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Comparison of trained panel and consumers' methodologies to discriminate chocolate samples based on industry quality control parameters

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Abstract

The aim of this study was to compare sensory trained panel and consumers' characterization of chocolates based on a factory's quality control attributes. Six chocolates were evaluated by a trained panel using descriptive analysis and consumers using Check-All-That-Apply for chocolate, bitter, alkalinity, acidity, woody, smoked, green, floral, burned, musty, and cocoa flavors. Analysis of variance, multivariate analysis-based reduction of dimensions, and multiple factor analysis were performed. The results show that the trained panel and consumers discriminated chocolate samples differently. Trained accessors characterized chocolates made of cocoa liquor from Rondônia and Bahia and those from organic cocoa from Pará to present chocolate and floral flavors; samples from Pará, Espírito Santo, and Cotê d'Ivoire were associated with alkalinity, acidity, smoked, burnt, cocoa, musty, bitter, green, and astringent flavors. Consumers perceived chocolate made of cocoa from Pará to musty, woody, smoked, and alkalinity flavors; chocolate made of liquor from Espírito Santo to burned, green, and astringent flavors; samples made of cocoa from Bahia and Cotê d'Ivoire were associated with bitterness; and those chocolates with Rondônia and organic sample from Pará were associated with floral, cocoa, and chocolate flavors. Multiple factor analysis indicated that consumers perceived samples close to trained panel when chocolates presented wider attribute intensity profile.

Keywords: flavors; descriptive analysis; check-all-that-apply; multiple factor analysis.

Practical Application: consumers perceive chocolate attributes differently them industry quality control.

1 INTRODUCTION

Latin America has stood out in cocoa bean production, driven mainly by Brazil, Peru, and Ecuador, although the sub-Saharan African countries, mainly Côte d'Ivoire and Ghana, remain the biggest producers (Eghbal, 2018; Fortune Business Insights, 2020).

In the context of huge competition, chocolate quality control within food industries is a key factor for product standardization. For chocolates, flavor and aroma are critical criteria for consumers' acceptance and consequently target of quality patterns (Cemin et al., 2022). Chocolates are quite complex foods, in terms of both taste and aroma, due to the unique interactions among compounds within the ingredients during the whole processing chain, in which degradation and formation of compounds happen through a network of reactions including natural components from the cocoa nuts, fermentation, drying, roasting, and chocolate industrial production (Engeseth & Pangan, 2018; Moreira et al., 2018; Tuenter et al., 2020).

Descriptive analysis (DA) is an important method for characterizing food flavor profiles and internal quality control of ingredients in food industries. Through this technique, trained accessors are able to describe and measure products' attributes and identify failures or nonconformities in raw materials and final products with high acuity and performance (Wansink, 2003). However, consumers' perception has driven important food industry decisions, and several methodologies to use them as sensorial tools have been proposed lately (Varela & Ares, 2018). Check-All-That-Apply (CATA) is a consumer-based sensory characterization based on the evaluation of specific attributes, in which volunteers tick all terms that they consider to be present in the evaluated sample, based on a pre-list of attributes. Due to its ease of understanding by the respondents and close relationship with descriptive methods, CATA has been the most popular consumer analysis method, as it is a versatile and sophisticated tool by providing a rapid description of foods' features and a better understanding of how consumers perceive and describe the sensory characteristics of products (Alcântara & Freitas-Sá, 2018; Varela & Ares, 2018). CATA has been used to characterize several foods, showing a good correlation to conventional DA by trained assessors (Ares et al., 2015; Aguiar et al., 2020). However, when the samples to be evaluated are quite similar and/or complex, consumers-based techniques may present lower performance, jeopardizing correlations between trained accessors and consumers or discrimination of samples (Ares et al., 2015).

In this context, trained panels present greater precision and accuracy, being essential for quality control in industries. However, in many cases, if the food does not meet the criteria established upon arrival at the receiving platform, the raw material can be rejected, or the finished product can be discarded or relocated to a sector with lower added value. Thus, evaluating within the sensory quality assurance sector whether all attributes evaluated by the trained panel are important and whether the

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parameters are perceived by consumers is a relevant analysis to create adequate criteria for acceptance or rejection of raw materials and finished foods and to design more accurate decision-making processes within food quality. Additionally, despite the fact that chocolate is a food with unique characteristics, the comparative study of trained panel data and descriptive methodologies with consumers is not yet found in the literature, which is important information for the area. Thus, the objective of this study was to evaluate whether the flavor attributes of chocolates from the quality control of a food industry for the sensory perception of consumers.

2 MATERIALS AND METHODS

2.1 Cocoa samples and chocolate production

Chocolate samples and production procedure were the same as previously reported by Cemin et al. (2022). Briefly, samples of cocoa liquors from Pará (Organic – OPA), Rondônia (RO), Bahia (BA), Espírito Santo (ES), Pará (PA), and Côte d'Ivoire (CI) were used to produce a 50% cocoa chocolate, by mixing them with sugar, cocoa butter, soy lecithin, ricinoleic acid esters interesterified with polyglycerol, and ethylvanillin at 3 kg capacity Cocoatown Melanger machine. The chocolate mixtures reached a particle size of 24 µm, and they were dosed in 90 g polycarbonate plastic molds, cooled at 7°C, and allowed to rest for 48 h. The chocolates were packed in 5 g pieces in a horizontal flow pack, into Figure 1.

(BOPP) package plus transparent BOPP packaging and left in a climate-controlled environment with humidity below 65% and temperature between 16 and 24°C until sensory analysis.

2.2 Sensory analyses

The methodological procedure deals with humans as a data source, and thus the experimental procedure was approved by the Ethics Committee of the Universidade Estadual do Rio Grande do Sul (approval certificate number 60158422.5.0000.8091), following the Declaration of Helsinki.

Sensory analyses were performed in Central-Location-Test in individual booths with adequate light for viewing the samples at a controlled temperature of 23°C, following the standard procedures as described by Dutcosky (2019).

2.2.1 Descriptive sensory analysis

Trained panel (n=7) used in DA was the same as previously reported (Cemin et al., 2022). The analyzed flavors and tastes were chocolate, bitter, alkalinity, acidity, woody, smoked, green, floral, burned, musty, and cocoa flavors, which are used as quality control in a local chocolate factory (Encantado, RS, Brazil) and recently used to describe chocolates (Cemin et al., 2022). Assessors were presented to the attributes and defined in consensus each attribute definition and standard references of very strong or very weak intensity. Definitions and references used are presented in Table 1. To memorize the anchors, panelists went

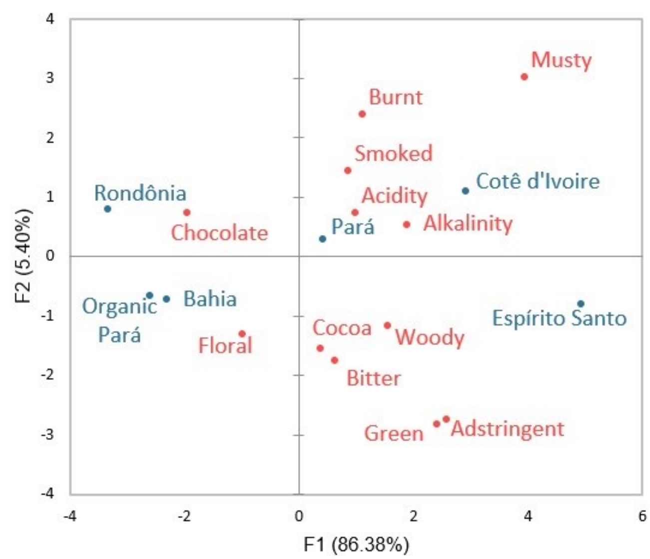

Figure 1. Principal component analysis biplot of descriptive profile of chocolates by the trained panel.

Table 1. Attributes and reference standards generated by the sensory panel.

Attribute	Definition	Reference	
		Weak intensity	Strong intensity
Chocolate	Characteristic flavor of milk chocolate	Cooked rice	Milk chocolate
Bitter	Bitter taste	Marshmallow	Olina®
Acidity	Characteristic flavor of acetic acid	Bread	Vinegar
Woody	Woody peanut and chestnut flavor	Tap water	Caju nut
Smoked	Characteristic flavor of smoke	Apple	*Commercial liquid smoke**
Alkalinity	Powder cocoa dissolved in water leaks alkaline taste	Tap water	Powder cocoa
Green	Characteristic flavor of grass	Tap water	Green banana
Astringent	Characteristic flavor of contraction of the mucous membranes in the mouth	Tap water	Green banana
Floral	Characteristic of floral citrus flavor	Crackers	*Commercial floral aroma**
Roasted	Excessed burned flavor	Apple	*Commercial roasted aroma**
Musty	Cheesy musty flavor	Tap water	*Commercial musty aroma**
Cocoa	Characteristic of powder cocoa	Crackers	Powder cocoa

*Donated by the company Carlos Cramer Produtos Aromáticos do Brasil®.

through 10 h of training divided into six sessions. To guarantee acuity and reproducibility, assessors evaluated three samples of chocolate in two duplicates on two independent tastes, using the definitive sheet for DA. All flavors and tastes were evaluated using a structured nine-point scale, anchored at the extremes by "none/weak" and "very strong." All samples were presented in monadic and balanced form.

2.2.2 CATA analysis

For consumers' CATA analysis, a two-step single section was performed. First, 10 g samples of chocolates were served sequentially to participants and coded with three random digits, following a balanced presentation order. A total of 128 (n=128) volunteers received the CATA questionnaire that consisted of a list containing the 12 sensory terms used in DA analysis, from which they should check all the attributes they considered that applied to describe each chocolate. The order of attributes was balanced among consumers. No explanation or other information, such like concept, about the attributes was given to the volunteers. Then, they were asked for their sociodemographic profile (i.e., gender, age, and frequency of consumption of chocolates).

All volunteers were recruited in Vale do Taquari region (RS, Brazil) based on the following criteria: older than 18 years, not presenting food allergies, regular consumer of chocolates, and interested to participate. There was any kind of incentive for attending the test.

2.3 Data analysis

DA sensory data were analyzed by the Panel Check software (PanelCheck software, 2006) to evaluate the significance of the interaction of panelist*samples, which was considered satisfactory when $p>0.05$ using two-way analysis of variance (ANOVA) (samples were considered fixed effect and accessors were considered random effect) followed by the least squared difference (LSD) test.

Principal component analysis (PCA), based on covariance matrix, was used to evaluate mean data from DA, and correspondence analysis (CA) was used to evaluate CATA results. Means of duplicates from DA were evaluated by ANOVA followed by LSD tests, and statistical differences were considered when $p<0.05$. The normality of the data and homogeneity of the variances were tested before ANOVA by Shapiro-Wilk and Hartley's maximum F tests, respectively, using the Rstudio software. Discrimination among samples by CATA results was evaluated by the non-parametric Cochran's Q test, and differences were considered statistically different when $p<0.05$.

The regression vector (RV) coefficient was calculated between the sample configurations obtained in CATA (CA) and DA (PCA) to analyze similarities between sample distributions for both methodologies.

3 RESULTS

Results from chocolate attributes intensities from DA are presented in Table 2. Chocolates made of cocoas from organic samples from Pará, Bahia, and Rondônia presented the highest intensity of chocolate ($p<0.05$); meanwhile, those made of liquors from Espírito Santo presented the lowest ($p<0.05$). Cocoa flavor was in lowest intensity in RO samples ($p<0.05$) and did not differ among other chocolates, indicating differences between cocoa and chocolate flavors. Bitter taste was lowest at RO and BA samples ($p<0.05$), and highest intensities were observed at ES, PA, CI, and OPA samples ($p<0.05$). Acid taste was in highest intensity at ES and CI samples ($p<0.05$) and did not differ among the other samples ($p>0.05$). Alkalinity taste and musty flavor were highly presented at samples from CI and ES ($p<0.05$), and the attribute intensity did not differ in OPA, RO, and BA samples ($p>0.05$), in which was the lowest. Astringent taste intensity was higher in Espírito Santo samples and lower in Rondônia chocolates. Espírito Santo samples presented the highest intensity of woody flavors ($p<0.05$); meanwhile, OPA and RO presented the lowest ($p<0.05$). Smoked flavor was in highest intensity in samples from Pará and in lowest intensity in OPA, BA, and RO. Green flavor and astringent taste were in highest intensity at ES sample and in lowest intensity at RO samples. Burnt flavor was in highest intensity in CI and in lowest intensity in OPA, RO, and BA. On the contrary, the floral intensity was highest in organic Pará chocolates ($p<0.05$); meanwhile, samples from ES and CI the lowest ($p<0.05$), and

Table 2. Sensory profile attribute means for the chocolates by DA.

	Organic Pará	Rondônia	Bahia	Espírito Santo	Cotê d'Ivoire	Pará
Chocolate	4.7±0.4^{a}	4.7±0.5^{a}	4.7±0.4^{a}	2.1±0.0^{c}	3.4±0.5^{b}	3.7±0.5^{b}
Cocoa	4.0±0.5^{a}	3.0±0.3^{b}	4.0±0^{a}	4.0±0^{a}	4.0±0^{a}	3.9±0.1^{a}
Bitter	3.6±0.8^{ab}	2.9±0.4^{c}	3.3±0.5^{bc}	4.1±0.4^{a}	3.4±0.5^{ab}	3.7±0.5^{ab}
Acidity	2.0±1.1^{b}	2.2±0.4^{b}	1.8±0.4^{b}	3.2±0.4^{a}	3.0±0^{a}	2.0±0^{b}
Alkalinity	3.1±0.7^{bc}	2.9±0.4^{c}	3.0±0.4^{bc}	5.1±0.4^{a}	4.9±0.4^{a}	3.7±0.5^{b}
Astringent	2.6±0.5^{cd}	1.0±0^{e}	2.0±0.4^{d}	4.9±0.7^{a}	3.6±0.8^{b}	2.9±0.4^{bc}
Musty	1.1±0.5^{c}	1.3±0.5^{c}	1.1±0.4^{c}	5.6±0.5^{a}	5.1±0.7^{a}	3.7±0.5^{b}
Woody	1.5±0.5^{cd}	1.1±0.4^{d}	2.0±0.4^{c}	3.4±0.5^{a}	2.9±0.4^{b}	1.9±0.1^{c}
Smoked	1.1±0.5^{c}	1.1±0.5^{c}	1.1±0.6^{c}	2.0±0^{b}	2.0±0^{b}	3.0±0^{a}
Burnt	1.2±0.2^{c}	1.0±0.1^{c}	1.0±0.4^{c}	2.0±0^{b}	3.0±0.6^{a}	1.0±0^{c}
Green	1.0±0.1^{d}	1.0±0^{d}	2.1±0.1^{c}	4.9±0.4^{a}	3.1±0.2^{b}	2.3±0.8^{c}
Floral	2.5±0.2^{a}	2.0±0.2^{b}	1.9±0.4^{b}	1.0±0^{c}	1.0±0^{c}	1.9±0.4^{b}

[a–e]Different superscript letters indicate statistical difference among columns at 5% of significance by the LSD test.

samples made of liquors from RO, BA, and PA did not differ among them ($p>0.05$).

PCA results from mean rates given by trained accessors to samples are presented in Figure 1. First principal component 1 (F1) explained 86.38% of the variance, and the second component (F2) explained 5.40% of the variance, indicating proper dimension reduction by the multivariate technique from the data. As F1 explained most of the variance, the results indicate that chocolates were segregated in two major groups. Chocolates made of cocoa liquor from RO and BA and those from OPA presented similar profile and were associated with chocolate and floral attributes. Samples from PA, ES, and CI presented similar profile and were associated with alkalinity, acidity, smoked, burnt, cocoa, musty, bitter, green, and astringent flavors. ANOVA and PCA analyses from rates given by trained panel are complementary, as PCA is an exploratory analysis and ANOVA deals with hypothesis test and is then able to evaluate significant differences between samples.

Table 3 shows the statistical evaluation of the data from consumers' sensory perception by the CATA method. A total of 75 (n=75, 58.6%) were women and 53 (41.4%) were men, with an average age of 35.6±11.5 years (minimum 18 years and maximum 64 years) and 20.3% (n=26) consumed chocolates every day or almost every day, 32.8% (n=42) consumed several times a week, 11.7% (n=15) once a week, and 35.2% (n=45) several times a month or less. Chocolate flavor presented higher ($p<0.05$) frequency of mention on samples made of organic sample from PA, RO, BA, ES, and CI, which did not differ among them ($p>0.05$); the lowest frequency was observed in samples from Pará. In relation to cocoa flavors, samples from Espírito Santo presented the lowest checking frequency ($p<0.05$) and other samples did not differ among them ($p>0.05$), indicating that also consumers perceive differences between cocoa and chocolate flavors in chocolates, such like the trained panel. Bitter taste was lower mentioned to Pará samples ($p<0.05$) and largely cited in RO, BA, ES, and CI samples, which did not differ among them ($p>0.05$). Acid taste was less perceived in RO samples ($p<0.05$) and largely checked in OPA, BA, ES, and CI samples. Alkalinity taste did not differ among samples ($p>0.05$); meanwhile, astringency was fewer times checked for Rondônia samples ($p<0.05$) and largely ($p<0.05$) in BA, ES, CI, and PA samples. Musty flavor presented higher ($p<0.05$) frequency of mention on samples made PA liquors, and the lowest frequency was observed in samples from organic liquors from PA, RO, BA, and CI. Woody flavor was highly checked for Espírito Santo, OPA, RO, CI, and PA samples; chocolates made with liquors from BA presented the lowest ($p<0.05$) frequency of mentions but did not differ among RO, OPA, and CI samples ($p>0.05$). Quite similar behaviors were observed to smoked, burnt, and green flavors. On the contrary, organic Pará sample presented the highest ($p<0.05$) citation frequency for floral flavors and others presented the lowest ($p<0.05$), although samples from RO did not differ ($p>0.05$) from OPA samples on frequency of ticking the attribute.

The perception map of consumers toward the chocolates is shown in Figure 2. The first two components explained 81.43% of the data variance, being F1 explained 59.09% and F2 explained 22.34%. Consumers perceived chocolate made of cocoa from

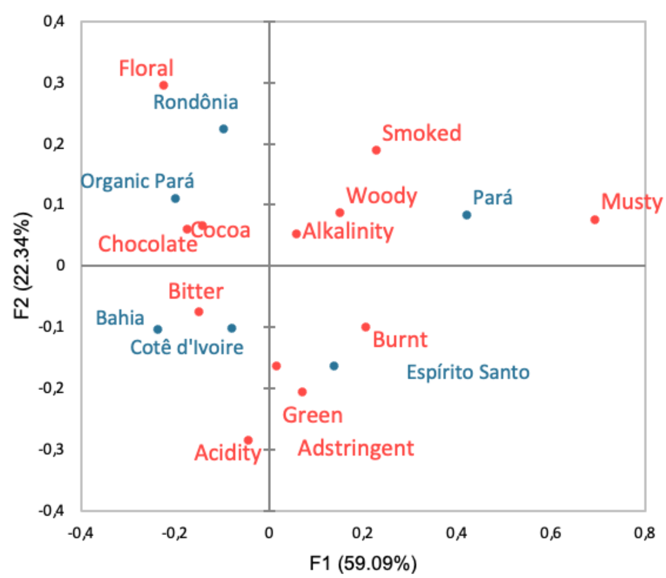

Figure 2. CA biplot of descriptive profile of cocoa liquors by consumers (n=128).

Table 3. Frequency mention of sensory attributes associated with chocolate samples by consumers (n=128) on CATA questions.

	Organic Pará	Rondônia	Bahia	Espírito Santo	Cotê d'Ivoire	Pará
Chocolate	74^{a}	77^{a}	77^{a}	66^{ab}	73^{a}	49^{b}
Cocoa	60^{ab}	57^{ab}	64^{a}	45^{b}	64^{a}	49^{ab}
Bitter	56^{bc}	49^{ab}	64^{ab}	71^{a}	51^{abc}	34^{c}
Acidity	21^{abc}	11^{c}	27^{abc}	37^{a}	32^{ab}	18^{bc}
Alkalinity	22^{a}	14^{a}	12^{a}	20^{a}	20^{a}	21^{a}
Astringent	16^{bc}	14^{c}	29^{abc}	32^{ab}	35^{a}	29^{abc}
Musty	13^{c}	14^{c}	8^{c}	35^{b}	13^{c}	57^{a}
Woody	20^{ab}	31^{ab}	15^{b}	33^{a}	30^{ab}	33^{a}
Smoked	12^{b}	28^{ab}	14^{b}	23^{ab}	17^{ab}	31^{a}
Burnt	22^{b}	18^{b}	16^{b}	42^{a}	29^{ab}	33^{ab}
Green	21^{abc}	11^{b}	22^{ab}	30^{a}	21^{ab}	20^{ab}
Floral	35^{a}	20^{ab}	15^{b}	12^{b}	15^{b}	15^{b}

[a–c]Different superscript letters indicate statistical difference among columns at 5% of significance by Cochran's Q test.

PA to musty, woody, smoked, and alkalinity flavors; chocolate made of liquor from Espírito Santo to burnt, green, and astringent flavors; samples made of cocoa from BA and CI were placed closed and associated with bitterness; meanwhile, those chocolate with RO and OPA were associated with floral, cocoa, and chocolate flavors.

Similarity between samples profile data from DA and CA is shown in Figure 3. Reduction of dimensions by the first two principal components explained 79.82%, being the first component explained 51.29% and the second principal component explained 28.53%. RV coefficient between methodologies was 0.509, which is not high, which can be observed in Figure 3, where chocolates made of liquors from PA and BA were placed far from each other and them were analyzed by trained panel and consumers. Samples from ES and OPA presented close description by both techniques.

4 DISCUSSION

Results from chocolate attributes' intensities from DA (Table 2) show significant differences for most attributes among samples, indicating a wide variety of sensory characteristics of chocolates when the origin and processing of cocoa liquors are changed. In a large review toward chocolate flavors, Toker et al. (2020) reported from the literature that cocoa from Cotê d'Ivoire has low acidity and bitterness; Brazilian beans are entirely acidic, bitter, and astringent, being those from Bahia stand up to smoked flavors; those from America and West India highlight for aromatic and winy notes; meanwhile, samples from Venezuela, Trinidad, or Ecuador possess tea-like and flowery aroma. However, cocoa varieties within Brazil perform different flavor and aroma profiles (Martinez et al., 2021; Menezes et al., 2016; Moreira et al., 2018). Recently, the same panel characterized the same samples for flavor attributes and observed that utilization of liquor from CI produces chocolates that stood out for musty and smoked flavors; cocoa liquor from ES produced chocolates

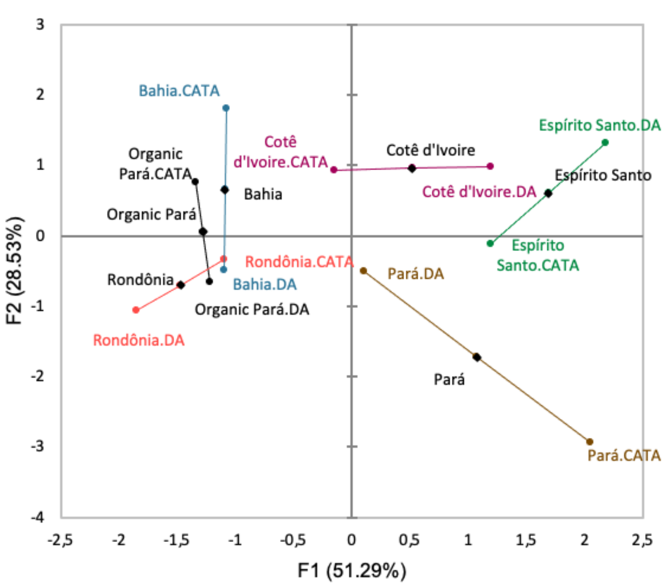

Figure 3. Biplot representation of MFA of the six chocolates evaluated by CATA and DA.

with woody, green flavors; chocolates made with samples from RO highlighted for chocolate flavors; and organic liquors from PA stood out for floral flavors (Cemin et al., 2022). These results show that, when sensory analyses bring more attributes and complex attributes (such as alkalinity and astringency), the chocolate profile changes. Also, although sensory maps change from consumers analysis and trained accessors, it is important to point out that consumers perceived these attributes within the products, indicating that they are important feature to be analyzed by the internal industry's quality control group.

In this study, similar behavior was observed when consumers evaluated the samples by CATA, in which just for alkalinity taste volunteers did not perceive differences ($p>0.05$) (Table 3). Comparison of PCA and CA results shows that the trained panel and consumers characterized the chocolate samples similarly. For example, the trained panel characterized chocolates with Rondônia, Bahia, and organic cocoa from PA as with floral and chocolate flavors (Figure 1). The same behavior was observed by consumers (Figure 2), although the results from CATA placed chocolates made with liquors from CI close to theses samples and volunteers' analyses also characterized them as with bitter and cocoa flavors. It is interesting to note that chocolate and cocoa flavor were placed close to each other in CA analysis (Figure 2), which indicate that, for consumers, both attributes are similar, although trained accessors showed them to be different.

Ares et al. (2015) observed that CATA is not suitable to evaluate products with very similar profile or complex foods. Alexi et al. (2018) observed that the increase in citation frequency of attributes in CATA tasks did not translate into a better discrimination. Thus, based on the DA results (Table 2), which are the data with higher precision and accuracy, chocolates evaluated presented quite different intensities of chocolate flavors (in the range of 4.7–2.1), alkalinity taste (in the range of 5.1–2.9), astringency and alkalinity tastes (in the range of 4.9–1.0 and 5.1–2.9, respectively), musty flavor (in the range of 5.6–1.1), and green flavors (in the range of 4.9–1.0). For cocoa, bitterness, acidity, woody, smoked, burnt, and floral intensities were in slighter ranges, indicating that samples did not present a big similarity.

MFA analysis (Figure 3) showed that all samples showed low convergence between the trained panel and consumers' characterization, which can be seen visually with the distances between the DA and CATA points and summarized by the low RV coefficient (0.509). The results from samples from PA showed the largest variance between the two methods, although data from other samples were also not close to each other, largely due to the disagreement between the descriptive and consumer maps. DA using the trained panel and CATA have shown a close relationship to several foods (Aguiar et al., 2020; Ares et al., 2015; Jaeger et al., 2020; Reinbach et al., 2014; Vidal et al., 2021) and the citation frequency reflecting attributes' intensity (Jaeger et al., 2020; Vidal et al., 2021). Differences between DA and CATA data in this study are probably due to the terms used, which, in some cases, are not fully understood by consumers, and which, unlike trained judges, consumers did not have references for these attributes, having to use their memory individual sensory input during the test. Another relevant issue is that, as some attributes were pointed out by the trained judges as present at low intensity, these may have gone unnoticed by consumers due to the perception thresholds of each individual. This is in line with observed that, when the samples to be evaluated are quite similar and/or complex, consumers-based techniques may present lower performance (Ares et al., 2015). Also, Ares and Jaeger (2015) observed differences between samples description when CATA terms lack a unique definition, are complex, intensity-related, or have hedonic connotations. Thus, the results show the need for care to correlate CATA data with those of the panel trained with chocolates and the terms used with consumers. Further studies are important to deepen the understanding of the relationship of methodologies to contribute to the advancement of consumer science in sensory analysis.

5 CONCLUSION

Sensory quality control parameters used by industry are perceived differently by consumers, mainly those complexes such as alkalinity, and may confuse chocolate and cocoa flavors. Results show the importance of utilization of a consumer-derived list for CATA methodology and that the trained panel can discriminate complex attributes of apparently similar samples, an important issue for critical industrial quality control.

As a limitation, because the consumer sampling was close to the University, the sample is not representative of the Brazilian population, which may introduce some bias in the data. However, this recruitment methodology has been applied in several sensory studies, providing interesting insights into the field; thus, in further studies, a different sampling methodology would be interesting in order to obtain a volunteer's profile more similar to the real population. Also, one kind of chocolate was evaluated (50% of cocoa) and a wider approach is important. In addition, sensory analysis was performed in a controlled environment and does not mimic the reality of chocolate consumption, which would be a home-use test. This is another point for further exploring the topic and conducting tests in more realistic situations. Finally, several other consumer-based methodologies (such as flash profile, sorting, and projective mapping) should also be compared with data from the trained panel. This study provides information of great relevance to the use of residues and food waste, and limitations may not negate the intrinsic value of this study.

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