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A byproduct of uvaia (*Eugenia pyriformis*) processing as a natural source for coloring sugar hard-panning confections

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Abstract

Due to the increased demand for healthier confectionery products and the great importance of finding environmentally appropriate destinations for fruit processing byproducts, this study evaluated the performance of a Brazilian fruit (uvaia, *Eugenia pyriformis*) byproduct in coloring sugar hard-panning confections compared to synthetic caramel color and a natural fruit/plant-based concentrate. The obtained products were characterized according to their sensory acceptance, instrumental texture and color, water activity, moisture content, glass transition temperature, and sorption isotherm. A strong influence of the coloring agents was observed on the coatings' physical and chemical parameters. Comparatively, the uvaia byproduct induced a significant increase in the hardness and glass transition temperature of the confection, which may result in better stability concerning the maintenance of crunchiness. A sensory preference for naturally colored confections compared to a synthetically colored confection was observed. The uvaia byproduct presents technological potential as a sustainable coloring agent with low cost for confections.

Practical applications

Panned products account for a considerable portion of the total confectionery volume consumed worldwide. The inclusion of fruit processing byproducts in panned confections, specifically for the uvaia byproduct, is presented as a viable alternative for the natural coloring of a confectionery using a sustainable and low-cost ingredient. The methodology developed in this study has the potential to replace the conventional coloring additive for hard sugar-panned confectionery products, and it may be applicable in several types of confectionery products. The use of fruit byproducts with ability to impact color to the coating of panned confections may allow the removal of synthetic color additives, reducing the consumption of artificially colored products, and the occurrence of adverse reactions in consumer health.

1 | INTRODUCTION

In recent years, there have been a growing number of confectionery product launches with the claim of naturalness, mainly in the category of candies and chewing gums (Mutlu, Tontul, & Erbaş, 2018; Queiroz & Nabeshima, 2014). Fruits and vegetables (dried pulps, juices, purees, and concentrates) and their processing byproducts (peels, seeds, and bagasse) have already been used as natural alternatives to achieve this claim and replace synthetic food colors and flavors in confectioneries (Cappa, Lavelli, & Mariotti, 2014; Mongia, 2014).

The use of fruit products may improve the sensory experience of confections, in addition to reducing the quantity of added sugar to the products due to the sweeteners naturally present in the fruit (Mongia, 2014). Both fruits and their byproducts may nutritionally improve the final product by providing vitamins, minerals, fiber, and antioxidant compounds (Silva et al., 2016). Furthermore, the use of industrial byproducts of processed fruits is considered one way to reduce environmental contamination by minimizing losses and waste (Ramos, Lessio, Mece, & Efraim, 2017).

Uvaia (*Eugenia pyriformis* Cambess) is a native fruit from southern and southeastern Brazil with a yellow/orange color, high vitamin C content, anti-inflammatory properties, and antimicrobial activity due to its composition of essential oils (Medeiros, Costa, Curi, Moura, & Tadeu, 2010; Stieven, Moreira, & Silva, 2009). After drying, the uvaia byproduct can develop a yellow-brown color that presents great potential for food applications as an alternative to caramel colors. Commercial uvaia production is limited, and its cultivation is predominantly domestic (Jacomino, da Silva, de Freitas, & de Paula Morais, 2018). Therefore, the research on this fruit is important to instigate its commercial cultivation and the consumption of its nutritional benefits.

There are four types of caramel colors, and the use of Type IV, produced by ammonium compounds, has been questioned due to the formation of carcinogenic 4-methylimidazole (Jacobson, 2012; Sarfaraz et al., 2017; Vollmuth, 2018), although it is still a common additive in confectioneries.

Panned confections, or dragees, are popular confectionery products that result from the controlled and continuous build-up of a core by applying successive layers of a coating material, for example, saturated sugar syrup, to produce a hard or crispy shell using a revolving pan (Kitt, 2004). Panning products are an important part of confectionery production, and large amounts of such products are manufactured annually (NPCS Board, 2013).

The use of fruit byproducts in confectioneries, specifically in panned products, is poorly explored, and studies are required to define processing conditions and evaluate the technological and sensorial effects on the obtained products. While there has been increasing use of natural dyes and other agents in confectionery, such as fruit pulps, the use of fruit byproducts may result in a reduction in cost (compared to other natural ingredients).

The aim of this study was to evaluate the performance of an uvaia byproduct as a low-cost coloring agent in hard sugar-panned confections compared to synthetic and fruit-plant based concentrate coloring agents.

2 | MATERIAL AND METHODS

2.1 | Material

The ingredients used in the preparation of the dragee cores were sucrose (União), glucose syrup (Excel 1040, Ingredion) and gelatin (150 Bloom, Ômega), for the production of gelatin gummies; or milk chocolate (Garoto), raisins (local market, Brazil), acacia gum (Instantgum BB, Nexira), and milled sugar (~100 μm, União), for the production of chocolate-panned raisins.

The ingredients used in sugar-panning production were acacia gum (Instantgum BB, Nexira) and milled sugar (~100 μm, União), for sealing the cores; sugar (União), dextrin (Amisol 4810, Ingredion), titanium dioxide (Reagem), the uvaia byproduct (*Eugenia pyriformis*, Paraibuna, Brazil), sulfite ammonia caramel (caramel color IV, Beraca) and a fruit/plant-based concentrate (Exberry Ambar 933907, GNT), for producing the sugar-panning syrups; and beeswax and carnauba wax (GM Ceras) for polishing the pan-coated confections.

2.2 | Preprocessing of uvaia byproduct

The byproduct from uvaia pulp processing (peels and seeds) was initially thawed, centrifuged, and oven dried at 40°C/24 hr (Ramos et al., 2017). The seeds were removed, and the peels were milled (MLW ball mill, model KM1, Berlin, Germany), producing particles of less than 37 μm.

2.3 | Production of the sugar panning cores

Two types of cores were produced for sugar-panning processing: gelatin gummies without flavoring, for the characterization of the panned coating, and chocolate-panned raisins, for the sensory analysis. Gelatin gummies were produced by dissolving sugar (53.8 g/100 g, db) and glucose syrup (34.5 g/100 g, db) in water, cooking this mixture at 110°C, adding gelatin (11.7 g/100 g, db) that was previously hydrated at 40°C, dosing in starch molds, drying in an oven with air circulation at 30°C until achieving water activity (a_w) below 0.6, and then demolding the product (Pullia, 2004). The chocolate-panned raisins were produced in a revolving pan (JHM, model N-10, Mogi das Cruzes, Brazil) according to the following steps: sealing (three intercalated applications of 1 g of acacia gum solution [40:60, gum/water, wt/wt] and 4 g of milled sugar/100 g of cores); storage in shallow trays at 23°C/12 hr/60% relative humidity for drying; chocolate coating (application of 10 g of chocolate/100 g of sealed cores until reaching the desired coating thickness of 1:4 core/chocolate, wt/wt); and storage at 23°C/12 hr for chocolate cocoa butter crystallization (Sufferlig, 2007).

2.4 | Production of the sugar hard panning confections

Three types of panned coatings, containing synthetic food coloring (SC), a fruit/plant-based concentrate (FC), or the uvaia byproduct (UB), were studied using two different cores: gelatin gummies (G) and chocolate-panned raisins (C).

Preliminary trials were performed to define the panning process conditions, the composition of the panning syrup, the concentration of and how to apply color and whitening agents (e.g., in syrup and/or mixed in drying powder) and the number of applications of each panning substep.

The hard-panning process consisted of the application of successive layers of coatings to the cores as they tumbled in the revolving pan following the below steps (Bogusz, 2004):

- Sealing: performed according to Section 2.3, with the aims of providing a smoother surface to the cores by filling in their imperfections, improving coating adhesion to the surface, and increasing deformation resistance for more sensitive cores (gummies);
- Panning: successive application of 1 g of sugar syrup/100 g of sealed cores tumbling in a revolving pan, followed by drying (moisture evaporation and sugar crystallization). This step was divided into four substeps:
  1. Engrossing (rapid buildup of the sugar shell);
  2. Whitening (providing a white base coat) using the inorganic pigment titanium dioxide (TiO_2; 5 g/100 g of 72 °Brix sugar syrup) for SC confections and dextrin (15 g/100 g of 72 °Brix sugar syrup) as a natural alternative for FC and UB confections;
  3. Smoothing (to achieve a uniform surface in the final product);
  4. Coloring (providing a color coat to add visual appeal to the product);
- Polishing: applying friction to the panned confections with wax blocks (1:1 beeswax/carnauba wax, wt/wt) for 30 min at 25°C in the revolving pan to add gloss and moisture resistance to the finished product.

The steps in the production of the hard-panned confections are shown in Figure 1.

2.5 | Physical and physicochemical determinations

Considering the relatively easy separation of the coating from the core, the panned confections with gelatin gummy as a core (SC-G, FC-G, and

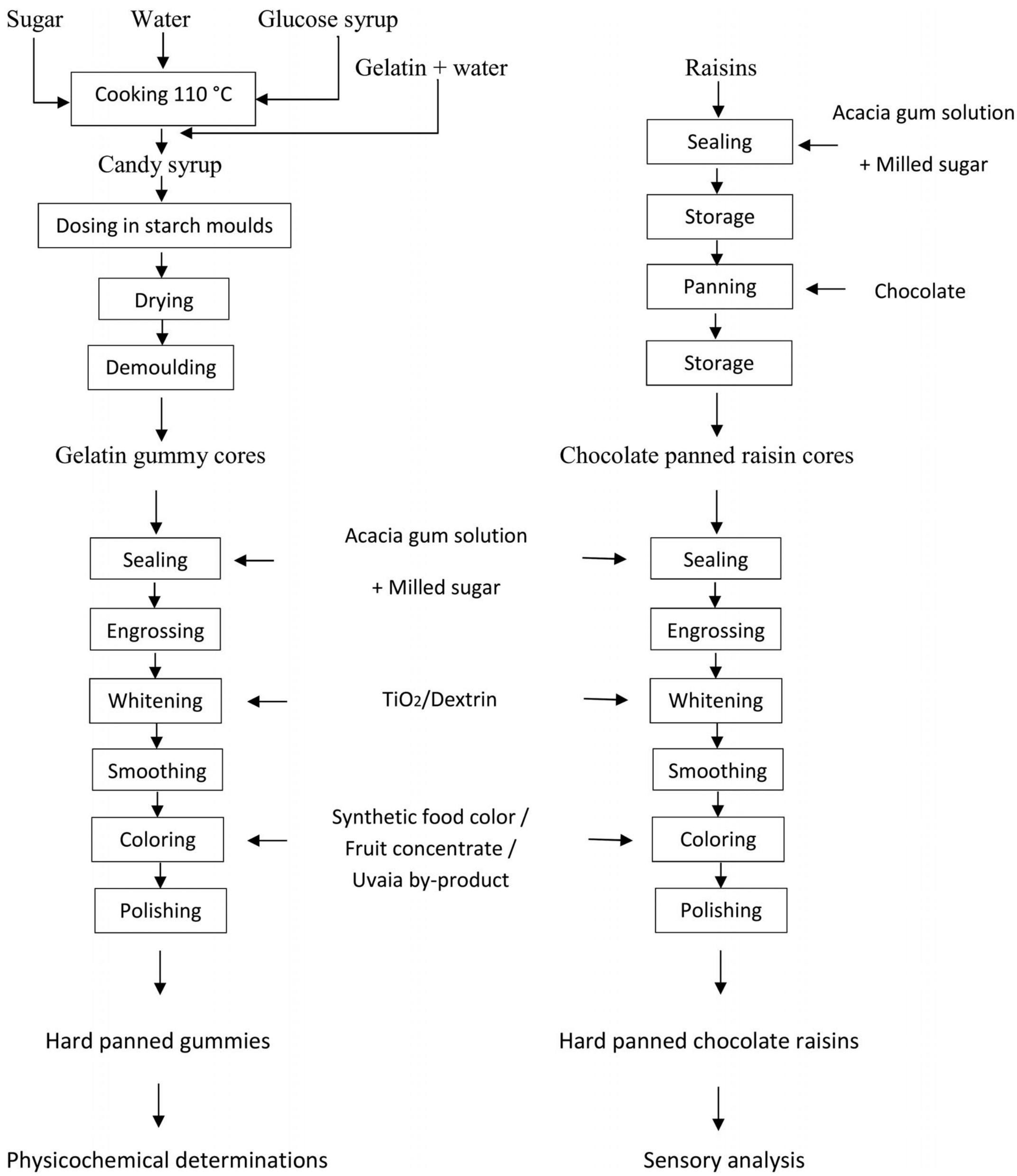

FIGURE 1 Fluxogram of the hard sugar panned confections manufacturing process

UB-G)-were characterized on the basis of the following analysis: water activity, determined using a water activity analyzer (Aqualab, model 4TEV, Decagon Devices, Inc., Pullman) after reaching equilibrium at 25°C in triplicate; moisture content according to AOAC Official Method 920.151 (AOAC, 2012), determined in a vacuum oven in triplicate; instrumental color, measured using a digital colorimeter (Hunter Lab UltraScan PRO, Washington DC) in a CIELAB system (L^*, a^*, and b*) with 10 replicates; and instrumental texture, determined for hardness parameter using a texture analyzer (TA-XT2i model, Surrey, England) according to Fadini et al. (2005) with some modifications (using a P/25 cylindrical aluminum probe; pretest, test, and post-test speeds of 1.0, 2.0, and 10.0 mm/s, respectively; and a penetration distance of 1 mm, with 10 replicates.

2.6 | Evaluation of the glass transition temperature

The color (uvaia byproduct) and whitening (dextrin) agents used in UB production as well as the panned coatings (SC, FC, and UB) were analyzed to determine the glass transition temperature following the method of Faria (2014). The samples were analyzed by differential scanning calorimetry (DSC) using a calorimeter (TA Instruments, model TA-MDSC-2920, New Castle) with cooling controlled by a refrigerated cooling accessory mechanic cooler. Scanning was performed between 30 and 210°C, with a heating rate of 10°C/min. The analyses were performed in triplicate, and the data were analyzed using Universal Analysis 2.6 software (TA Instruments, New Castle).

2.7 | Sorption isotherms

The sorption isotherms were collected in an aw and isotherm generator (Aqualab model VSA 1102, Pullman, WA) using the dynamic dewpoint isotherm method, in which adsorption curves were constructed, followed by desorption curves at 25°C. Finally, three mathematical models were applied to fit the curve: the double log polynomial (DLP) model, the Brunauer, Emmet, and Teller (BET) model, and the Guggenheim, Anderson, de Boer (GAB) model, which were evaluated by using the coefficient of determination (R^2). The model equations are presented below (Equations (1)–(3)):

$$\mathrm{Xeq} = \mathrm{b3\,chi}^3 + \mathrm{b2\,chi}^2 + \mathrm{b1\,chi} + \mathrm{b0} \tag{1}$$

$$\mathrm{Xeq} = \frac{\mathrm{Xm\,C\,aw}}{((1-\mathrm{aw})(1-(\mathrm{Cln}(1-\mathrm{aw}))))} \tag{2}$$

$$\mathrm{Xeq} = \frac{\mathrm{Xm}\,C\,k\,\mathrm{aw}}{(1-k\,\mathrm{aw})(1-k\,\mathrm{aw})+C\,k\,\mathrm{aw}} \tag{3}$$

Xeq = equilibrium moisture content on a dry basis (kg water/kg dry solids); Xm = moisture content in the molecular monolayer on a dry basis (kg water/kg dry solid); aw = water activity; *C*, *k*, b0, b1, b2, and b3 = empirical coefficients; chi = ln (ln aw).

2.8 | Sensory analysis

Due to similarity with popular commercial products, the chocolate-panned raisin cores were chosen for the sensory acceptance evaluation performed at the Food Sensory Analysis Laboratory of the Department of Food Technology—FEA/UNICAMP (approved by the Research Ethics Committee of the University of Campinas, under Certificate of Presentation for Ethical Assessment—CPEA 47862015.5.0000.5404). The 120 voluntary consumers used a hedonic structured scale of 9 points rated based on a range from 9 = I liked it very much, to 1 = I disliked it very much, for the analysis of the following attributes: appearance, color, flavor, and crispness (Stone & Sidel, 2004).

2.9 | Statistical analyses

The statistical package System of Analysis of Variance for Balanced Data—SISVAR (Ferreira, 2000) was used for data analyses (ANOVA variance and Tukey's test).

3 | RESULTS AND DISCUSSION

3.1 | Production of the sugar hard panning confections

The conditions of the panning process are shown in Table 1.

During the coloring tests it was verified that the incorporation of uvaia byproduct in the coloring sucrose syrup resulted in irregular deposition of the particles of the residue on the surface of the confection, making it rough and heterogeneous in coloring. Due to this result, it was decided to use the byproduct in a drying powder after the smoothing step.

The use of 1 g of adhesive solution (34.3:5.7:60.0, acacia gum/sugar/water, wt/wt/wt)/100 g of cores contributed to better adhesion of the powdered uvaia byproduct, to which a mixture of sugar and gum (47.5:47.5:5.0, sugar/uvaia byproduct/acacia gum, wt/wt/wt) was also used to obtain a more uniform surface. It was also observed that the longer the period between each application of adhesion solution and drying powder was, the greater the particle compaction and the better the formation of a homogeneous coating were. The method established for the coloring step of the UB confections included a total of eight applications, which only in the third and fourth layers were injected air at room temperature (23°C) for 5 min aiming to intensify the coating drying.

3.2 | Physical and physicochemical determinations

3.2.1 | Instrumental color and texture measurements

The results of the instrumental color and texture determinations are presented in Table 2.

Significant differences in the chromatic characterization of the samples were observed. UB-G showed the highest a^* and b^* values

TABLE 1 Panning process conditions to produce sugar hard panning confections colored by different color agents

Confection		Engrossing	Whitening	Smoothing	Coloring
SC-C SC-G	Syrup	72 °brix sucrose syrup	72 °brix sucrose syrup +5% TiO_2	69 °brix sucrose syrup	69 °brix sucrose syrup +5% of caramel color IV
	Number of applications	35	20	20	3
	Weight gain (g/100 g)[a]	14.9	6.75	9.05	2.12
FC-C FC-G	Syrup	72 °brix sucrose syrup	72 °brix sucrose syrup +15% of dextrin	69 °brix sucrose syrup	69 °brix sucrose syrup +3% of fruit concentrate
	Number of applications	24	20	20	10
	Weight gain (g/100 g)[a]	10.21	10.66	9.05	6.08
B-C UB-G	Syrup	72 °brix sucrose syrup	72 °brix sucrose syrup +15% of dextrin	69 °brix sucrose syrup	Adhesion solutions + drying powder containing uvaia residue (37 μm)
	Number of applications	20	20	20	
	Weight gain (g/100 g)[a]	8.51	10.66	9.05	5.95

[a]Weight gain in relation to the initial weight of the cores.
Abbreviations: C, chocolate panned raisin core; FC, fruit/plant-based concentrate; G, gelatin gummy core; SC, synthetic food color; UB, uvaia byproduct.

TABLE 2 Mean values of the physical and physicochemical parameters of the different hard sugar panning confections

Confection	Coating aw	Coating moisture (%)	Confection aw	Confection moisture (%)	Colorimetric parameters			Hardness (*N*)
					*L**	*a**	*b**	
SC-G	0.68 ± 0.01 a	0.25 ± 0.01 a	0.69 ± 0.00 b	2.85 ± 0.00 b	67.39 ± 1.38 a	9.03 ± 0.11 c	31.26 ± 1.49 b	21.68 ± 5.81 c
FC-G	0.67 ± 0.04 a	0.26 ± 0.01 a	0.70 ± 0.00 a	2.86 ± 0.14 a	64.89 ± 1.35 b	11.63 ± 0.18 b	43.70 ± 4.61 a	24.91 ± 7.35 b
UB-G	0.67 ± 0.01 a	0.24 ± 0.02 a	0.67 ± 0.12 c	2.83 ± 0.14 c	61.45 ± 1.39 c	16.72 ± 0.25 a	44.25 ± 2.22 a	25.64 ± 8.69 a
MSD	0.03	0.03	0.13	0.20	3.45	0.48	7.71	3.10

Notes: Mean values followed by different letters in the same column are significantly different ($p < .05$) according to Tukey's test.
Abbreviations: FC, fruit/plant-based concentrate; G, gelatin gummy core; SC, synthetic food color; UB, uvaia byproduct; MSD, minimum significant difference as determined by Tukey's test at 5% significance.

and the lowest value for lightness (*L**), indicating a darker and more intense color compared to the other samples. SC-G presented opposite behavior.

Regarding the instrumental texture, UB-G presented the greatest hardness. Such a result may be explained by the fact that the UB coating matrix was generated through the deposition of drying powder (a mixture of the uvaia byproduct, sugar, and acacia gum).

FC-G presented intermediate hardness. In this case, the use of dextrin as a whitening agent may explain the greater hardness compared to SC-G (with titanium dioxide), while the absence of the uvaia byproduct explains the lower value compared to UB-G. Dextrin, as a reducing sugar, can directly influence the crystallization of the coating because it alters the solubility and final morphology of the sucrose crystals (Mantelatto, 2005) and, consequently, the final texture of the product (Jeffery, 1993; Richter & Lannes, 2007). In our study, we found that dextrin interfered in the crystallization of sucrose, increasing the drying period during the whitening step. However, there was no interference with the formation or final texture of the coating considering the hardness values obtained for the confection.

3.2.2 | Moisture content and water activity

The results of the moisture and water activity determinations for the panned confections formulated with gelatin gummy cores are presented in Table 2.

The moisture content and aw of the confections differed statistically ($p < .05$) and ranged from 2.83 to 2.86 g/100 g and 0.67 to 0.70, respectively. The aw values of the samples (SC-G, FC-G, UB-G) were close to the value indicated for the category of hard sugar-panned confections of approximately 0.65 (Troller & Christian, 1978). The average moisture content of the different hard sugar-panned coatings was less than 1.0%, which is the value indicated for this type of product (Hartel, 2001), without a significant difference among the samples.

3.3 | Glass transition temperature

The average values obtained for the glass transition temperature (Tg) of dextrin, the uvaia byproduct and the coatings of the three products studied are presented in Table 3.

The uvaia byproduct exhibited a Tg that was lower (123.29°C) than that obtained by Faria (2014) for passion fruit peel flour (165.72°C). The Tg value of dextrin (102.743°C) was, as expected, below the Tg of starch and maltodextrins with 5–25 DE, which show values between 121 and 243°C (Levine & Slade, 1992).

The Tg of the coating of the samples differed significantly ($p < .05$). The UB-G coating presented a higher Tg than FC-G and SC-G due to the simultaneous incorporation of dextrin and the uvaia byproduct.

We found that the added ingredients significantly interfered with the Tg of the products. The Tg value for the SC-G coating was lower than the average range for sucrose (the panned confectionery coating main constituent), which is 52–56°C according to Roos and Karel (1991). It is likely that the other ingredients used to form the coating significantly increased Tg.

TABLE 3 Average values of the glass transition temperature (Tg) of the coatings of the panned confections, uvaia byproduct, and dextrin

Confection	Tg (°C)
SC-G coating	63.46 ± 4.96 a
FC-G coating	69.28 ± 2.93 b
UB-G coating	75.04 ± 9.74 c
MSD	16.33
Uvaia byproduct	123.29 ± 25.37
Dextrin	102.74 ± 6.45

Notes: Mean values followed by different letters in the same column are significantly different ($p < .05$) according to Tukey's test.
Abbreviations: FC, fruit/plant-based concentrate; G, gelatin gummy core; SC, synthetic food color; UB, uvaia byproduct; MSD, minimum significant difference as determined by Tukey's test at 5% significance.

3.4 | Sorption isotherm

The isotherm curves of the panned confections are shown in Figure 2.

The three isotherm curves showed low hysteresis. The aw for the SC-G coating ranged from 0.100 to 0.758 in the curves. According to the coefficient of determination (R^2; Table 4), the model that best adjusted the isotherm curve of SC-G was DLP, and the critical water activity in that experiment was 0.465.

The curves of the FC-G coating presented aw values that varied between 0.100 and 0.826 and a critical aw value of 0.442. The best fit of the isotherm curve for this experiment was obtained with the GAB model. For UB-G, the curves exhibited aw values varying between 0.100 and 0.794, while the critical aw value was 0.388. The model that best adjusted the isotherm curve was the DLP model. Table 4 shows the sorption isotherm parameters of the coatings for the models tested.

The curves of the three samples showed a proportional increase in aw related to equilibrium moisture. FC-G and UB-G presented behavior typical of type III isotherms, whereas SC-G exhibited a type II isotherm (IUPAC, 1985). Type II isotherm curves are characteristic of nonporous solids and solids with reasonably large pores, and type III isotherms refer to systems in which the adsorbate molecules exhibit greater interaction with each other than with the solid (Webb & Orr, 1997). The different type of isotherm for SC-G and UB-G may be explained by the presence of dextrin and uvaia byproduct, respectively, which impact the structure of the coating matrix.

According to the obtained results, a decrease in the critical aw was verified with the modifications of the composition of the coatings. Depending on the environmental temperature, the Tg transition occurs at critical values of aw and moisture content, which can be considered determinants of the stability of the product (Mosquera, Moraga, & Martínez-Navarrete, 2012).

Other studies have also identified the direct impact of the panning coating composition on the sorption isotherm and stability of the final

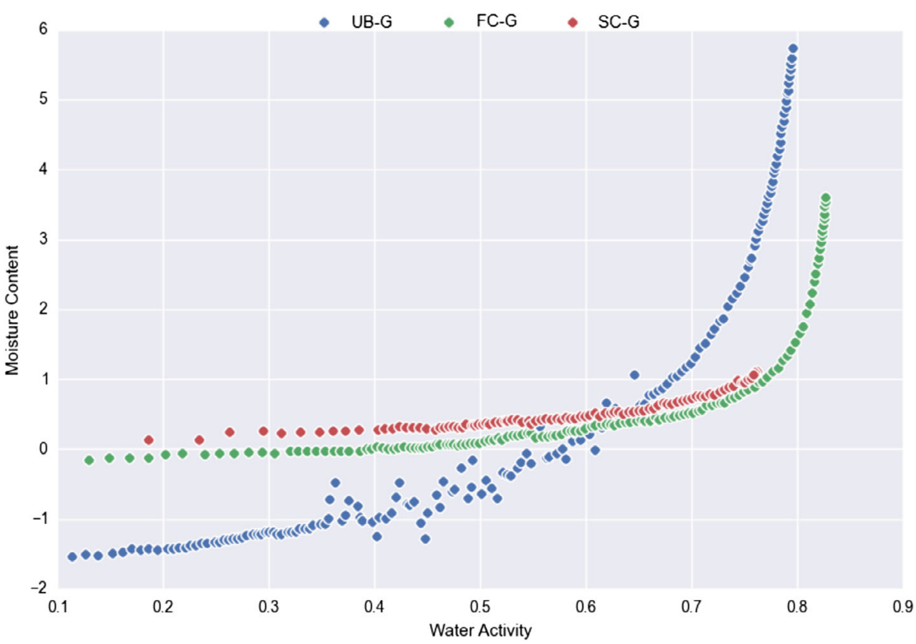

FIGURE 2 Sorption curves of the different coatings of the sugar hard panning confections. *Notes*: moisture content (g/100 g); Abbreviations: G, gelatin gummy core; SC, synthetic food color; FC, fruit/plant-based concentrate; UB, uvaia by-product

TABLE 4 Parameters of the sorption isotherm of the three confectionery coatings to the tested models and the determination coefficient (R^2) at 20°C

	DLP					GAB				BET		
Confection	b0	b1	b2	b3	R^2	C	k	Xm	R^2	C	Xm	R^2
SC-G	0.275	−0.197	−0.075	−0.300	0.992	60.681	1.124	0.154	0.991	10.098	0.191	0.838
FC-G	0.084	0.036	−0.649	−1.019	0.950	0.035	1.129	0.0660	0.987	−0.0001	203.105	0.927
UB-G	−0.987	−0.457	0.182	−1.549	0.988	0.022	1.144	2.849	0.958	−0.000	22,598.400	0.918

Abbreviations: BET, Brunauer, Emmet, and Teller; DLP, double log polynomial; FC, fruit/plant-based concentrate; G, gelatin gummy core; GAB, Guggenheim, Anderson, de Boer; SC, synthetic food color; UB, uvaia byproduct.

TABLE 5 Attribute means obtained in the sensorial acceptance test for the sugar hard panning confections with chocolate panned raisin core

Confection	Appearance	Color	Flavor	Crispness
SC-C	4.31 ± 1.98 b	4.01 ± 1.89 b	7.53 ± 1.02 a	7.16 ± 1.43 a
FC-C	5.11 ± 2.04 a	5.00 ± 1.94 a	7.03 ± 1.60 b	6.77 ± 1.71 b
UB-C	5.13 ± 1.93 a	5.11 ± 1.90 a	7.05 ± 1.49 b	6.61 ± 1.47 b
MSD	1.03	1.12	0.89	0.33

Notes: Mean values followed by different letters in the same column are significantly different ($p < .05$) according to Tukey's test.
Abbreviations: C, chocolate panned raisin core; FC, fruit/plant-based concentrate; SC, synthetic food color; UB, uvaia byproduct; MSD, minimum significant difference as determined by Tukey's test at 5% significance.

products. Fadini, Silva, Jardim, Vissoto, and Queiroz (2006), for example, found that the presence of salt and different sucrose and maltodextrin ratios in the drying powder used for sweet and salty panned macadamia induces differences in the sorption isotherms and the behavior of physical and sensorial modifications (melting and loss of crunchiness) in environments with a range of water activities, implying different storage needs for each panned product.

The ingredients participate by generating and altering the stability characteristics of the product. Mosquera et al. (2012) verified that maltodextrin and acacia gum added to strawberry pulp before lyophilization increased the stability of the strawberry powder, with a reduction in hygroscopicity and an increase in Tg. However, in the strawberry powder, no significant differences were observed between the sorption isotherms at 20°C. For the confection coatings produced in our study, we observed that the use of dextrin and the uvaia byproduct tended to decrease the critical aw of the coatings. However, there was an increase in Tg, contributing to the stability of the products.

3.5 | Sensory analysis

The results of the sensory acceptance test are presented in Table 5. UB-C and FC-C did not differ statistically ($p < .05$) and presented the highest average acceptance regarding their appearance and color attributes compared to SC-C. However, SC-C was better accepted by consumers regarding flavor and crispness, suggesting that the other coloring agents may lead to perceptible sensory differences in the products.

By comparing the sensory and instrumental data for color parameters, it was possible to identify a sensorial preference for darker and more intense colors, which were better achieved by the addition of the uvaia byproduct.

We may infer the consumer's preference for confections with lower hardness, by comparing the instrumental texture and sensory data. It was observed that coloring with the byproduct tended to increase the product's hardness, reducing its crispness acceptance, which may be corrected by decreasing the coating thickness.

4 | CONCLUSION

The results of our study indicated that the coating ingredients imply significant differences ($p < .05$) on the physical and physicochemical parameters. The use of dextrin and the combined use of uvaia byproduct and dextrin increased the hardness by 14.89 and 18.26%, respectively. The uvaia byproduct showed to be a suitable and promising alternative for use as a natural coloring agent in panned confections. Further studies on the effect of the use of fruit processing byproducts on the crystallization of hard-panned confectionery coatings are still necessary to better elucidate their influence on the structure and behavior of panned confections during their shelf life.

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