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Sensory impact of three different conching times on white chocolates with spray-dried and freeze-dried açai (*Euterpe oleracea*)

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Abstract

Nutritional profile of white chocolate is discussed for its high contents of sugar and fat, without benefits provided by cocoa polyphenols present in milk and dark chocolate. Thus, fruit addition may increase its nutritional characteristics. In this study, white chocolates with freeze-dried and spray-dried açai (*Euterpe oleracea*) were developed and their sensory characteristics were mapped through quantitative descriptive analysis and consumers' acceptance. Samples were submitted to three different conching times (6, 12, and 18 hours). Quantitative descriptive analysis results suggest type of dehydrated açai had much greater impact over samples' sensory characteristics than conching time, freeze-dried açai samples having greater intensity of açai sensory features, while spray-dried açai samples showing predominance of white chocolate sensory characteristics. Conching time had impact over texture of freeze-dried açai samples, since assessors considered sample conched for only 6 h was significantly harder and less melting than samples conched for 12 and 18 h. Consumer's acceptance analysis results showed that freeze-dried açai samples were more widely accepted by consumers for appearance, aroma, and texture, and exhibited segmentation of acceptance for flavor and overall liking, although freeze-dried açai samples conched for 12 and 18 h were more accepted than sample conched only for 6 h.

Keywords

Chocolate, açai, *Euterpe oleracea*, sensory analysis, acceptance

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INTRODUCTION

In recent years, the obesity epidemic caused by changes in diet and lifestyle has increased the incidence of cardiovascular diseases, type II diabetes, cancer, osteoarthritis, sleep apnea, and other health problems, especially in developing countries' populations (Popkin, 2001; Visscher and Seidell, 2001).

Many consumers, regulatory bodies, and media vehicles often criticize the confectionery sector for offering products with high sugar and/or fat content and artificial colorings and flavorings (Wetter and Hodge, 2016). The development of more nutritious and functional products is a very promising path for the adaptation of confectioneries to the new reality of consumers and adding fruits to chocolates is an example of this trend (Castilho et al., 2014).

Chocolates are good carriers of nutrients and bioactive compounds, such as antioxidants, vitamins, and fibers, due to their high content of lipids, low moisture, and low water activity (Alvim et al., 2014; Moloughney,

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2011). In recent years, consumption of high cocoa chocolate increased, following the ''healthy indulgence'' movement, characterized by revamping traditionally indulgent products so they also bring nutritional benefits (Rego et al., 2014). Evidences show that regular consumption of high cocoa chocolate may have health benefits, such as lowering blood pressure and protective effect on cardiovascular system (Magrone et al., 2017), due to the presence of polyphenolic compounds with antioxidant activity (Cruz et al., 2015), specially flavonoids (Efraim et al., 2011; Zyzelewicz et al., 2018).

However, white chocolate, made of cocoa butter, sugars, milk powder, emulsifiers, and flavorings (Jardim et al., 2011), does not carry significant amounts of polyphenols, since those are found in cocoa mass, ingredient that such product lacks. A study by Shiina et al. (2009) found that the intake of flavonoids-rich dark chocolate (420 mg in 35 g of product) increased coronary blood flow comparing to white chocolate intake (0 mg of flavonoids in 35 g), indicating positive effect of these substances on endothelial activity of main arteries and, consequently, on vascular health.

Adding fruits to chocolates has been widely used as a way of bringing nutritional benefits and sensory innovation to these products (Queiroz and Nabeshima, 2014). Açai (*Euterpe oleracea*), a native fruit from Amazon with great occurrence and economic importance in Brazil, is highly energetic, due to its high fat content (approximately 48% in dry basis), besides presenting protein and total fiber contents of 11 and 32% in dry basis, respectively. It is an important source of anthocyanins and other phenolic compounds, which possess antioxidant activity (Tonon et al., 2010).

According to Mintel Group Ltd (2015), processed foods containing açai launched worldwide in the last five years presented the following claims: no preservatives (21%), antioxidant (18%), no added/lower/reduced sugar content (14%) or of calories (13%), natural (13%) and functional (11%). Countries with the largest number of açai products in the market were USA (30%), Brazil (19%), and Canada (8%) in 2015.

Nonetheless, chocolates' segment accounted for only 4% of worldwide launches of products containing açai (Silva et al., 2016). Therefore, it is possible to point out that consumers, especially from those countries, expect a certain type of nutritional benefit and/or product functionality from foods containing the fruit and that there is still space in market for the development of chocolates with açai.

From technological point of view, chocolates' water activity is between 0.40 and 0.50 and moisture content around 0.5%, thus addition of any fruit must be done in dehydrated form (Burndred, 2009). Drying is used in food processing to reduce products' water activity to ensure microbiological stability and minimize chemical and enzymatic changes during storage (Oliveira et al., 2010). Spray-drying corresponds to transformation of liquid materials into solid particles by spraying them in drying chamber where temperatures can exceed 200 °C, usually mixed with carrier agent, such as maltodextrin, to increase process yield (Tonon et al., 2011). On the other hand, freeze-drying is the sublimation of ice present in the frozen sample and happens under vacuum and in absence of liquid water, so that temperature is well below those used in spray-drying, providing better integrity of sensory and nutritional characteristics of original product (Nireesha et al., 2013; Ratti, 2001).

One of the most important steps in chocolate manufacture is the conching, responsible for flavor improvement and texture development, through formation of *Maillard* reaction's products, removal of volatile acids and moisture, homogenization, and coating the particles with fat (Beckett, 2009). During conching, there is constant movement of chocolate under temperatures above 50 °C (Afoakwa, 2010). Prawira and Barringer (2009) studied the impact of conching time on consumer preference to milk chocolates and discovered that consumers preferred samples conched for 21 h or more than those conched up to only 8 h.

Sensory analysis is a science used to measure, raise, and interpret sensory information of foods, cosmetics, and other goods using people's five senses as instrument. Techniques are classified according to analysis' objective, for example discriminative tests differentiate between samples, descriptive tests scan products' sensory profile, and affective tests give information on how much consumers accept or prefer different products. Quantitative descriptive analysis (QDA) is an extremely sophisticated descriptive sensory methodology that allows complete screening of products' sensory properties, as well as the intensity in which they are perceived (Stone and Sidel, 1993).

White chocolate has always been viewed as an exclusively indulgent product, and present study aimed to contribute to the notion that such product is suitable for fruit incorporation, under the light of sensory quality. In order to accomplish that, the researchers developed samples of white chocolate with dehydrated açai and had their sensory profiles and consumers' acceptances mapped. In addition, this study aimed to assess how sensory information of such product varied in function of type of dehydrated açai used (freeze-dried and spray-dried) and chocolate conching time (6, 12, and 18 hours).

MATERIAL AND METHODS

Sample preparation

The chocolates were prepared at Cereal Chocotec—Instituto de Tecnologia de Alimentos, Campinas—SP, with following ingredients (and respective supplier): extra-fine refined sugar (*Mais Doce Açucareira*), deodorized cocoa butter (*Barry Callebaut Brazil*), whole milk powder and skim milk powder (*La Sereníssima*), freeze-dried organic açai powder (*Liotécnica Food Technology*), spray-dried açai powder (*Duas Rodas Ingredientes*), and soy lecithin Solec CH (*Solae do Brasil*).

Suppliers provided technical data sheets with composition of dehydrated açai powders, which is summarized in Table 1. Freeze-dried açai is a dark purple coarse powder, with strong açai aroma and flavor, while spray-dried açai has a lighter purple color, finer texture, and a much milder açai flavor and aroma, and both are packed in water-barrier metallic material due to hygroscopicity.

Samples were manufactured according to two slightly different formulations, one for the freeze-dried açai and another for the spray-dried açai. Both formulations contained 38.0 g/100 g of refined sugar, 31.5 g/100 g of cocoa butter, 12.5 g/100 g of whole milk powder, and 0.5 g/100 g of soy lecithin, so that the amounts of cocoa and milk fat, added sucrose and emulsifier were the same. Since spray-dried açai contained 70% of fruit in its composition (the rest being basically maltodextrin) and freeze-dried açai was composed entirely of fruit, adjustments in the amount of dehydrated açai were done in order to have the same amount of açai in both formulations. Thus, freeze-dried açai formulation had 10.0 g/100 g of freeze-dried açai and 7.5 g/100 g of skim milk powder, while spray-dried açai formulation contained 14.3 g of spray-dried açai and 3.2 g/100 g of skim milk powder.

Ingredients were measured on semi-analytical scales and mixed for 5 min at 40 °C. The powdered ingredients and part of the melted cocoa butter (approximately one-third of total) were mixed together to form a mass suitable for refining. Refining was carried out in a three-cylinder *Draiswerke*® mill until maximum particle size between 17 and 22 µm.

The refined masses were divided into three samples which were conched individually. Classic steps of chocolate conching were re-created in a *INCO*® jacketed mixer: dry conching is the initial phase in which refined chocolate (with a powdery texture) is submitted to constant mixing and heating, in order to coat particles with fat and evaporate moisture; pasty conching happens after the addition of the remainder of cocoa butter that was not added in mixing step and is important to integrate additional fat into chocolate; liquid phase takes place when emulsifier is added and is shorter because soy lecithin may lose emulsifying properties if exposed to high temperatures for too long. Conching temperature was kept between 50 and 55 °C for all samples to avoid lump formation due to crystallization of amorphous lactose (Ziegleder et al., 2004). Time parameters (Table 2) were set in a way that pasty phase (after addition of remainder of cocoa butter) and liquid phase (after addition of emulsifier) were the same and only dry phase varied between the samples.

Table 1. Composition of spray-dried açai and freeze-dried açai informed by suppliers.

	Spray-dried açai	Freeze-dried açai
Energetic value	280.5 kcal	541.0 kcal
Carbohydrates	52.5 g	5.0 g
Proteins	1.3 g	9.8 g
Total fat	7.1 g	54.0 g
Saturated fat	0 g	15.0 g
Total fiber	33.5 g	27.0 g
Moisture	4.0 g	2.5 g

All values present in 100 g of product.

Tempering of samples took place in a room kept at 20 °C, on a marble slab previously heated to around 35 °C, in order to control cooling rate. Since milk fat has an inhibitory effect on cocoa butter crystallization, chocolate containing milk fat must be tempered at slightly lower temperatures than dark chocolate to offset this effect and allow more rapid cocoa butter crystallization (Metin and Hartel, 2012). Thus, samples were cooled down to 27.5 °C after being heated up to 45 °C to ensure complete melting of fat crystals, respecting as much as possible a cooling rate of 2.0 °C/min, following a final heating to 30.5 °C to melt any unstable crystals formed during the process. Tempering was monitored through Temper Index analysis in Sollich® I3 Temper Meter, and all results ranged from 4.0 to 6.0, indicating proper tempering. Samples were then molded, cooled, and packed. Cooling took place in 8 m Siaht® cooling tunnel, with temperature profile of approximately 10 °C in central portion and between 12 and 14 °C in extremities.

Samples were packed in metalized BOPP film, sealed and stored at around 25 °C. They were coded to promote easier understanding of results. The ones with freeze-dried açai were coded as FRZ, and those with spray-dried açai as SPY. Conching time was indicated as numbers followed by the letter H to represent hours, as in FRZ 6H, FRZ 12H, FRZ 18H, SPY 6H, SPY 12H, and SPY 18H.

Sensory profile assessment

Sensory analysis took place in the Sensory Analysis Laboratory of the Department of Food and Nutrition (DEPAN), Faculty of Food Engineering (FEA/UNICAMP). Sensory profile of samples was assessed through QDA, according to the methodology proposed

Table 2. Flow chart of conching time parameters.

6 h conching	12 h conching	18 h conching
Dry phase	**Dry phase**	**Dry phase**
–	6 h	12 h
Addition of remainder of cocoa butter		
Pasty phase	**Pasty phase**	**Pasty phase**
5 h	5 h	5 h
Addition of soy lecithin		
Liquid Phase	**Liquid Phase**	**Liquid Phase**
1 h	1 h	1 h

by Stone and Sidel (1993). Those interested in participating in panel training were recruited through posters in UNICAMP and ads in social media and were asked in a quick interview if they had any food restriction and if they would have availability to participate in training and evaluation sessions. Twelve eligible candidates were submitted to preselection based on their sensory acuity through triangular tests (Meilgaard et al., 2006), in which they were asked to detect differences in sweetness intensity of two chocolate milk beverages prepared with different concentrations of sucrose (Paixão et al., 2014). The results were evaluated according to Wald's sequential analysis (Amerine et al., 1965).

The 10 preselected subjects determined the descriptors through repertory grid method (Moskowitz, 1983), a technique that allows mapping all samples' sensory characteristics by subjects themselves. They were asked to evaluate the six samples in pairs and describe their similarities and differences in appearance, aroma, taste, and texture. Next, subjects discussed all sensory characteristics in a meeting, mediated by a sensory analyst, who helped them refine the terms and consensually select those who described the samples, eliminating synonyms, antonyms and irrelevant terms.

Sweetness is a gustative response to the presence of sugars and other substances in the mouth, and one of the five tastes. Thus, the perception of something sweet could only be achieved by tasting the substance. However, during lexicon formation, subjects have distinguished sweet aroma when smelling the samples, which can be attributed to common perceptual confusion between the senses of smell and taste (Rozin, 1982). For this reason, to represent the maximum reference for this descriptor, subjects have chosen a mixture of milk powder and vanillin, since both aromas evoke sweet characteristics, which is a perceptual event, as opposed to physiological, and very dependent on experience and tradition of use (Stevenson et al., 1999).

For each descriptor, subjects determined definitions and minimum and maximum intensity references that were used in training, guided by a sensory analyst. Subjects tested the references and some needed adjustments to reach consensus. The list of descriptors, their definitions, and references for maximum and minimum intensity is given in Table 3.

Subjects were asked to memorize the references and indicate the intensity of each descriptor for the six samples until consensus between responses was reached. A ballot with 9 cm nonstructured linear scales was designed as a tool to assist subjects during training, as well as assess their discrimination and repeatability skills in panel selection and final sample evaluation.

After training, subjects evaluated samples in triplicate using the same 9 cm nonstructured linear scales, and results were submitted to analysis of variance (ANOVA) (Damasio and Costell, 1991). Selection aimed to choose subjects for final panel based on their ability to discriminate descriptors between samples (samples p-value under 0.30) and replicate responses (repetitions p-value above 0.05).

Panel performed final evaluation using previous ballot in three replicates for all samples, presented monadically in incomplete balanced blocks (Stone and Sidel, 1993). Results were submitted to ANOVA, subject and sample as sources of variation, Tukey's means test (5% significance), and principal components analysis (PCA). Statistics were performed using Statistical Analysis System—SAS (2016) software.

Consumers' acceptance assessment

Acceptance test was held with 118 consumers of white chocolate that did not reject açai. They evaluated the samples and indicated how much they liked appearance, aroma, taste, texture, and overall impression in nonstructured 9 cm scales, anchored at extreme left as "dislike extremely" and at extreme right as "like extremely." Samples were presented to subjects monadically in complete balanced blocks (Macfie et al., 1989).

Statistics were ANOVA, samples as the only source of variation, and Tukey's means test (5% significance). When associated with data obtained through sensory profiles, it was possible to obtain information on how each sensory characteristic impacts on consumers' acceptance. Thus, multivariate statistical analysis partial least square (PLS) correlation was performed to determine the most and least liked descriptors by subjects (Tenenhaus et al., 2005), using software XLSTAT (Addinsoft Inc., Paris, France, 2017).

RESULTS AND DISCUSSION

Panel selection

Table 4 shows subjects' P-values for sample and repetition. Values in both bold and italic correspond to descriptors in which subjects did not properly discriminate between samples ($p<0.3$), while values only in bold represent descriptors in which subjects did not

Table 3. List of descriptors, their definitions, and references for minimum and maximum intensities.

Descriptors	Definition	References
Appearance		
Purple color	Visual perception caused by electromagnetic waves corresponding to the spectrum of purple when viewed from the side of the cup (never from above)	Weak: 1 g of freeze-dried organic açai *Liotécnica* + 10 g whole milk powder *Ninho* + 100 ml filtered water Strong: Freeze-dried organic açai *Liotécnica*
Aroma		
Açai aroma	Aroma characteristic to freeze-dried açai pulp	Weak: 0.5 g freeze-dried organic açai *Liotécnica* + 150 ml filtered water Strong: 5 g freeze-dried organic açai *Liotécnica* + 100 ml filtered water
Sweet	Olfactive perception of aromas often related to sweetness	Weak: 20 g whole milk powder *Ninho* + 100 ml filtered water + 2 drops of vanilla extract *Yoki* Strong: White chocolate *Laka*
Cocoa butter	Aroma characteristic to deodorized cocoa butter	Weak: 10 g vegetable shortening *Triângulo* + 1 g deodorized cocoa butter *Barry Callebaut* Strong: Deodorized cocoa butter *Barry Callebaut*
Flavor		
Açai flavor	Flavor characteristic to freeze-dried açai pulp	Weak: 0.5 g freeze-dried organic açai *Liotécnica* + 100 ml filtered water, strained in coffee filter Strong: 5 g freeze-dried organic açai *Liotécnica* + 10 g whole milk powder *Ninho* + 100 ml filtered water
Sweetness	Perception of sweet taste due to the presence of sugars in chocolate	Weak: 20 g whole milk powder *Ninho* + 10 g sucrose + 100 ml filtered water Strong: White chocolate *Laka*
Milk powder	Aroma characteristic to full-cream milk powder	Weak: 2.5 g whole milk powder *Ninho* + 100 ml filtered water Strong: 20 g whole milk powder *Ninho* + 100 ml filtered water
Cocoa butter	Flavor characteristic to deodorized cocoa butter	Weak: White chocolate flavored compound *Talismán* Strong: White chocolate *Garoto*
Texture		
Hardness	Force needed to break a piece of chocolate with the teeth	Weak: Milk chocolate *Kinder* Strong: White chocolate *Laka*
Melting	Speed in which chocolates' fatty matrix melts in mouth	Weak: White chocolate *Laka* Strong: Milk chocolate *Kinder*
Grittiness	Tactile perception of gritty particles in mouth	None: Milk chocolate *Lindt Extra-Creamy* Strong: Caramel milk fudge *Portão do Cambuí*
Residual fat	Tactile perception of waxiness characteristic to solid fat in mouth	None: White chocolate *Laka* Strong: Milk chocolate *Lindt Extra-Creamy*

obtain good reproducibility between replicates ($p>0.05$). The 10 trained subjects were selected to perform final evaluation and compose the panel, which is regarded as enough assessors in a QDA study, according to Stone (2018). Consensus between subjects' responses was assessed through comparison of means they attributed for each descriptor and sample.

QDA

Trained and selected assessors determined the sensory profile of samples using ballot previously created. Table 5 presents the means obtained from statistical treatment of results, Figure 1 displays a spider chart with the samples' means for each descriptor and Figure 2 shows PCA chart.

Results suggest that type of dehydrated açai had much more impact than conching time over samples' sensory profiles. Panel distinguished freeze-dried açai samples from spray-dried açai samples but did not distinguish those made with the same type of dehydrated fruit and conched at different times for appearance, aroma, and flavor descriptors. Descriptors' purple color, açai aroma, and açai flavor had much higher

Table 4. P-values for samples and repetitions used in selection of panelists.

Subjects		Purple color	Açai aroma	Sweet aroma	Cocoa butter aroma	Açai flavor	Sweetness	Milk powder flavor	Cocoa butter flavor	Hardness	Melting	Grittiness	Residual fat
1	Sample	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	Repetition	0.4302	0.0631	0.8528	0.3451	0.1592	**0.0017**	0.0873	0.6679	0.1368	**0.0036**	**0.0354**	0.7356
2	Sample	0.0001	0.0001	0.0120	0.0001	0.0001	0.0038	0.0001	0.0001	0.0014	0.0001	0.0001	0.0210
	Repetition	0.5402	0.7714	0.2072	0.5285	0.3887	0.8045	0.2630	0.4543	0.2200	0.4228	0.8130	0.5013
3	Sample	0.0001	0.0001	0.0007	0.0001	0.0001	0.0086	0.0009	0.0001	0.0005	0.0001	0.0001	0.0016
	Repetition	0.0566	0.3369	**0.0216**	0.4753	0.8219	0.6272	0.3054	0.6586	0.1010	0.3833	**0.0240**	0.8031
4	Sample	0.0001	0.0007	0.0004	0.0004	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0023
	Repetition	0.1181	0.4968	0.5438	0.8647	0.9531	0.7387	0.7220	0.8922	**0.0356**	0.3847	0.8396	0.5171
5	Sample	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	Repetition	0.6814	0.4694	**0.0367**	0.5046	0.3361	0.0693	0.2484	0.3969	0.6532	0.8102	0.5619	0.6709
6	sample	0.0001	0.0001	0.0015	0.0100	0.0001	0.0001	0.0032	0.0002	0.0102	0.0001	0.0001	0.0004
	repetition	0.6836	0.4325	0.1070	0.6773	0.2682	0.8931	0.3826	0.4628	0.6866	**0.0060**	0.9082	0.6134
7	Sample	0.0001	0.0001	***0.3481***	0.1290	0.0001	0.1217	0.0202	0.0001	0.0012	0.0001	0.0001	0.0001
	Repetition	0.7848	0.9830	0.1429	**0.0467**	0.9638	0.7993	0.3329	0.1650	0.7088	0.1032	0.1162	0.6399
8	Sample	0.0001	0.0001	0.0094	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0080
	Repetition	0.2840	0.1311	0.2357	0.0666	0.4258	0.2079	0.6902	0.2386	0.5307	0.1436	0.8746	0.2861
9	Sample	0.0001	0.0001	0.0433	0.0004	0.0001	0.0103	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	Repetition	0.9039	0.8404	0.6853	0.4589	0.8170	0.0748	0.3453	0.1036	0.4325	0.2470	0.8288	0.3520
10	Sample	0.0008	0.0001	0.0003	0.0001	0.0004	***0.3345***	0.0001	0.0005	0.0112	0.0007	0.0001	0.0116
	Repetition	0.4882	0.4375	0.0552	0.9367	0.4915	0.9518	0.7740	0.5946	0.1029	0.4706	0.2211	0.3959

Table 5. Means of each descriptor obtained in QDA for chocolate samples.

	Samples						
Descriptors	SPY 6H	SPY 12H	SPY 18H	FRZ 6H	FRZ 12H	FRZ 18H	LSD [2]
Purple color	1.690b[1]	1.400b	1.783b	8.200a	8.110a	8.263a	0.517
Açai aroma	1.630b	1.790b	1.987b	7.283a	7.097a	6.983a	0.636
Sweet aroma	6.017a	6.077a	5.900a	4.267b	4.273b	4.320b	0.558
Cocoa butter aroma	5.733a	5.847a	5.833a	3.000b	3.480b	3.210b	0.756
Açai flavor	1.707b	1.660b	1.790b	7.893a	7.800a	7.770a	0.532
Sweetness	7.240a	7.023a	7.250a	5.983b	5.933b	5.817b	0.612
Milk powder flavor	5.577a	5.560a	5.367a	3.367b	3.077b	3.360b	0.748
Cocoa butter flavor	5.383a	5.620a	5.410a	2.590b	2.293b	2.377b	0.709
Hardness	5.630a	5.580a	5.713a	2.280b	1.510c	1.540c	0.682
Melting	2.413c	2.517c	2.637c	6.043b	6.987a	6.853ab	0.874
Grittiness	4.450a	3.560b	4.553a	0.823c	0.150c	0.163c	0.864
Residual fat	3.483a	3.507a	3.530a	2.040b	1.933b	1.933b	0.524

[1]In same row, means with letters in common do not differ significantly from each other at $p \leq 0.05$, according to Tukey's mean test.
[2]LSD: least significative difference obtained through Tukey's mean test ($p \leq 0.05$).

means for freeze-dried açai samples, while descriptors' sweet aroma, cocoa butter aroma, sweetness, cocoa butter flavor, and milk powder flavor scored higher for spray-dried samples. That was somewhat expected, since freeze-dried açai had much more intense açai characteristics like appearance, aroma, and flavor than spray-dried version, in which the sensory characteristics of the other ingredients (cocoa butter, sugar, and milk powder) became much more evident to panel. Freeze-drying is a milder process of dehydration compared to spray-drying, and because drying temperatures are much lower, loss of original color, aroma, and flavor is

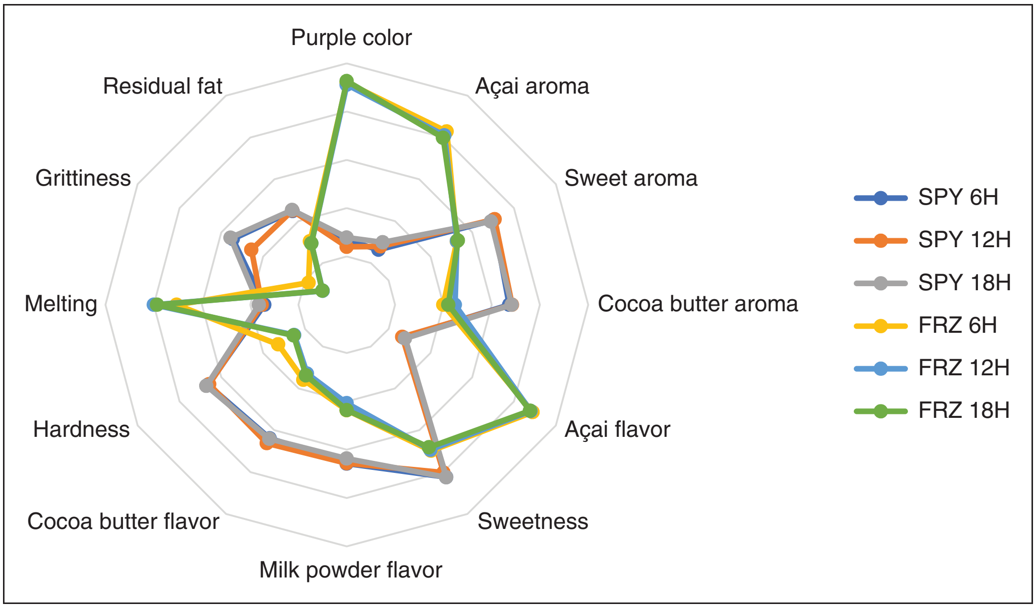

Figure 1. Spider chart showing means obtained from Tukey's means test.

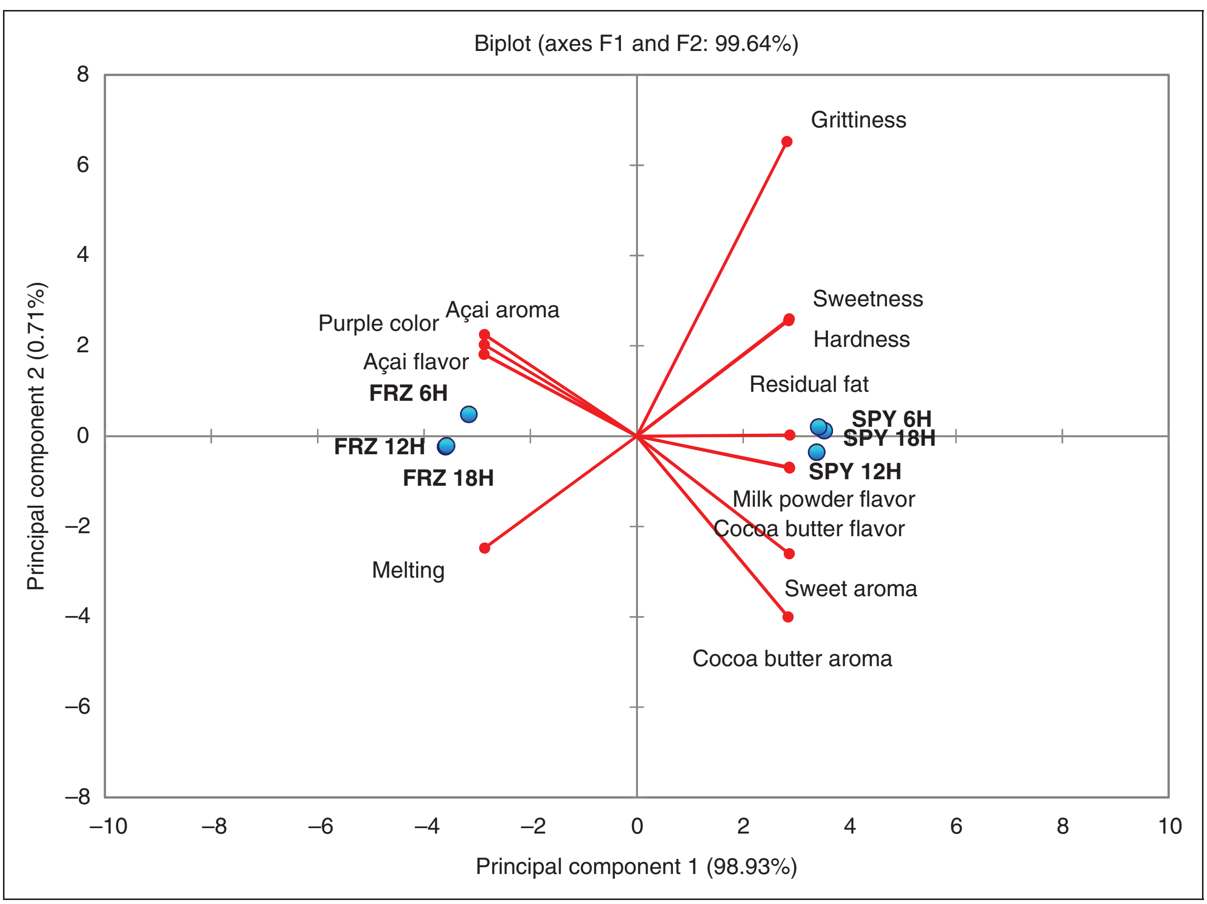

Figure 2. PCA Chart. Blue dots represent samples and red vectors are descriptors. The closer the vectors are to the dots, the more the corresponding descriptor is present in sample.

Table 6. Means from consumers' acceptance for chocolate samples.

Sample	Appearance[1]	Aroma	Flavor	Texture	Overall liking
SPY 6H	5.181b	5.231ab	5.939a	5.965c	5.798ab
SPY 12H	5.314b	5.252ab	5.939a	6.092bc	5.899a
SPY 18H	5.047b	5.031b	5.251ab	5.796c	5.295b
FRZ 6H	6.996a	5.564a	4.865b	6.593ba	5.574ab
FRZ 12H	7.316a	5.670a	5.410ab	6.959a	6.049a
FRZ 18H	7.219a	5.638a	5.640a	6.899a	6.084a
LSD2	0.553	0.506	0.692	0.569	0.564

[1]In same row, means with letters in common do not differ significantly from each other at $p \leq 0.05$, according to Tukey's mean test.
[2]LSD: least significative difference obtained through Tukey's mean test ($p \leq 0.05$).

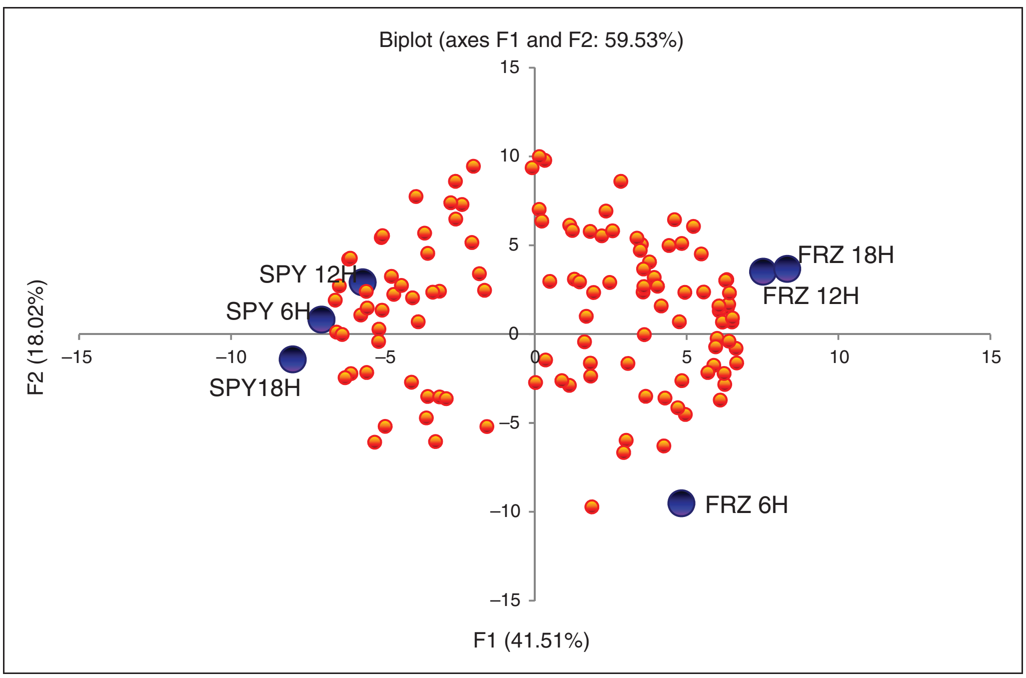

Figure 3. Internal preference map. Orange dots represent consumers (118) and blue dots represent samples; the greater the density of dots near a sample, the more that sample was preferred over others.

minimized. Spray-drying, in turn, involves much higher temperatures, which favors degradation of colorants and aromatic compounds naturally present in açai and require addition of maltodextrin to increase yield, which dilutes aromatic and colorant substances.

However, panel considered freeze-dried açai chocolate samples conched for 6 h to be significantly harder than freeze-dried açai samples conched for 12 and 18 h and not as easily melting as freeze-dried açai chocolate conched for 12 h. The first step of conching, known as "dry conching", is crucial in developing chocolates' proper rheological properties, by favoring particle coating with fat and moisture withdrawal (Beckett, 2009). As shown in Table 2, this phase did not take place in samples conched for 6 h, only in those conched at 12 and 18 h. Thus, results suggest that the lack of dry conching in freeze-dried açai samples had impact on the development of texture and viscosity of this sample, which was perceived by assessors, even though the same discrimination was not observed for spray-dried açai chocolate samples.

PCA chart evidenced the differences of the samples made with freeze-dried açai from the ones made with spray-dried açai, but it was not able to show differences between samples with the same type of dehydrated açai but conched at different times. This reinforces the greater impact of dehydrated açai type than chocolate conching time on assessor's perception. The sum of explanations of main components 1 (98.93%) and 2 (0.71%) is quite high (99.64%), which highlights the

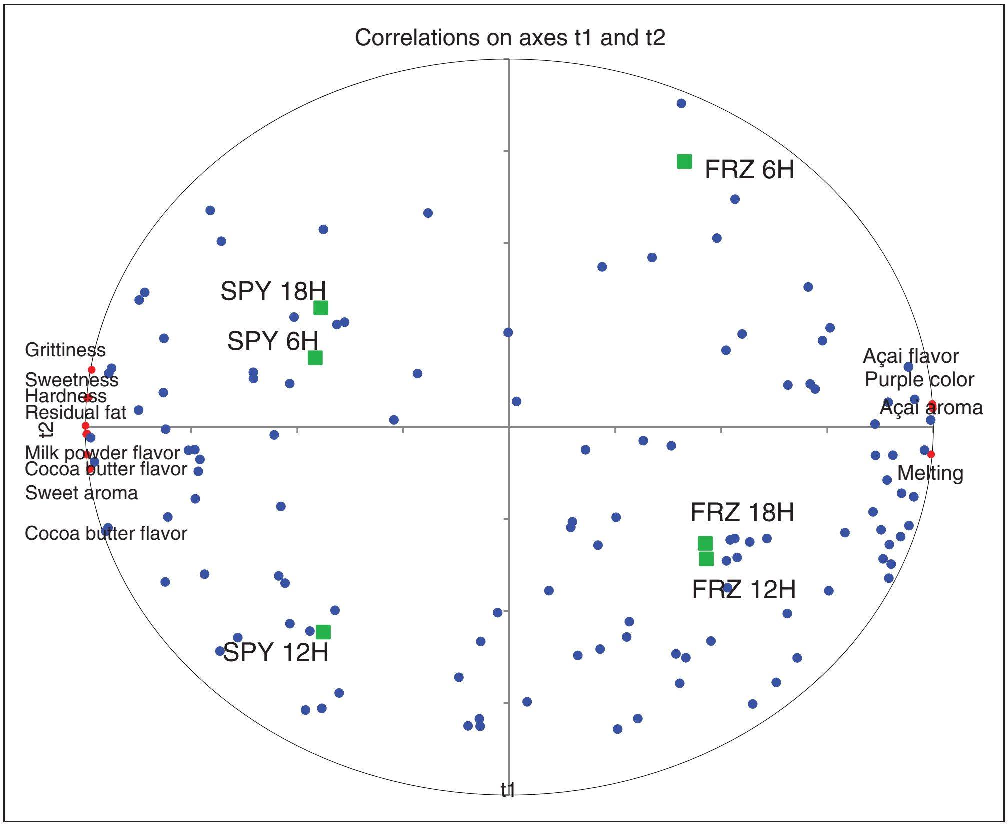

Figure 4. External preference map. Blue dots represent consumers, green squares are samples, and red dots are descriptors. Samples are located near consumers who preferred them and near descriptors most present in them.

importance of explaining this multivariate analysis for graphical representation of results.

Acceptance analysis

Acceptance analysis' results were submitted to ANOVA and Tukey's means test. Table 6 presents means for appearance, aroma, taste, texture, and overall liking. Additionally, overall liking means were plotted in internal preference map, displayed in Figure 3, showing which samples were most and least accepted by consumers through visual density of dots near each sample. From crossing consumers' individual overall liking means and means obtained through QDA, it was possible to establish the correlation between the data through PLS technique, thus generating the external preference map in Figure 4 (Tenenhaus et al., 2005).

Consumers attributed higher means to freeze-dried açai samples for appearance, aroma, and texture. As for appearance and aroma, consumers' expectation of purple color and açai aroma might have held up higher means to freeze-dried açai samples, since these possessed more intense açai characteristics. Regarding texture, freeze-dried açai samples were generally considered softer, more melting, and less gritty by trained panel, emphasizing the importance of softness, creaminess, and smoothness over consumers' acceptance of white chocolate.

Consumers' test results did not indicate higher acceptance of samples made with one specific type of dehydrated açai for flavor and overall liking, which indicates that these descriptors are closely dependent on each other in studied products. Although there was segmentation of acceptance among samples made with both types of dehydrated açai, results suggest that freeze-dried açai samples submitted to "dry conching", 12 and 18 h conching, were liked by a larger number of consumers than the one conched only for 6 h.

Internal preference map shows that there was preference segmentation in overall liking as well, since there were consumers who gave higher means for spray-dried açai samples while others attributed higher means for freeze-dried açai samples. In external preference map, samples are closer to descriptors that best translate them, according to sensory profile, and concentration of blue dots represents regions of greater or lesser acceptability. Samples with freeze-dried açai are preferred because they exhibit superior açai flavor/aroma and purple color, which is confirmed by Tukey's means test ($p \leq 0.05$). In contrast, samples with spray-dried açai are preferred by another group of consumers (as opposed to those cited above) for they have more sweetness, milk powder flavor, cocoa butter aroma, cocoa butter flavor, descriptors characteristic to white chocolate, also confirmed by Tukey's mean test ($p \leq 0.05$).

CONCLUSION

Regarding texture, freeze-dried açai samples performed better than spray-dried açai samples, and the fact that texture differences between conching times were only perceived for freeze-dried açai samples highlights that. Probably the higher amount of fat in freeze-dried açai (54 g/100 g versus 7 g/100 g in spray-dried açai) favored the development of milder and creamier texture in these chocolates.

It is stated by supplier that freeze-dried açai has 385 mg/100 g of anthocyanins (HPLC), antioxidant capacity of 70.000 µmol eq. trolox/100 g and total polyphenols of 3.300 mg eq. gallic acid/100 g ($ORAC_{FL}$). According to the review made by Di Mattia et al. (2017), several studies show that conching does not impair cocoa's phenolic content and antioxidant activity, regardless of the time/temperature combination applied. In fact, it may even increase trolox equivalent antioxidant capacity (+16% on average) by promoting complexation of polyphenols. Although the impact of conching over açai's phenolic content and antioxidant activity remains unknown, it is possible to infer that similar behavior takes place for açai's phenolic compounds such as anthocyanins. Thus, although this study did not aim to assess the antioxidant benefits of adding açai to white chocolate, it is possible to consider some improvement of functionality of such product, especially the one with freeze-dried açai.

The study accomplishes its main objective of establishing a sensory profile and assessing consumers' acceptance of a white chocolate with addition of dehydrated açai. Both freeze-dried and spray-dried açai chocolates showed good acceptance among customers (overall liking scores above 5), despite having very different sensory profiles. It is common to find chocolates with fruits in the market, though the addition of the fruit is rarely done as part of the chocolate mass, as natural flavoring and coloring materials. Assessing the sensory characteristics of such innovative products through QDA and consumers' acceptance indicates that white chocolates with açai have a good potential in the market, especially considering their novelty aspect.

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