

Qualification of native fruit juices produced by family agroindustries in Rio Grande do Sul

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ABSTRACT

Native fruits have been gaining prominence in recent years due to their nutritional characteristics and high levels of fiber, minerals, water, and antioxidant compounds, as well as nutraceutical properties. For the most part, they have great potential for economic exploitation, as they allow for local food production that was mostly consumed only by farmers or even not utilized at all, with low or no implementation and maintenance costs. Although they have great potential for use and exploitation by family farming, due to the high perishability of most of these fruits, their availability in more distant locations and at times outside of harvest periods has only been made possible through processing in agribusinesses. This study aimed to analyze the physicochemical and microbiological characteristics of juices made from native fruits of pineapple, butiá, and guabiroba produced by family agroindustries registered in the State Program of Family Agroindustry of Rio Grande do Sul. Physicochemical analyses of pH, soluble solids content, titratable acidity, and soluble solids/titratable acidity ratio were carried out, as well as microbiological analyses (investigation of *Salmonella* spp., enumeration of thermotolerant and total coliforms, *Staphylococcus aureus*, and *Escherichia coli*). The experimental design adopted was completely randomized. As for the results obtained, the juice samples were found to be within Brazilian legislation due to the absence of microbiological contaminants, thus being suitable for consumption. The native fruit juices from family agroindustries registered in the PEAFA meet most of the identity and quality standards of current legislation.

RESUMO

As frutas nativas vêm ganhando destaque nos últimos anos em virtude de conterem características nutricionais e teores elevados de fibras, minerais, água e compostos antioxidantes, bem como propriedades nutraceuticas. Na sua maioria, possuem grande potencial para exploração econômica, uma vez que propiciam produções locais de alimentos que estavam em sua maioria sendo consumidos apenas pelos agricultores ou até nem sendo aproveitados, com baixo ou nenhum custo de implantação e manutenção. Embora com grande potencial para uso e exploração pela agricultura familiar, devido à alta perecibilidade da maioria desses frutos, apenas mediante o processamento em agroindústrias tem sido viabilizada a sua oferta em locais mais distantes e em momentos extemporâneos às safras. Este trabalho teve como objetivo analisar as características físico-químicas e microbiológicas dos sucos de frutas nativas de ananás, butiá e guabiroba produzidos por agroindústrias familiares cadastradas no Programa Estadual de Agroindústria Familiar do Rio Grande do Sul. Foram realizadas análises físico-químicas de pH, teor de sólidos solúveis, acidez titulável e relação sólidos solúveis/acidez titulável, e análises microbiológicas (pesquisa de *Salmonella* spp., contagem de coliformes termotolerantes e totais, *Staphylococcus aureus* e *Escherichia coli*). O delineamento experimental adotado foi inteiramente casualizado. Como resultados obtidos as amostras dos sucos se encontram dentro da legislação brasileira pela inexistência de contaminantes microbiológicos, sendo assim aptas para o consumo. Os sucos de frutas nativas de agroindústrias familiares cadastrados no PEAFA atendem à maioria dos padrões de identidade e qualidade da legislação vigente.

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Introduction

Native fruit species boast a wealth of nutrients and bioactive chemical compounds, whose inclusion in the human diet has been associated with a wide range of health benefits (Fonseca Antunes *et al.*, 2024). In the specific context of the state of Rio Grande do Sul, there is an increasing prominence of these native fruit varieties, due to their superior nutritional properties, notably highlighting the high vitamin C content and the significant presence of antioxidants (Coradin and Camilo, 2018; Rodrigues *et al.*, 2020).

Recent studies have identified 213 native fruit species in Rio Grande do Sul, distributed among 48 families and 102 genera. Among these, the standout species are: Butiás, Pineapples, and Guabirobas (Brack *et al.*, 2020).

In Rio Grande do Sul, there are programs aimed at family farmers, intended to make the production, processing, and marketing of native fruits feasible. Two of these programs are the State Program of Family Agroindustry (PEAF) and the Solidarity Chain of Native Fruits (CSFN). They provide support so that farmers can integrate these activities in a sustainable and profitable way (CETAP, 2015; Rio Grande do Sul, 2013).

Most native fruits are intended for the processing industry, where they are transformed into a wide range of products, including juices, ice creams, popsicles, jams, and liqueurs, among others (Lima *et al.*, 2018; Morais *et al.*, 2022).

When native fruits are directed towards juice production, one of the main procedures adopted is pasteurization. This process ensures the stability of the product and food safety by eliminating pathogenic and deteriorating microorganisms, without significantly compromising the sensory and nutritional properties of the juice (Branco *et al.*, 2016).

The production of fruit juices and pulps follows the regulations established by the Ministry of Agriculture, Livestock, and Supply (*Ministério da Agricultura, Pecuária e Abastecimento* - MAPA). Through the definition of strict physicochemical parameters and the implementation of identity and quality standards, these regulations ensure that fruit-derived products are safe, nutritious, and of high quality (Brasil, 2018).

In this context, the present research aimed to evaluate the physicochemical and microbiological parameters of pineapple, butiá, and guabiroba juices registered in the State Agroindustry Program and made available for sale in the pavilion dedicated to family farming during the 45th International Animal Exhibition (Expointer).

Materials and Methods

The experiment was conducted with juices from native fruits from family-owned agro-industries registered in the State Family Agro-industry Program. To obtain the samples, agro-industries that sold their products at the Family Agriculture Pavilion, located at the Assis Brasil

State Exhibition Park, during the 45th International Animal Exhibition (Expointer) from August 27th to September 4th, 2022, in the municipality of Esteio, RS, were selected.

The samples came from the municipalities of Antônio Prado, Canguçu, and São Lourenço do Sul, located in the State of Rio Grande do Sul, with the sample group being conditioned to the species that were being marketed during the 45th Expointer. Two commercial brands of pineapple juice were obtained (*Ananas comosus* L.), three commercial brands of Butiá juice (*Butia* spp.) is a commercial brand of Guabiroba juice (*Campomanesia xanthocarpa* O. Berg).

Physico-Chemical Analyses

The physicochemical evaluations were conducted at the Microbiology Laboratory of the State University of Rio Grande do Sul (*Universidade Estadual do Rio Grande do Sul - UERGS*), Santana do Livramento unit, RS. Analyses of soluble solids (SS), pH, titratable acidity (TA), and the soluble solids/titratable acidity ratio (SS/TA) were carried out, following the methodology described by Adolfo Lutz (2008).

The determination of soluble solids was carried out using a refractometer, which indicated the concentration of soluble sugars present in the sample, presenting the result in degrees Brix (°Brix).

The determination of pH was carried out by direct reading in homogenized pulp solutions. First, a 10 mL aliquot of the sample was obtained and measured with the help of a pH meter previously calibrated with buffer solutions of pH 4.0 and 7.0 to ensure measurement accuracy.

The determination of acidity was carried out by titration with a 0.1 mol/L sodium hydroxide solution until a color change of the solution occurred at the equivalence point (pH 8.2), indicating the end point of the titration, the result of which was expressed as a percentage of the predominant acid. For the preparation of the sample, 10 mL of the sample was pipetted and homogenized with 60 mL of distilled water. From the prepared dilution, 10 mL was collected and added to an Erlenmeyer flask, along with 3 drops of phenolphthalein indicator. A 25 mL burette was filled with the sodium hydroxide solution, and the titration was carried out until reaching the endpoint, indicated by the color change of the solution upon reaching the equivalence point (pH 8.2). The results were expressed as a percentage of citric acid (% citric acid).

The relationship between soluble solids/titratable acidity (SS/TA) is used as a criterion for taste evaluation. The SS/TA ratio was obtained through the quotient between soluble solids and titratable acidity.

The color assessment of the juices was carried out using the Minolta® colorimeter, model CR400, and the CIELAB color scale. The device was calibrated using a white ceramic plate, employing the D65 illuminant ($z=93.6$; $x=0.3133$; $y=0.3195$). The juices were analyzed in triplicate for the parameters of (L^*) lightness, (a^*) red/green intensity (+/-), (b^*) yellow/blue intensity (+/-), (C^*) chroma, and (h^*) hue angle.

Microbiological Analyses

Microbiological analyses were carried out at the Microbiology Laboratory of the Federal University of Pampa (*Universidade Federal do Pampa - Unipampa*), Dom Pedrito campus, RS. The Most Probable Number (MPN/mL) of total and thermotolerant coliforms was determined, as well as the detection of *Escherichia coli*. In addition, the count of mesophilic aerobic bacteria (CFU/mL), the search for *Salmonella* spp., and the quantification of coagulase-positive *Staphylococcus* were performed.

The test for the detection of *Salmonella* spp. was conducted according to the ISO 6579 method. The count of Total and Thermotolerant Coliforms (*Escherichia coli*) followed the Most Probable Number (MPN) method of the AHPA. For the count of Coagulase-Positive *Staphylococcus*, the standard plate count was adopted for the quantification of microbial groups, according to the methodology described by Silva *et al.* (2010). For the analyses, 25 mL of each sample were transferred to flasks containing 225 mL of sterile peptone water, corresponding to the 10^{-1} dilution. From this dilution, further dilutions were prepared 10^{-2} and 10^{-3} .

For the determination of the most probable number (MPN/mL) of total and thermotolerant coliforms, 1 mL of each dilution was transferred to test tubes containing 9 mL of Lauryl Tryptose Sulfate (*Lauril Sulfato Tryptose - LST*) broth with inverted Durham tubes. The procedure was performed in triplicate, and the tubes were incubated in an oven at 35 °C for 24-48 hours. For the confirmatory test, with the aid of a platinum loop, a loopful from the positive LST tubes was inoculated into tubes containing Brilliant Green Bile 2% (VB) broth, incubated under the same previous conditions, with positivity also verified for those that produce gas. The MPN/mL of total coliforms was determined according to the reference values of Silva, Junqueira, and Silveira (2017).

For the analysis of thermotolerant coliforms, inocula from positive CLS tubes were transferred to tubes containing *Escherichia coli* (EC) Broth, which were incubated in a water bath at 44 °C for 24 hours. The results were expressed according to the MPN/mL table (Silva *et al.*, 2017). In the case of positive EC tubes, the analyses for the search of *E. coli*.

For the detection of the presence of *Salmonella* spp., 1 mL of the 10^{-1} dilution (225 mL of sterile peptone water plus 25 mL of each of the samples), after incubation for 20 hours at 35

°C, was transferred to tubes containing 10 mL of Kauffmann Tetrathionate broth (TT), which were incubated at 35 °C for 24 hours. Subsequently, these samples were inoculated by streaking onto selective media Hektoen Enteric Agar (HE), Bismuth Sulfite Agar (BS), and Xylose Lysine Deoxycholate Agar (XLD) and incubated for 72 hours at 36 °C to verify the presence of typical colonies.

Statistical Analysis

The experimental design adopted was the completely randomized design (CRD). Three replications per treatment were used. The data were subjected to analysis of variance. In the case of a significant difference, the means were compared using Tukey's test, at a 5% probability of error, using the free software Genes®.

Results and Discussion

The results of the physicochemical analyses of the pineapple juice samples showed significant variations in the soluble solids content parameters - SS (°Brix), pH, titratable acidity - TA (% citric acid) and the soluble solids/titratable acidity ratio (SS/TA), as indicated in Table 1.

Table 1.

Soluble solids content - SS (°Brix), pH, titratable acidity - TA (% citric acid) and soluble solids/titratable acidity ratio (SS/TA) of pineapple juices.

Juices	Location	SS	pH	TA (%)	SS/TA
Pineapple	São Lourenço do Sul - RS	12.53 a	3.14 b	2.37 a	5.32 b
Pineapple	Canguçu - RS	8.17 b	3.63 a	0.91 b	9.03 a
CV (%)		2.62%	2.64%	9.96%	8.61%

Means followed by different letters in the column differ statistically from each other at the 5% probability of error level, according to the Tukey Test. Source: Authors, 2025.

According to Normative Instruction No. 37, of October 1st, 2018, the minimum soluble solids content for pineapple juice must be 11 °Brix. Based on the results obtained, it is verified that the juice produced by the agroindustry in the municipality of São Lourenço do Sul, RS, meets the minimum value stipulated by the Ministry of Agriculture, Livestock and Supply (*Ministério da Agricultura, Pecuária e Abastecimento* - MAPA), showing a value of 12.53 °Brix. On the other hand, the juice produced by the agroindustry in the municipality of Canguçu, RS, registered a content of 8.17 °Brix, not reaching the minimum value required by the regulation.

The measurement of soluble solids is a reliable indicator of ripening, as sugars and other compounds increase over time in the plant. A high soluble solids content indicates a more

mature fruit, with fully developed aroma, flavor, and organoleptic characteristics (CEAGESP, 2016). According to Chitarra and Chitarra (2005), a decrease in soluble solids values can result in a loss of sensory characteristics, since this variable is linked to the content of solids dissolved in the solution, including sugars. In this context, it is understood that the juice produced by the Agroindustry of Canguçu, RS, comes from fruits harvested at a maturity stage still early compared to the ideal development of soluble solids. Vollmer *et al.* (2020) investigated pineapple juice pasteurized at 90°C and found soluble solids contents ranging between 11.7 and 11.9 °Brix.

The pH values of the analyzed juices were 3.14 and 3.63. These values indicate an acidity level that can be considered typical for many fruit juices.

Pinheiro (2006) observed pH values in a similar range, between 3.46 and 3.63, for juices of the same species. This conformity suggests consistency in acidity levels over time, possibly indicating that the production methods and the fruit varieties used remain similar. Difonzo *et al.* (2019), in their study on pineapple pulp juices, found a pH value of 4.05. This value is significantly higher compared to the obtained data (3.14 and 3.63) and those reported by Pinheiro (2006). The difference may be attributed to various factors, including the ripening of the pineapple, cultivation conditions, pulp processing, and possible additions of preservatives or other additives that could alter the final pH of the juice. Chadaré *et al.* (2021) investigated pasteurized pineapple juices at different temperatures (75 °C, 80 °C, and 85 °C) and reported pH values between 3.93 and 4.27. These results suggest that pasteurization may influence the juice's pH, possibly due to protein denaturation and other heat-induced chemical changes.

Titrateable acidity values of 0.91% and 2.37% were recorded in pineapple juices. According to current regulations, the minimum acidity expressed as citric acid must be 0.3 g/100 g, which is equivalent to 0.3%. The acidity of the juices is a determining factor for their stability and sensory acceptance. According to Leonel *et al.* (2014), the interaction between acidity and the sugars present in the juice contributes significantly to the flavor and aroma of the product.

Based on these values, it can be concluded that both analyzed juice samples meet the established criteria for pineapple juices. Azeredo *et al.* (2006) highlight that the variety of fruits used, as well as the methods of handling and storage, can significantly influence the levels of acidity in the final product. Fruits from different cultivars or harvested at different stages of ripeness may exhibit natural variations in acidity. Additionally, storage conditions such as temperature and humidity can affect the stability of the acids present in the juice.

The relationship between soluble solids and titrateable acidity (SS/TA) ranged from 5.32 to 9.03. When analyzing pineapple juices individually, a distinct relationship between soluble solids and acidity is observed. Although this ratio is higher, the sugar content in the Canguçu juice is relatively low compared to the juice from the other region. This results in a sensory

profile characterized by a less sweet and more acidic taste. This observation is relevant for understanding the sensory variations of pineapple juices from different origins. Titratable acidity should be balanced with the content of soluble solids, such as sugars, to create a harmonious flavor profile (Cades, 2014; Chitarra, 2005). Therefore, the balance between acidity and soluble solids is essential to ensure that the juice has a pleasant taste and is well accepted by consumers.

The results of the physicochemical analyses of the Butiá juice samples revealed significant variations in the parameters of soluble solids content ($^{\circ}$ Brix), pH, and soluble solids/titratable acidity ratio, as indicated in Table 2. However, the titratable acidity (% citric acid) did not show significant differences between the samples.

Table 2.

Soluble solids content - SS ($^{\circ}$ Brix), pH, titratable acidity - TA (% citric acid) and soluble solids/titratable acidity ratio (SS/TA) of Butiá juices.

Juices	Location	SS	pH	TA (%)	SS/TA
Butiá	São Lourenço do Sul - RS	8.5 b	3.30 a	1.18 ^{*ns}	7.23 b
Butiá	Canguçu - RS	11.8 a	3.27 a	1.22	9.77 a
Butiá	Antônio Prado - RS	4.4 c	3.04 b	1.16	3.78 c
CV (%)		6.38%	2.72%	3.94%	8.87%

*Averages followed by different letters in the column differ statistically from each other, at a 5% probability of error, according to Tukey's Test. *ns: Not significant. Source: Authors, 2025.*

According to IN No. 37, of October 1st, 2018, MAPA established the standards of identity and quality (SIQ) for butiá juice/pulp, whose minimum value for soluble solids must be 6 $^{\circ}$ Brix at 20 $^{\circ}$ C; pH 2, at least; and titratable acidity, expressed as citric acid, 0.8 g per 100 g (0.8%) at least (Brasil, 2018).

The content of soluble solids found ranged from 4.4 to 11.87 $^{\circ}$ Brix. According to the values stipulated by the regulations, only the Butiá juice produced by the agroindustry in Antônio Prado, RS, does not reach the minimum content of soluble solids. Souza *et al.* (2020) report that the levels of soluble solids are often associated with the ripening and quality of the fruits. During the ripening process, the polysaccharides present in the fruits are converted into simpler sugars, resulting in an increase in soluble solids (Prado, 2009).

Martins *et al.* (2018) evaluated chemical parameters of Butiá juices pasteurized at 80 $^{\circ}$ C, whose fruits were from the North Coast of Rio Grande do Sul. As a result of their evaluations, a low soluble solids content (3.51 $^{\circ}$ Brix) was obtained, a value lower than the smallest of the results evidenced in this study. On the other hand, a pH value of 3.91 was found, slightly above the values observed in the present study of 3.04 to 3.30. In Butiá fruits, the

significant presence of these acids can contribute to the reduction of pH, giving them a characteristic flavor and a distinctive acidity (Sganzerla, 2010).

The analysis of titratable acidity in butiá juices did not reveal significant differences, with values ranging from 1.16% to 1.22% citric acid, within the limits established by legislation. These results suggest uniformity in the acidity of the juices examined, indicating a consistent characteristic among the samples. On the other hand, the SS/TA ratio varied from 3.78 to 9.77. The lowest recorded value in this ratio is associated with the presence of low soluble solids content in the corresponding juice, resulting in a reduced proportion. Martins *et al.* (2019) evaluated physicochemical parameters in butiá pulp in the municipality of Giruá, RS. The analysis results revealed that the soluble solids content (°Brix) varied between 11.1 and 12.74. The recorded pH was consistently 3.4. In terms of acidity, expressed as a percentage of citric acid, values ranged from 1.3% to 1.5%. The SS/TA ratio was determined to be between 8.43 and 8.71. Veiga, Del Puerto, and Cabrera (2022) conducted an assessment of the same parameters, obtaining comparable results. The soluble solids content was 11.48 and 12.97, while the pH ranged from 2.99 to 3.53. As for acidity, expressed as a percentage of citric acid, the values found were 1.69% to 1.99%, whereas the SS/TA ratio varied from 6.49 to 7.25.

The results obtained from the physicochemical analyses of the guabiroba juice sample are shown in Table 3.

Table 3.

Soluble solids content - SS (°Brix), pH, titratable acidity - TA (% citric acid) and soluble solids/titratable acidity ratio (SS/TA) of Guabiroba juice.

Juice	Location	SS	pH	TA (%)	SS/TA
Guabiroba	Canguçu - RS	11.37	3.90	0.27	41.63

Source: Authors, 2025.

The Normative Instruction establishes that the minimum value of soluble solids for guabiroba juices must be 12 °Brix, pH of 3.6, and an acidity of at least 0.3 g per 100 g of citric acid (0.3%). The results obtained show compliance regarding soluble solids and pH; however, the acidity is below the minimum required value. The levels of soluble solids, as highlighted by Robaskewicz *et al.* (2016), are closely linked to the concentration of sugars present in the fruit. The higher the concentration of soluble solids, the greater the perceived sweetness of the fruit, directly reflecting its sensory acceptance by consumers.

A pH above 4.5 can create an environment conducive to the growth of microorganisms, representing a significant threat to microbiological safety and the quality of the final product (Fiorda and de Siqueria, 2009). Souza *et al.* (2013) describe titratable acidity as a parameter

to indicate the preservation process of fruit-based beverages. Low acidity in fruit-based beverages can result in a bland taste and a lack of freshness. Acidity is essential for enhancing the flavor of the fruits and balancing the sensory profile of the beverage. Araújo *et al.* (2016) note that pasteurized acerola juice tends to show a reduction in acidity as the temperature increases, which may result in the degradation of the acids present in the juice.

The SS/TA ratio was found to be high for guabiroba juice. This parameter represents the balance between the sugars and acids present in the fruits, exerting a direct influence on the flavor formation of both the fruits and the processed products. Fruits that have higher SS/TA values tend to have a more pronounced sweetness and reduced acidity, which generally makes them more attractive to consumers. This ratio is crucial in determining the sensory quality of the products and can significantly influence their acceptance in the consumer market (Gurak *et al.*, 2012; Viana *et al.*, 2017).

Martins *et al.* (2020) investigated the pasteurization and the physicochemical parameters of guabiroba pulp using different combinations of time and temperature, according to the requirements of Normative Instruction No. 37, of October 1st, 2018. The most satisfactory result was achieved with the combination of 3 minutes at 85°C, presenting soluble solids of 14.73 °Brix, pH of 4.02, and titratable acidity of 6.10%.

The results obtained from the analysis of luminosity parameters (pure white to pure black) (L^*), green (-) and red (+) intensity (a^*), blue (-) and yellow (+) intensity (b^*), chroma (C^*) and color angle (h^*) of the evaluated juices are presented in Table 4.

Table 4.

Average values corresponding to the determination of the parameters of brightness (pure white to pure black) (L^), intensity of green (-) and red (+) (a^*), intensity of blue (-) and yellow (+) (b^*), chroma (C^*) and color angle (h^*) of the evaluated juices.*

Juices	Location	L^*	a^*	b^*	C^*	h^*
Pineapple	Canguçu - RS	19.42	-1.26	5.97	6.10	78.09
Pineapple	São Lourenço do Sul - RS	15.18	-0.42	4.34	4.36	84.42
Butiá	São Lourenço do Sul - RS	18.97	-0.04	6.45	6.45	82.46
Butiá	Canguçu - RS	20.04	1.92	11.66	11.81	80.63
Butiá	Antônio Prado - RS	19.07	1.16	8.74	8.82	89.67
Guabiroba	Canguçu - RS	19.48	0.54	8.64	8.66	86.42

Source: Authors, 2025.

The observed brightness values indicate a predominance of dark tones, as they are close to absolute black. The negative values obtained for a^* (color component that ranges from green

(-) to red (+)) suggest a tendency of the color of the analyzed juices towards a slight neutrality, subtly oscillating between green and red intensities.

The positive values of b^* indicate a tendency towards yellow intensity. Chromaticity showed a slight fluctuation among the results, ranging from 4.36 to 11.26. The same behavior was observed in the values obtained for the color angle (h^*), which ranged from 78.09 to 86.42. The values of h^* range from 0° (pure red), 90° (pure yellow), 180° (pure green) to 270° (pure blue) (Ramallo and Mascheroni, 2012).

Based on these data, it can be understood that the angles move away from a pure green and tend toward pure yellow. Veiga, Del Puerto, and Cabrera (2022) found in their studies on the coloration of yellow, orange, and red butiá pulps that the pulp of yellow-colored fruits contained twice the amount of lutein compared to fruits of other colors. Lutein is a carotenoid present in foods with coloration ranging from yellow to red, recognized for its beneficial effects on eye health and its antioxidant properties.

González-Peña *et al.* (2023) report that orange/yellow-colored foods are rich in carotenoids, such as beta-carotene, lutein, and zeaxanthin, and play a crucial role in the prevention of ophthalmological diseases. These compounds, present in fruits, are accompanied by other phytochemicals, such as terpenes and flavonoids, like quercetin, which contribute to additional health benefits, including visual health, the immune system, and cardiovascular health.

Color influences the attraction or inhibition regarding food consumption. It is the first characteristic perceived by consumers and often determines whether the food will be accepted or rejected (Rocha and Reed, 2014). Observing color plays a crucial role in assessing the quality of food products, allowing consumers to quickly detect anomalies or defects. The color of a food is a visible and immediate indicator of its condition, reflecting freshness, ripeness, proper processing, and the presence of contamination or spoilage (Carrilha and Guiné, 2010).

The results obtained from the microbiological analyses of the juice samples are presented in Table 5.

Table 5.

Research of Salmonella spp., total coliform count (TCC), thermotolerant coliform count (TCC), coagulase-positive Staphylococcus (Staph. G+) and Escherichia coli (E. coli).

Juices	Location	<i>Salmonella</i> spp.	CTT (NMP mL ⁻¹)	CTTE (NMP mL ⁻¹)	<i>Staph.</i> G+	<i>E. coli</i>
Pineapple	Canguçu - RS	Abs	< 3.0	< 3.0	Abs	Abs
Pineapple	São Lourenço do Sul - RS	Abs	< 3.0	< 3.0	Abs	Abs
Butiá	São Lourenço do Sul - RS	Abs	< 3.0	< 3.0	Abs	Abs
Butiá	Canguçu - RS	Abs	< 3.0	< 3.0	Abs	Abs
Butiá	Antônio Prado - RS	Abs	< 3.0	< 3.0	Abs	Abs
Guabiroba	Canguçu - RS	Abs	< 3.0	< 3.0	Abs	Abs

Abs - Absence. Source: Authors, 2025.

Testing the microbiological quality of food is essential to prevent waterborne and foodborne diseases (DTHA), that is, those caused by the ingestion of contaminated water and/or food. There are more than 250 types of DTHA in the world, which can be caused by bacteria and their toxins, viruses, opportunistic intestinal parasites, or chemical substances. A literature review conducted by Seixas and Muttoni (2020), investigating outbreaks of DTA that occurred in Brazil, showed that most outbreaks have been related to the consumption of food with normal appearance, taste, and odor, without visible organoleptic changes. In the last 17 years, the main agents causing DTA outbreaks have been *Salmonella* spp., *Escherichia coli* and *Staphylococcus aureus*.

According to Normative Instruction - IN No. 161, of July 1st, 2022, which establishes the microbiological standards for food, for juices and other “fresh” beverages, the mandatory parameters to be tested are *Salmonella* spp. and *Escherichia coli*. In the present study, both microorganisms are absent, which indicates characteristics suitable for consumption.

Escherichia coli and *Salmonella* spp. bacteria are among the main microorganisms used as indicators of the microbiological quality of food. The presence of *E. coli*, in particular, is widely recognized as an indicator of fecal contamination. Some *E. coli* serotypes are potential pathogens, which can cause symptoms such as frequent, liquid stools with blood or mucus; severe stomach pain; vomiting; mild fevers; and reflux (Noronha *et al.*, 2019). *Salmonella* spp. is an enteric bacterium responsible for serious food poisoning, identified as one of the main agents involved in outbreaks recorded in various countries, being a public health problem in different countries due to its characteristics of endemicity, high morbidity, and especially due to the difficulty in adopting control measures (Shinohara *et al.*, 2008).

Sharma *et al.* (2001) reported an outbreak of *Salmonella enteritidis* attributed to inadequate washing of fruits used in the production of orange juices. In the study by Jesús *et al.* (2022), *E. coli* and *Salmonella* sp. were found in 85% of fresh juice samples sold in popular markets in Mexico. On the other hand, Vilas Boas *et al.* (2019), when evaluating some microbiological parameters, including *Salmonella* sp., in 323 fruit juice samples from different establishments located in the mesoregions of the state of Bahia, over a period of two years, found the absence of this microorganism in all samples. Another study, conducted in Campos dos Goytacazes/RJ, evaluating 27 fruit juice samples and analyzing microbiological parameters such as total coliforms, thermotolerant coliforms, and the presence of *Salmonella* spp., observed that all the analyzed samples were in microbiological conditions suitable according to current legislation and, therefore, safe for consumption (Brasileiro *et al.*, 2011).

Martins *et al.* (2020) conducted a study to assess the presence of *Salmonella* spp. in guabiroba pulps after the pasteurization process, carried out at temperatures between 85°C

and 90°C. The results revealed the absence of this pathogenic bacterium in the analyzed samples. This finding highlights the effectiveness of the pasteurization process in eliminating potential pathogenic agents, thus ensuring the microbiological safety of these food products.

Based on the results shown in Table 5, minimal results were found for the presence of total and thermotolerant coliforms, with values < 3 NMP/mL for all samples in both parameters. According to Leivas *et al.* (2017), careful attention to the hygiene of the place and personnel handling, equipment, and quality raw materials makes it possible to achieve these satisfactory results.

It is worth noting that the current legislation for fresh juices does not establish parameters for the presence of *Staphylococcus aureus*, which is commonly found in water and food, as this microorganism is part of the normal microbiota of humans, making the contamination process easier. Therefore, the development of *S. aureus* in food may be related to problems in packaging sterilization, as well as to the recontamination process, mainly due to the lack of use of PPE (personal protective equipment) by food handlers (Andrade Júnior *et al.*, 2019).

Thus, because it is a widely distributed bacterium and due to its opportunistic pathogenic potential, microbiological analyses were carried out to detect the possible presence of coagulase-positive *Staphylococcus* (the group to which *S. aureus* belongs) in the juice samples. In none of the evaluated samples was the presence of coagulase-positive *Staphylococcus* found, which rules out the possibility of the presence of *S. aureus*.

When analyzing orange juice samples sold in Uberlândia/MG, 40% of the samples tested positive for coagulase-positive *Staphylococcus*, in both types of products, whether stored in an electric cooler or not, therefore, posing a risk to the health of the final consumer. Thus, the research concludes that the hygienic-sanitary conditions of most establishments and/or personal hygiene of the handlers were not adequate, as they allowed contamination of the product, highlighting the importance of instructing and encouraging handlers on good handling practices (Godoi *et al.*, 2017).

Final considerations

With this study, it can be concluded that native fruit juices represent an interesting and promising path, as they end up involving the appreciation of native fruit species, environmental conservation, and becoming an income alternative for family farmers.

The analyses carried out allowed a preliminary study of the physicochemical and microbiological aspects of the juices, data still incipient for native fruits. The native fruit juices,

coming from family agribusinesses registered in the PEAf, meet most of the identity and quality standards of the current legislation.

Regarding the microbiological findings, it is concluded that possibly the hygienic and sanitary conditions of the establishments producing the analyzed juices, as well as the personal hygiene of the handlers, were adequate as they allowed the production of beverages without contamination by total coliforms, thermotolerant coliforms, *E. coli*, *Salmonella* spp., and coagulase-positive *Staphylococcus*.

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