Acceptability of bonbons made with camu-camu (*Myrciaria dubia* L)

Aceptabilidad de los bombones elaborados con camu-camu (*Myrciaria dubia* L)

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Abstract

The aim of this study was to formulate and evaluate different formulations of camu-camu bonbons, verifying which formulations obtained greater acceptability and maintenance of their nutraceutical potential. The bonbons were made of 2 chocolate-based toppings (white chocolate and milk chocolate), with three types of camu-camu-based fillings (candy, candy + jelly and candy + syrup). A sensory analysis was performed using a questionnaire and a hedonic scale ranging from 9 to 1 to evaluate appearance, colour, taste and texture. The hedonic scale used to assess purchase intentions ranged from 5 to 1. The physicochemical characteristics and bioactive compounds of the bonbons were evaluated. Bonbons had excellent acceptability rates, where consumers would definitely buy bonbons: white chocolate stuffed with camu-camu candy+camu-camu syrup (F3) and milk chocolate stuffed with camu-camu candy (F4). Consumers would 'probably buy' white chocolate stuffed with camu-camu candy (F1) based on its texture and high levels of vitamin C (VitC), antioxidant activity (FRAP) and (DPPH), phenolic compounds (Phen), and flavonoids (Flavon). Milk chocolate stuffed with camu-camu candy (F4), white chocolate stuffed with camu-camu candy+camu-camu syrup (F3), and white chocolate stuffed with camu-camu candy (F1) have excellent purchase percentages and levels of VitC, FRAP and DPPH, Phen, and Flavon, and especially titratable low acidity; these formulations are highlighted among consumers.

Keywords
by-products • functional properties • human health • industrial potential

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Resumen

El objetivo de este estudio fue formular y evaluar diferentes formulaciones de bombones de camu-camu, verificando cuáles obtuvieron mayor aceptabilidad y mantenimiento de su potencial nutracéutico. Los bombones se elaboraron con 2 coberturas a base de chocolate (chocolate blanco y chocolate con leche), con tres tipos de rellenos a base de camu-camu (dulce, dulce + gelatina y dulce + jarabe). Se realizó un análisis sensorial utilizando un cuestionario y una escala hedónica que iba del 9 al 1 para evaluar la apariencia, el color, el sabor y la textura. La escala hedónica utilizada para evaluar las intenciones de compra iba del 5 al 1. Se evaluaron las características fisicoquímicas y los compuestos bioactivos de los bombones. Los bombones tuvieron excelentes tasas de aceptabilidad, donde los consumidores definitivamente comprarían bombones: chocolate blanco relleno de dulce de camu-camu + jarabe de camu-camu (F3) y chocolate con leche relleno de dulce de camu-camu (F4). Los consumidores 'probablemente comprarían' chocolate blanco relleno de dulce de camu-camu (F1) basado en su textura y altos niveles de vitamina C (VitC), actividad antioxidante (FRAP) y (DPPH), compuestos fenólicos (Phen) y flavonoides (Flavon). El chocolate con leche relleno de dulce de camu-camu (F4), el chocolate blanco relleno de dulce de camu-camu + jarabe de camu-camu (F3) y el chocolate blanco relleno de dulce de camu-camu (F1) tienen excelentes porcentajes de aceptabilidad de compra y niveles de VitC, FRAP y DPPH, Phen y Flavon, y especialmente baja acidez titulable; estas formulaciones se destacan entre los consumidores.

Palabras clave
subproductos • propiedades funcionales • salud humana • potencial industrial

Introduction

Camu-camu (*Myrciaria dubia* (Kunth) Mc Vaugh), which belongs to the Mytaceae family, is among the native Amazonian species with great industrial potential. This potential for economic exploitation occurs due to the great benefits of the fruit, especially due to the high levels of vitamin C and bioactive compounds.

Among the chemical compounds present in camu-camu fruits, vitamin C is the most abundant, reaching up to 7,355 mg ascorbic acid (4). In addition, fruits contain other compounds, such as catechins and their derivatives, carotenoids, anthocyanins and flavonoids, which, together with vitamin C, provide high levels of antioxidant capacity (5).

Combined with the benefits of chemical compounds, fruits contain considerable amounts of micronutrients, such as mineral salts and fibre, which provide excellent nutritional and functional sources (16). However, due to several factors inherent to the culture, such as production concentrated at specific times of the year, the rapid loss of postharvest quality and the high acidity of the fruit when consumed in natura, the commercialization of the fruits is limited, and the fruits are little used by consumers.

One of the ways to explore the potential of camu-camu fruits is the development of industrial processing technology, a solution that seeks to reduce costs, add value and promote family farming (15). This technique has been used for the production of jellies (17), popsicles (15, 16) and yogurts (6) with high nutritional potential and food safety; therefore, this technique is a viable alternative to the use of camu-camu in byproducts (13). However, the use of bonbons as a byproduct of camu-camu fruit has not yet been tested.

Bonbons are some of the most consumed foods in the world and are one of the ways to market chocolate; they can contain several types of fillings that can be made with fruits, pieces of fruit, oil seeds, sugar, milk, butter, cocoa, liqueurs and other food substances covered with a layer of chocolate (8, 27). The insertion of products derived from fruits with excellent functional properties, whether artisanal or industrial, increases the possibility of consumer acceptance.

The commercialization of bonbons (of the most varied flavours) produced on an artisanal and/or industrial scale is growing and constant, moving the formal market (21). In the Amazon region, a large exploitation of products with fillings containing the most diverse fruits has been noted, such as Brazil nuts, cupuaçu and açai (19, 30, 32). Thus, due to the great functional and nutraceutical potential of the fruits, we emphasize the importance of the production and characterization of byproducts based on camu-camu through the processing of parts of the fruit (seed, peel or pulp), in this way adding value to the product and maintaining its organoleptic and nutraceutical characteristics.

Thus, the objective of this study was to formulate and evaluate different formulations of camu-camu bonbons, verifying which formulations obtained greater acceptability and maintenance of their nutraceutical potential.

Materials and methods

Raw material

The fruits used were obtained from the Serra da Prata experimental farm belonging to Embrapa Roraima, located in the municipality of Mucajaí 62 km from Boa Vista and located at the geographical reference coordinates W 60°58'40" N 2°23'49". The fruits were manually harvested in the early hours of the day, considering the greenish-red bark colour, because at this stage, a longer shelf life is provided to the fruits, and the fruits retain their good quality attributes for a longer time (14, 18).

After harvesting, the fruits were packed in plastic bags, packed in coolers with ice and transported to the Post-Harvest, Agroindustry and Tissue Culture Laboratory, Embrapa - RR. Then, they were cleaned and sanitized with 0.02% sodium hypochlorite (NaClO) for 30 minutes, following the recommendations of the National Health Surveillance Agency (ANVISA). After cleaning, the fruits were manually pulped without water, and the pulp was separated from the peel and the seeds. A schematic representation of the steps for the production of byproducts is shown in figure 1 (page XXX).

Experimental design

The experimental design was completely randomized in a 2 x 3 factorial scheme with three repetitions, each repetition consisting of 3 bonbons. The factors were the addition of 2 chocolate-based toppings (white chocolate and milk chocolate) with three types of camu-camu-based fillings (candy, candy + jelly and candy + syrup).

The mixtures of the formulations resulted in six different bonbons: F1-bonbon covered with white chocolate and stuffed with camu-camu candy (WCC); F2-bonbon covered with white chocolate and stuffed with camu-camu candy + camu-camu jelly (WCC+J); F3-bonbon covered with white chocolate and stuffed with camu-camu candy + camu-camu syrup (WCC+S); F4-bonbon covered with milk chocolate and stuffed with camu-camu candy (MCC); F5-bonbon covered with milk chocolate and stuffed with camu-camu candy + camu-camu jelly (MCC+J); and F6-bonbon covered with milk chocolate and stuffed with camu-camu candy + camu-camu syrup (MCC+S).

Industrial process

The camu-camu candy (the truffle type) used in all treatments was made using 48% white chocolate (Mavaleiro, São Paulo - Brazil), 24% can of cream (Bela Vista Dairy products, Goiás - Brazil), 4.8% tablespoons of condensed milk (Goias Minas industry, GOIAS - BRAZIL), 0.8% teaspoon of butter (INDUSTRY BRF, PARANA - BRAZIL) 20% cup of camu-camu pulp (Embrapa, Roraima - Brazil), and 2.4% dessert spoon of corn syrup (Industry Arco-íris, São Paulo - Brazil). The white chocolate was melted in a bain-marie model Magio MS-800F (Lactea Scientific, São Paulo - Brazil), and then the other ingredients were added and mixed until a homogeneous mass was formed. After this procedure, the homogeneous mass was refrigerated for cooling.

The jelly was obtained using the following ingredients in percentages: pure jelly (51% jelly, 49% sugar and 0.005% pectin) according to Grigio *et al.* (2021b). The ingredients were brought to medium heat until they were cooked and homogenized. Then, they were placed in glass jars to be added to the other treatments.

The seeds were removed manually and the camu-camu syrup was manufactured using the following ingredients at the percentages described: 45% fruit (peel+pulp) without seeds, 30% sugar and 25% water. The ingredients were placed over medium heat until the sugar had completely melted, forming a syrup next to the fruits. After this process, they were placed in glass jars to be added to the other treatments.

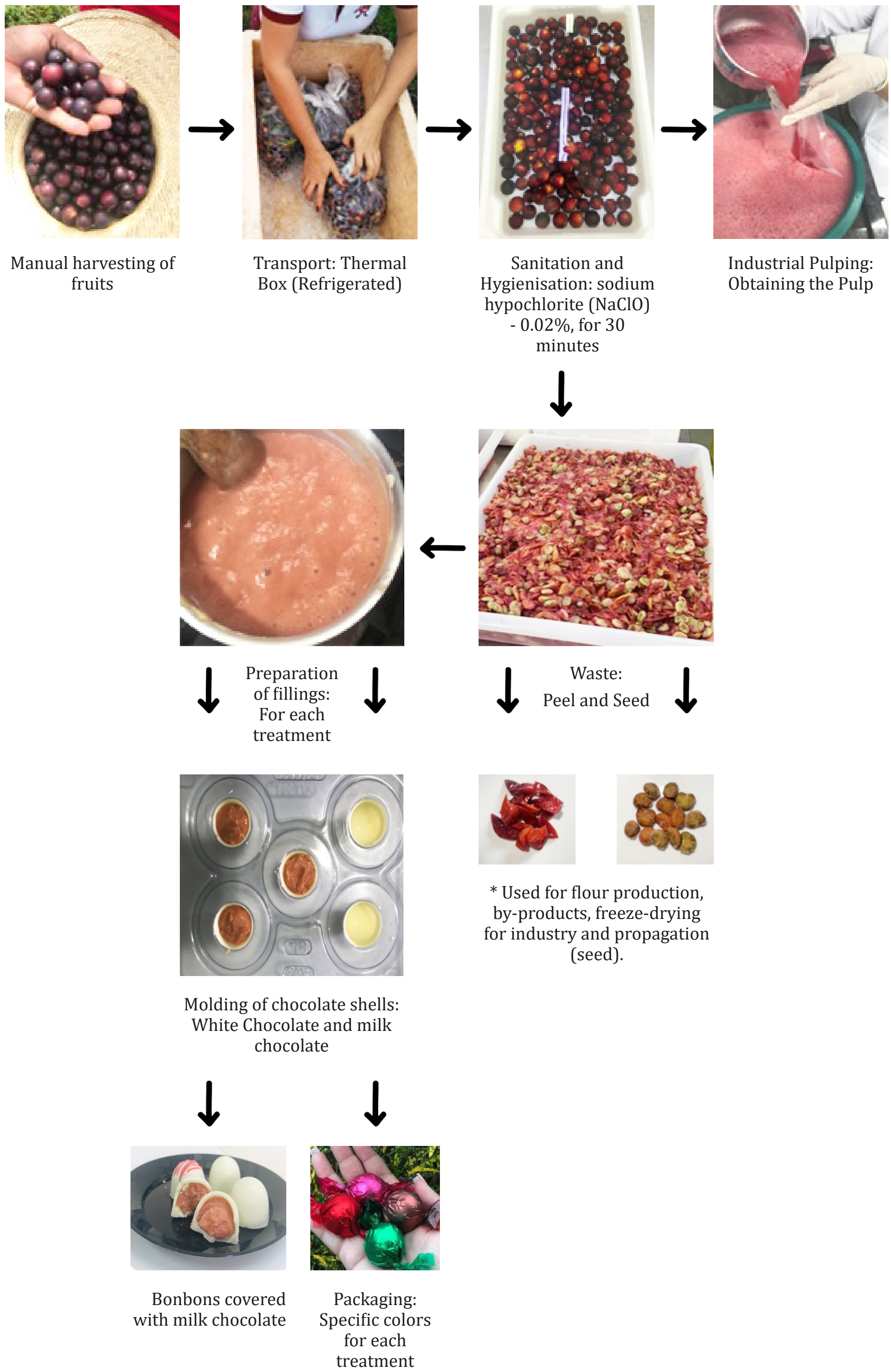

Figure 1. Schematic representation of the steps for the production of byproducts.
Figura 1. Representación esquemática de los pasos para la producción de subproductos.

The chocolates were melted in a bain-marie and moulded in round acetate moulds with a 5 cm cavity to cover the candy. After the chocolates were moulded, the fillings were distributed according to the treatments and then covered with a layer of chocolate to finish the moulding of the chocolates. Once finished, the chocolates were wrapped in aluminium foil with different colours that indicated the different treatments so that the sensory analysis of the products could be conducted.

Sensory analysis

This study was duly registered and approved by the Research Ethics Committee of the Federal University of Roraima, under number 41734015.0.0000.5302, and the sensory analyses were performed at Embrapa Roraima, with the participation of 40 untrained tasters. The samples were placed in disposable cups and coded with random numbers. Each appraiser received all six jelly formulations and one sheet containing a questionnaire and a hedonic scale ranging from 9 to 1 to evaluate appearance, colour, taste and texture (9-Liked it extremely, 8-Liked it a lot, 7-Liked it, 6-Somewhat liked it, 5-Indifferent, neither liked nor disliked, 4-Somewhat disliked, 3-Disliked, 2-Disliked moderately and 1-Disliked extremely), and another scale to gauge purchase intent, as previously reported (9), (1-Definitely would buy, 2-Probably would buy, 3-Maybe yes/maybe no, 4-Probably wouldn't buy, 5-Definitely would not buy). During the evaluations, the evaluators drank water to ensure no interference between the formulations analysed.

We calculated the product acceptability index using the expression IA (%) = A × 100/B, where A = the average grade obtained for the product and B = the maximum grade given to the product. Usually, an acceptability index ≥ 70% is considered to indicate good repercussion (11).

Physicochemical characteristics and bioactive compounds

pH (hydrogen potential): The pH was determined according to the methodology of AOAC (2012), by directly immersing a pH meter in the formulations. Soluble Solids (SS): SS were determined by refractometry with a portable refractometer (SOLOESTE brand, model RT-30ATC) with automatic temperature compensation (10 to 30°C), and the results are reported in °Brix (1). Titratable acidity (TA): Using the methodology described in AOAC (2012), 10 g of each formulation was diluted in 100 mL of distilled water. After the addition of the phenolphthalein indicator, the solution was titrated with a 0.1 M NaOH solution. The results are reported as mg of citric acid per 100 g-1 sample.

Ratio: The ratio between the quantities of SS and TA. Ascorbic acid (VitC) was extracted with 0.5% oxalic acid and titrated with 2,6-dichlorophenolindophenol (26).

Antioxidant activity (FRAP): The antioxidant capacity of each sample was estimated with the iron reduction method (FRAP) following a procedure adapted previously (29). Approximately 1 g of sample was mixed with 40 mL of 50% methanol, homogenized, and allowed to stand for 60 minutes at room temperature. After this period, the samples were centrifuged (25.406,55 g) for 15 minutes, and the supernatant was transferred to a 100 mL volumetric flask. Forty millilitres of 70% acetone was added to residue of the first extraction, and the residue was homogenized and allowed to stand for 60 minutes at room temperature. After one hour, the samples were centrifuged again (25.406,55 g) for 15 minutes, and the supernatant was transferred to a volumetric flask containing the first supernatant and the volume was completed with distilled water. The obtained extract, which was added to the FRAP reagent, was placed in a warm water bath at 37°C. The absorbance of the samples was measured at 595 nm, and the results are presented as mg of ferrous sulfate g^{-1} sample.

Antioxidant activity (DPPH): The antioxidant activity can be determined in terms of the oxidation inhibition potential using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical as a reference (3). One gram of sample was weighed, after which 10 ml of ethyl alcohol was added, and the sample was homogenized and centrifuged for 50 minutes. After this period, the supernatant was removed with a pipette, and the solution was placed in a dark flask in an ice bath, to which 3 mL of ethanol was added. The absorbance of 500 µL of the sample extract supplemented with 300 µL of the DPPH solution was measured at 517 nm with a spectrophotometer. The results are expressed as µg of ascorbic acid equivalent g^{-1} sample.

The phenolic compound (Phen) content was determined according to the Folin-Ciocalteu spectrophotometric method described by Singleton *et al.*, 1999. An aliquot of 20 µL of sample was diluted to 1.58 mL with water, 100 mL of Folin-Ciocalteu reagent was added, and the sample was homogenized. Between 30 sec and 8 min, 300 µL of the sodium carbonate solution was added, and the mixture was homogenized again. The solutions were incubated at 20°C for 2 hours, and the absorbance of each solution was determined at 765 nm. The results are expressed as mg of g^{-1} gallic acid in the sample.

Total flavonoid (Flavon) content was determined with the aluminium chloride colorimetric assay (34) using quercetin as a standard. For extraction, a methanol solution and 5% aluminium chloride were added. After 30 minutes, the absorbance was measured at 441 nm with a spectrophotometer. For each sample, a blank was made containing the added methanol sample. The results are expressed in µg quercetin equivalents g^{-1} sample. The total anthocyanin content was determined according to the method described by Lees and Francis (1972), using cyanidin as a standard. Samples were added to an acidified methanol solution (HCl (85:15)), and after homogenization, the samples were stored in the dark. After storage for 24 h, the absorbance of the samples was measured at 520 nm using a spectrophotometer. The results are expressed as µg cyanidin equivalent g^{-1} sample.

Statistical analysis

The statistical analysis of the data is reported as the mean ± standard deviation. Analyses of variance (ANOVAs) were performed with F ($p<0.01$). Means were compared according to the test of minimum significant difference (LSD test) ($p<0.05$). The relationships between the parameters evaluated for the different bonbon formulations were estimated by calculating the Pearson correlation coefficient ($p<0.05$). The variables were subjected to a multivariate analysis. Multivariate data analysis was performed using principal component analysis (PC) to better show the distribution of different bonbon formulations and the effects of the intention to buy products on sensory characteristics, organoleptic quality and bioactive compounds. The analyses were performed with R software (Boston, USA) (25).

Results

Sensory characteristics

According to the sensory analysis (figure 2A, page XXX), the bonbons covered with white chocolate filled with camu-camu candy (F1), camu-camu candy + camu-camu jelly (F2) and camu-camu candy+camu-camu syrup (F3) and those covered with milk chocolate with camu-camu sweet filling (F4) showed greater acceptability in terms of appearance, colour, flavour and texture, with indices greater than 73% (figure 2A, page XXX).

The F4 and F3 bonbons had the most favourable flavours. The F1 and F4 bonbons, on the other hand, showed greater acceptance in terms of texture (figure 2A, page XXX). Bonbons covered with milk chocolate and stuffed with camu-camu candy + camu-camu syrup (F6) and milk chocolate with camu-camu candy filling + camu-camu jelly (F5) provided poor consumer acceptance in terms of texture acceptability, with a low acceptability index (<70%) (figure 2A, page XXX).

For purchase intent, consumers would definitely buy bonbons in the following order: F3 and F4 (figure 2B, page XXX). Consumers would probably buy bonbons F1 and F4 (figure 2B, page XXX). The lowest consumer uncertainty was recorded for the F3 and F4 bonbons, where participants reported maybe yes/maybe they would not buy (figure 2B, page XXX). The greatest rejections, where consumers probably would not and decidedly would not buy the bonbons, were for the F5, F2, and F6 formulations, respectively (figure 2B, page XXX).

Physicochemical and nutraceutical qualities

The results showed significant individual effects of coverage (white chocolate-WC and milk chocolate-MC) and fillings (candy, candy+jelly and candy+syrup) on the pH and soluble solid (SS) contents of the bonbons ($p<0.01$) (table 1, page XXX).

Formulations: (F1) (white chocolate stuffed with camu-camu candy); (F2) (white chocolate stuffed with camu-camu candy + camu-camu jelly); (F3) (white chocolate stuffed with camu-camu candy + camu-camu syrup); (F4) (milk chocolate stuffed with camu-camu candy); (F5) (milk chocolate stuffed with camu-camu candy + camu-camu jelly); and (F6) (milk chocolate stuffed with camu-camu candy + camu-camu syrup). Means + standard deviations (*n*=40).

Formulaciones: (F1) (chocolate blanco y relleno de dulce de camu-camu); (F2) (chocolate blanco y relleno de dulce de camu-camu + gelatina de camu-camu); (F3) (chocolate blanco y relleno de dulce de camu-camu + camu-camu en almíbar); (F4) (chocolate con leche y relleno de dulce de camu-camu); (F5) (chocolate con leche y relleno de dulce de camu-camu + gelatina de camu-camu); y (F6) (chocolate con leche y relleno de dulce de camu-camu + camu-camu en almíbar). Medias + desviación estándar (n=40).

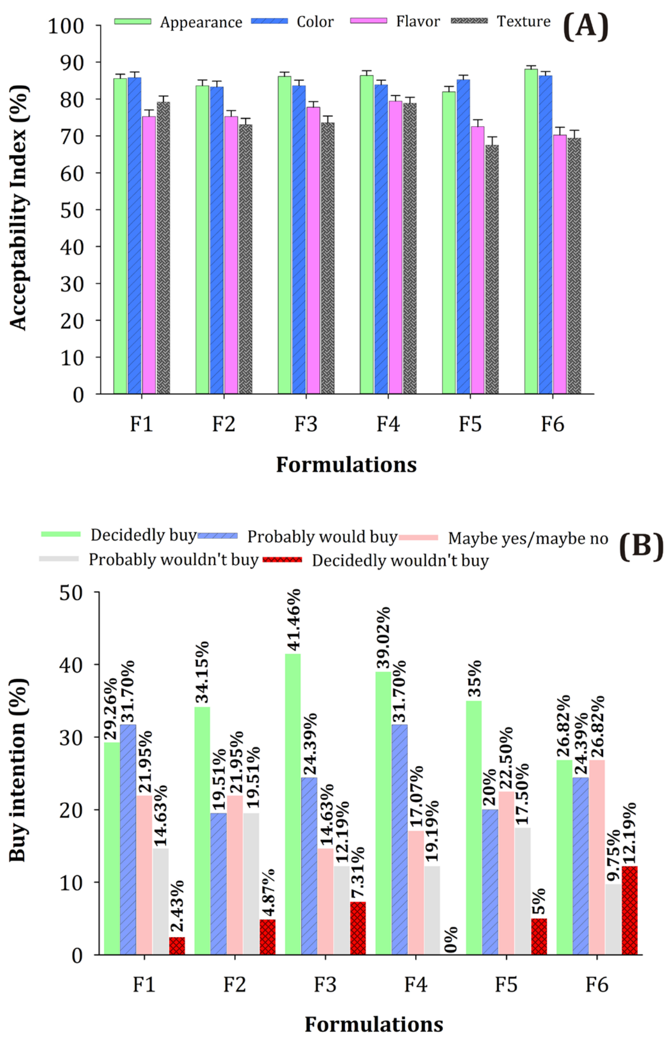

Figure 2. Acceptability index (A) and purchase intention (B) of different bonbon formulations.

Figura 2. Índice de aceptabilidad (A) e Intención de compra (B) de diferentes formulaciones de bombones.

Table 1. The average pH and soluble solid contents of bonbons covered with white and milk chocolate and stuffed with camu-camu candy, camu-camu candy + camu-camu jelly and camu-camu candy + camu-camu syrup.

Tabla 1. Valores promedio de pH y sólidos solubles de bombones cubiertos de chocolate blanco y con leche, rellenos de dulce de camu-camu, dulce de camu-camu + gelatina de camu camu y dulce de camu-camu + jarabe de camu-camu.

Covered	pH	Soluble Solids (°Brix)
White chocolate	4.87 a ± 0.27 a	52.55 ± 5.32 a
Milk chocolate	4.69 b ± 0.25 b	49.33 ± 5.83 b
Stuffed		
Camu-camu candy	5.06 ± 0.16 a	52.33 ± 1.63 b
Candy + camu-camu jelly	4.78 ± 0.07 b	56.5 ± 1.87 a
Candy + camu-camu in syrup	4.50 ± 0.17 c	44 ± 2.37 c
CV (%)	2.09	2.09

* Averages followed by the same letter in the column are not different from each other according to the least significant difference (LSD) test (p>0.05). ** Means ± standard deviations.

* Promedios seguidos de la misma letra en la columna no son diferentes entre sí, por la prueba de diferencia mínima significativa (LSD) (p>0.05). ** Media + desviación estándar.

The pH of the bonbons that were covered with WC was less acidic than that of the bonbons covered with MC (p<0.05). The pH of the bonbons that received the candy filling was less acidic than that of the bonbons that received candy+jelly or candy+syrup (p<0.05). The bonbons were also shown to have greater sweetness when receiving WC coverage than when receiving MC (p<0.05). The chocolates with the candy+jelly filling had the greatest sweetness, while those that received candy+syrup had the least sweetness, with low SS values (p<0.05) (table 1, page XXX).

For the variables titratable acidity (TA), ratio (SSTA), ascorbic acid (VitC), anthocyanins (Antho), flavonoids (Flavon), phenolic compounds (Phen) and antioxidant activity (FRAP and DPPH), a significant effect of the interaction between the type of chocolate coating and filling with camu-camu was observed (p<0.01) (table 2).

Table 2. Average values of physicochemical characteristics, bioactive compounds and antioxidant activity of the bonbons covered with white and milk chocolate stuffed with camu-camu candy, camu-camu candy+camu-camu jelly and camu-camu candy+camu-camu syrup.

Table 2. Valores promedio de características fisicoquímicas, compuestos bioactivos y actividad antioxidante de los bombones cubiertos de chocolate blanco y con leche, rellenos de dulce de camu-camu, dulce de camu-camu+gelatina de camu-camu y dulce de camu-camu+jarabe de camu-camu.

Covered	**Camu-camu candy**	**Candy+camu-camu jelly**	**Candy+camu-camu syrup**
	Titratable acidity (mg citric acid 100 g sample^{-1})		
White Chocolate	2.63±0.17a A	3.23±0.10 a A	3.03±0.15 b A
Milk chocolate	2.90±0.32 a B	3.10±0.10 a B	4.66±0.57 a A
CV (%)	9.23		
	***Ratio* SSTA**		
White Chocolate	21.85±0.65 a A	17.97±0.50 a B	15.19±0.98 a C
Milk chocolate	17.64±1.41 b A	17.75±0.89 a A	9.10±1.22 b B
CV (%)	6		
	Ascorbic acid (mg 100 g sample^{-1})		
White Chocolate	828.79±6.15 a A	567.08±4.61 a B	307.34±4.61 a C
Milk chocolate	314.39±6.04 b B	359.69±7.99 b A	311.37±9.06 a B
CV (%)	1.48		
	Anthocyanins (µg cyanidin g sample^{-1})		
White Chocolate	44.55±0.67 a B	63.01±0.51 a A	34.15±0.51 a C
Milk chocolate	34.93±2.05 b B	39.97±0.88 b A	34.15±1.27 a B
CV (%)	2.69		
	Flavonoids (µg quercetin g sample^{-1})		
White Chocolate	913.42±13.42 a A	630.08±5.12 a B	341.49±5.12 a C
Milk chocolate	349.32±6.71 b B	399.66±8.87 b A	341.49±12.70 a B
CV (%)	1.87		
	Phenolic compounds (mg gallic acid g sample^{-1})		
White Chocolate	0.91±0.01 a A	0.63±0.01 a B	0.34±0.01 a C
Milk chocolate	0.34±0.00 b B	0.40±0.01 b A	0.34±0.01 a B
CV (%)	1.87		
	Antioxidant Activity (DPPH) (µg of ascorbic acid g sample^{-1})		
White Chocolate	91.34±1.34 a A	63±0.51 a B	34.14±0.51 a C
Milk chocolate	34.93±0.67 b B	39.96±0.88 b A	34.14±1.27 a B
CV (%)	1.87		

* Averages followed by the same lowercase letter in the column and uppercase letter in the row are not different according to the least significant difference (LSD) test (p>0.05). ** Means ± standard deviations.

* Promedios seguidos de la misma letra minúscula en la columna y mayúscula en la fila no son diferentes, por la prueba de diferencia mínima significativa (LSD) (p>0,05). ** Media + desviación estándar.

* Averages followed by the same lowercase letter in the column and uppercase letter in the row are not different according to the least significant difference (LSD) test (p>0.05). ** Means ± standard deviations.

* Promedios seguidos de la misma letra minúscula en la columna y mayúscula en la fila no son diferentes, por la prueba de diferencia mínima significativa (LSD) (p>0,05). ** Media + desviación estándar.

Covered	Camu-camu candy	Candy+camu-camu jelly	Candy+camu-camu syrup
	Antioxidant Activity (FRAP) (mg ferrous sulfate g sample^{-1})		
White Chocolate	920.13±6.71 a A	630.08±5.12 a B	341.49±5.12 a C
Milk chocolate	349.32±6.71 b B	399.66±8.87 b A	341.49±12.70 a B
CV (%)	1.61		

No significant differences in TA were observed between the bonbons with WC and MC coverage that received the fillings with candy and candy+jelly (p>0.05). The bonbons coated with MC and stuffed with candy+syrup were less acidic than the candies coated with WC filled with candy+syrup (p<0.05). WC bonbons with different fillings did not show significant differences regarding the TA (p>0.05). However, MC bonbons had higher TA values with candy+syrup fillings, differing statistically from those of bonbons filled with candy and candy+jelly (p<0.05) (table 2, page XXX).

The bonbons with WC coatings filled with candy and candy+jelly had higher levels of ascorbate acid, anthocyanin, flavonoids, and phenolic compounds and greater antioxidant activity (DPPH and FRAP) than the bonbons with MC coatings (p<0.05). A significant difference was not observed between the bonbons coated with WC and those coated with MC that received candy+syrup fillings (p>0.05) (table 2, page XXX).

The bonbons coated with WC and filled with candy had higher levels of ascorbic acid, flavonoids, phenolic compounds, DPPH and FRAP, differing statistically from the bonbons filled with candy+jelly and candy+syrup (p<0.05). The bonbons with the MC coating, which were filled with candy+jelly, presented the highest levels of ascorbic acid, flavonoids, phenolic compounds, DPPH and FRAP (p<0.05) (table 2, page XXX). The values of anthocyanins were greater in bonbons filled with candy+jelly, both with WC and MC coatings (p<0.05) (table 2, page XXX).

Multivariate analysis

The multivariate analysis of principal components (PCs) showed a cumulative variance of 89.06%. For PC1, the F1 and F6 bonbons contributed the most, with contributions of 51.60% and 27.34%, respectively. For PC2, the largest contributions were from bonbons F6 and F4, at 49.27% and 27.03%, respectively (figure 3, page XXX).

The variables that showed the greatest correlations with PC1 were phenolic compounds (Phen), antioxidant activity (DPPH and FRAP), flavonoids, and ascorbic acid (AA) (r2= 0.95, p=0.03), pH (r2= 0.89, p=0.02) and the SSTA ratio (r2= 0.87, p =0.02). For PC2, only the purchase index of would definitely buy was significantly correlated (r2= -0.84, p=0.03) (figure 3, page XXX).

The question of flavour acceptability (figure 2B, page XXX) was what led most consumers to decide to buy the bonbons (r2= 0.78, p= 0.05), and colour negatively influenced this decision (r2=-0.82, p=0.01) (figure 3, page XXX). The texture of the bonbons was the factor that influenced consumers to probably buy the bonbons (r2= 0.84, p=0.01); consumers who preferred the bonbons due to the texture also considered the greater flavour (r2= 0.75, p= 0.05) and lower acidity (>pH) (r2= 0.75, p=0.05) (figure 3, page XXX). The flavour and colour acceptability indices of the bonbons contributed to greater uncertainty among consumers, as the lower the flavour (r2=-0.90, p=0.01) was, the greater the uncertainty of purchase, and the greater the colour intensity of the bonbons (r2= 0.74, p= 0.05) was, the greater the uncertainty of the purchase (figure 3, page XXX).

The factors that influenced consumers to probably not buy bonbons were high levels of anthocyanins (Antho) (r2= 0.84, p=0.01) and soluble solids (SS) (r2= 0.93, p= 0.001) (figure 3, page XXX). The majority of consumers who did not like the appearance probably would not buy bonbons (r2= -0.90, p= 0.001) (figure 3, page XXX). For consumers who definitely would not buy bonbons, a high TA content was one of the indices that most contributed to this decision (r2= 0.86, p= 0.01), and F6 bonbons were the ones that most contributed to this decision. The greater the acidity of the sweets (pH) (r2 = -0.86, p= 0.01) and the smaller the SSTA ratio (r2= -0.85, p=0.01) were, the greater the percentage of consumers who decidedly would not buy the bonbons (figure 3, page XXX).

Formulations: (F1) (white chocolate stuffed with camu-camu candy); (F2) (white chocolate stuffed with camu-camu candy + camu-camu jelly); (F3) (white chocolate stuffed with camu-camu candy + camu-camu syrup); (F4) (milk chocolate stuffed with camu-camu candy); (F5) (milk chocolate stuffed with camu-camu candy + camu-camu jelly); and (F6) (milk chocolate stuffed with camu-camu candy + camu-camu syrup).

Formulaciones: (F1) (chocolate blanco y relleno de dulce de camu-camu); (F2) (chocolate blanco y relleno de dulce de camu-camu + gelatina de camu-camu); (F3) (chocolate blanco y relleno de dulce de camu-camu + camu-camu en almíbar); (F4) (chocolate con leche y relleno de dulce de camu-camu); (F5) (chocolate con leche y relleno de dulce de camu-camu + gelatina de camu-camu); y (F6) (chocolate con leche y relleno de dulce de camu-camu + camu-camu en almíbar).

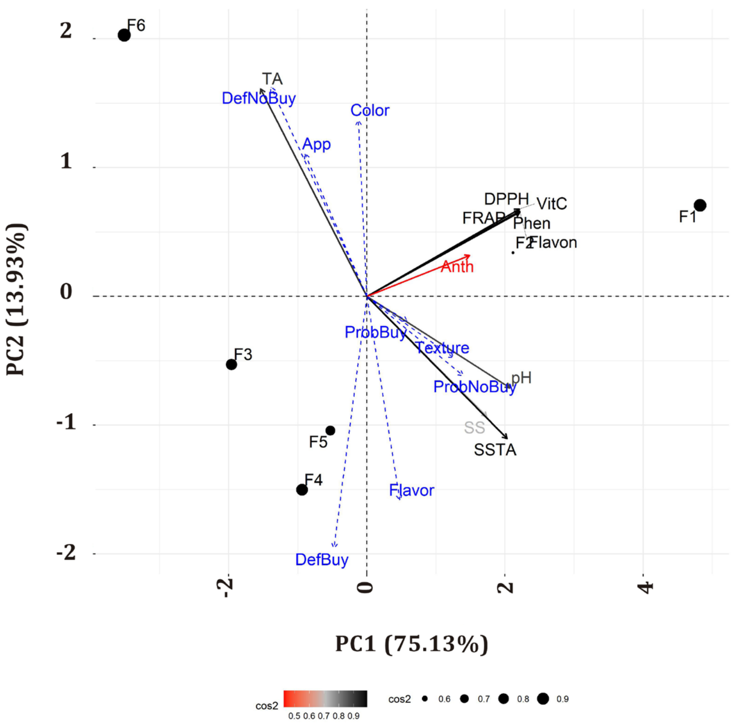

Figure 3. Principal component (PC) analysis of sensory characteristics, organoleptic quality and bioactive compounds was performed on different bonbon formulations with the intention of purchasing products (*n* = 114).

Figure 3. Análisis de componentes principales (PC) realizados en diferentes formulaciones de bombones y con la intención de adquirir productos sobre características sensoriales, calidad organoléptica y compuestos bioactivos (n = 114).

Confirming the results of the descriptive analysis (table 2, page XXX), F1 bonbons showed the highest correlations with antioxidant activity (Pheno, Flav, AA, DPPH, FRAP and Antho) (figure 3, page XXX). The lowest levels of antioxidant activity were found in the F4 and F3 bonbons, which consumers would definitely buy (figure 3, page XXX).

Discussion

The highest taste acceptance index of bonbons occurs because products processed from camu-camu improve their acceptance (23), and when products are processed as jellies, improvements in acceptance and purchase intent occur (17, 33). The greater acceptance of products with stronger colours is because the first contact of consumers is through the visual aspect of the product (7, 22, 28). These flavour and colour parameters, along with the texture, provided bonbons with lower acidity and rigidity, resulting in higher levels of acceptability and purchase intent, which were also observed in jellies made from camu-camu (17).

The largest rejections of the bonbons were due to higher acidity, leading to low acceptance (<70%). The lowest acceptability rates (< 70%) due to acidity have already been observed in other studies, such as those involving popsicles (15, 16) and jelly (17); therefore, such formulations must be rejected. The use of a sensory analysis to better understand consumers is highly important because it provides valid and reliable product results (7). The evaluation of purchase intentions, on the other hand, provides us with important real parameters for the possible commercialization of products (17).

The pH values of the bonbons were higher than those observed in the literature for other products based on camu-camu (16, 17), and consequently, the products had higher acceptability rates. The lower acidity (>pH) of the candy filled with candy was caused by its composition containing a good percentage of white chocolate (48%), which increases the pH of the products (17, 27).

The bonbon covered with milk chocolate and filled with candy + camu-camu syrup (F6) showed a lower quality index SSTA ratio due to higher TA and lower SS (°Brix) contents and higher acidity (<pH) because the camu-camu syrup has camu-camu peel in its composition, and a second (14, 16, 24) had a greater amount of acids, as already observed in camu-camu fruits.

The higher levels of bioactive compounds in the F1 and F2 bonbons indicated a low purchase intention, especially regarding anthocyanin contents, where consumers probably would not buy the bonbons (figure 3, page XXX). Formulations with higher levels of bioactive compounds cause astringency in the products, which has already been observed in other studies (16, 17). The presence of milk in the formulations negatively affects the amount of phenolic compounds, degrading an abundant portion of these compounds (2, 16), which was also observed in the present study, both for phenolic compounds and for other bioactive compounds that showed strong correlations with each other (figure 3, page XXX).

The antioxidant activity has a direct correlation with the content of phenolic compounds (10, 12), which was also observed in the present study. High concentrations of ascorbic acid and other acids during cooking resulted in low consumer acceptance (17), which proves the low levels of these compounds in the formulations with candy + jelly and candy + camu-camu syrup fillings, together with the fact that milk chocolate negatively affects bioactive compounds, as already described.

Conclusions

Milk chocolate stuffed with camu-camu candy (F4), white chocolate stuffed with camu-camu candy+camu-camu syrup (F3), and white chocolate stuffed with camu-camu candy (F1) showed excellent purchase percentages and low rejection, with the highest acceptability evaluations of flavour and texture. In addition, due to the excellent levels of vitamin C, FRAP and DPPH antioxidant activity, phenolic compounds, and flavonoids, and especially the titratable low acidity and medium sweetness, these formulations are highlighted among consumers.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Conflict of Interest

Declarations of interest: none'

Ethics approval statement

This study was duly registered and approved by the Research Ethics Committee of the Federal University of Roraima, under number 41734015.0.0000.5302