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Comparison of quick descriptive sensory methods in the evaluation of dulce de leche

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Abstract. Sensory analysis plays a significant role in the food industry that needs to characterize and evaluate its products. Although there are various studies and sensory methods, the fast, dynamic, and low-cost, descriptive evaluations are gaining space in the market, due to the saving of time and financial investment. The Pivot Profile (PP), Projective Mapping (PM), and Check-all-that-apply (CATA) are examples of these tests. This study aimed to evaluate the results obtained by different rapid descriptive methods to provide information on the tasters' perceptions of different brands of dulces de leche, in addition to analyzing and comparing the evaluator opinions regarding the ease and understanding in the execution of sensory evaluations performed. The methods used (PP, PM, and CATA) presented similar results, indicating an excellent discriminative capacity of the attributes and similar sensory maps. Regarding the ease of execution concerning the evaluated test, the CATA method was selected by the tasters as the easiest to perform, followed by PP and PM respectively ($p < 0.05$), strengthening the particularity of each methodology and reinforcing its potential in description of the sensory characteristics of dulces de leche. Therefore, it is possible to highlight the effectiveness of the three descriptive sensory methods used in the evaluation of dulce de leche pasty.

Keywords: sensory analysis, pivot profile, projective mapping, check-all-that-apply.

Introduction

Classical descriptive sensory analyzes, such as QDA (Quantitative Descriptive Analysis), are techniques recognized as adequate for determining food' sensory profiles since they provide detailed, robust information with reproducible results of the evaluated products (Moussaoui & Varela, 2010). However, its application may become unfeasible for small and large companies due to the great diversity of products (Cruz et al., 2013) and the disadvantages of being time-consuming, static, and not considering the dynamics involved consumption (Esmerino et al., 2017).

As an alternative, industries have sought to use fast methods to replace the traditional ones, methods which do not require long training, have a low financial impact, and optimize time and savings for companies (Varela & Ares, 2012). Thus, the use of methodologies involving temporal sensory assessments are highly recommended and are becoming popular in research fields, especially with consumers (Belusso, Nogueira, Breda & Mitterer-Daltoé, 2016; Cadena et al., 2014; Castura, Antúnez, Giménez & Ares, 2016; Fonseca et al., 2016). These methods provide practical information about physiological responses and sensory changes over time, approaching the real perception of food by consumers (Alcaire et al., 2017).

Currently, studies are being carried out with the purpose of comparing new descriptive techniques with traditional methodologies or even comparisons between the rapid techniques themselves (Antúnez, Vidal, Saldamando, Giménez & Ares, 2017; Ares, Deliza, Barreiro, Giménez, & Gámbaro, 2010; Costa et al., 2020; Esmerino et al., 2017; Fleming, Ziegler & Hayes, 2015; Fonseca et al., 2016; Lazo, Claret & Guerrero, 2016; Pearson, Schmidtke, Francis & Blackman, 2020; Reinbach, Giacalone, Ribeiro, Bredie & Frost, 2014; Silva et al., 2020; Vidal et al., 2014). Examples of quick descriptive sensory methods include Pivot Profile (PP), Projective Mapping (PM), and Check-all-that-apply (CATA).

The idea of the PP is to use a comparison strategy, where each product is presented with a stable reference. The evaluators must describe the differences between the sample and the reference (pivot) (Valentin, Chollet, Lelièvre & Abdi, 2012). This method does not impose any descriptor or scale and involves a sequential presentation of the samples (Thuillier, Valentin, Marchal & Dacremont, 2015).

The PM is performed by positioning the samples on a sheet of paper and the data obtained through the Cartesian coordinates X and Y on said paper, with the grouping of terms performed through priorities (Fonseca et al., 2016; Guerrero et al., 2010). This test allows evaluators to define their discrimination criteria, with the addition of information describing each product being common (Alcantara & Freitas-Sá, 2018).

The CATA consists of a set of structured questions, in which the list of terms is presented to the judges, guiding them to select all those that apply to the focus sample (Lee, Findlay, Meullenet, 2013; Meyners, Castura & Carr, 2013). This methodology can collect information through the perceived attributes, without requiring a schedule, thus allowing a less artificial description of the main characteristics of the product being evaluated (Dooley, Lee & Meullenet, 2010).

Multivariate statistical techniques, including principal components analysis (PCA) and hierarchical clustering analysis (HCA) are exploratory methodologies that aim evidence similarity or difference between samples, in a given complex set of data (Tahir, Xiaobo, Xiaowei, Jiyong & Mariod, 2016). Correspondence Analysis (CA) can be understood as a particular case of PCA, being used for categorical data (Greenacre & Blasius, 2006). These tools are used in several scientific studies associated with sensory food analysis (Esmerino et al., 2017; Silva et al., 2020; Vicente, Varela, Saldamando & Ares, 2014).

Dulce de leche is a food commonly produced and sold mainly in Brazil and Argentina (Mologhoni, Valese, Lorenzetti, Daguer & De Dea Lindner, 2016). It is a product obtained by cooking milk and added sucrose, which throughout the process, acquires color, texture, and characteristic flavors due to non-enzymatic browning reactions (Silva et al., 2020). It is widely consumed as a dessert and used as an ingredient in the preparation of other foods such as confectionery, cakes, cookies, churros and ice cream, and is highly appreciated by consumers (Gaze et al., 2015; Queiroz et al., 2020). In this sense, dulce de leche was adopted for this work due to its popularity in the Brazilian territory. Therefore, the sensorial analysis of this product can provide information that helps optimize the production process and, thus, increases its competitiveness in the market.

The objective of this study was to evaluate the results obtained by different rapid descriptive methods, in order to provide information on tasters' perceptions of the different brands of dulce de leche, in addition to analyzing and comparing the opinion of the evaluators regarding the ease and understanding in the execution of the performed descriptive tests.

Materials and Methods

Samples

Five commercial samples of traditional dulce de leche (A1, A3, A5, A7, and A9) were purchased in local stores in the city of Belo Horizonte (Minas Gerais, Brazil). During the sensory test performance, approximately 25 grams of each sample were served to each evaluator, in disposable plastic cups, randomly coded with three-digit numbers, and presented in a balanced way, together with 200 mL of water (for cleaning the palate). All products evaluated were approved by the Federal Inspection Service (SIF) (Brasil, Ministério da Agricultura, 2017).

Evaluators

The Participants were recruited at the University Federal of Minas Gerais (UFMG), among employees, students, and visitors of the institution, through posted posters, e-mail, and social media. They were selected according to consumption habits of *dulce de leche*, motivation and interest in the study, absence of aversion to the product, availability to participate in the analysis, and absence of health restrictions regarding milk and sugar intake. As a result, 60 participants (gender and balanced age group - 65% female and 35%

male, 18 to 54 years old) were divided into three groups made up of 20 evaluators. Each descriptive analysis (Pivot Profile, Projective Mapping, and Check- All-That-Apply) was represented by an evaluation group, with participation restricted to only one sensory test per evaluator, to avoid the learning effect (Esmerino et al., 2017).

Sensory analysis

Sensory analysis was carried out after approval by the Research Ethics Committee (COEP) of the Federal University of Minas Gerais (UFMG), Brazil, under protocol number (CAAE-99674918.2.0000.5149/2018), by signing the Informed Consent Form by the evaluators. Sensory tests were performed at the Sensory Analysis and Consumer Studies Laboratory (LASEC) of the Food Department, at the UFMG Faculty of Pharmacy (FAFAR), during three independent sessions, one for each descriptive analysis and one-day intervals between them. The evaluation took place in individual booths with temperature adjustment and adequate lighting, certifying evaluator comfort and privacy (Stone, Bleibaum & Thomas, 2012).

Pivot Profile

The first group of evaluators performed the descriptive analysis of the five dulce de leche samples using the Pivot Profile method. In this test, the dulce de leche were served in pairs (one pair at a time), corresponding to the coded sample together with the pivot sample. Totaling five pairs (Brand A1 - Pivot, Brand A3 - Pivot, Brand A5 - Pivot, Brand A7 - Pivot, Brand A9- Pivot), it is emphasized that the pivot corresponded to one of the studied brands (A9). The pivot dulce de leche was chosen according to the criteria proposed by Esmerino et al. (2017), represented by a product that contemplates the diversity of the evaluated samples.

According to Thuillier et al. (2015), for the Pivot Profile test, the choice of the pivot sample does not significantly affect the descriptive results. Any displayed product can be chosen, directing the selection according to the objectives of the study developed. In this sense, an evaluation form was delivered. The tasters were instructed to report coded sample attributes presented greater or lesser intensity than the pivot sample, leaving them free to describe any characteristics (Fonseca et al., 2016; Lelièvre-Desmas, Valentin & Chollet, 2017).

Projective Mapping

The second group of evaluators were invited to try the five samples of dulce de leche and place them on a rectangular white card with dimensions 40x60 mm (Pagès, 2005), according to their similarities and dissimilarities. According to Cadena et al. (2014), the closer the samples are positioned on the sheet, the more similar they are. Thus, this information is passed on to the tasters. At the end of the sensory test, the evaluators provided a list of sensory descriptive terms, responsible for the positioning performed (Alcantara & Freitas-Sá, 2018).

Check-All-That-Apply (CATA)

Work The third group of evaluators answered the questions of the CATA test, which included 34 sensory attributes related to the characteristics of dulce de leche (Gaze et al., 2015; Giménez, Ares & Gámbaro, 2008; Silva et al., 2020), which are: light brown, dark brown, yellow, caramel color, shiny, opaque, sweet aftertaste, remaining milk flavor, bitter residual flavor, condensed milk flavor/aroma, caramel flavor, milk flavor, characteristic dulce de leche flavor, vanilla flavor/aroma, cooked flavor, sweet aroma, consistent, creamy, liquid, pasty fluid, homogeneous appearance, firm, gelatinous, porous, sweet, salty, very sweet, sour, acid taste, adherent in the mouth and sandy.

The terms were selected based on previous studies with dulce de leche (Hough, Bratchell & Macdougall, 1992) and complemented with those generated in the analyzes of the Pivot Profile and Projective Mapping. Each evaluator was directed to verify and mark on the evaluation form all the attributes considered appropriate to describe the target sample, served monadically.

Ease of testing

At the end of each test, the evaluators were asked to indicate the ease of carrying out the analyzes. The results were obtained using a structured 9-point scale (Esmerino et al., 2017), ranging from "Extremely difficult to perform" to "Extremely easy to perform," having as its central point "neither easy nor difficult to perform", in addition to providing a space for personal comments on the understanding and development of the tests.

Statistical Analysis

After collecting the data obtained in the PP test, the results were tabulated by surveying the number of times each sensory attribute was mentioned as “less intense than the Pivot” (negative frequency), and “more intense than the Pivot” (positive frequency). The negative frequency was then subtracted from the positive frequency, thus obtaining different values, including the negative. Subsequently, all the results obtained were added to the lowest value presented among the reported attributes. Thus, the lowest value in the table assumed zero, and the rest assumed absolute numbers. Correspondence analysis (CA) was then applied, allowing obtaining a two-dimensional map of the results using the free software R, version 3.6.3 (Esmerino et al., 2017; Fonseca et al., 2016; Lelièvre-Desmas, Valentin & Chollet, 2017; Thuillier et al., 2015).

By positioning the cardboard samples, data from the Cartesian coordinates X and Y were obtained (Fonseca et al., 2016; Guerrero et al.,

2010) on PM. The frequency of sensory attribute was determined by counting the number of evaluators who used the term to describe the samples, considering those cited by at least 10% of the evaluators. Finally, a matrix was elaborated, applying Principal Component Analysis (PCA) to obtain a two-dimensional sensory map using the XLSTAT program according to the analysis attributes.

Based on the recommendations made by Meyners, Castura e Carr (2013), the data obtained during the application of the CATA analysis were subjected to randomization and a paired comparison test to confirm the interpretability of the data in detail. The frequency of use of each sensory attribute was determined by counting the number of tasters who indicated the attribute to describe each sample. In order to obtain a sensory map of the samples and show the relationship between the products and the terms of the CATA test, Correspondence Analysis (AC) was applied, generating a two-dimensional graph of the sensory terms described using the free software R, version 3.6.3 (Bruzzone et al., 2015; Esmerino et al., 2017).

Hierarchical cluster analysis

The hierarchical analysis of clusters was performed on the coordinates of the samples in the first and second dimensions, in the spaces defined by the developed descriptive tests (Pivot Profile, Projective Mapping and CATA), in order to identify the group of samples with different sensory characteristics (Sokal & Rohlf, 1962). Hierarchical cluster analysis provides a basis for interpreting the bi-plot and identifying clusters of closely related clusters (Murtaza, Rehman, Anjum & Huma, 2013).

For the analysis, Ward's method was used through the XLSTAT software. In this method, averages of all variables are calculated for each cluster. For each case, the squared Euclidean distance for the cluster means is calculated; the two clusters that merge result in the smallest increase in the overall sum of squared distances within the cluster (Szymandera-Buszka, Waszkowiak, Jędrusek-Golińska & Hes, 2020).

Ease of execution of descriptive methods

The results regarding the ease of execution of the sensory tests were submitted to statistical analysis using ANOVA and the Tukey test averages at 5% probability, using the SPSS version 15.0 pt program.

Results and discussion

Pivot Profile

For the first test developed (Pivot Profile), the descriptive terms of the different brands of dulce de leche were collected in contrast to the pivot sample. One matrix (5x28) was used to obtain the figure and the variation in the score values, considering the number of samples and sensory attributes for this method. The results are shown graphically in Figure 1.

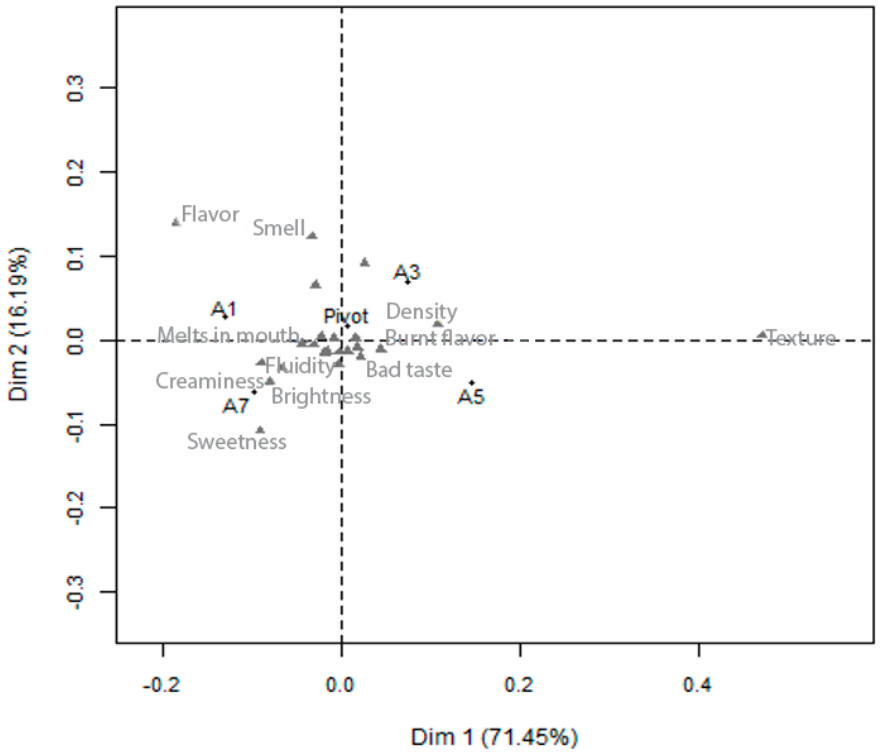

Figure 1. Graphical projection of five samples of dulce de leche (•), with the pivot sample as a supplementary variable and the main sensory attributes (▲), used to describe them in the first two dimensions of the sensory map generated by the Correspondence Analysis (CA) for Dynamic Profile data.

According to the graph, the first and second dimensions of correspondence analysis represent 87.64% of the total data variance. The first dimension (DIM 1) was strongly positive for the

attribute "texture" and negatively correlated with the descriptor "flavor." The second dimension (DIM 2) correlated positively with the attribute "flavor" and negatively with the descriptors "sweetness" and "bad taste."

The attribute "bad taste" was related to sample A5 in the second graphic dimension. This characteristic was presented only for this brand of dulce de leche. The descriptors "sweetness," "brightness," and "creaminess" were associated with sample A7 and "flavor" and "smell" of dulce de leche with the product A1. Samples A3 and Pivot (A9), grouped in the upper right quadrant and related to the attributes of "density" and "texture", showed similar descriptors and behavior in both dimensions, both for the strongly characterized attributes and the central ones.

In general, the sensory attributes were distributed in all dimensions. The majority concentrated very close to the intersection of the axes, closely correlated with the central Pivot sample. Therefore, it is possible to observe that, even if not in the same quadrant, there is a correspondence between the different dulce de leche brands.

The Pivot Profile is a relatively new assessment, being applied for the first time in the sensory description of wines (Thuillier, 2007). In the last years, its use has also been observed in studies involving other foods such as honey (Deneulin, Reverdy, Rébénaque, Danthe & Mulhauser, 2018), greek yogurt (Esmerino et al., 2017), and chocolate ice cream (Fonseca et al., 2016).

Projective mapping

One matrix (5x52) was used to obtain the figure and the variation in the score values, considering the number of samples and sensory attributes for projective mapping method. The first two dimensions of the analysis of the main components represent approximately 72.3% of the variance of the experimental data, as shown in Figure 2. It can be seen that the results suggest the formation of four groups, which can be proven in the Hierarchical Cluster Analysis (Figure 4C). The first is composed of sample A3, the second by A9, the third represented by dulce de leche A1 and A7, and finally, the fourth group represented by sample A5, presented in the different quadrants.

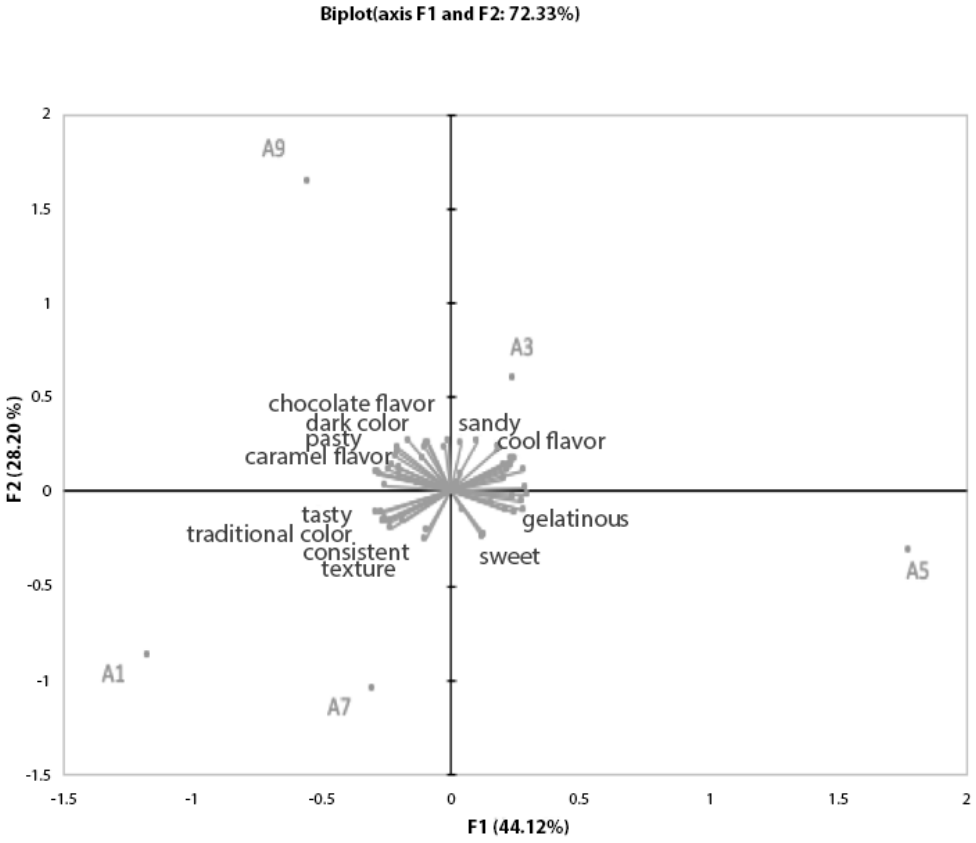

Figure 2. Graphical representation of five samples of *dulce de leche* (●) in the first and second dimensions through Principal Component Analysis (PCA) performed on the Projective Mapping data.

By grouping the samples, one can observe their similarities and dissimilarities, according to the sensory attributes raised by the tasters. Dulces de leche A1 and A7 were closer, showing similarities related to the attributes "color," "traditional dulce de leche flavor," and "consistency."

The other samples (A3, A5, and A9) are arranged distant from each other, in different quadrants. Thus, indicating they have few similarities. The main terms that differentiate them are "texture," "flavor" and "color," with sample A3 being described as sandy and pleasant in taste, A5 with gelatinous texture and sweet flavor; and the A9 with dark color, caramel and chocolate flavor, as well as a pasty texture.

Studies on the use of projective mapping with untrained tasters, in the evaluation of different potato and strawberry genotypes, made it possible to discriminate the samples, with the perception of the similarities and differences of the groups formed through the sensory terms raised by the evaluators (Vicente et al., 2014, 2017). The authors state that the method is simple, economical, allows a proper evaluation of the products, with quick, reproducible, reliable, and robust results.

As the samples were projected in a 2D space, according to Dehlholm (2014), the minimum number of samples used during the analysis to be considered should be four. Thus, the grouping of evaluated dulce de leche in this experiment contemplates the amount of product needed to cover the sheet's dimensions. There are no conclusive studies on the minimum number of judges necessary to carry out the methodology, ranging from eight (Kennedy & Heymann, 2009; Pagès, 2005) to 100 individuals (Esmerino et al., 2017), this definition being related to the nature of the assessed group and with the type of evaluator (trained or untrained).

Check-all-that-apply (CATA)

Figure 3 shows the graphical representation of the sensory terms raised by the tasters for the CATA method. Of the 34 sensory terms presented in the evaluation form, 16 were significant, all of which were mentioned less than ten times, as recommended by Tarancón, Salvador, Sanz, Fiszman e Tárrega (2015). One matrix (5x16) was used to obtain the figure and the variation in the score values, considering the number of samples and sensory attributes for this method.

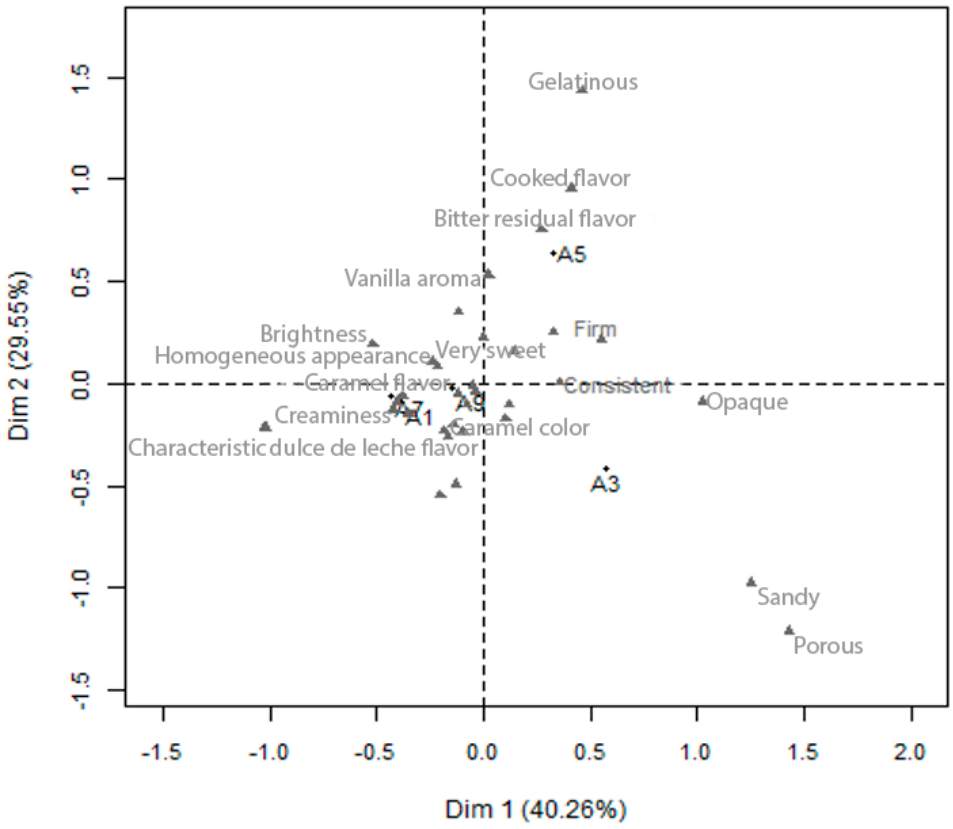

Figure 3. Graphical representation of five samples of dulce de leche (⋆) and their sensory attributes (▲) used to describe them in two dimensions of the correspondence analysis on the frequency presented in the CATA questions.

Three groups of samples were identified from the data analysis, representing 69.81% of the experimental variance. Samples A1, A7, and A9, were distributed in the negative part of both

dimensions, sample A3 in the positive extension of the first dimension and negative in the second dimension, and sample A5 in the positive region of both dimensions.

The graph shows that the dimension (DIM 1) was characterized strongly positive for the attributes "opaque," "sandy," and "porous" and negatively correlated with the descriptor "characteristic dulce de leche flavor." The dimension (DIM 2) was positively correlated with the "gelatinous" attribute and negatively correlated with the "sandy" and "porous" descriptors.

Sample A5 was associated with the terms "firm," "gelatinous," "very sweet," "cooked flavor," and "bitter residual," the last two attributes being associated with the negative characteristics of the product, making it different from the others. The milk caramel A3, located in the fourth quadrant, with the terms "caramel color," "opaque," "sandy" and "porous," demonstrating that its most striking peculiarities are related to texture and color.

The attributes "characteristic flavor of dulce de leche" and "creaminess" correlate with samples A1, A7, and A9, making it possible to state that tasters were able to identify similar characteristics, demonstrating similarity between the three brands of dulce de leche.

Della Lucia, Gomes, Nachtigall, Cavalcante e Minim (2003) characterized seven commercial brands of dulce de leche pasty by quantitative descriptive analysis to determine the sensory attributes that would best describe the samples. The attributes referred to the texture (consistency, gritty, and stickiness), appearance (brightness and color), and flavor, which allowed for product distinctions and demonstrated the great sensory variability of the dulce de leche available on the market.

The results of dynamic sensory methodologies can provide a real and quick description of different dulce de leche involved in different production processes. With this, rapid tests become important tools for producers, as they can assist them in decision making, improvement in quality procedures, and clarity within a consumption perspective (Silva et al., 2020). Furthermore, according to Gambaro (2018), projective tests are also recommended in the evaluation of consumer perception concerning different sensory messages.

Similarities between descriptive methods

About similarities between descriptive methods, an HCA on the raw data was used to cluster closely related samples in terms of sensory characteristics. The clusters were formed using the Euclidean distance Ward's method as the agglomeration method. When comparing the three methods, had two isolated groups, composed of samples A3 and A5, as shown in Figure 4, except in the projective mapping method (Figure 4C). Although the tests were carried out with different evaluators and from different ways of evaluating the dulces de leche, all enabled the distinction of products. The CATA method (Figure 4B) and the Projective Mapping (Figure 4A) grouped samples A1 and A7, proving similarity between them in both tests.

Regarding the Pivot Profile method, the brands A3 and A5 were associated, however different from Pivot. Although products A1 and A7 were in different quadrants, they also show similarity with the reference Pivot (A9).

One of the main differences of the PP method concerning the other methodologies is its ability to bring quantitative and qualitative results, since, in addition to describing the attributes of the products, it also allows them to evaluate their intensity based on the reference sample. PP is a type of sensory test suitable for descriptive assessment of sample sets, with different degrees of similarity, as it allows for better dispersion of descriptive terms and differs from other rapid taster-based methods (Lelièvre-Desmas, Valentin & Chollet, 2017).

In general, it appears that the tests performed showed similar results, indicating an excellent discriminative capacity of terms and similar sensory maps. In a study by Esmerino et al. (2017) based on the comparison of PP, PM and CATA methods in the sensory characterization of Greek yogurt samples, similar results were also observed associated with the ability to identify the main sensory characteristics in each product, although the sensory profiles varied between the methods.

According to Table 1, Projective Mapping was considered as the method with the lowest degree of ease ($p < 0.05$), with an average result of 5.80, falling within the range from "neither easy nor difficult to execute" to "slightly easy to perform." The Pivot Profile (6.15) corresponding to the range from "slightly easy to perform" to "moderately easy to perform" and CATA (7.15) presenting itself in the "moderately easy to perform" to "very easy to execute range."

The present work strengthens each evaluated methodology's particularity, reinforcing the potential of quick techniques for describing the sensory characteristics of the products. All tests were considered easy to execute according to taster responses, helping to interpret the descriptive terms and more precise associations between the attributes of the caramel.

The main difficulty concerning the PM described by the evaluators is related to the ability to position the samples according to their similarities and dissimilarities. As the main limitation of the test, the hypothesis is raised that the number of samples tested, presented simultaneously to the tasters, may hinder easy discrimination among products. Regarding the CATA test, although the list of attributes was broad, the limitation of the analysis is related to the options of a pre-defined list, and some characteristics may be lost (Thuillier et al., 2015). As for the Pivot Profile, some evaluators mentioned the difficulty in differentiating the intensity of the attributes and using the specific vocabulary to describe the samples.

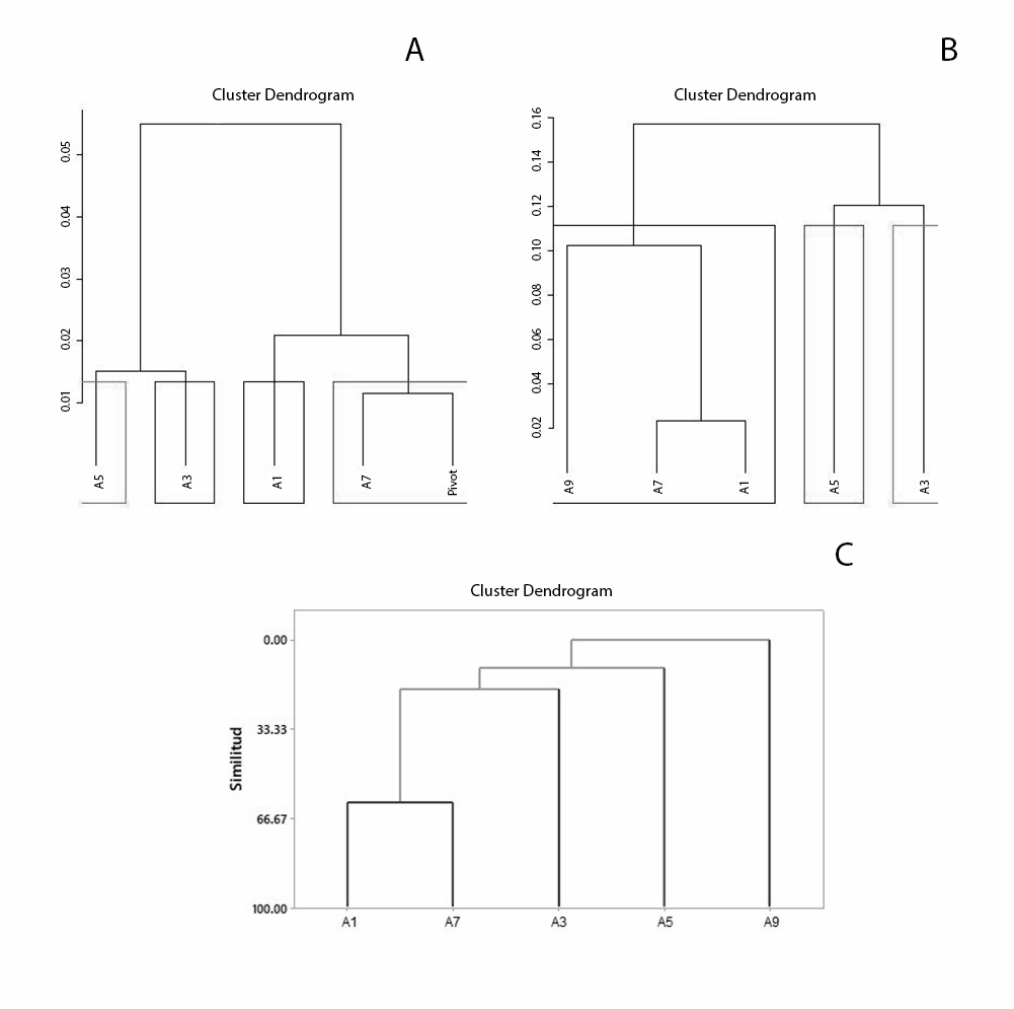

Figure 4. Dendrograms obtained from the Hierarchical Cluster Analysis (HCA) on the representation of five samples of dulce de leche: (A) in the first and second dimensions of the Correspondence Analysis carried out on the Pivot Profile data. (B) in the first and second dimensions of the Correspondence Analysis performed on data from Check-all-that-apply. (C) The first and second dimensions of Principal Component Analysis (PCA), performed on data from Projective Mapping.

Table 1: Average values in evaluating the ease of execution of the Pivot Profile, Projective Mapping, and CATA tests in the sensory characterization of dulce de leche samples by the evaluators.

Descriptive methods	**Ease of execution**
Projective mapping	5.80 ± 0.21 [b]
Pivot Profile	6.15 ± 0.45 [b]
Check-all-that-apply	7.15 ± 0.09 [a]

* Averages followed by the same letter do not differ at the level of 5% significance

Conclusion

According to the results obtained in the application of the rapid tests, it is possible to highlight the effectiveness of the methods used in the description of dulce de leche. The tests carried out showed similar results, indicating the functional discriminatory capacity of terms and similar sensory maps. Furthermore, the three evaluated methodologies (CATA, PP, and PM) provide essential information about the samples and maintain similarities among the attributes selected by the evaluators.

On the other hand, given the test's ease of execution, the CATA method was selected by the tasters as the easiest to perform, which may be related to the information that is already available, leaving the evaluators to perform only recognition activities.

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