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Product of sugar-free banana similar to jam: development and characterization, sensory, physicochemical, and microbiological

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Abstract

Banana is a fruit widely produced and consumed, and its processing in the form of jams can be an alternative to improve its use. Jams of fruit, sugar free, are a market trend and can be important foods for schoolchildren. The objective was to develop a sugar-free banana product, similar to jam, and evaluate their acceptability, composition, and microbiological and sensory stability. Three formulations were developed using banana, lemon juice, cinnamon, and cocoa, which were stored at an average temperature of 25°C for up to 2 months. The acceptability of the products was evaluated by 102 consumers, and 8 trained evaluators were also selected to carry out the quantitative descriptive analysis (QDA). The QDA and microbiological (*Salmonella* spp., *Escherichia coli*, molds, and yeasts) parameters were analyzed on the day of production and two months after manufacturing. There was no statistical difference between the three formulations for all sensorial attributes evaluated, and the average scores indicated excellent acceptability. The results of the microbiological and QDA analyses indicated that during storage, the formulations were stabilized. Thus, it was possible to develop, with simple technology, sugar-free banana products, similar to jam, with good acceptability and acceptable microbiological parameters.

Keywords: banana jelly; National School Feeding Program; family farming; clean label products; market trend; feeding of schoolchildren.

Practical Application: Bananas are a highly produced product and processing reduces losses. Products without added sugar are of interest to the current food market and can be a healthy eating strategy, especially for children. This study presents the stages of preparing sugar-free banana products, similar to jam, with a simple technique. The results indicated products with adequate physicochemical and sensory characteristics and sensory and microbiological stability. The developed product can be an alternative source of income for family farmers who serve school meals and also specific market segments.

1 INTRODUCTION

Banana (*Musa* spp.) is one of the most produced and consumed fruits worldwide (Ribeiro et al., 2012), with a world production of approximately 116.8 million tons in 2019 (FAO, 2020). In 2023, Brazil distinguished itself by securing the fourth spot in banana production rankings, yielding a substantial 6.8 million tons (IBGE, 2024).

In Brazil, consumption was estimated at 25 kg per capita, per year in 2019, representing 0.87% of Brazilian food expenses. Practically, all banana production, that is, 98%, is utilized for fresh consumption, with the rest of it being processed into fruit products (Oliveira et al., 2021).

Banana is an important food in the feeding of the population, not only because of its high nutritional value but also because of its low cost (Borges et al., 2006). It is a good source of energy, with 95 Kcal in 100 grams of dwarf banana pulp, having a high content of carbohydrates — starch and sugars. It also contains considerable levels of vitamins A, B1 (thiamine), B2 (riboflavin), and C, and minerals, such as potassium, phosphorus, calcium, sodium, and magnesium (Folegatti & Matsuura, 2004).

Banana can be consumed in several ways: *raw*, as jam, boiled, fried, baked, dehydrated, caramelized, or in cakes, pies, ice cream, sweets, and even drinks. The high rate of losses in the commercialization of bananas in Brazil means that only a portion — between 50% and 60% of the production — reaches the consumer's table (Silva & Ramos, 2009). In this sense, the processing and/or industrialization of the fruit provides an option for the use of surplus fruits — which do not meet the quality standards for fresh consumption — to be used in the production of new products, without compromising on the quality of the pulp. The industrialization of bananas also promotes an increase in shelf life and adds value to the product (Jesus et al., 2005; Silva & Ramos, 2009).

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The National School Feeding Program (from Portuguese: *Programa Nacional de Alimentação Escolar* — PNAE) is a program of the Brazilian government to offer school meals and education on food and nutrition to students, at all stages of basic public education. The resources transferred by the PNAE must be used in accordance with the legislation in force. Provisional Measure n. 2.178/2001 (Brasil, 2001a) determines that 70% of the funds transferred must be applied exclusively to basic resources, while Law n. 11.947/2009 (Brasil, 2009) established that 30% of the resources acquired must be used for the direct purchase of products from family farming. These measures are aimed at the economic and sustainable development of local communities. It is also worth mentioning that Resolution n. 6 of May 8, 2020 (Brasil, 2020), established that the addition of sugar, honey, and sweetener to foods and beverages for children up to 3 years of age is prohibited.

Banana jam has always been a food used in the diet of schoolchildren. However, from the moment the referred Resolution came into force, small producers were no longer able to meet the demand for school meals with the fruit sweets they produced, such as banana jam, because they had added sugar. In addition, it is important to highlight that the production of jams and fruit paste products similar to paste-like candies, without the addition of sugar, is a technological challenge as the removal of this ingredient can affect the microbiological, rheological, and sensory stability of the product (Al Qadr Imad Wan-Mohtar et al., 2021; Souza et al., 2022). Thus, it is necessary to look for viable alternatives to produce products similar to jams, but without added sugar.

The aim of the present study is to develop formulations for products of banana that are sugar free, similar to jam, and to evaluate their acceptability, composition, and microbiological and sensory stability during storage.

2 MATERIAL AND METHODS

The ingredients used for manufacturing the product of sugar-free banana are similar to the jam of banana. They included fresh caturra banana (*Musa acuminata Colla* x *Musa balbisiana Colla*, Group AAA), lemon-clove (*Citrus limonia* Osbeck), cinnamon (*Cinnamomum* sp) powder, and cocoa powder 50%. All the ingredients were donated by the women associated with the Coopervereda of Verê and the National Association of Cooperatives of Family Agriculture and Solidarity Economy of Francisco Beltrão, Paraná, Brazil. The development and sensory analysis of the product were carried out in the Nutrition Laboratory and the microbiological analyses in the Microbiology Laboratory of the Universidade Estadual do Oeste do Paraná, Francisco Beltrão, Paraná, Brazil. The physicochemical analyses were conducted at the Foundation for Scientific and Technological Development, Cascavel, Paraná, Brazil. All the physicochemical and microbiological analyses were conducted in triplicate.

2.1 Production of banana product similar to the jam

Before starting the production of the product, the bananas and lemons were sanitized in running water, immersed in a chlorinated solution at 200 ppm for 15 min, and rinsed in drinking water. The bananas were weighed and peeled, and the pulp was crushed in a domestic multiprocessor (Phillips Walita, RI7774), after which the correction factor (gross weight/net weight) of the fruit was calculated. The lemons were cut and squeezed to obtain the entire juice.

Three formulations of the banana product were developed, similar to the jam: formulation produced with banana pulp, cinnamon powder, and lemon juice (BCn); formulation with banana pulp, cocoa powder 50%, and lemon juice (BCc); and formulation with banana pulp, cinnamon powder, cocoa powder 50%, and lemon juice (BCnCc). The ingredients were weighed in the proportions shown in Table 1.

The banana pulp and the dry ingredients (cinnamon powder and/or cocoa powder 50%) were mixed, placed in an aluminum pan, and heated; subsequently, the whole lemon-clove juice was added and cooked until the product was obtained, then the cooking factor of the recipe was calculated (cooked weight of the food/net weight of the ingredients). To carry out the filling of the product, the glasses were first sanitized under running water and boiled in water for 30 min. Then, the banana product, similar to the jam, was placed in the jars, leaving an empty space at the top of the jar of approximately 3 centimeters, and was subsequently sealed with the lid. The sealed products were placed in pressure cookers, with approximately 4 cm of water at the bottom, and sterilized for 30 min under pressure. At the end, storage was carried out at an average temperature of 25°C until analyses were carried out, as described below. The production process flowchart is presented in Figure 1.

2.2 Physicochemical analysis

The physicochemical characterization of the products was carried out by analysis of the proximate composition and determination of the pH (method 017/IV) and soluble solids, by refractometry (method 315/IV) according to the procedures described in the Manual of the Instituto Adolfo Lutz (2008). The methods used to evaluate the proximate composition were total lipid analysis by Soxhlet (method 032/IV), moisture content by drying in an oven at 105°C (method 012/IV), protein analysis by Kjeldahl (method 037/IV), ash analysis by incineration residue (method 018/IV), and carbohydrates calculated by difference. The results, on a wet basis, were expressed as means and standard deviation, in grams per 100 g.

Table 1. Formulations in percentage (%) of banana products similar to jam.

Ingredients	BCn (%)	BCc (%)	BCnCc (%)
Pulp of dwarf banana mashed/crushed	96.7	96.2	95.3
Cinnamon powder	0.5	-	0.5
Cocoa powder 50%	-	0.9	1.4
Whole juice of lemon-clove	2.9	2.9	2.8

BCn: formulation produced with banana pulp, cinnamon powder, and lemon juice; BCc: formulation with banana pulp, cocoa powder 50%, and lemon juice; BCnCc: formulation with banana pulp, cinnamon powder, cocoa powder 50%, and lemon juice.

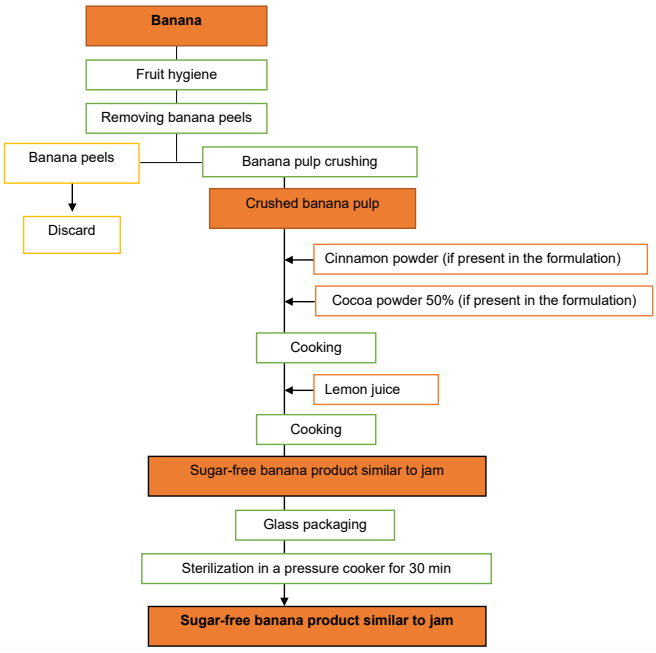


Figure 1. Production flowchart of a banana product similar to jam.

2.3 Microbiological analysis

The samples of jams were submitted to mold and yeast counts, *Escherichia coli* research, and *Salmonella* spp. research (Brasil, 2003). The analyses were performed following the methodologies recommended by Silva et al. (2010) in triplicate. They were performed at time 0 (T0), the day after the end of the production process, and time 2 (T2), after two months of storage of the product, at an average temperature of 25°C.

2.4 Sensory analysis

The project was submitted to the Human Research Ethics Committee and received a favorable opinion, N. 5.386.431. All evaluators were over 18 years of age and agreed to participate in the study by signing the Terms of Free and Informed Consent. Consumer sensory analysis was conducted using the affective method, while trained evaluators employed the descriptive method for evaluation, with the first method being applied only for samples taken at time T0 and the second method applied to samples taken at T0 and T2. In both methods, the samples were served to the evaluators in a monadic and randomized manner, in cups coded with three-digit numbers and with standardized amounts of approximately 10 g. In addition, water was always offered to the evaluators to rinse the taste buds, among the evaluations. All the analyses were performed in sensory booths.

In the affective sensory analysis, the evaluators/consumers evaluated the samples in relation to the global acceptance, appearance, aroma, flavor, and texture of the attributes, using a 9-point hedonic structured scale (with the scale being 1. "I disliked it very much" and 9. "I liked it very much"). From the acceptance scores, the Acceptability Index (IA) was calculated, using Equation 1:

$$IA\ (\%) = A \times 100/B \quad (1)$$

Where:

A: the average score obtained for the product;

B: the maximum score given to the product.

Purchase intention was also assessed using a structured 5-point scale, with point 1. corresponding to "I would certainly not buy" and point 5. to "I would certainly buy" (Dutcosky, 2013). A total of 102 evaluators, who were consumers of jam and jellies, with an average age of 26.7 ± 9.16 years old, participated in the sensory analysis using the affective method. Of these participants, 82.4% were female, 16.7% were male, and 1% another option.

The quantitative descriptive analysis (QDA method) was carried out in five stages: (1) selection of evaluators, (2) survey of descriptors, (3) development of terminologies, (4) training, and (5) sensory test (Dutcosky, 2013). A total of 13 evaluators participated in the selection and training, all consumers of jam and jellies. The descriptors were defined by the team, using the network method. The established appearance attributes were as follows: glossy, brown, and homogeneous; the aroma attributes were as follows: banana, sweet, cocoa, and cinnamon; the flavor attributes were as follows: banana, sweet, cocoa, cinnamon, clove, astringent, and acidic; and the texture attributes were as follows: pasty and sandy. After defining the attributes, the reference standards for the extremes of the scales were established. The scales used were unstructured 9 cm scales, with terms at the ends that indicated the intensity of the attribute (little - 0 to very much 9 cm). The training sessions totaled three meetings. After the training, 8 evaluators were selected for the final evaluation of the samples, with an average age of 28.13 ± 8.18 years old; 87.5% were female, and 12.5% were male.

2.5 Data analysis

The data obtained in the physicochemical and sensory analyses were tabulated and described as mean and standard deviation. Statistical analysis to compare the product formulations was performed by analysis of variance (ANOVA), and the means were tested using Tukey's test ($p < 0.05$) in Excel. The comparison of the sensory evaluation for the QDA method in relation to time was performed using the T-test.

3 RESULTS AND DISCUSSION

The correction factor identified in this study for dwarf bananas was 1.54. The cooking factor of the formulations was 0.54 for BCn,0.63 for BCc, and 0.56 for BCnCc. An edible part indicator or a correction factor is defined as the ratio between the weight of the raw food, that is, the way it was purchased, and the weight of the liquid food, after going through a cleaning process (Botelho & Camargo, 2005; Moreira, 2016). According to Ornellas (2006), the correction factor for water banana (also known as dwarf banana) is 1.66, higher than that found in this study.

Cooking factor is the tool used to understand the performance of a food after it has been subjected to the cooking process. This is obtained by the ratio between the weight of the cooked processed food and the sum of the weight of the food in its initial state, or the net weight of the raw food (Philippi, 2014). This element is crucial as it helps us in gauging the quality of food post cooking.

3.1 Physicochemical analysis

Table 2 shows the proximate composition (g/100 g), pH, and soluble solids (° Brix) of the product of sugar-free banana, similar to jam. The results show that the samples differed statistically for the protein content, which was higher in the BCn formulation. For the lipids, moisture, ash, pH, and soluble solids, the samples did not show any statistical difference, and for the carbohydrate value, as was performed by calculating the difference, no statistical analysis was performed.

Silva and Ramos (2009), when comparing the physicochemical composition of dough sweets made with banana pulp and whole banana, observed that there was no significant difference in the composition between the two samples of banana jam in most of the components evaluated ($p < 0.05$). The sweets showed differences only in the contents of dietary fiber and ash, with higher percentages for the whole banana jam, which can be attributed to the higher content of these compounds in the banana peel.

The pH results are similar to those found in the literature for banana jams — with added sugar and different acidifying agents (Aimi Azira et al., 2021; Al Qadr Imad Wan-Mohtar et al., 2021) — and banana peel jams (Fibrianto et al., 2020). It is noteworthy that pH is an important factor in terms of both conservation and microbiological quality as it can inhibit or favor the growth of pathogenic and spoilage microorganisms; in addition, pH also impacts the rheological and sensory characteristics of jams and jellies, mainly by acting on the structure of pectin (Al Qadr Imad Wan-Mohtar et al., 2021).

Regarding the results of soluble solids, banana products similar to the jam produced in this study are lower than those reported in the literature, which are around 60-75 °Brix (Aimi Azira et al., 2021; Al Qadr Imad Wan-Mohtar et al., 2021); however, this difference is justified by the absence of sugar in the formulations developed in our study.

3.2 Microbiological analysis

Table 3 shows the results of the microbiological analysis of the products at the two storage times (T0 and T2). The data indicate that at time 0 (T0), the BCc and BCnCC samples showed very low mold and yeast counts, but the absence of *E. coli* and *Salmonella* spp. At time 2 (T2), in addition to all samples showing mold and yeast counts, the presence of *E. coli* was also observed. The legislation, which regulates the sanitary microbiological standards for food, does not establish the allowed limit of *E. coli* and *Salmonella* for jam. Regarding molds and yeasts, the legislation provides for the presence of a maximum of 10^4 CFU/g of food (Brasil, 2001b).

Sugar, in addition to sweetening and helping to form the gel, also plays an important role in food preservation as it reduces water activity, that is, the water available for microbial multiplication (Morris, 2006). Therefore, sweets with low sugar content are more vulnerable to the growth of most microorganisms, and Al Qadr Imad Wan-Mohtar et al. (2021) proved this when evaluating banana jams stored at 25°C produced with different concentrations of sugar, and those with less sugar, which developed mold more quickly (within up to 7 days of manufacturing).

Despite the low sugar content present in the sweets, it was possible to verify a low count of molds and yeasts, over 2 months, for all treatments analyzed, even though they were stored at an average temperature of 25°C. These results are related to the satisfactory quality resulting from the processing and/or storage techniques of the product (Castro et al., 2015).

3.3 Sensory analysis

The acceptability results are shown in Table 4 and reveal that the consumers did not perceive a significant difference between the samples in all the attributes evaluated. Regarding the average scores of the samples, for all attributes, they were close to 7, which indicates that the evaluators "moderately liked" the samples. As for the IA, for all the samples and all the attributes, the percentage found was greater than 78%, a result considered excellent, as will be discussed below.

Table 3. Colony forming unit ($CFU.g^{-1}$) of molds and yeast and research of *E. coli* and de *Salmonella spp*. of banana products similar to jam.

Samples	Molds and yeast UFC/g	Presence/absence of E. coli	Presence/absence of Salmonella spp.
		T0	
BCn	0	Absence	Absence
BCc	1×10^2	Absence	Absence
BCnCc	3×10^1	Absence	Absence
		T2	
BCn	4×10^2	Presence	Absence
BCc	3×10^2	Presence	Absence
BCnCc	2×10^2	Presence	Absence

T0: time 0, the next day after the end of the product production process; T2: time 2 months, after 2 months of product storage at an average temperature of 25°C; BCn: formulation produced with banana pulp, cinnamon powder, and lemon juice; BCc: formulation with banana pulp, cocoa powder 50%, and lemon juice; BCnCc: formulation with banana pulp, cinnamon powder, cocoa powder 50%, and lemon juice.

Table 2. Proximate composition, pH, and soluble solids of banana products similar to jam.

Parameters	BCn	BCc	BCnCc	MSD	*P*-Value
Protein (g/100 g)	2,10 ± 0.07 a	1.89 ± 0.03 b	1.75 ± 0.06 b	0.202	0.008
Lipid (g/100 g)	< 0.1 a	< 0.1 a	< 0.1 a	0	1
Moisture (g/100 g)	59.08 ± 0.53 a	57.43 ± 0.22 a	57.82 ± 0.65 a	1.716	0.058
Ash (g/100 g)	1.33 ± 0.11 a	1.42 ± 0.05 a	1.43 ± 0.04 a	0.194	0.285
Carbohydrate (g/100 g)*	37.49	39.27	39.01	-	-
pH	4.18 ± 0.14 a	4.39 ± 0.06 a	4.36 ± 0.03 a	0.282	0.114
Soluble solids (° Brix)	40.70 ± 0.60 a	40.00 ± 0.00 a	41.00 ± 1.00 a	1.521	0.174

BCn: formulation produced with banana pulp, cinnamon powder, and lemon juice; BCc: formulation with banana pulp, cocoa powder 50%, and lemon juice; BCnCc: formulation with banana pulp, cinnamon powder, cocoa powder 50%, and lemon juice; MSD: Minimum significant difference; *Carbohydrate calculated by difference = 100 - (protein + lipid + Moisture + Ash). Different letters in the line indicate that there was a statistical difference at a 5% significance level. Equal letters on the line indicate that there was no statistical difference at a 5% significance level.

Carneiro and Mendonça (2009), when developing sugar-free banana jam using the peel, evaluated the sensory attributes of color, flavor, consistency, and general acceptance. They found that in the color attribute, the product had an average of 6.88, which indicated acceptance between slightly and moderately liked. For the evaluation of flavor, consistency, and the product, in general, the averages obtained were 7.28, 7,26, and 7.42, respectively, indicating acceptance between "moderately liked" and "liked a lot". On the other hand, Al Qadr Imad Wan-Mohtar et al. (2021) evaluated 16 banana jam formulations produced with banana, pectin, sugar, and citric acid and found that the jam with the lowest sugar content was the least accepted, with acceptability scores between 2 and 3 for the attributes of color, flavor, aroma, texture, and global acceptance.

The IA of 70% is the minimum value for a product to be considered as "accepted", in terms of its sensory properties, to be launched in the market (Dutcosky, 2013). Thus, all formulations presented with acceptability rates higher than 70%, demonstrating that the products obtained good acceptance and that the non-addition of sugar may be viable.

In Figure 2, a histogram is presented, showing the distribution of the purchase intention of the samples. The mean values of each sample were 3.75 ± 1.04 for the BCn sample, 3.60 ± 0.97 for the BCc sample, and 3.44 ± 1.24 for the BCnCc sample, with no statistical difference between the samples ($p > 0.05$). Gonçalves et al. (2010), when evaluating the intention to purchase banana jam in dough with added peanuts, found that 88% of the evaluators indicated that they would "certainly buy" or "probably buy" the product.

Regarding the sensory analysis performed by the QDA method, the results are shown in Figure 3. The statistical analysis revealed that the samples differed for the attributes of brown appearance at T0 (= 0.019), brown appearance at T2 ($p = 0.041$), and sweet taste at T0 ($p = 0.013$), and the mean scores of the samples for brown appearance at T0 were 4.01 ± 1.98b (BCn), 5.16 ± 2.24ab (BCc), and 5.63 ± 2.23a (BCnCc) and at T2 were 3.66 ± 2.31b (BCn). 4.69 ± 2.44ab (BCc), and 5.03 ± 2.62a (BCnCc). The mean scores for sweet taste at T0 were 3.20 ± 2.29a (BCn), 2.29 ± 1.70b (BCc), and 2.56 ± 2.16ab (BCnCc). The other attributes of the samples did not differ statistically from each other ($p < 0.05$).

The difference between the formulations in relation to the brown color is probably because of the incorporation of cocoa, which increased the brownness of the samples. Regarding the sweet taste, the presence of cinnamon and the absence of cocoa contributed to an increase in the perception of sweetness, which is justified by the fact that cinnamon is considered essentially a sweet spice (Spence, 2024). It is also worth noting that although sugar was not added in any of the samples, the sweet flavor and aroma were attributes identified by the evaluators in all three formulations, as well as the banana flavor and aroma, which remained even after the sterilization technique. When comparing the results of the QDA performed on banana candies with sugar concentrations ranging between 50 and 70%, it is possible to observe that the formulations developed in this study, even without any added sugar, presented a slightly lower sweet flavor intensity than that observed by Fibrianto et al. (2020).

When comparing the impact of time on the sensory attributes of the product, there was a statistical difference only for the pasty texture of the BCc sample ($p = 0.012$) and the sandy texture of the BCn sample ($p = 0.03$). For the BCc pasty texture, the mean score at T0 was 4.14 ± 2.51 and at T2 was 6.26 ± 1.78. For the BCn sandy texture, the mean score at T0 was 1.33 ± 0.76 and at T2 was 3.29 ± 2.51. For the other attributes, the samples did not differ statistically in the different times evaluated ($p < 0.05$). Therefore, the product did not significantly alter its sensory attributes throughout storage, showing that the product remained stable in relation to sensory characteristics for 2 months, when stored at an average temperature of 25°C.

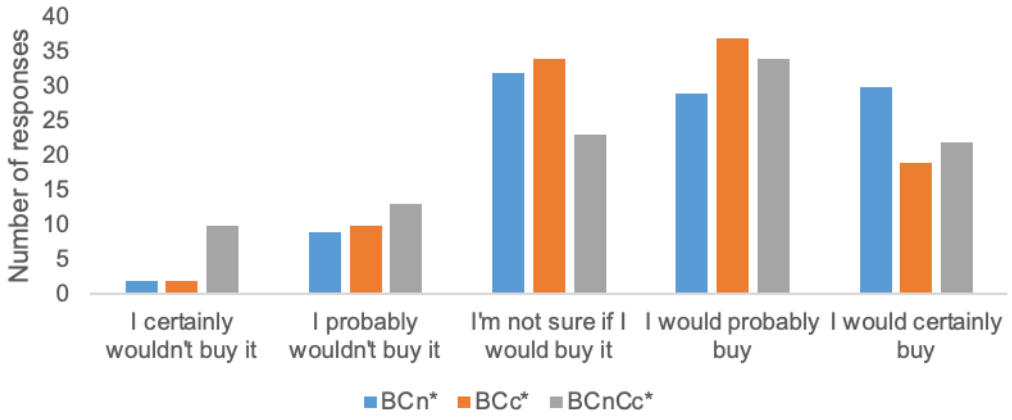
It is worth mentioning that the texture results corroborate with those of Aimi Azira et al. (2021), who produced three banana jams sterilized at 80°C for 10 min and stored for 2 months at an average temperature of 25°C. These authors verified an increase in texture with storage, which may be a result of the high pectin content, because very ripe bananas were used in the production of the jam, similar to our study. On the other hand, unlike our results, Aimi Azira et al. (2021) identified greater browning and less brightness in the candy with storage. This difference may be due to the presence of cocoa and cinnamon in our formulations, which contributed to an already high initial brown color.

It is important to highlight that the ingredients and processing used, as well as the results obtained from physical-chemical

Table 4. Average acceptability scores and acceptability index of banana products similar to jam.

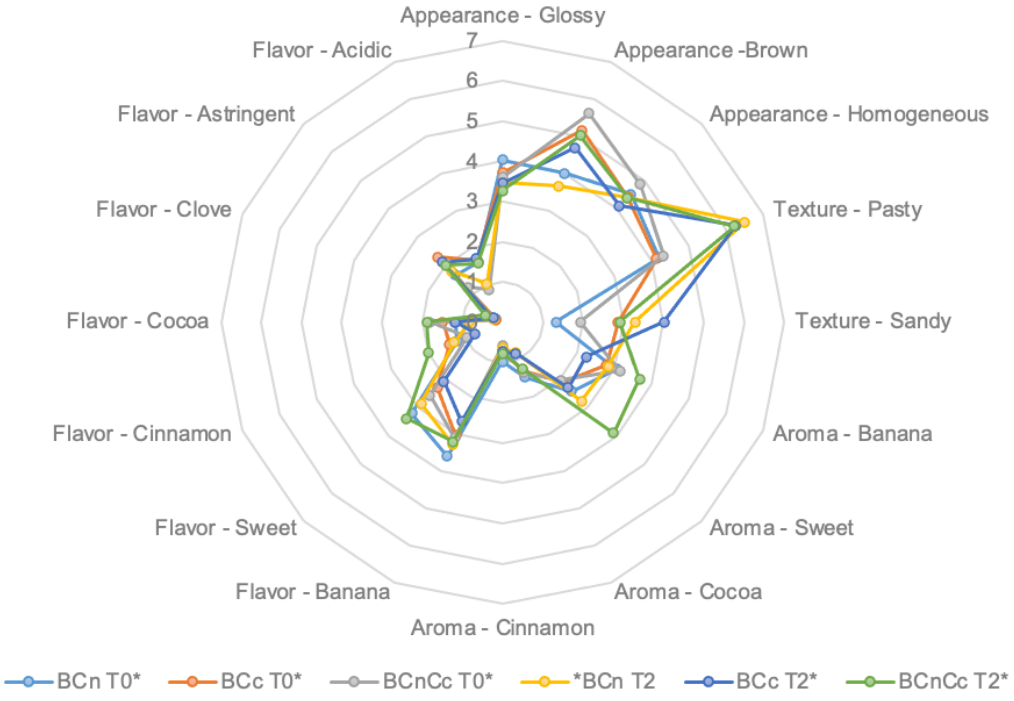
Attributes	BCn	BCc	BCnCc	MSD	P-value
Global acceptance	7.38 ± 1.24 a	7.20 ± 1.50 a	7.02 ± 1.44 a	0.363	0.066
IA (%)	*82.03%*	*79.96%*	*78.00%*		
Appearance	7.24 ± 1.37 a	7.14 ± 1.53 a	7.05 ± 1.55 a	0.312	0.376
IA (%)	*80.39%*	*79.30%*	*78.32%*		
Aroma	7.35 ± 1.52 a	7.37 ± 1.60 a	7.41 ± 1.46 a	0.409	0.943
IA (%)	*81.70%*	*81.92%*	*82.35%*		
Flavor	7.15 ± 1.52 a	6.98 ± 1.65 a	6.83 ± 1.75 a	0.441	0.250
IA (%)	*79.41%*	*77.56%*	*75.93%*		
Texture	7.35 ± 1.39 a	7.25 ± 1.63 a	7.13 ± 1.64 a	0.388	0.396
IA (%)	*81.70%*	*80.50%*	*79.19%*		

BCn: formulation produced with banana pulp, cinnamon powder, and lemon juice; BCc: formulation with banana pulp, cocoa powder 50%, and lemon juice; BCnCc: formulation with banana pulp, cinnamon powder, cocoa powder 50%, and lemon juice; MSD: Minimum significant difference; AI (%): Acceptability index. Different letters in the line indicate that there was a statistical difference at a significance level of 5%. Equal letters on the line indicate that there was no statistical difference at a 5% significance level.



BCn: formulation produced with banana pulp, cinnamon powder, and lemon juice; BCc: formulation with banana pulp, cocoa powder 50%, and lemon juice; BCnCc: formulation with banana pulp, cinnamon powder, cocoa powder 50%, and lemon juice.

Figure 2. Histogram of purchase intention for a banana product similar to jam.



BCn: formulation produced with banana pulp, cinnamon powder, and lemon juice; BCc: formulation with banana pulp, cocoa powder 50%, and lemon juice; BCnCc: formulation with banana pulp, cinnamon powder, cocoa powder 50%, and lemon juice. T0: time 0, the next day after the end of the product production process; T2: time 2 months, after 2 months of product storage at an average temperature of 25°C.

Figure 3. Sensory attributes of a banana product similar to jam evaluated through quantitative descriptive analysis (QDA).

characteristics, consumer acceptability, and microbiological and sensory stability, indicate that the developed product can be a viable alternative for family farming producers who comply with the PNAE. The lack of banana jam (with sugar) as a control in the analyses performed can be considered a limitation of this study; however, the objective was to develop and evaluate the characteristics of sugar-free banana product formulations. Other limitations and recommendations for future studies include analyses of texture, water activity, and fiber, as well as performing physical-chemical analyses at both storage times and conducting sensory analysis with children since this product may be intended for the PNAE.

4 CONCLUSION

It was possible to develop, with simple technology, sugar-free products of banana, similar to jam, with adequate nutritional characteristics, good acceptability by consumers, stability in descriptive sensory attributes throughout storage, and acceptable microbiological parameters, with storage at an average temperature of 25°C. Furthermore, the products are suitable for the PNAE and meet the demand of family farmers who produce food for school meals, being a new alternative for industrializing bananas and consequently generating income.

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