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Grumixama (Eugenia brasiliensis) e jambolão (Eugenia jambolana): fonte de compostos bioativos e viabilidade na preparação de geleias e iogurtes

Grumixama (Eugenia brasiliensis) and jambolan (Eugenia jambolana): source of bioactive compounds and viability in the preparation of jams and yogurts

Grumichama (Eugenia brasiliensis) y jambool (Eugenia jambolana): fuente de compuestos bioactivos y viabilidad en la preparación de mermeladas y yogures

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Resumo

A utilização da grumixama e do jambolão na elaboração de produtos alimentícios é uma alternativa interessante, considerando os compostos bioativos presentes e suas características sensoriais. Com o propósito de propagar o consumo destas frutas, desenvolveram-se formulações de geleia e iogurte de grumixama e de jambolão. Análises de umidade, resíduo

mineral fixo, proteínas, lipídeos, fibras, pH, acidez e sólidos solúveis foram realizadas nos produtos obtidos. A aceitabilidade sensorial dos produtos foi verificada pelos testes de escala hedônica e intenção de compra. A influência do processamento foi verificada pela quantificação de compostos fenólicos totais, antocianinas e atividade antioxidante. Verificou-se que a composição química e as características físicas dos produtos desenvolvidos são similares à de outras geleias e iogurtes produzidos com diferentes frutas. O processamento da grumixama e do jambolão na forma de geleia reduziu o teor de fenóis de 664,58 para 613,07 e 590,67 para 563,08 mg AG/100g, a quantidade de antocianinas de 1,46 para 0,14 e 4,37 para 2,23mg/100g e a atividade antioxidante de 1273,25 para 1522,63 e 1292,53 para 1427,23 g amostra/g de DPPH, respectivamente, porém a quantidade destes compostos encontrada nas geleias ainda é significativa. O índice de aceitabilidade foi superior a 70% para todos os produtos, e a maioria dos provadores (66% para as geleias de grumixama e jambolão, 70% para o iogurte de jambolão e 55% para o iogurte de grumixama) indicou que provavelmente ou certamente compraria, demonstrando boa aceitação. Portanto, os resultados obtidos indicam o potencial dessas frutas para a elaboração de produtos alimentícios.
Palavras-chave: Composição nutricional; Aceitabilidade sensorial; *Syzigium cumini*; Frequência de consume.

Abstract

The use of grumixama and jambolan in the preparation of food products is an interesting alternative, when considering the bioactive compounds present and their sensorial characteristics. In order to propagate the consumption of these fruits, both jams and yogurts of grumixama and jambolan were developed. The analysis of moisture content, fixed mineral residue, proteins, lipids, fibers, pH, acidity, and soluble solids were performed on the products obtained. The sensorial acceptability of the products was verified by hedonic scale tests and purchase intention. The influence of the type of processing was verified by the quantification of the total phenolic compounds, anthocyanins, and antioxidant activity. It has been found that the chemical composition and physical characteristics of the products developed are similar to other jams and yoghurts produced with different fruits. Processing grumixama and jambolan into jam reduced the phenolic content from 664.58 to 613.07 and 590.67 to 563.08 mg GAE/100 g, the anthocyanin content from 1.46 to 0.14 and 4.37 to 2.23 mg/100 g, and the antioxidant activity from 1273.25 to 1522.63 and 1292.53 to 1427.23 g sample/g of DPPH, respectively. However, the amount of these compounds in jams is still significant. The acceptability index was over 70% for all products, and majority of the tasters indicated (66%

for the jams of grumixama and jambolan, 70% for the yogurt of jambolan and 55% for the yogurt of grumixama) that they would probably or would certainly buy the products, showing that it was well received. Therefore, the results obtained indicate potential use of these fruits in food products.

Keywords: Nutritional composition. Sensorial acceptability. *Syzigium cumini*. Frequency of consumption.

Resumen

El uso de grumichama y jambool en la preparación de productos alimenticios es una alternativa interesante, considerando los compuestos bioactivos presentes y sus características sensoriales. Con el fin de difundir el consumo de estas frutas, se desarrollaron formulaciones de mermelada y yogur de grumichama y jambool. Se realizaron análisis de humedad, residuos minerales fijos, proteínas, lípidos, fibras, pH, acidez y sólidos solubles en los productos obtenidos. La aceptabilidad sensorial de los productos se verificó mediante pruebas de escala hedónica e intención de compra. La influencia del procesamiento se verificó mediante la cuantificación de compuestos fenólicos totales, antocianinas y actividad antioxidante. Se verificó que la composición química y las características físicas de los productos desarrollados son similares a las de otras mermeladas y yogures producidos con diferentes frutas. El procesamiento de grumichama y jambool en forma de mermelada redujo el contenido de compuestos fenolicos de 664.58 a 613.07 mgAG/100g y 590.67 a 563.08 mgAG/100g, la cantidad de antocianinas de 1.46 a 0.14 mg/100g y 4,37 para 2.23 mg/100g y la actividad antioxidante de 1273.25 a 1522.63 g de muestra/g de DPPH y 1292.53 a 1427.23 g de muestra/g de DPPH, respectivamente, sin embargo, la cantidad de estos compuestos que se encuentran en las mermeladas sigue siendo significativa. El índice de aceptabilidad fue superior al 70% para todos los productos, y la mayoría de los catadores (66% para mermeladas de grumichama y jambool, 70% para yogur de jambool y 55% para yogur de grumichama) indicaron que probablemente o sin duda compraría, mostrando una buena aceptación. Por lo tanto, los resultados obtenidos indican el potencial de estas frutas para la preparación de productos alimenticios.

Palabras clave: Composición nutricional. Aceptabilidad sensorial. *Syzygium cumini*. Frecuencia de consumo.

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1. Introduction

The *Myrtaceae* plant family includes the genus *Eugenia*, which is considered one of the biggest genera covering more than 3800 edible species, dispersed in both tropical and subtropical regions of the world. *Eugenia* species are considered medicinal plants with beneficial physiological properties, such as antidepressant, antirheumatic, diuretic, and anti-inflammatory characteristics, due to the presence of antioxidant compounds, including phenols and anthocyanins (Aguiar *et al*., 2016; Chhikara *et al*., 2018).

Antioxidants act against oxidative effects and diseases such as cancer, atherosclerosis, diabetes, and arthritis. Several studies have demonstrated the antibacterial, antihypertensive, and antioxidant effects from the phenolic compounds in fruits, medicinal herbs, and teas. Anthocyanins confer color, which varies from red to purple, and are considered bioactive (Chhikara *et al*., 2018). However, few studies show the viability of these substances in processed foods (Tobal and Rodrigues, 2019), since they are very sensitive to temperature and light (Zepka and Mercadante, 2009).

Among the species of the genus, *Eugenia jambolana*, is a large tree that produces fruits known by names such as Jamun, Black plum, Jambul, and Jambolan, found in India, Bangladesh, Thailand, Philippines, Florida, Brazil, California, Algeria and Israel. In the ovoid form, the fruit is 2 to 3 cm long, with a large black purplish seed and white pulp, acid/sweet taste with variable astringency, and can help prevent chronic diseases, due to the phenolic compounds that provide an antioxidant capacity to this fruit. The fruit is usually consumed *in natura*, industrially, and it is still poorly studied. However, it can be processed into jams, liqueurs, wines, nectar, vinegar, pies, or sweets (Chhikara *et al.* 2018).

Eugenia brasiliensis, popularly known as grumixama and native to the Brazilian coastal regions, from the south of Bahia to Santa Catarina, is a small tree that can be used for landscaping and has large aromatic leaves and flowers with smooth ovaries. The ripe fruits are either purple or red and are edible, with potential for consumption because of their flavor (Aguiar *et al*., 2016; Nascimento *et al*., 2017).

Currently, the consumption of natural antioxidants is valued due to its beneficial effects. Grumixama and jambolan are fruits that have a significant antioxidant action attributed to the bioactive compounds from the plants secondary metabolism (Chhikara *et al*., 2018; Nascimento *et al*., 2017), but the consumption and commercialization has been poorly explored. Therefore, the objective of this study was to prepare jams and yogurts of grumixama and jambolan and to analyze their composition, sensorial acceptability and the effect of the processing on the bioactive compounds of these fruits.

2. Materials and Methods

2.1. Material

Grumixama fruits (*Eugenia brasiliensis*) were purchased in São Paulo/Brazil, in a place of natives fruits, jambolan fruits were harvested acquired in the rural region of Angélica/Mato Grosso do Sul. For the elaboration of the jams the following ingredients were used: sucrose, citric acid and high-methoxylated pectin (CPkelco/ São Paulo/Brazil). To obtain the yogurt, Rich baking powder, consisting of *Lactobacillus acidophilus* (10^6 CFU/g), *Bifidobacterium*, and *Staphylococcus thermophilus* (10^6 CFU/g), was purchased from Bio Rich®, and ultrapasteurized milk. The sucrose and milk were purchased at a local market in Dourados/ Mato Grosso do Sul.

2.2. Preparation of jam

The selection and classification of the fruits were performed according to the presence of mechanical damages, health, and maturation by visual analysis. For sanitation, the fruits were washed in running water, immersed in a 2% sodium hypochlorite solution for 15 minutes and then rinsed in running water. The fruits were kept frozen at -18 ºC until the products were prepared.

To obtain the pulp, the fruits were cut with a stainless-steel knife and the seed was manually separated and then discarded. The fruit peel and pulp were homogenized with water in a (w/v) fruit to water ratio of 0.7:0.3, using a blender. The pH of the grumixama and jambolan pulps was adjusted to 3.4 and 3.3, respectively, using citric acid, and the jam was prepared using a pulp to sugar ratio of 6:4 and 1% high-methoxylated pectin (CPKelco).

The cooking was carried out in a stainless-steel pan with continuous stirring until a final concentration of soluble solids of 65 ºBrix, determined in a refractometer (Abbe). After this step, the jam was packaged still hot in glass containers previously sterilized at 121 ºC/15min and immediately in cold water for 15 minutes and kept at room temperature.

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2.3. Yogurt processing

After heating the UHT milk to 45 ºC, the inoculum, *Lactobacillus acidophilus* (10^6 CFU/g), *Bifidobacterium*, and *Staphylococcus thermophilus* (10^6 CFU/g), was added to the milk in the ratio of 400 mg to 1 L of milk and incubated in a BOD incubator at 42 ºC for 5 hours. Subsequently, to prepare the grumixama yogurt, the yogurt was refrigerated for 24 hours and 16% of grumixama jam was added. For the jambolan yogurt, the yogurt was refrigerated for 18 hours and 26.5% of the jambolan jam was added.

2.4. Physical and chemical analysis of the products

The analyses of protein fixed mineral residue, titratable acidity (expressed as citric acid for jam and lactic acid for yoghurt), pH, and soluble solids (ºBrix) were performed according to the methodology of the Adolfo Lutz Institute (2008). The moisture content was obtained by oven drying at 105 ºC. Total lipids were quantified for jams by the Bligh-Dyer method and for yogurts by the Gerber butyrometer method. Fibers were determined by the Weend's method and carbohydrates by the difference.

2.5. Determination of phenolic compounds, anthocyanins, and antioxidant activity

The fruits and jams extracts were prepared as described by Larrauri *et al*. (1997) with some modification. Total phenolic compounds were quantified by the spectrophotometric method using the Folin-Ciocalteu reagent and 0.5 mL of the extract obtained from the samples were added to 2.5 ml of Folin-Ciocalteu solution (10%), 0.45 mL of distilled water and 2 mL of sodium carbonate (7.5%). The mixture was incubated at 50 ºC, protected from light, for 15 min. The absorbance was immediately read at 760 nm and the concentration of phenolic compounds was expressed in gallic acid equivalents (Magina *et. al.*, 2010). A PG Instruments spectrophotometer, model T70 UV/VIS Spectrometer, was used for all absorbance measurements.

The anthocyanin content was determined by the pH difference method described by Giusti and Wrolstad (2001). Samples were diluted in two buffer systems: potassium chloride pH 1.0 (0.025M) and sodium acetate pH 4.5 (0.4M) and incubated at room temperature. After 20 min, the absorbance was read at 510 and 700 nm. The total amount of anthocyanins was calculated using an absorptivity of 26900 $L \cdot mol^{-1} \cdot cm^{-1}$, and the cyanidin-3-glycoside molecular weight of 449.2 g/mol and expressed in mg per 100 g of sample.

The quantitative analysis of the antioxidant activity of the samples was performed by the DPPH method (Brand-Williams *et al.*, 1995), based on the capture of the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical (Sigma Aldrich, São Paulo, Brazil) by the extract of the samples, producing a decrease in absorbance at 515 nm, after 20 min of reaction time. The total result was expressed in g of sample per g of DPPH.

2.6. Sensory analysis of products

Acceptance and purchase intention tests were applied in the laboratory of Sensory Analysis of Food, in individual booths, under white light. A total of 120 untrained sensory panelists, of both sexes, including University employees and students, agreed to participate in the study and signed the informed consent form previously approved by the Human Research Ethics Committee (opinion nº 1.005.024). About 30 g/mL of jam/yogurt, coded with three-digit numbers at random, were served one by one in complete randomized blocks (Dutcosky, 1996).

For the acceptance test, a structured nine-point hedonic scale was used, anchored in the extremes with the expressions “I dislike it very much” and “I liked it very much,” evaluating the appearance, color, smell, taste, texture, and overall impression. The panelists' attitude towards the purchase of the product was also assessed using a five-point scale of purchase intention ranging from “I would certainly buy” to “I would certainly not buy the product” (Dutcosky, 1996). To characterize the frequency of consumption of the jams and yogurts, a food frequency questionnaire was used with the alternatives ranging from “I never consume” to “I consume 4 times or more per week”.

2.7. Statistical analysis

All measurements were performed in triplicate. The results were submitted to analysis of variance (ANOVA) and the means compared by the Tukey’s test ($p \leq 0.05$), using the software Origin 6.0.

3. Results and Discussion

3.1. Physical and chemical analysis of the jams

The results obtained in the chemical characterization of the jams (Table 1) showed a composition profile similar to what is usually found for jams of fruits such as jambolan (Barcia *et al.*, 2010), pitanga (Tobal and Rodrigues, 2019) and Pera (Foppa *et al.*,2009).

Table 1: Nutritional composition of grumixama and jambolan jams.

Components	Grumixama jam (g/100g)	Jambolan jam (g/100g)
Moisture content	25.65 ± 2.28[a]	28.95 ± 0.43 [a]
Fixed mineral residue	0.34 ± 0.01 [a]	0.24 ± 0.03[b]
Proteins	0.67 ± 0.01 [a]	0.44 ± 0.02[b]
Carbohydrates	71.31 ± 2.01 [a]	70.10 ± 0.37[a]
Lipids	2.04 ± 0.01 [a]	0.27 ± 0.03[b]
Fibers	0.72 ± 0.01 [a]	0.23 ± 0.16[b]

* Different letters in the same line indicate a significant difference according to the Tukey's test ($p<0.05$). Source: authors.

The grumixama jam exhibited a higher content of proteins, lipids, mineral and fibers compared with jambolan jam. The amount of carbohydrates in jams is high due to the formulation itself, which includes significant amounts of sugar. The lipid content is low since the fruits used do not present large amounts of this nutrient. The pH of the jams was 3.6, which is slightly less than the pH of 3.75 for pera jam (Foppa *et al.*, 2009) and higher than the pH of 3,33 for grumixama jam (Aguiar *et al*., 2016). The jams had 65% soluble solids and an acidity of 0.7% and 0.5% for grumixama and jambolan jams, respectively. The fiber content of the grumixama jam (0.72%) is similar to the result found by Foppa *et al*. (2009) for pera jam (0.75%). The jambolan jam (0.28%) has a fiber content similar to that reported by Barcia *et al.* (2010).

3.2. Phenolic compounds, anthocyanins, and antioxidant activity

Table 2 shows the results of the bioactive compounds and antioxidant activity of grumixama and jambolan pulps and jams.

Table 2: Anthocyanin and phenolic compound content and antioxidant activity of grumixama and jambolan pulps and jams (mean ± standard deviation).

Samples	Anthocyanins (mg/100g)	Phenolic compounds (mg GAE/100g)	Antioxidant activity (g of samples/g of DPPH)
Grumixama pulp	1.46[a] ± 0,01	664.58[a] ±0,01	1273.25[a] ± 0,01
Grumixama jam	0.14[b] ± 0,01	613.07[b] ± 0,01	1522.63[b] ± 0,03
Jambolan pulp	4.37[a] ± 0,03	590.67[a] ± 0,01	1292.53[a] ± 0,01
Jambolan jam	2.23[b] ± 0,01	563.08[b] ± 0,01	1427.23[b] ± 0,01

* Different letters in the same column indicate a significant difference according to the Tukey's test ($p<0.05$), for each fruit. Source: authors.

The high content of phenolic compounds of grumixama pulp (664.58 mg/100 g) was higher than the one obtained by Souza *et al.* (2014), in a study that analyzed the number of phenolic compounds in raspberries (357.83 mg/100 g), strawberries (621.92 mg/100 g) and blueberries (305.38 mg/100 g). However, the anthocyanin values and the antioxidant activity of these fruits were similar to those found for grumixama. The jambolan also has a high content of phenolic compounds, significantly higher than for the raspberries (357.83 mg/100 g) and blueberries (305.38 mg/100 g) found by Souza *et al.* (2014).

The content of the bioactive compounds and the antioxidant activity decreased significantly after processing the pulps into jams. Among the several factors responsible for the degradation of these compounds during the production of jams, contact with oxygen, heating, and light are all of importance. Other studies have also shown a significant decrease of these compounds after the processing of fruits. For example, the anthocyanin content, total phenols, antioxidant activity was found for pitanga pulp and jam to be 0.24mg/100g and 0.08mg/100g, 824.64 mg GAE/100mL extract and 469.36 mg GAE/100mL extract, 1522.61 g sample/g DPPH 2384.93 g sample/g DPPH, respectively (Tobal and Rodrigues, 2019).

Souza *et al*. (2015) assessed the influence of processing on the content of phenolic compounds and anthocyanins, and on the antioxidant activity of seven blackberry cultivars and their respective jams, showing a significant reduction of these compounds after processing. This was similar to the data found in the present study, that the processing of grumixama and jambolan into jam significantly reduced the amount of the bioactive compounds and the antioxidant potential. However, the obtained jams still present significant and similar amounts of these compounds as the blackberry jams (Souza *et al.*, 2015).

3.3. Physical and chemical analysis of the yogurts

Regarding the composition of yogurts, the moisture content, protein, carbohydrate, and ash contents (Table 3) are similar to the results obtained by Rodas *et al.* (2001) who analyzed yogurt made with pineapple, strawberry, passion fruit, apple, melon, papaya, raspberry, grape, blackberry, banana, orange, lemon, tangerine, kiwi, coconut, and peach. These authors reported values for moisture content from 77.91 to 82.88%, proteins from 2.3 to 4.81%, carbohydrates from 8.18 to 20.84% and ashes from 0.89 to 1.03%. The similar results allow us to affirm that the product presents good nutritional quality, since there is no specific parameter for these chemical constituents (Rodas *et al.*, 2001).

Table 3: Nutritional composition of grumixama and jambolan yogurt.

Components	Grumixama yogurt (g/100g)	Jambolan yogurt (g/100g)
Humidity	80.32 ± 0.04	81.06 ± 0.04
Ashes	0.53 ± 0.05	0.46 ± 0.02
Proteins	2.95 ± 0.07	2.3 ± 0.02
Carbohydrates	12.71 ± 0.59	11.68 ± 0.34
Lipids	3.5 ± 0.70	4.5 ± 0.70
Fibers	0.25 ± 0.20	0.29 ± 0.05

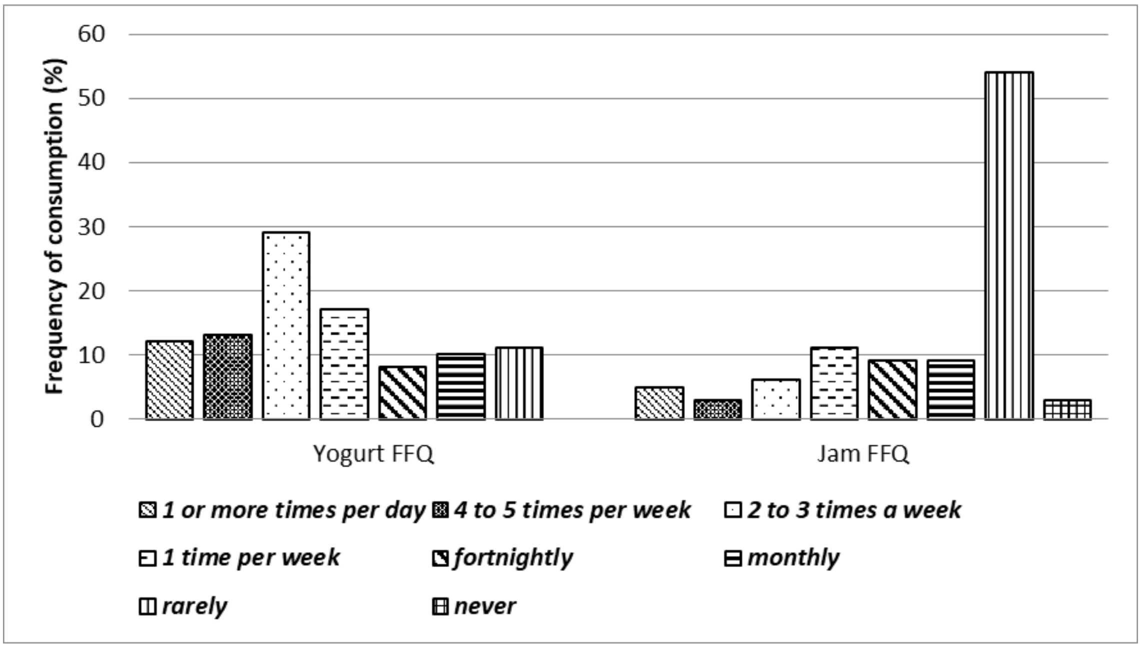
Source: authors.

A lactic acid content of 0.85 g and 0.84 g were found for the yogurts of grumixama and jambolan, respectively, and the lipid content, comply with the recommended standard according to Normative Instruction No. 46 of the Technical Regulation on fermented milk quality and identity, which establishes the parameter of 0.6 to 1.5 g of lactic acid/100 g and 3 to 5.9% of lipids (Brasil, 2007). Although there is no parameter for the pH of yogurt, the value found in grumixama and jambolan yogurts was 4.4, a result similar to the one found by Oliveira *et al.* (2011) in a study that analyzed strawberry yogurt and found pH values ranging from 3.7 to 4.1.

3.4. Sensory analysis of products

The results of the food frequency questionnaire (FFQ) applied to the panelists indicate that the majority consume yogurt two to three times a week (Figure 1) and this consumption frequency could positively influence the sensorial analysis, since it can be considered that the consumer likes the typical product. The results obtained for the consumption of jam showed that most individuals rarely consume the typical product, which could negatively influence the sensorial analysis, since they are not accustomed to consuming jams. Moreover, it should be considered that the consumption of jams is more frequent in regions of mild and cold weather and the sensorial tests of the present study were carried out in a tropical region.

Figure 1: Distribution of the frequency of consumption of yogurt and jam by individuals from the region of Dourados-MS



Source: authors.

Regarding the sensory acceptance analysis, both products, grumixama, and jambolan yogurts and jams, had scores greater than 6.8 for all attributes evaluated (Table 4) showing that they were positively accepted, since the average for the overall impression corresponded to “I moderately liked it” and “I liked it very much” and the index of acceptance was greater than 70% (Table 4), considering that, in order for them to be a well-accepted product, the index of acceptability needs to be ≥ 70% (Dutcosky, 1996).

Table 4: Sensory acceptability scores obtained by the standard grumixama and jambolan yogurts and jams (mean ± standard deviation, n=60).

Attributes	Grumixama yogurt	Jambolan yogurt	Grumixama jam	Jambolan jam
Appearance	6.8±1.7	7.3 ± 1.3	7.2±1.5	7.7 ± 1.2
Color	6.9±1.6	7.3 ± 1.3	7.4±1.4	7.9 ± 1.1
Smell	6.9±1.6	7.1 ± 1.5	7.2±1.3	7.1 ± 1.4
Taste	6.9±1.6	7.5 ± 1.5	7.3±1.7	7.4 ± 1.7
Texture	6.8±1.6	6.9 ± 1.6	7.5±1.4	7.6 ± 1.1
Overall impression	7.0±1.3	7.3 ± 1.3	7.3±1.4	7.5 ± 1.3
Index of acceptability	77,7%	81,1%	81,1%	83,3%

Source: authors.

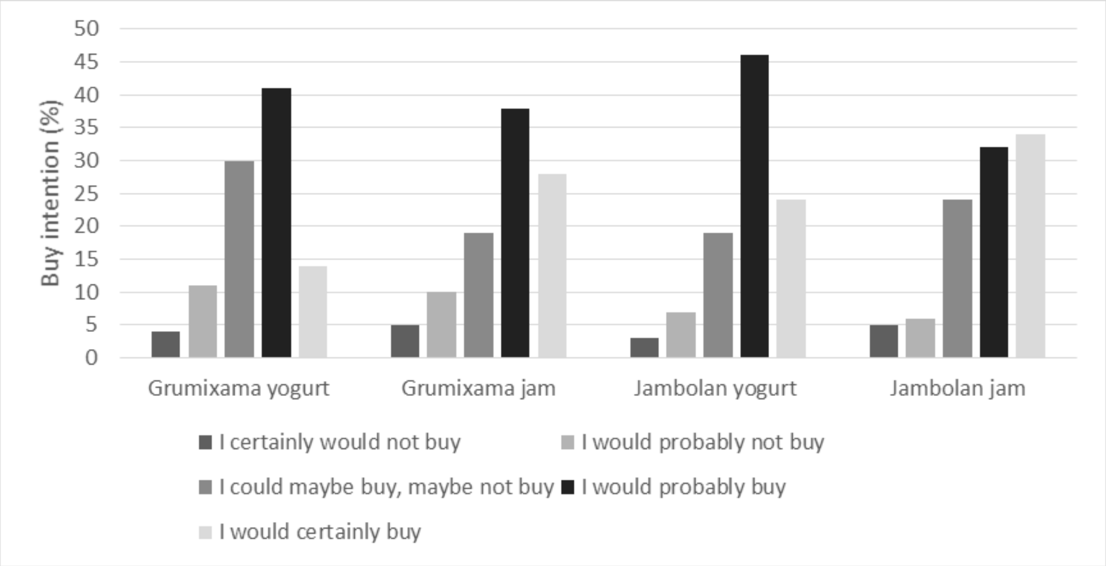
The products prepared with jambolan showed significantly higher scores (7.1 to 7.9) for all attributes, except for the texture of the yogurt (6.9 ± 1.6) compared to the grumixama products. The astringent taste of the jambolan did not influence the sensorial evaluation. The slightly more liquid aspect of the jambolan yogurt may have influenced the evaluation of the texture, since the consumer expects the yogurt to be creamy, unlike the milk beverages, which explains the lower acceptance.

The sensorial results for jambolan jams showed that the color was the attribute that presented the highest score due to the purple and shiny appearance of the fruit itself, a result identical to the one found in the study by Barcia *et al.* (2010). For the products prepared with grumixama, the average obtained for the different attributes evaluated was very similar.

Compared to other studies evaluating exotic fruit jams and yogurts, such as jambolan, and pitanga jams, and açaí yogurt, the averages obtained in the acceptance test for the same attributes ranged from 6 to 8, which was similar to the present study and considered to reflect positive product acceptance (Barcia *et al.*, 2010; Oliveira *et al.*, 2011; Tobal and Rodrigues, 2019).

Regarding intent to purchase, most panelists indicated that they either would probably or would certainly buy the products (Figure 2), confirming that the prepared yogurts and jams were well accepted and have marketing potential.

Figure 2: Frequency of the scores attributed in the purchase intention test for grumixama and jambolan yogurts and jams.



Source: authors.

The growing interest in foods that are rich in bioactive compounds, such as anthocyanins and phenolic compounds with antioxidant action, as well as the search for alternatives to raw materials for industrial use, justify the development of new food products with grumixama and jambolan, since the results presented were as significant as fruits and commercial fruit products.

4. Conclusions

Yogurts and jams made with grumixama and jambolan possessed beneficial characteristics for consumption and met the parameters of the legislation regarding physical and chemical aspects, with an acceptability index of more than 70%.

The processing degraded the analyzed bioactive compounds, although the retained content of anthocyanins and phenolic compounds in the jams was still significant, which contributed to the consumption of these compounds, as well as the energetic and functional value of the products.

The present study showed that grumixama and jambolan are both promising alternative fruits for use in food products, contributing both bioactive compounds and sensorial characteristics.

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