Sensory Profile and Consumer Acceptability of Prebiotic White Chocolate with Sucrose Substitutes and the Addition of Goji Berry (*Lycium barbarum*)

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Abstract: Functional food is a product containing nutrients that provide health benefits beyond basic nutrition. The objective of the present study was to evaluate the descriptive sensory profile and consumers' acceptance of functional (prebiotic) white chocolates with and without the addition of an antioxidant source (goji berry [GB]) and sucrose replacement. The descriptive sensory profile was determined by quantitative descriptive analysis (QDA) with trained assessors ($n = 12$), and the acceptance test was performed with 120 consumers. The correlation of descriptive and hedonic data was determined by partial least squares (PLS). The results of QDA indicated that GB reduces the perception of most aroma and flavor attributes, and enhances the bitter taste, bitter aftertaste, astringency, and most of the texture attributes. The consumers' acceptance of the chocolates was positive for all sensory characteristics, with acceptance scores above 6 on a 9-point scale. According to the PLS regression analysis, the descriptors cream color and cocoa butter flavor contributed positively to the acceptance of functional white chocolates. Therefore, prebiotic white chocolate with or without the addition of GB is innovative and can attract consumers, due to its functional properties, being a promising alternative for the food industry.

Keywords: chocolate, goji berry, prebiotics, sensory analysis

Practical Application: Development of white chocolate with functional properties (prebiotic and with the addition of an antioxidant source—goji berry) was well accepted by the consumers to meet the emerging demands for healthier food. The results of this research can contribute to food industry in developing healthier chocolates.

Introduction

Functional food is a product that has been enriched with added nutrients or other substances that provide health benefits beyond basic nutrition (Corradini and others 2013). Prebiotics stand out among the functional ingredients, for being nondigestible food ingredients that promote the growth or activity of selected species of bacteria in the colon of host, thus conferring health benefits (Gibson and others 2004). One of the most important prebiotics used in food formulations is the fructooligosaccharides (FOS). Despite its moderate sweetness—one-third of sucrose sweetness—, it can be used as a sugar replacer, and has advantageous technological properties such as increased viscosity, leading to improved body and mouthfeel properties (Corradini and others 2013; Dominguez and others 2014).

Goji berry (GB) (*Lycium barbarum)* is a fruit rich in antioxidant compounds (Lam and others 2016). It is a *Solanaceous* deciduous shrubbery native from Asia, 1 to 2 cm long, with bright orange-red ellipsoid berries (Donno and others 2015). Its health benefits include effects on aging, neuroprotection, general well-being, endurance, metabolism/energy expenditure, glucose control in diabetics, immunomodulation, antitumor activity, and cytoprotection (Donno and others 2015).

Sucrose is widely used in industries of traditional chocolate, and white chocolate contains up to 50% sucrose (Beckett 2009; Aidoo and others 2013). Several studies have shown that a diet high in sucrose is associated with several diseases (de Morais and others 2015); thus, the replacement of sucrose by high-intensity sweeteners may be helpful in the management of obesity and diabetes, besides attracting consumers who search for low-calorie foods (Gardner 2014).

Nevertheless, changes in white chocolate formulations, including the addition of FOS and dried GB and the replacement of sucrose by high-intensity sweeteners, can result in sensory alterations. Thus, sensory tests, as descriptive analysis and acceptance tests, are required to guarantee the quality and acceptability of the processed product. Quantitative descriptive analysis (QDA) is one of the most complete and informative tools for the sensory characterization of products' attributes (Lawless and Heymann 2010). The success of a food in the consumer market implies that it has sensory characteristics well accepted by the consumers, safety characteristics for consumption, and nutritional quality (Cruz and others 2010).

The objective of the present study was to evaluate the sensory properties (descriptive and consumer acceptability) of white chocolates with functional properties (prebiotic and with the addition of an antioxidant source—GB) and sucrose replacement.

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Table 1–Formulations of prebiotic white chocolates.

	Chocolate samples			
% Ingredients	Control	Sucrose (Sucro)	Sucralose (Sucra)	Rebaudioside A (Reb)
Sucrose	40.50	27.40	–	–
Cocoa butter	29.00	30.00	28.00	28.00
Milk powder	29.90	30.00	22.90	22.90
Vanilla flavor	0.10	0.10	0.10	0.10
Refined soy lecithin	0.30	0.30	0.30	0.30
PGPR	0.20	0.20	0.20	0.20
FOS	–	12.00	12.00	12.00
Maltitol	–	–	36.45	36.40
Sucralose	–	–	0.05	–
Rebaudioside A	–	–	–	0.10

Material and Methods

The following ingredients: deodorized cocoa butter (Barry Callebaut®, Extrema, Brazil), milk powder (Piracanjuba, Governador Valadares, Brazil), icing sugar (Mais Doce, Limeira, Brazil), artificial vanilla flavor powder (Synergy, Vinhedo, Brazil), refined soy lecithin (Solae, Barueri, Brazil), polyglycerol polyricinoleate (PGPR) Grinsted® Super (Danisco, São Paulo, Brazil), maltitol (Sweet Pearl® P90 Roquette, Lestrem, France), FOS (Orafti® P95 Beneo, Mannheim, Germany), stevia with 97% rebaudioside A (Steviafarma, Maringá, Brazil), sucralose (Sweetmix, Sorocaba, Brazil), and dried GB (Grings, São João da Boa Vista, Brazil) were used for the production of white chocolate samples.

Sample preparation

Seven different white chocolate formulations were made, as follows: control (sweetened with sucrose); 3 prebiotic white chocolates (with 12% FOS, w/w) sweetened with sucrose, sucralose, and stevia with 97% rebaudioside A; and these 3 prebiotic samples containing dried GB (9% w/w). The chocolate formulations (Table 1) were based on a previous study on the equivalent sweetness of the prebiotic white chocolates when compared to the traditional (control), and the amount of dried GB used (Morais and others 2016). All chocolate samples contained at least 29% of fat content (cocoa butter plus milk fat) as recommended by Beckett (2009).

The formulations with addition of GB were similar to those in Table 1 containing high-intensity sweeteners sucralose and stevia with 97% rebaudioside A. The amounts of sucrose, cocoa butter, and milk powder in the chocolate sweetened with sucrose and addition of GB were 45.6%, 24%, and 18% (w/w), respectively.

The chocolate samples were produced by a conventional method in the Cereal and Chocolate Research Center (ITAL, Campinas, Brazil). Part of cocoa butter (30% of total) was mixed with the dried ingredients in a conch (Inco, Avaré, SP, Brazil) at 40 °C for 30 min, and the mass was refined in a 3-roll refiner (Draiswerk GMBH, Manheim Waldo, Mahwah, N.J., U.S.A.) to obtain particle size of 20 to 25 μm. Then, the mass plus the remaining cocoa butter was conched at 55 °C for 16 h, and the emulsifiers were added 1 h before the end of conching phase. The chocolates were hand tempered, molded in polycarbonate molds, and cooled in a cooling tunnel (Siaht, Jundiaí, SP, Brazil). The chocolates were wrapped in an aluminum foil and stored at 20 °C until analysis. For the formulations containing dried GB, the fruits were added to the mass before tempering. All chocolates were produced in batch (3 kg).

Sensory evaluation

Sensory tests were performed in individually air-conditioned booths (22 °C) equipped with computers in the Sensory Analysis Laboratory of the School of Food Engineering, using the FIZZ Network Sensory Software (Biosystems, Couternon, France). Four gram of chocolate samples was presented in disposable napkin coded with a 3-digit number. Water at room temperature and cracker biscuits were provided for palate cleansing.

The sensory profiling of all 6 prebiotic white chocolates and the control was determined by QDA, according to Stone and Sidel (2004). A consumer test was performed to assess the acceptability of the samples.

Preselection of assessors. Eighteen volunteers recruited among Unicamp graduates and staff were subjected to triangle tests applied to Wald's sequential analysis (Meilgaard and others 2007) for a preselection to build up the team of assessors. Two white chocolate samples containing different sweetness, at 5% significance level, were used and previously tested by paired comparison test with 30 judges. The preselection aimed at evaluating the discriminatory ability of each individual. Fourteen individuals were selected as potential assessors.

Quantitative descriptive analysis. The network method (Moskowitz 1983) was used at the stage of development of descriptive terminology. All samples were presented by pairs, and the judges described the similarities and differences for each pair with respect to the attributes appearance, aroma, flavor, and texture. After discussion, the redundant terms were excluded by consensus of all judges, and a total of 18 descriptive terms were defined with their respective references (Table 2).

Training for the formation of sensory memory was carried out by direct contact of the assessors with the maximum and minimum references for each attribute. Six 1-h training sessions were performed for the QDA trials.

Each assessor ($n = 14$) evaluated the 6 prebiotic white chocolate samples and the control in 3 repetitions. Assessors were chosen to participate according to the discriminatory power ($P \leq 0.5$) and repeatability ($P > 0.05$), using data from the training sessions, and the individual consensus was also considered (Damásio and Costell 1991). Twelve assessors (1 male and 11 females, aged from 21 to 32) were selected to evaluate the sensory profile of the prebiotic white chocolates with or without the addition of dried GB, based on the selection criteria.

All selected assessors ($n = 12$) evaluated the 6 white prebiotic chocolates plus the control sample in 3 repetitions, according to the references previously determined for all attributes. Assessors received the sample and were asked to rate the intensity of each attribute, using a continuous 9-cm unstructured line scale anchored on the left by "weak" or "none" and on the right by "strong" or "much." The samples were presented in a monadic way with 3 repetitions (each repetition was performed in one session) using a randomized complete block design to avoid artifacts due to order of sample presentation according to Lawless and Heymann (2010).

Acceptance test. The acceptance test was conducted with 120 consumers (67% females and 33% males) aged from 18 to 42 y. All consumers were provided with a written informed consent. A 9-cm linear hedonic scale (unstructured) was used, anchored with "dislike extremely" on the left and "like extremely" on the right. The attributes appearance, aroma, texture, flavor, and overall liking were evaluated. Each consumer conducted the

Table 2–Descriptors used for sensory profiling of white prebiotic chocolates.

	Descriptor	Definition	References
Appearance	Cream color (CCO)	Cream color characteristic of white chocolate	Weak: Mococa® (Mococa, Mococa, SP, Brazil), condensed milk diluted in water (4:1, v:v) Strong: mixture of Mococa condensed milk and Danette® (Danone, Poços de Caldas, MG, Brazil), white chocolate dairy dessert (5:3, w:w)
	Brightness (BRI)	Ability of the white chocolate to reflect light	Weak: Barry Callebaut® cocoa butter Strong: Danette white chocolate dairy dessert
Aroma	Milk powder aroma (MPA)	Characteristic aroma of commercial Ninho® (Nestlé, Araraquara, SP, Brazil), milk powder (Nestle)	Weak: Ninho milk powder diluted in water (1:20, w/v) Strong: Ninho milk powder diluted in water (1:5, w/v)
	Cocoa butter aroma (CBA)	Characteristic aroma of cocoa butter	Weak: Neugebauer® (Neugebauer, Porto Alegre, RS, Brazil), white chocolate bar Strong: Barry Callebaut cocoa butter
	Sweet aroma (SAR)	Characteristic aroma of aromatic compounds in chocolate perceived when smelling	Weak: mixture of 6.5 g Ninho milk powder diluted in 50 mL water and 30g Mococa condensed milk Strong: Galak® (Nestlé, Caçapava, SP, Brazil), chocolate bar
	Goji berry aroma (GBA)	Characteristic aroma of dried goji berry	None: water Much: dried goji berry
Flavor	Cocoa butter flavor (CBF)	Characteristic flavor of cocoa butter	Weak: Galak chocolate bar Strong: Barry Callebaut cocoa butter
	Milk powder flavor (MPF)	Characteristic flavor of commercial Ninho milk powder (Nestle)	Weak: Ninho milk powder diluted in water (1:8, w/v) Strong: Ninho milk powder diluted in water (1:1, w/v)
	Sweet taste (STA)	Characteristic taste of sucrose or sweeteners solution	Weak: Ninho milk powder diluted in water (1:8, w/v) Strong: Ki-Doçura® (Ki-Doçura, Ribeirão Preto, SP, Brazil), coconut candy
	Sweet aftertaste (SAT)	Remaining sweet taste in the mouth after eating white chocolate	Weak: Ninho milk powder diluted in water (1:8, w/v) Strong: Ninho milk powder diluted in water (1:8, w/v) with addition of 0.1% aspartame
	Bitter taste (BTA)	Characteristic taste of dried goji berry or other bitter compounds	None: water Much: dried goji berry
	Bitter aftertaste (BAT)	Remaining bitter taste in the mouth after eating white chocolate with or without addition of goji berry	None: water Much: Ninho milk powder diluted in water (1:8, w/v) with addition of 0.1% caffeine
	Goji berry flavor (GBF)	Characteristic flavor of dried goji berry	None: Galak chocolate bar Much: dried goji berry
	Astringency (AST)	The sensation of mouth constriction after eating dried goji berry	None: water Much: dried goji berry
Texture	Hardness (HAR)	Force required to compress the sample between molar teeth	Weak: Kinder® (Ferrero, Poços de Caldas, MG, Brazil), chocolate bar Strong: Galak chocolate bar stored at 10 °C for at least 1 h
	Melting (MEL)	Chocolate property of melting in mouth while chewing	Weak: Amaro® (Lacta, Curitiba, PR, Brazil), chocolate 43% cocoa Strong: Kinder chocolate bar
	Grittiness (GRI)	Presence of perceptible particles in the oral cavity	Weak: Kinder chocolate bar Strong: Dulce de leche bar
	Adherence (ADH)	Chocolate property of adhering to teeth while chewing	Weak: Suflair® (Nestlé, Caçapava, SP, Brazil), chocolate bar Strong: dried goji berry

assessment of the 7 chocolate samples in a single session. All samples were monadically presented using balanced complete blocks (Wakeling and MacFie 1995). No information about the samples was given to the consumers to prevent bias.

Statistical analysis

QDA results were analyzed by ANOVA using 2 factors (assessor and sample) and their interaction followed by Tukey's test averages ($P \leq 0.05$). The acceptability results were analyzed by ANOVA

Table 3–Mean scores for each prebiotic white chocolate sample in QDA.

	Samples							
Attributes	**Control**	**Sucro**	**Sucro GB**	**Sucra**	**Sucra GB**	**Reb**	**Reb GB**	**MSD**
Cream color	4.98^{ab}	5.18^{a}	4.35^{bc}	3.86^{c}	4.32^{bc}	3.90^{c}	3.98^{c}	0.82
Brightness	4.57^{a}	4.77^{a}	4.78^{a}	4.46^{a}	4.47^{a}	4.45^{a}	4.35^{a}	0.57
Milk powder aroma	5.90^{a}	5.17^{bc}	4.70^{cd}	5.80^{ab}	4.21^{d}	5.90^{a}	4.60^{cd}	0.68
Cocoa butter aroma	4.53^{a}	4.34^{a}	4.25^{a}	4.56^{a}	4.26^{a}	4.57^{a}	4.04^{a}	0.73
Sweet aroma	4.77^{bc}	4.35^{bcd}	4.42^{bcd}	5.00^{ab}	3.80^{d}	5.50^{a}	4.34^{cd}	0.66
Goji berry aroma	0.00^{b}	0.00^{b}	5.07^{a}	0.00^{b}	5.28^{a}	0.00^{b}	5.13^{a}	0.56
Cocoa butter flavor	4.58^{a}	4.52^{a}	3.43^{c}	4.16^{ab}	3.90^{abc}	4.36^{ab}	3.76^{bc}	0.69
Milk powder flavor	6.21^{a}	5.82^{a}	5.02^{bc}	5.61^{ab}	4.90^{bc}	5.64^{ab}	4.82^{c}	0.76
Sweet taste	5.81^{a}	5.51^{ab}	4.96^{bc}	6.08^{a}	4.49^{c}	5.96^{a}	4.61^{c}	0.77
Sweet aftertaste	2.51^{b}	1.66^{cd}	1.34^{d}	2.23^{bc}	1.36^{d}	3.69^{a}	1.33^{d}	0.75
Bitter taste	0.41^{b}	0.33^{b}	3.72^{a}	0.24^{b}	3.79^{a}	0.39^{b}	4.16^{a}	0.52
Bitter aftertaste	0.23^{b}	0.35^{b}	2.00^{a}	0.70^{b}	2.07^{a}	0.53^{b}	2.28^{a}	0.55
Goji berry flavor	0.00^{c}	0.00^{c}	6.57^{a}	0.00^{c}	6.09^{b}	0.00^{c}	6.51^{ab}	0.43
Astringency	0.59^{b}	0.51^{b}	4.19^{a}	0.75^{b}	3.79^{a}	0.79^{b}	4.10^{a}	0.44
Hardness	3.41^{b}	3.86^{ab}	4.35^{a}	3.99^{ab}	4.42^{a}	3.82^{ab}	4.24^{a}	0.79
Melting	5.26^{a}	5.00^{ab}	4.20^{b}	5.29^{a}	4.33^{b}	5.17^{a}	4.29^{b}	0.82
Grittiness	1.52^{c}	2.07^{bc}	2.84^{b}	2.27^{bc}	4.28^{a}	2.60^{b}	4.09^{a}	0.77
Adherence	2.28^{b}	2.22^{b}	6.26^{a}	2.38^{b}	5.86^{a}	2.18^{b}	5.84^{a}	0.63

Samples: Sucro, Sucrose; Sucra, Sucralose; Reb, Rebaudioside; GB, Goji berry.
Means with different lowercase letter in a line are significantly different at a 5% level.
MDS, minimum significant difference by Tukey's test ($P \leq 0.05$).

using 2 factors (consumer and sample) followed by Tukey's test averages ($P \leq 0.05$). These analyses were carried out using the Statistical Analysis System (SAS) 9.4 software (SAS Institute Inc., Cary, NC, USA., 2013).

Data from QDA (descriptive information) were correlated with consumer's acceptance data using partial least-square (PLS) regression (Morais and others 2014), considering the overall impression as dependent variable (Y-matrix), and the descriptive information from QDA as the independent variable (X-matrix). External preference mapping was used to analyze the descriptive and affective data (Cadena and others 2012). These statistical analyses were carried out using XLSTAT 2012.5 (Adinsoft, Paris, France), software, at a 5% significance level.

Results and Discussion

Quantitative descriptive analysis

The mean scores for the sensory attributes of prebiotic white chocolates with or without the addition of dried GB and the control are shown in Table 3.

Significant differences were observed for the appearance of the samples ($P \leq 0.05$) concerning the attribute cream color. The lowest score was found for both the prebiotic chocolates with sucrose replacers (Sucra and Reb) and the sample sweetened with 97% rebaudioside A containing GB (Reb GB), which were different ($P \leq 0.05$) from the control. However, these samples were similar to the other samples containing GB (Sucro GB and Sucra GB). A recent study on prebiotic and diet/light chocolate dairy dessert observed no difference in brown color of the sample with sucralose when compared to the control (sucrose), with higher color intensity in the samples containing stevia, neotame, and aspartame (de Morais and others 2015).

Although the samples with sucrose replacers (Sucra and Reb) exhibited higher ($P \leq 0.05$) sweet aroma than their equivalent samples containing GB, the sample Sucra was not different from the control for this attribute. The samples with addition of GB (Sucra GB, Reb GB, and Sucro GB) showed lower scores for milk powder aroma when compared to the control or to their counterparts without addition of GB, except for the samples sweetened with sucrose (Sucro and Sucro GB), which were similar to each other for this attribute. The dried GB extract has a characteristic pungent and plant aroma (Lee and others 2008), which may have masked the other aromas of white chocolate samples, affecting assessors' perception. In addition, high-intensity sweeteners can alter the perception of some aromas in different foods when compared to sucrose (Cardoso and Bolini 2008); thus, explaining the similarity between the samples Sucro and Sucro GB for milk powder aroma. Another study described that the addition of dried red raspberry leaf extract to milk, semisweet, and dark chocolates has also affected the sensory perception of aroma attributes, besides reducing the milk taste and sweetness scores in the enriched chocolates when compared to the control (Belščak-Cvitanović and others 2012).

Samples with the addition of GB (Sucro GB, Sucra GB, and Reb GB) presented lower scores ($P \leq 0.05$) for the descriptors milk powder flavor, sweet taste, and sweet aftertaste when compared to the control. However, the sample with sucralose (Sucra) was similar to its equivalent with GB (Sucra GB) for milk powder flavor, while the sample with sucrose (Sucro) did not differ from Sucro GB for the descriptors sweet taste and sweet aftertaste. Higher sweet aftertaste scores were observed only for the sample with rebaudioside A (Reb), which differed significantly ($P \leq 0.05$) from the other samples, including the sample sweetened with sucralose. The descriptor sweet aftertaste was also observed for espresso coffee (Azevedo and others 2015) and chocolate dairy dessert (de Morais and others 2015) sweetened with stevia with 95% rebaudioside A. It is worth noting that the sweet aftertaste of the sample sweetened with sucralose (Sucra) was similar to the control, confirming that sucralose is a viable alternative to the high-intensity sweeteners to substitute sucrose in different foods, such as soy-based chocolate (Palazzo and Bolini 2014), milk chocolate (De Melo and others 2007), and prebiotic chocolate dairy dessert (Morais and others 2016), once it exhibits a similar sensory profile to sucrose.

Table 4–Mean acceptance scores for the prebiotic white chocolate with and without addition of dried goji berry.

	Samples							
Attributes	Control	Sucro	Sucro GB	Sucra	Sucra GB	Reb	Reb GB	MSD
Appearance	7.58^{ab}	7.63^{a}	7.23^{bc}	7.67^{a}	6.99^{c}	7.50^{ab}	7.23^{bc}	0.38
Aroma	6.97^{a}	7.04^{a}	7.15^{a}	7.03^{a}	7.14^{a}	7.09^{a}	7.11^{a}	0.37
Flavor	7.15^{a}	6.82^{ab}	6.64^{ab}	6.58^{b}	6.79^{ab}	6.52^{b}	6.66^{ab}	0.56
Texture	7.34^{a}	7.31^{a}	6.40^{b}	7.16^{a}	6.21^{b}	7.03^{a}	6.35^{b}	0.51
Overall liking	7.30^{a}	7.13^{ab}	6.73^{b}	6.94^{ab}	6.78^{b}	6.96^{ab}	6.72^{b}	0.47

Samples: Sucro, Sucrose; Sucra, Sucralose; Reb, Rebaudioside; GB, Goji berry.
Means with different lowercase letter in a line are significantly different at a 5% level.
MDS, minimum significant difference by Tukey's test ($P \leq 0.05$).

The addition of GB in the prebiotic chocolates resulted in higher ($P \leq 0.05$) bitter taste, bitter aftertaste, and astringency, regardless of the sweetener used (sucrose, sucralose, or 97% rebaudioside A), when compared to the control or their counterparts without the addition of dried fruit. The higher perception of these attributes is due to the characteristic bitter taste of GB used in the formulations (Potterat 2010). The natural bitterness of GB probably led to a lower perception of sweet taste and sweet aftertaste in the chocolates containing this fruit, which may also have masked the sweet aftertaste in the sample containing rebaudioside. Azevedo and others (2015) reported that the bitterness of roasted ground coffee beverages also interfered and masked the perception of sweetness in espresso coffee sweetened with 95% rebaudioside A.

As expected, the flavor and aroma of GB were only perceived in chocolates containing this dried fruit (Sucro GB, Sucra GB, and Reb GB). The scores for both attributes were higher than 5 on a 9-point scale, which demonstrates that the characteristic aroma and flavor of this fruit were not masked in the white chocolate.

The texture of chocolates was affected by the addition of dried GB. The samples with GB exhibited higher scores ($P \leq 0.05$) for adherence (Sucro GB, Sucra GB, and Reb GB) and grittiness (Sucra GB and Reb GB), and lower scores ($P \leq 0.05$) for melting (Sucro GB, Sucra GB, and Reb GB), when compared to the control and their counterparts without GB, except the samples Sucro and Sucro GB, which were similar to each other for the attribute melting. The water loss during fruit drying changes its texture, enhancing its adherence and grittiness (Sagar and Suresh Kumar 2010).

Acceptance test

The consumers ($n = 120$) evaluated the prebiotic white chocolates with or without the addition of GB for appearance, aroma, flavor, texture, and overall liking and the results of the acceptance test are shown in Table 4.

The prebiotic white chocolate samples showed similar consumers' acceptance ($P > 0.05$) for all attributes regardless of the sweeteners used (sucrose, sucralose, or rebaudioside), except for the samples with sucrose replacers (Sucra and Reb), which showed lower acceptance ($P \leq 0.05$) for the attribute flavor, when compared to the control. However, these samples were similar ($P > 0.05$) to the prebiotic chocolate with sucrose (Sucro). Markey and others (2015) studied the consumers' acceptance of milk chocolate sweetened with maltitol as a sucrose replacer, and observed no differences in the flavor acceptance when compared to a

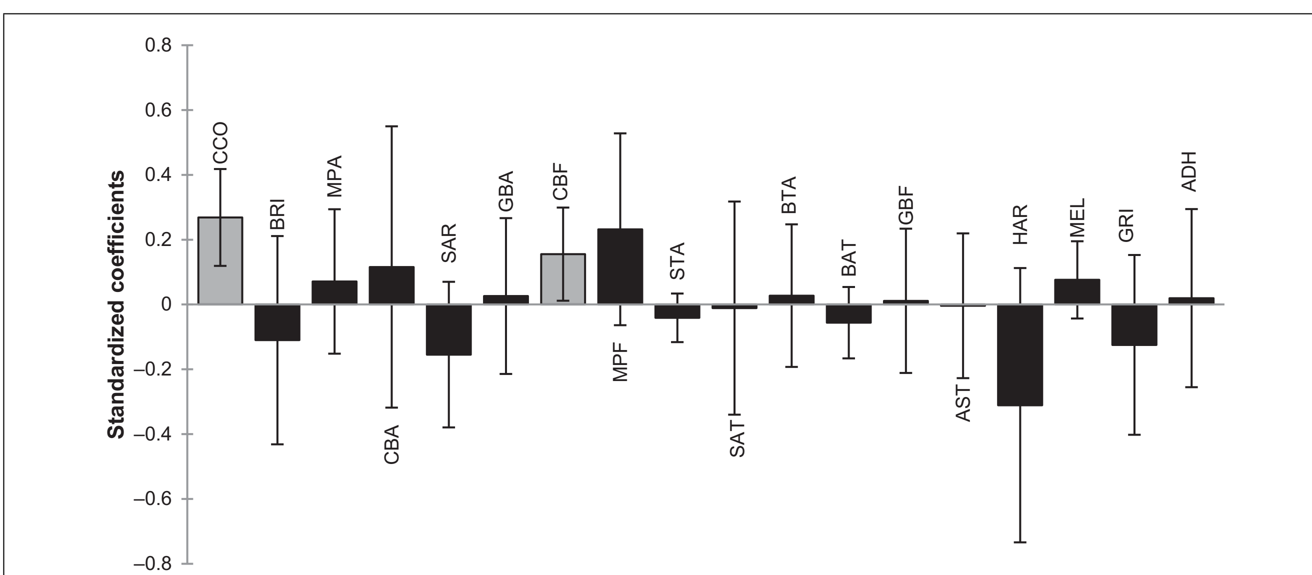

Figure 1–Partial least squares standardized coefficients of functional white chocolates (gray, descriptor terms that contribute positively to consumers' acceptance; black, descriptive terms that did not significantly contribute to consumers' acceptance). CCO, cream color; BRI, brightness; MPA, milk powder aroma; CBA, cocoa butter aroma; SAR, sweet aroma; GBA, goji berry aroma; CBF, cocoa butter flavor; MPF, milk powder flavor; STA, sweet taste; SAT, sweet aftertaste; BTA, bitter taste; BAT, bitter aftertaste; GBF, goji berry flavor; AST, astringency; HAR, hardness; MEL, melting; GRI, grittiness; ADH, adherence.

Sensory & Food Quality

traditional formulation (sucrose), with a lower acceptance for the attribute texture, differing from the findings of the present study.

For the samples with addition of GB (Sucro GB, Sucra GB, and Reb GB), the appearance, aroma, and flavor scores were similar ($P > 0.05$) to the control, except for the sample Sucra GB, which showed lower appearance scores ($P \leq 0.05$). Nevertheless, the addition of GB in all prebiotic white chocolate samples (Sucro GB, Sucra GB, and Reb GB) negatively affected the texture acceptance ($P \leq 0.05$) when compared to the control and the counterparts without addition of dried fruit. Lower ($P \leq 0.05$) scores were also observed for the overall liking of the samples with GB as compared to the control, but similar to their counterparts without addition of dried fruit (Sucro, Sucra, and Reb).

Although lower consumers' acceptance was observed for the attributes texture and overall liking of the samples with addition of GB (Sucro GB, Sucra GB, and Reb GB), the scores were above 6. In addition, according to Pintado and others (2016), scores above 6 on a 9-point scale indicate positive consumers' acceptance, thus in the present study, all prebiotic white chocolates with or without addition of dried GB showed scores above 6 for all acceptance attributes (Table 4).

The development of foods with health benefits, so-called functional foods, is an innovative and promising alternative for the food industry. The chocolates studied in this research are a healthier alternative when compared to the conventional white chocolate, once they are prebiotic, can be made with sucrose replacement, and contain the antioxidant property of GB (Morais Ferreira and others 2016), which can increase the consumers' demand for this product. Furthermore, the substitution of sucrose and the addition of prebiotics did not affect the sensory characteristics of the prebiotic white chocolates for most of the attributes, when compared to the control. The samples were well accepted by consumers, diminishing the potential problems of such substitutions for the manufacturers. In addition, the prebiotic white chocolate with sucrose replacement and addition of GB has proven to be a potential new product to be explored by the food industry to attend the growing demand for healthier foods.

Drivers of liking of functional white chocolates

The descriptive data were correlated with the hedonic data by PLS regression. The PLS allows the identification of the attributes that contribute positively or negatively to the acceptance of the functional white chocolate samples (Figure 1). The columns with descriptive terms located on the positive portion of the *Y* axis are positively correlated with the acceptance, while those located on the negative portion of the *Y* axis are negatively correlated

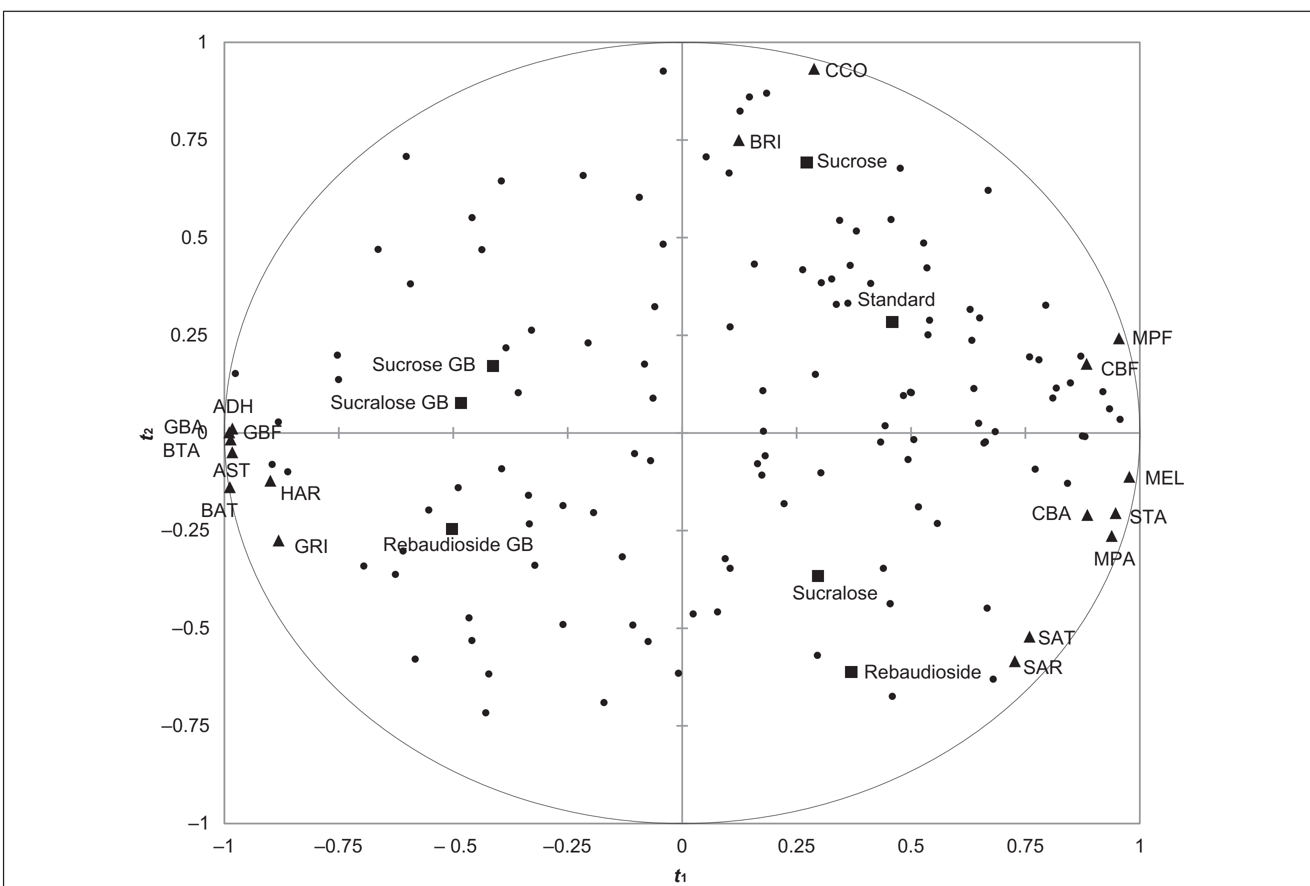

Figure 2–External preference mapping obtained by partial least squares regression of the descriptive sensory profile and consumers overall impressions of the functional white chocolates. (Square, samples; Circle, consumers; Triangle, quantitative descriptive analysis attributes). CCO, cream color; BRI, brightness; MPA, milk powder aroma; CBA, cocoa butter aroma; SAR, sweet aroma; GBA, goji berry aroma; CBF, cocoa butter flavor; MPF, milk powder flavor; STA, sweet taste; SAT, sweet aftertaste; BTA, bitter taste; BAT, bitter aftertaste; GBF, Goji berry flavor; AST, astringency; HAR, hardness; MEL, melting; GRI, grittiness; ADH, adherence.

with this attribute. The magnitude of the columns also represents the effect (both positive and negative) of the attribute on the acceptance of the sample. However, when the vertical line crosses the *X* axis, no effect of the corresponding attribute was observed on the driver of consumer preferences (Gomes and others 2014). As shown in Figure 1, only the attributes cream color and cocoa butter flavor contributed positively to the acceptance of functional white chocolates. In relation to the color, positive acceptance was observed for white to pale yellow color, while dark yellow or even light brown was undesirable according to consumers' opinion (Rossini and others 2011). The cocoa butter flavor is expected in white chocolate, possibly because this ingredient is present in high concentrations (22% to 30%), while lower concentrations (19% to 24%) are used in milk chocolate, for example (Beckett 2009). In addition, other chocolate formulations, such as milk or bitter type, contain cocoa liquor, which has an intense and characteristic aroma and flavor that can mask cocoa butter flavor. In this study, there was no attribute that contributed negatively to the acceptance of the samples.

The results of the external preference mapping are shown in Figure 2. Data are represented by 2 principal components. The dimension 1 (horizontal axes) divided the samples into chocolates sweetened with sucrose (control, Sucro, and Sucro GB) above the axis, and chocolate with sucrose replacer (Sucra, Reb, and Reb GB) below the axis, except for the sample Sucra GB that was located near the sample Sucro GB. The dimension 2 (vertical axes) divided the samples into chocolate without addition of GB (right side) and chocolate with addition of the dried fruit (left side).

The attributes associated with the samples sweetened with sucrose were appearance (cream color and brightness), milk powder flavor, and cocoa butter flavor. The attributes associated with the samples with sucrose replacer (Sucra and Reb) were sweet aroma, cocoa butter aroma, milk powder aroma, sweet taste, sweet aftertaste, and melting. Chocolates with GB were characterized for the attributes GB flavor, GB aroma, bitter taste, bitter aftertaste, astringency, hardness, and grittiness. As can be seen in Figure 2, consumers were positioned near and far from the samples, indicating the lack of preference for a specific sample. Thus, all prebiotic chocolates sweetened with sucrose or high-intensity sweeteners, with or without addition of dried GB, were appreciated by consumers.

Conclusion

The main differences observed in the sensory descriptive analysis were between the prebiotic white chocolates without addition of GB and those containing the dried fruit. GB reduces the perception of some attributes as milk powder aroma, milk powder flavor, sweet aroma, sweet taste, and sweet aftertaste while enhancing other attributes including bitter taste, bitter aftertaste, astringency, and adherence. However, consumer's acceptance was positive (with scores above 6 on a 9-point scale) for all white chocolate samples. The external preference map demonstrated no consumers' preferences for a specific sample. Nevertheless, the development of functional white chocolate containing prebiotics (FOS) and antioxidant source (GB), with the option of sucrose replacement, may be a promising alternative for the food industry. This kind of product with better nutritional value may attend the consumers' market tendency.

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