEIRA et al. 2024).

Another excellent alternative for the production of fermented beverages is soursop (*Annona muricata*), a tropical fruit known not only for its distinctive flavor but also for its beneficial health properties. Mainly appreciated in the North and Northeast regions of Brazil, soursop has aroused interest due to its high content of vitamin C and amino acids, in addition to containing a good amount of mineral salts, especially calcium and potassium (SILVA 2023, RADY et al. 2018).

However, despite its promising potential, soursop-flavored ginger beer is still a relatively unexplored area of research, lacking significant scientific investigation. Also, no patent documents related to this specific beverage were identified. Therefore, this study aims to fill this gap, focusing on the characterization of ginger and the analysis

of naturally fermented ginger beer, using physicochemical and kinetic parameters. This effort will not only enrich knowledge about this unique beverage, but it can also boost agricultural production by encouraging the consumption of a fermented drink with high added value in the market (CNI 2020).

Thus, this study aimed to explore the production of ginger beer flavored with soursop. By thoroughly characterizing the production process and evaluating its physical-chemical, kinetic, microbiological, and sensory parameters, the aim is not only to fill a knowledge gap but also to promote agricultural development by introducing a new, high-value alternative to the fermented beverage market.

MATERIALS AND METHODS

The study was conducted at the Applied Thermodynamics Laboratory of the Faculty of Agricultural Sciences (FCA) at the Federal University of Amazonas (UFAM), using ginger and soursop purchased from local shops in the city of Manaus for the production of the fermented product.

Hygiene of materials

The materials used in the production of the fermented product were cleaned with water and detergent, followed by immersion in a sodium hypochlorite solution at 100 mg/L of active chlorine for 30 minutes. After this period, the solution was removed, as described by OLIVEIRA et al. (2020).

Characterization of raw materials

The rhizomes and soursop were prepared using kitchen utensils, followed by pH and Total Soluble Solids (TSS) analyses in all samples, as well as determinations of total titratable acidity for the ginger and total acidity in citric acid for the soursop, according to the IAL methodology (2008).

Production process

The ginger beer production process was developed based on the studies of DESHPANDE et al. (2019), LIMA et al. (2021), and OLIVEIRA et al. (2020), with adaptations.

For natural fermentation, two musts were prepared for this process, differing from each other by the addition of ginger bug. During the preparation process of the ginger bug, it was fed daily with 10 g of sugar and 3 g of ginger for three consecutive days (Figure 1). The initial quantities of ingredients for this culture are detailed in Table 1.

Table 1. Ingredients and quantities used in the process.

Ginger bug	Initial quantity
Sugar	10 g
Water	160 mL
Ginger	4.8 g

The production process of ginger bug is shown in Figure 1.

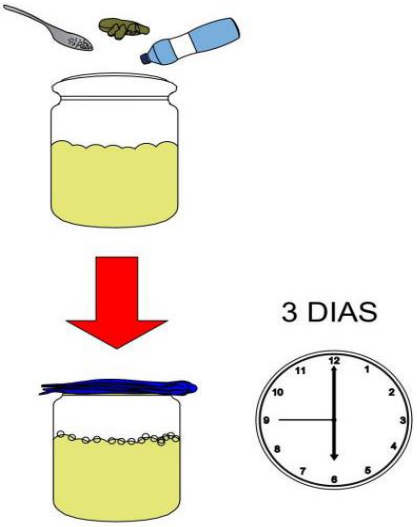

Figure 1. The ginger bug production process.

To prepare the must in both fermentation processes, the ginger rhizomes were cut and crushed, using ginger in a proportion of 30 g/L. This process was repeated until a homogeneous mixture was obtained. Next, the mixture was transferred to a stainless steel pot, where more water and ginger were added to form a syrup. The mixture was then cooled to a temperature of approximately 30 ºC. At this point, the granulated sugar was added, and the process continued until the mixture reached a concentration of 18 ºBrix. In the method using ginger bug, it was added to the must after chaptalization to reach 18 °Brix.

In the induced fermentation process, the *Saccharomyces cerevisiae* yeast was prepared according to the supplier's instructions, by hydrating it in water at the ideal temperature. Subsequently, the must was pasteurized in a water bath at 65 ºC for 30 minutes, cooled, and the activated yeast was added to start the fermentation.

In both types of fermentation, the must was then transferred to a fully sealed fermentation vessel equipped with an airlock, and fermentation was initiated at a temperature of approximately 25°C. To interrupt the fermentation process, the must was pasteurized again in a water bath at 65°C for 30 minutes.

After the first fermentation, flavoring was carried out by adding soursop to the must in proportions of 10% and 20%. This step was completed after approximately 48 hours, followed by filtration using filter paper to remove any remaining sediment from the product.

The ginger beer was then stored in previously sterilized amber glass bottles. After bottling, a second pasteurization was performed in a water bath at 65 ºC for 30 minutes to stop fermentation and eliminate potential pathogenic microorganisms. After pasteurization, the ginger beer was packaged at room temperature. Figure 2 shows a flowchart of this process.

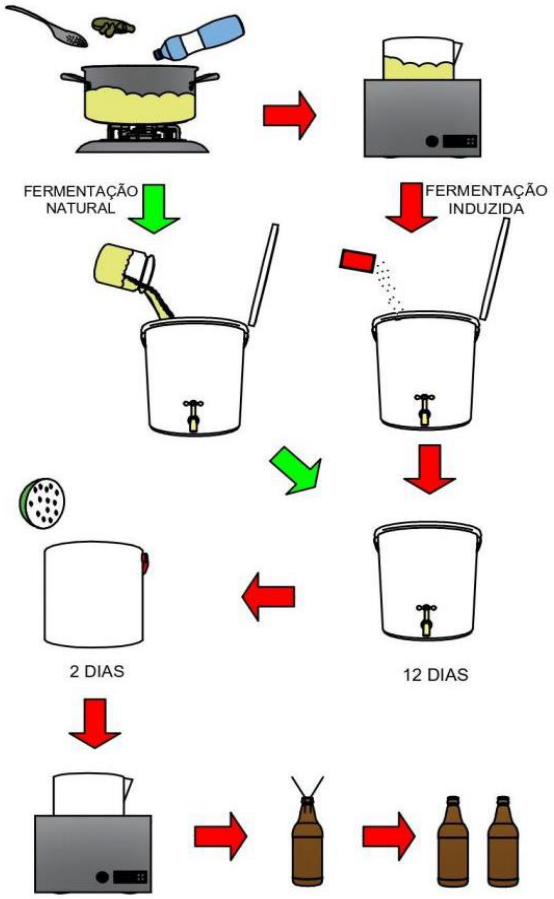

Figure 2. Productive process from ginger beer.

Physicochemical and kinetic analyses

Physicochemical and kinetic analyses were performed on the product following the IAL (2008) methodology. Measurements included total titratable acidity, pH, and total soluble solids. In addition, the alcohol content was determined using equation 11 from the study by FARIAS (2019).

Microbiological analysis

After the fermentation process was completed, a microbiological analysis was performed on triplicate samples of the products to detect the presence or absence of molds and yeasts, total and thermotolerant coliforms, *Salmonella spp*., and mesophilic aerobes, according to the microbiological standard established by BRAZIL (2022).

Sensory analysis

The sensory evaluation was conducted at the Sensory Analysis Laboratory of the Faculty of Agricultural Sciences (FCA), located at the Federal University of Amazonas (UFAM). The test involved 44 untrained tasters who were seated in individual booths. Each taster received approximately 20 ml of each sample in disposable plastic cups and also received a form for sensory evaluation. The beverage was evaluated based on the attributes of color, appearance, aroma, flavor, sweetness, acidity, and overall acceptance, using a nine-point structured hedonic scale with the extreme terms "disliked extremely" and “liked extremely”.

Hedonic values from 1 to 4 are configured as the "rejection region," while hedonic

values from 6 to 9 are characterized as the "acceptance region," and the value 5 is characterized as the "indifference region" (neither liked nor disliked). The intention to purchase the beverage was assessed using a five-point purchase attitude scale, structured with the extreme terms "would certainly not buy" and "would certainly buy" (SOUSA 2023).

Statistical analysis

The results obtained were analyzed using analysis of variance (ANOVA), and the differences in means were compared using Tukey's test at a 5% probability level. The most important constituents were analyzed using the Origin 8.0 software.

RESULTS AND DISCUSSION

Characterization of the raw material

The total soluble solids found in ginger showed an average value lower than that obtained by SILVA et al. (2020), which was 6.0 ± 0.48 °Brix in the same raw material. Regarding pH, the value found was also lower than that obtained by SILVA et al. (2020), which was 6.4 ± 0.79. As for titratable acidity, the value found in ginger was lower than that obtained by CRISTOFEL (2018), which was 10.8 ± 0.3 mEq/100 g for the same raw material. Possible reasons for these differences include variations in the origin of the raw material, different analytical methods, seasonal fluctuations in the chemical composition of the plants, as well as diverse storage and post-harvest processing conditions among the studies. These results are indicated in Table 2.

Table 2. Physico-chemical analysis of ginger.

Parameters	Ginger rhizomes	SILVA et al. (2020)	CRISTOFEL (2018)
Total Soluble Solids (°Brix)	3.0 ± 0.0	6.0 ± 0.48	-
pH	5.58 ± 0.03	6.4 ± 0.79	-
Total titratable acidity (mEq/100 g)	4.38 ± 0.88	-	10.8 ± 0.3

The TSS results obtained for soursop were in accordance with the identity and quality standards (IQS) for fruit pulp, which require a minimum of 9 °Brix (BRAZIL 2000). This indicates that the soursop analyzed meets the minimum sweetness requirements, although the values were lower than those reported by SILVA (2016), with 14.5 °Brix, and SANTOS et al. (2014), with 17.5 °Brix for the same raw material.

Regarding pH, the results were within the limits established by legislation, which requires a minimum of 3.5 for soursop pulp. They were similar to those recorded by SILVA (2016), of 3.64, and by SANTOS et al. (2014), who obtained 3.80 ± 0.06.

Regarding total acidity, expressed as citric acid, the results met the parameters required by the IQS, which establish a minimum of 0.6%, but were below the levels observed by SILVA (2016) and SANTOS et al. (2014), with values of 1.67% ± 0.00 and 0.79 ± 0.02%, respectively. The complete data can be found in Table 3.

Table 3. *Physico-chemical analysis of soursop.*

Physicochemical characterization	Soursop	BRAZIL (2000)	SANTOS et al. (2014)	SILVA (2016)
Total Soluble Solids (°Brix)	11.0 ± 0.0	Minimum 9	17.5 ± 0.0	14.5
pH	3.83 ± 0.05	Minimum 3.5	3.80 ± 0.06	3.64
Total acidity in citric acid (%)	0.61 ± 0.05	Minimum 0.6	0.79 ± 0.02	1.67

Kinetic analyses

Kinetics of induced fermentation

The TSS, which started at 18, was at 10 °Brix on the 12th day, showing the expected decreasing behavior during the fermentation stage. This value is lower than that described by Araújo et al. (2020), which was 12.5 for a fermented cupuaçu alcoholic beverage with an initial °Brix of 25. Therefore, it can be observed that the TSS has not yet remained constant, indicating that there are still fermentable sugars in the must.

The initial pH of 6.5 was around 4.25 on the 12th day of fermentation, with a gradual variation in this variable. This value is higher than that found by SANTOS et al. (2020), which was 3.5 at the end of the fermentation of a fermented guava alcoholic beverage. This difference may have occurred because the initial pH of the guava fermentate started at a different value than in this study. In addition, other factors such as the chemical composition of the fruit and fermentation conditions can influence the pH throughout the process.

The total titratable acidity, initially at 0.81 ± 0.0 mEq/L, was 31.98 ± 0.4 on the 12th day, lower than that found by ROCHA et al. (2019), who obtained a value of 74.73 mEq/L for alcoholic fermentation from buriti pulp with an initial °Brix of 21. This difference can be attributed to several factors, including the specific chemical composition of the substrate (buriti pulp), the diversity of microorganisms involved in the fermentation, and the particular fermentation conditions used in both studies.

On the 12th day of fermentation, the alcohol content reached 4.32 °GL. It is crucial to note that this value falls within the range stipulated by legislation for alcoholic fruit ferments, which specifies an alcohol content between 4 and 14% volume by volume (v/v). This compliance with legal parameters is a positive indicator that the fermentation is progressing as expected, and that the final product is within the established limits (BRAZIL 2024). This suggests that the fermentation process is occurring in a controlled and efficient manner, resulting in an alcohol content suitable for a fermented beverage category. The results of the kinetic analysis during the induced fermentation are shown in Figure 3.

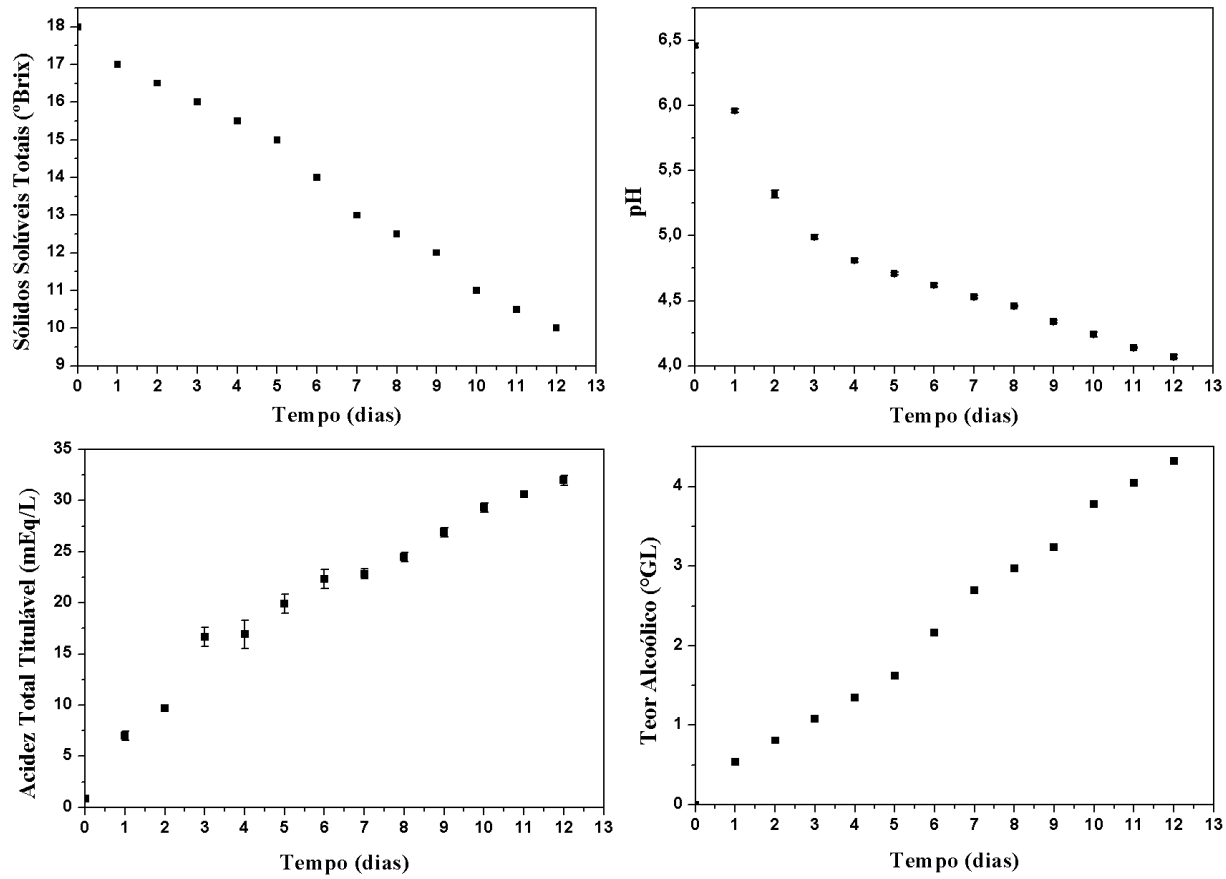

Figure 3. Parameters monitored during induced fermentation.

Kinetics of natural fermentation

The results show that the addition of ginger bug to the fermentation had a significant effect on the TSS levels throughout the process. The TSS, which started at 18, was at 16.8 °Brix on the 5th day of fermentation, remaining at that value until the 7th day. On the 8th day, the TSS dropped to 16.6 °Brix, remaining at that value until the end of the kinetic analysis of the fermentation with the addition of ginger bug, indicating a decrease of 7.78%. Meanwhile, the study by OLIVEIRA et al. (2024) showed a decrease of 5.77% (from 13 to 12.25 °Brix) in 14 days, indicating that the present study was more efficient in converting sugar into alcohol.

In contrast, the group without the addition of ginger bug did not show a significant variation in TSS levels. The influence of the ginger bug on the results is crucial for the interpretation of the data. According to AQUARONE et al. (2001), the ginger fermentation yeast, *Saccharomyces pyriformis*, appears not to have the capacity to consume the sugar in the must. This peculiarity of the yeast is central to understanding the developments of this fermentation. Its limited ability to metabolize the sugars in the must can have significant implications for the final production of the fermented beverage. This phenomenon can influence the alcohol content and the sensory profile of the beverage, since the sugars are not completely consumed during the fermentation process.

The pH results throughout the fermentation process showed significant variations between the groups with and without the addition of ginger bug. Initially, the starting

pH was six, and on the 5th day of fermentation in the group with ginger bug, a sharp drop to approximately 3.12 was observed. This trend of decreasing pH was gradual until the 12th day of the kinetic study, when it reached the most acidic value of 2.56, similar to that obtained by OLIVEIRA et al. (2024), of 2.66 after 14 days of fermentation. On the other hand, the group without the addition of ginger bug maintained a higher pH, around 4.09, on the last day of kinetic analysis.

It is interesting to note that the results obtained in this study differ from those found by SANTOS et al. (2020) in their research on the fermentation of a guava alcoholic beverage. In this study, the pH was around 3.4 on the 5th day and 3.3 on the 8th day of fermentation. This notable difference can be attributed, in part, to the fact that the initial pH of the guava fermentate was different from the initial pH value in this study. Besides, variations in the products and fermentation conditions may have played a significant role in the discrepancy of the results.

The analysis of total titratable acidity revealed notable variations throughout the kinetic study of fermentation with the addition of ginger bug. Initially, the acidity was 2.04 ± 0.5 mEq/L, and on the 5th day of fermentation, there was a significant increase to 9.06 ± 1.33. This upward trend continued until the 12th day, reaching a remarkably high value of 31.86 ± 5.7. In contrast, in the fermentation group without ginger bug, the total titratable acidity was 15.59 ± 0.4 mEq/L on the 12th day.

Comparing these results with the study by Rocha et al. (2019), there is a substantial discrepancy. In the previous study, alcoholic fermentation from buriti pulp, with an initial TSS of 13 °Brix and pulp diluted in 75% water, resulted in an acidity of 34.63 mEq/L. This difference can be attributed to variations in the substrates used, as well as in the fermentation processes.

It is important to emphasize that the values obtained are below the limit indicated by the legislation for fermented fruit products, which requires a minimum of 50 mEq/L of total titratable acidity. This result can be explained by the peculiarities of the ginger beer production process, which may not fully align with the category established by this legislation.

The analysis of the alcohol content throughout the fermentation process showed distinct results between the groups with and without the addition of ginger bug. In the group with ginger bug, the alcohol content was 0.64 ± 0.18 ° GL on the 5th day of fermentation. This quantity remained relatively stable until the 12th day, reaching 0.71 ± 0.16 °GL, classifying the beverage as low in alcohol content. On the other hand, the group without ginger bug did not show any detectable amount of alcohol content throughout the fermentation period, remaining at 0 °GL. Therefore, this fermentation does not qualify as an alcoholic beverage.

The explanation for this low alcohol content, as pointed out by AQUARONE et al. (2001), is linked to the yeast used in ginger fermentation, known as *Saccharomyces pyriformis*. Despite driving the fermentation process, this yeast results in a relatively low alcohol concentration. This characteristic of *Saccharomyces pyriformis* is crucial to understanding the limitation in alcohol content achieved during the ginger beer fermentation process.

This difference in alcohol content between the groups highlights the decisive influence of adding ginger bug to the fermentation process and the final composition

of the beverage. Furthermore, it reinforces the importance of understanding the specific characteristics of the yeasts used in fermentations, since they play a crucial role in the production of compounds such as alcohol.

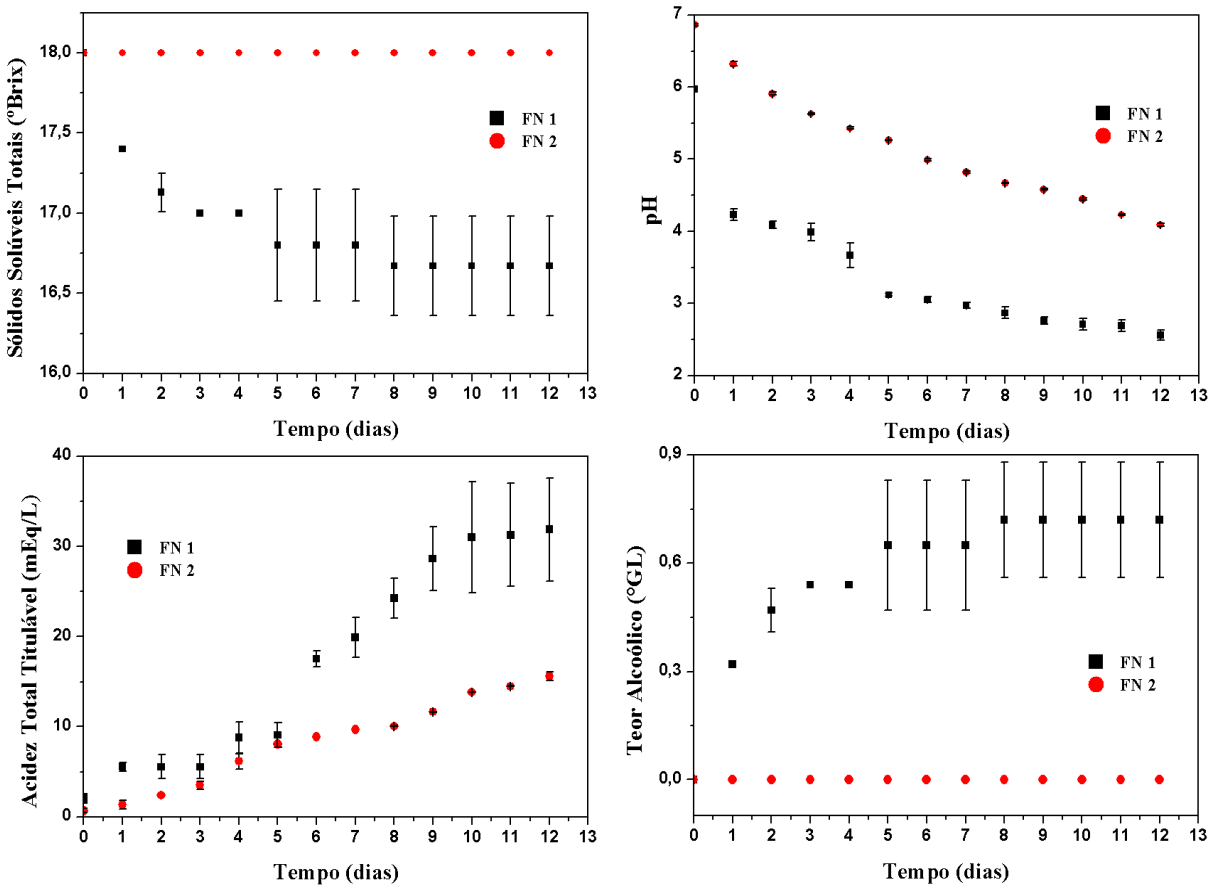

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Figure 4. Parameters monitored during natural fermentation. FN 1 = Fermentation with ginger bug; FN 2 = Fermentation without ginger bug.

Physicochemical analyses of the beverages produced

Regarding the total soluble solids (TSS) content, ginger beer flavored with soursop showed lower values under all fermentation conditions and soursop concentrations, ranging from 9.0 to 16.0 °Brix. In contrast, the cupuaçu and açaí beverages analyzed by ARAÚJO et al. (2020) showed values of 12.5 and 14.9 °Brix, respectively. This suggests that the ginger beer samples with soursop have a lower concentration of total soluble solids compared to the Cupuaçu and Açaí drinks. MITROI & DIACONESCU (2024) found a higher value than this study, 7.25 °Brix for artisanal ginger beer.

Regarding alcohol content (°GL), these beverages also show lower values (ranging from 1.08 to 4.86 °GL) compared to cupuaçu and açaí beverages, which register 6.76 and 5.45 °GL, respectively.

Regarding Total Titratable Acidity (mEq/L), the samples show lower values (ranging from 32.45 to 38.02 mEq/L) compared to cupuaçu and açaí beverages, which register 90.77 and 54.73 mEq/L, respectively. This suggests that the beverages are less acidic compared to the other drinks.

Finally, regarding pH, the ginger beer samples are more acidic (ranging from 2.95 to 3.18) compared to the cupuaçu and açaí beverages, which have a pH of 3, and less acidic than that found by MITROI & DIACONESCU (2024), which was 3.6 for artisanal ginger beer. This indicates that they have a lower pH, which can influence the flavor and stability of the product. The physicochemical characterization of the fermented beverages is shown in Table 4.

Table 4. Physico-chemical characterization of the fermented products produced.

Parameters	Induced fermentation (10% soursop)	Induced fermentation (20% soursop)	Natural fermentation (10% soursop)	Natural fermentation (20% soursop)
Total soluble solids (°Brix)	9.6 ± 0.0^{d}	9.0 ± 0.0^{a}	16.0 ± 0.0^{b}	15.5 ± 0.0^{c}
pH	3.04 ± 0.0^{b}	$3.18 \pm .,0^{a}$	2.95 ± 0.0^{b}	3.02 ± 0.0^{b}
Total Titratable Acidity (mEq/L)	31.87 ± 0.6^{b}	38.02 ± 0.8^{a}	32.45 ± 0.5^{d}	36.74 ± 0.7^{c}
Alcohol content (°GL)	4.54 ± 0.0^{b}	4.86 ± 0.0^{a}	1.08 ± 0.0^{c}	1.35 ± 0.0^{d}

*Averages followed by the same letter, uppercase in the column and lowercase in the rows, do not differ statistically from each other according to Tukey's test at a 5% significance level.

Microbiological analysis

The results obtained demonstrate that the ginger ferments flavored with soursop, produced using different types of fermentation and percentages of soursop, were manufactured under appropriate sanitary conditions. The absence of the microorganisms tested confirms compliance with the microbiological standards established by Resolution RDC No. 12, of January 2, 2001, which approves the technical regulation for quality control in food in Brazil (BRASIL 2001). The data from the microbiological analysis of the 4 samples of the beverage produced are presented in Table 5.

Table 5. Microbiological analysis of the products produced.

Analyses	Induced fermentation (10% soursop)	Induced fermentation (20% soursop)	Natural fermentation (10% soursop)	Natural fermentation (20% soursop)
Total and thermotolerant coliforms	Absent	Absent	Absent	Absent
Salmonella	Absent	Absent	Absent	Absent
Mesophiles	Absent	Absent	Absent	Absent
Molds and yeasts	Absent	Absent	Absent	Absent

Sensory analysis

The samples showed similar scores in the overall appearance attribute, ranging between 6.7 and 6.98, indicating that the tasters did not perceive significant differences, characterizing the beverage as cloudy and carbonated, as mentioned by OLIVEIRA et al. (2024). All samples received scores below the reference of 8.29 for overall acceptance of the ginger beer, according to TOZETTO (2017). Regarding color,

the evaluations ranged around six, suggesting that the yellow hue of the beverage was considered acceptable. The formulation resulting from fermentation induced with 10% soursop received the highest score for color, 6.98, with 75% of the tasters assigning scores above six.

Regarding aroma, the samples showed similar acceptance, with a focus on citrus, refreshing, and fermented aromas. In terms of flavor, the fermented beverage with 20% soursop stood out, as 70% of the tasters gave scores above seven (indicating "moderately liked"), presenting an acidic profile, as observed by OLIVEIRA et al. (2024). Figure 5 illustrates the results of the sensory analysis in relation to the attributes evaluated.

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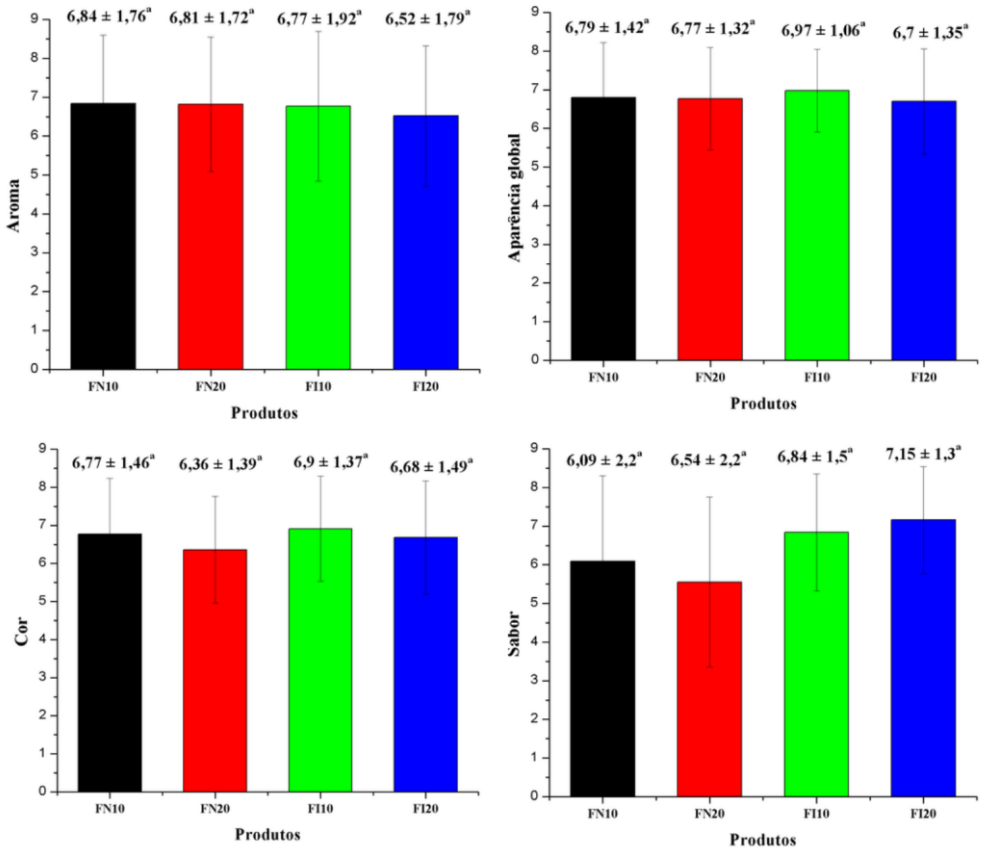
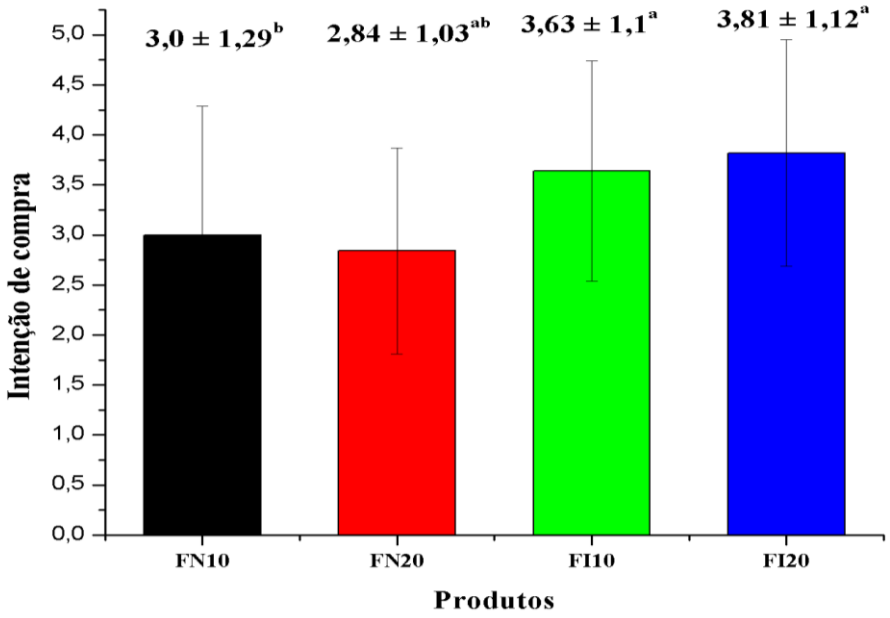


*Averages followed by the same letter, uppercase in the column and lowercase in the rows, do not differ statistically from each other according to Tukey's test at a 5% significance level.

Figure 6. Attributes evaluated in the sensory analysis.

Regarding purchase intention, the beverage produced by natural fermentation with 20% soursop stood out negatively, as it was the only one that did not reach an average of 3 or higher, with 40% of tasters indicating a tendency not to purchase it. In contrast, the formulation resulting from induced fermentation, flavored with 20% soursop, received the highest score, with an average of 3.82. This option received the approval of 72.5% of the tasters, who assigned scores equal to or greater than 3, similar approval to that described by SANTOS (2013) who obtained more than 70% of scores equal to or above 3. The results regarding purchase intention are illustrated in Figure 6.



*Averages followed by the same letter, uppercase in the column and lowercase in the rows, do not differ statistically from each other according to Tukey's test at a 5% significance level.

Figure 6. Purchase intention of the tasters.

CONCLUSION

The study evaluated the physicochemical and microbiological characterization of fermented ginger beverages flavored with soursop, highlighting differences in soluble solids, pH, total acidity, and alcohol content compared to other beverages such as cupuaçu and açaí. Kinetic analyses showed that fermentation with ginger bug positively influenced pH and acidity parameters, resulting in more acidic beverages with detectable alcohol content, while fermentation without ginger bug did not show any alcohol content. Kinetic analyses showed that fermentation with ginger bug positively influenced pH and acidity parameters, resulting in more acidic beverages with detectable alcohol content, while fermentation without ginger bug did not show any alcohol content.

AUTHOR'S CONTRIBUTIONS

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Conceptualization, methodology and formal analysis, investigation, writing - preparation of the original draft, writing - review and editing, visualization.
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All authors have read and agreed to the published version of the manuscript.

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STATEMENT OF THE INSTITUTIONAL REVIEW BOARD
The present study, involving sensory analysis with human subjects, was approved by the Institutional Review Board (Research Ethics Committee – CEP), through the Brazil Platform, under CAAE number 69770223.0.0000.5020 and Opinion number 6419942.

INFORMED CONSENT STATEMENT
All participants in the study were previously informed about the objectives, procedures, and possible risks of the study, and voluntarily agreed to participate by signing the Informed Consent Form, as required by the ethical guidelines established by the Brazil Platform and the Research Ethics Committee.

DATA AVAILABILITY STATEMENT
The data can be made available upon request.

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CONFLICTS OF INTEREST
The authors declare that they have no conflicts of interest.

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