Advance Journal of Food Science and Technology 14(1): 6-14, 2018
DOI:10.19026/ajfst.14.5420
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: April 20, 2017 Accepted: June 3, 2017 Published: January 25, 2018

Research Article

Sensory Characterization of Commercial Dulce De Leche with Consumers and Trained Assessors

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Abstract: The objective of this study was to characterize commercial dulce de leche samples by Quantitative Descriptive Analysis (QDA) and affective tests and instrumental color and texture measurements. Thirteen sensory descriptors were assessed as follows: color, brightness, hardness, spreadability, cooked milk aroma, dulce de leche aroma, caramel aroma, sweet taste, milk flavor, dulce de leche flavor, caramel flavor; adhesiveness and firmness. Sample A differed from the other samples for the attributes milk flavor, dulce de leche flavor, caramel flavor, cooked milk aroma, dulce de leche aroma and caramel aroma ($p \leq 0.05$), which contributed to the depreciation of the product`s quality. In contrast, the samples E and F were the most accepted ($p \leq 0.05$) for overall impression and showed greater purchase intention by consumers. Both samples were characterized by the attributes dulce de leche aroma and dulce de leche flavor, which is considered the most important acceptance attributes for this product. In addition, sample E and F presented ideal creaminess and sweetness, respectively. These attributes were less pronounced in sample A, which presented less acceptance and purchase intention among all samples. The results for color and texture of the samples A and B followed the same trend as those obtained in the QDA, while the other samples exhibited opposite behavior. Thus, it is worth emphasizing the importance of the sensory evaluation, which cannot be replaced by instrumental analyses.

Keywords: Affective test, descriptive sensory profile, dulce de leche, Instrumental texture

INTRODUCTION

Dulce de leche is a typical product of Latin America, with Brazil and Argentina being the largest producers and Italy, Spain, Mexico, Uruguay and Chile large consumers (Gaze *et al*., 2015). The creamy dulce de leche is a dairy product similar to sweetened condensed milk, containing approximately 20% sucrose and produced by concentrating the milk up to 68% of total solids by boiling at atmospheric pressure (Ares and Giménez, 2008; Giménez *et al*., 2008). Sodium bicarbonate is also used in the formulation to prevent casein coagulation and favor the Maillard reaction, responsible for the typical brown color of the product (Oliveira *et al*., 2009; De Silva *et al*., 2015). In addition, dulce de leche can be used as raw material in the confectionery industry and also consumed alone or combined with bread, biscuits, cheeses, among other foods, due to its pleasant taste and high nutritional value (Hentges *et al*., 2010).

Dulce de leche is a promising segment in the Brazilian market, with a growing interest in the exploration of the external market such as Europe and the United States (Hentges *et al*., 2010). This fact leads

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Table 1: Definitions and references for the dulce de leche descriptors raised by the sensory team

Attributes		Definition	Reference
Appearance	Brightness	Product's surface capacity to reflect light	Little: Boiled white egg yolk Very much: Karo® corn syrup
	Color	Color of milk with caramelized sugar	Weak: Color Book Palette 10YR9/4 Strong: Color Book Palette 10YR3/6
	Hardness	Ability to spoon penetrate into creamy dulce de leche	Little: Mococa® condensed milk Very much: *Brigadeiro*Moça®
	Spreadability	Ease of spreading with a spatula in cracker biscuit	Little: *Brigadeiro*Moça® stored at 7°C for 2 h Very much: Mococa® condensed sweetened milk
Aroma	Cooked milk	Characteristic aroma associated with cooked milk	None: water Strong: Pasteurized milk type A Fazenda® boiled for 10 min
	Dulce de leche	Characteristic aroma associated with dulce de leche	Weak: 0.3% solution of dulce de leche aroma identical to the natural Citromax ® Strong: Dulce de leche Viçosa® with 1% dulce de leche aroma identical to natural Citromax ®
	Caramel	Aroma associated with caramel	Weak: 1% solution of the caramel coating Marvi® Strong: Caramel coating Marvi®
Flavor	Sweet	Sweet taste associated with corn syrup	Weak: 10% corn syrup Karo® Strong: corn syrup Karo®
	Milk	Characteristic taste of milk	None: water Strong: Pasteurized milk type A Fazenda®
	Dulce de leche	Characteristic taste of dulce de leche	None: water Strong: Dulce de leche Viçosa®
	Caramel	Characteristic taste of caramel	Weak: 1% solution of the caramel coating Ingredient® Strong: Caramel coating Ingredient®
Texture	Adhesiveness	Degree in which the product adheres to the tooth	Little:Mococa® condensed sweetened milk Very much: Butter Toffee® candy milk flavor
	Firmness	Force required pressing the product with the tongue on the palate	Little:Mococa® condensed sweetened milk Very much:*Beijinho*Moça®

to the need for standardization of the manufacturing process, since there is a lack of control during the processing and low equipment efficiency, which negatively affects the quality of the final product. However, several changes have been made in the formulations, including the use of the vacuum system, the increase in solids content in the initial blend and variations in the amounts of ingredients and sequence of cooking (Oliveira *et al*., 2009; Ranalli *et al*., 2012).

Color of dulce de leche can vary from light cream to very dark brown due to the intensity of the Maillard and caramelization reactions during manufacture (Klein *et al*., 2010), affecting the quality of the final product. Thus, measuring the color of this product is quite important (Ferreira *et al*., 2012), requiring sensitive instrumental methods, together with studies on the relationship between instrumental and sensory evaluation (Pauletti *et al*., 1992, 1996).

Sensory evaluation is a very important field of research in the food industry, as it contributes directly or indirectly to numerous activities, such as the development of new products, quality control, cost reduction, process conditions, ingredients and analytical and sensory characterization (Stone *et al*., 2012). Therefore, assessing the sensory profile of creamy dulce de leche can contribute with important information on its characteristics such as color, texture, brightness, among other attributes.

The objective of this study was to characterize commercial samples of creamy dulce de leche using Quantitative Descriptive Analysis (QDA) and affective tests and to perform instrumental color and texture measurements.

MATERIALS AND METHODS

Material: Six commercial dulce de leche samples were purchased from supermarkets in Campinas, SP, coded as A, B, C, D, E and F, of which B was a low-fat sample with 66% fat reduction. Sensory evaluation was carried out in the Laboratory of Sensory Science and Consumer Studies of the Faculty of Food Engineering at University of Campinas (UNICAMP), in individual booths in a temperature and light-controlled room.

Sensory evaluation:

Descriptive quantitative analysis: The Repertory Grid Kelly's Method was used to describe the sensory descriptors of dulce de leche (Moskowitz, 1983). The assessors evaluated 6 samples divided into 3 pairs presented in complete balanced blocks and were asked to describe comparatively the similarities and differences of each sample pair.

After the assessors generated their own terms, a group discussion was held with the purpose of bringing together the similar descriptors and the respective intensity references to compose the descriptive form Table 1.

The assessors were trained in 4 different sessions carried out in different days and a test was performed at the end of the training to define the team. The 6 samples were evaluated in three replicates, using the Quantitative Descriptive Analysis and a 9-cm unstructured scale for each term, as shown in Table 1. The samples were offered in monadic form, in complete balanced blocks (Macfie *et al*., 1989) in individual cabins.

The assessors were selected based on the discriminatory power, reproducibility and agreement between judges (Ibáñez and Damasio, 1991), assessed by two-factor analysis of variance (F_{sample} and $F_{repetition}$) for each assessor for each attribute (Stone *et al*., 2012). The selected team of 8 advisors presented significant values of F_{sample} ($p \leq 0.30$), indicating discrimination between the samples and non-significant $F_{repetition}$ ($p \geq 0.05$) representing reproducibility and agreement between assessors.

Acceptance test and purchase intention: The acceptance and purchase intent tests were carried out in the Laboratory of Sensory Science and Consumer Studies of the Faculty of Food Engineering (UNICAMP) with 124 consumers, representative of the target audience. The acceptance attributes were appearance, aroma, flavor, texture and overall impression. A 9-cm unstructured hedonic scale was used, anchored in the extremes by "I disliked very much" and "I liked it very much" (Stone and Sidel, 2004). Ideal sweetness and creaminess were also evaluated, using a 9-cm unstructured scale, with the central point of the scale corresponding to "ideal" (Stone *et al*., 2012).

Consumers' attitude towards the purchase intention was also evaluated, using a five-point scale ranging from "I certainly would buy" to "I certainly would not buy" (Meilgaard *et al*., 2006).

Instrumental color and texture measurements: The instrumental color was determined in a previously calibrated ColorQuest II colorimeter (Hunterlab, USA). The coordinates of the CIE Lab system (L *, a *, b *) were measured, with L* representing the luminosity (L * = 0 black, 100 white); a* representing red (+) to green (-); and b* representing yellow (+) to blue (-) (Freire *et al*., 2009).

The texture of the dulce de leche was determined using the Texture Analyzer (TA XT2, England) with automatic data acquisition. A cylindrical acrylic probe (60/40) 40 mm long was used, under the following conditions: pre-test and test speed: 1 mm/s, post-test speed 3 mm/s, distance 10 mm and time of 0.5 sec. The following attributes were evaluated: hardness (maximum compression force during the first cycle); cohesiveness (extent to which a material can be deformed prior to rupture, provided by the ratio of the positive first areas under the first and second compression curves, A_2/A_1); adhesiveness (force necessary to overcome the attractive forces between the surface of the food and the surface of other materials with which the food comes into contact, given by the negative force area after the first compression); chewing (energy required to chew a solid product until swallowing, determined by multiplying the values of hardness, elasticity and cohesiveness) and gumminess (energy required to disintegrate a semisolid food until swallowing, given by multiplying the values of hardness and cohesiveness) (De Silva *et al*., 2015). All analyses were performed in triplicate.

Statistical analysis: The results of the acceptance test, color parameters and instrumental texture were analyzed by Analysis of Variance (ANOVA) and Tukey's test at the 5% level of significance ($p \leq 0.05$). The results of QDA were submitted to Analysis of Variance (ANOVA), Tukey's test and Analysis of Principal Components using the SAS statistical program (2012).

The correlation between the QDA and the acceptance data was determined through the Partial Least Square Regression Analysis (PLS) using the XLStat program (2012).

RESULTS AND DISCUSSION

Descriptive quantitative analysis: The performance of the assessors was analyzed by the p $F_{sample}$and p $F_{repetition}$, as shown in Table 2. The assessors who presented p $F_{sample} < 0.30$ and p $F_{repetition} > 0.05$ and group consensus were selected for the test. Thus, eight assessors were selected for the Descriptive Quantitative Analysis of dulce de leche.

The main descriptors selected through the Grid`s method to evaluate the sensory profile of dulce de leche corroborated with those described by Giménez *et al*. (2008).

The descriptors and their respective brands (A, B, C, D, E and F) obtained in the Quantitative Descriptive Analysis are shown in Table 3.

Color represents one of the main sensory characteristics of dulce de leche (Pauletti *et al*., 1992). As can be seen in Table 3, sample D presented the highest score for this attribute when compared to the others ($p \leq 0.05$), followed by the samples F and E, with no significant difference between them ($p \geq 0.05$). However, these samples presented higher scores when compared to the samples B, C and A. In contrast, the sample A had the lowest score ($p \leq 0.05$).

Differences in dulce de leche color may be due to the changes in processing, such as initial acidity of milk, amount and stage of addition of sodium bicarbonate, reducing sugars content and cooking conditions (time, temperature and vapor pressure) (Della Lucia *et al*., 2003; Ferreira *et al*., 2012).

Sample F had the lowest score for the attribute brightness ($p \leq 0.05$). According to the list of ingredients stated on the label, this sample did not contain glucose, which may have influenced the lower brightness, since glucose increases the brightness of dulce de leche due to its bright physical structure (Gaze *et al*., 2015).

Sample B presented the highest score for the attribute hardness ($p \leq 0.05$) and the lowest score for

Table 2: P-values of F_{sample} and $F_{repetition}$ of analysis of variance for each assessor per attribute

		Assessors							
Attribute		1	2	3	4	5	6	7	8
		pF_{sample}							
Appearance	Color	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Brightness	0.0001	<0.0001	<0.0001	0.0061	0.0071	0.0015	<0.0001	0.0033
	Hardness	0.0084	0.0008	0.0038	<0.0001	0.1553	0.0142	0.0739	0.0061
	Spreadability	0.0035	0.0187	0.1812	0.0150	0.0331	0.2569	0.8734	0.8138
Aroma	Cooked milk	<0.0001	0.0020	0.2617	0.0004	<.0001	0.0006	0.0001	0.0213
	Dulce de leche	<0.0001	<0.0001	<0.0001	<0.0001	0.0007	<0.0001	<0.0001	<0.0001
	Caramel	0.0017	0.0002	0.0043	<0.0001	0.0080	0.0157	0.0001	0.0033
Flavor	Sweet	0.5319	0.2012	0.0006	0.0001	0.0768	0.1162	0.1689	0.0443
	Milk	<0.0001	0.0164	0.1745	0.0004	0.0200	<0.0001	0.6003	0.0297
	Dulce de leche	0.0004	0.0013	0.0017	<0.0001	0.0019	<0.0001	0.0001	0.0002
	Caramel	0.0017	0.0002	0.0043	<0.0001	0.0080	0.0157	0.0001	0.0033
Texture	Adhesiveness	0.7519	0.0088	0.0131	0.1216	0.0371	0.0075	0.0052	0.0874
	Firmness	0.0006	0.0065	0.0020	0.0221	0.8564	0.0144	0.0004	0.5787
Attribute		$pF_{repetition}$							
Appearance	Color	0.5920	0.2107	0.8516	0.3621	0.7945	0.9822	0.1812	0.2690
	Brightness	0.4404	0.4889	0.1389	0.8898	0.9404	0.1936	0.0814	0.3169
	Hardness	0.1587	0.3510	0.5909	0.3196	0.6699	0.0314	0.6474	0.7031
	Spreadability	0.5758	0.0107	0.6950	0.1508	0.6378	0.0357	0.7912	0.8097
Aroma	Cooked milk	0.9546	0.2608	0.8588	0.0870	0.0481	0.9583	0.1599	0.1275
	Dulce de leche	0.1059	0.5228	0.0908	0.2117	0.9027	0.2020	0.8759	0.5883
	Caramel	0.2705	0.1973	0.7692	0.4815	0.0994	0.8729	0.8536	0.8658
Flavor	Sweet	0.5243	0.9804	0.2698	0.1199	0.1053	0.3546	0.0315	0.6864
	Milk	0.9805	0.3388	0.0410	0.7304	0.5341	0.0360	0.5438	0.2664
	Dulce de leche	0.4502	0.2740	0.9354	0.2910	0.9626	0.3367	0.7715	0.3448
	Caramel	0.2705	0.1973	0.7692	0.4815	0.0994	0.8729	0.8536	0.8658
Texture	Adhesiveness	0.0427	0.4060	0.0076	0.5289	0.7986	0.0030	0.2069	0.7502
	Firmness	0.0064	0.0824	0.0210	0.3696	0.4746	0.0009	0.4919	0.4993

Table 3: Mean[1] scores for the descriptors[2] of the dulce de leches defined by the assessors in QDA

	Appearance						
Descriptors	A	B	C	D	E	F	MSD[3]
Color	1.28^{e}	6.09^{c}	5.48^{d}	7.89^{a}	6.53^{b}	6.73^{b}	0.3429
Brightness	5.68^{b}	4.03^{c}	7.56^{a}	5.92^{b}	5.68^{b}	2.55^{d}	0.6095
Hardness	4.22^{c}	5.85^{a}	4.88^{b}	5.90^{a}	4.20^{c}	3.87^{c}	0.4663
Spreadability	5.10^{c}	3.79^{e}	5.61^{b}	4.45^{d}	5.33^{bc}	6.11^{a}	0.4711
	Aroma						
Cooked milk	3.00^{a}	1.16^{bc}	1.05^{c}	1.17^{bc}	1.53^{b}	1.30^{bc}	0.3974
Dulce de leche	1.07^{d}	4.50^{c}	4.60^{c}	4.83^{bc}	5.22^{b}	7.71^{a}	0.4693
Caramel	0.97^{c}	3.25^{b}	5.45^{a}	5.40^{a}	5.23^{a}	3.41^{b}	0.6406
	Flavor						
Sweet	5.91^{c}	5.94^{c}	6.15^{bc}	6.54^{ab}	6.78^{a}	6.09^{bc}	0.4628
Milk	2.76^{a}	1.15^{cd}	0.91^{d}	1.22^{c}	1.13^{cd}	1.82^{b}	0.309
Dulce de leche	1.75^{e}	4.79^{cd}	4.60^{d}	5.30^{bc}	5.70^{b}	7.36^{a}	0.5289
Caramel	1.25^{c}	5.77^{b}	6.46^{a}	6.45^{a}	6.41^{a}	5.68^{b}	0.3767
	Texture						
Adhesiveness	4.65^{b}	5.55^{a}	4.71^{b}	5.24^{a}	4.52^{b}	3.69^{c}	0.3613
Firmness	4.53^{b}	5.56^{a}	4.35^{b}	5.32^{a}	3.68^{c}	3.34^{c}	0.4316

[1]Means±standard deviation in the same line accompanied by the same letter are not significantly different by the Tukey's test ($p \geq 0.05$); [2]Descriptors defined by the assessors; [3]MSD: Minimal significant difference

spreadability ($p \leq 0.05$). In addition, greater adhesiveness and greater firmness were observed in relation to the other samples ($p \leq 0.05$). Whereas it is a light sample, it contains thickening agents (xanthan, guar gum and sodium alginate) in its formulation, which probably affected the appearance and texture of the product. Opposite results were found for the sample F, which presented lower hardness, greater spreadability, lower adhesiveness and lower firmness when compared to the other samples ($p \leq 0.05$). According to the information stated on the label, this sample had no ingredient in its formulation to increase product's viscosity, such as thickening agents (gums, starch, pectin, among others) (Ferreira *et al*., 2012; De Silva *et al*., 2015).

Sample A presented higher scores for milk flavor and cooked milk flavor ($p \leq 0.05$) and lower scores for dulce de leche and caramel flavor and aroma ($p \leq 0.05$). Probably the manufacturing process of sample A was different from the others, with a lower intensity of the Maillard reaction during processing. The Maillard reaction is a chemical interaction between a free amino group of the protein with a reducing sugar and is responsible for the taste, aroma and color of dulce de leche (Gaze *et al*., 2015).

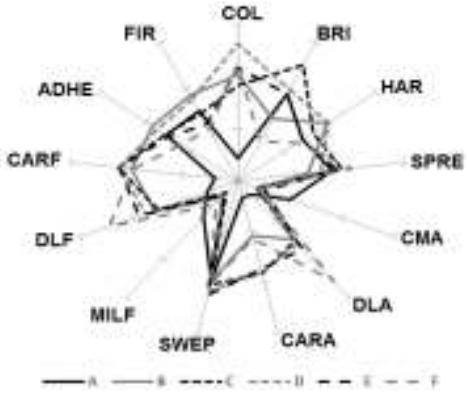

Fig. 1: Diagram representation of the results of the descriptive quantitative analysis of the sensory evaluation of commercial dulce de leche samples (A, B, C, D, E and F). Descriptors: Color (COL); Brightness (BRI); Hardness (HAR); Spreadability (SPRE); Cooked Milk Aroma (CMA); Dulce de leche aroma (DLA); Caramel aroma (CARA); Sweet flavor (SWEF); Milk flavor (MILF); Dulce de leche flavor (DLF); Caramel flavor (CARF); Adhesiveness (ADHE); Firmness (FIR)

Figure 1 shows the spider diagram of the sensory evaluation of commercial dulce de leche and the heterogeneity in the descriptors.

As previously discussed, the differences between the brands may probably be due to the use of different ingredients and processing methods. In addition, regional factors have a great influence on products' characteristics, since the industries seek to meet the regional consumers' preferences (Della Lucia *et al*., 2003).

The Principal Component Analysis (PCA) graph is shown in Fig. 2. Each dulce de leche sample and its repetitions are represented by three points, each point corresponding to an average of the repetitions attributed by the sensory team.

The samples are located close to the vectors that characterize them. Two major components accounted for 72.2% of the total variability between samples. According to Minim (2010), values above 70% corresponding to the accumulative PC 1 and PC 2 are considered representative. Sample A was characterized by cooked milk aroma and milk flavor. Samples B and D were characterized by the attributes firmness, adhesiveness and hardness. Sample C was characterized mainly by the attributes brightness, caramel aroma and caramel flavor, while the samples E and F were characterized by the dulce de leche aroma, dulce de leche flavor and spreadability. These results corroborate with the results found in QDA (Table 3).

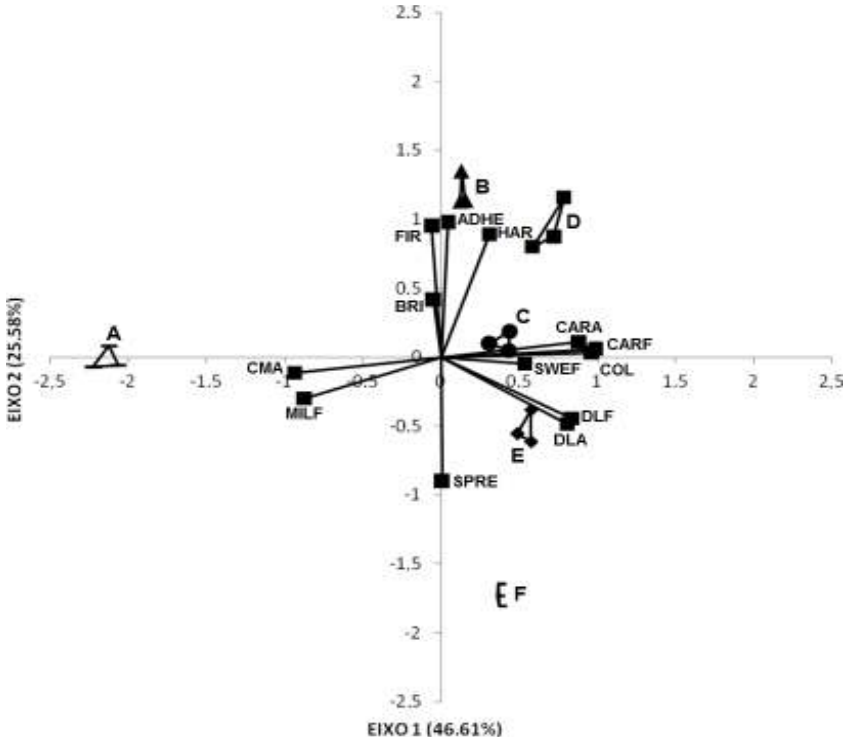

Fig. 2: Principal Component Analysis (PCA) graph. Each dulce de leche sample (A, B, C, D, E and F) and its repetitions are represented by three points, each point corresponding to an average of the repetitions attributed by the sensory team.Descriptors:Color (COL); Brightness (BRI); Hardness (HAR); Spreadability (SPRE); Cooked Milk Aroma (CMA); Dulce de leche aroma (DLA); Caramel aroma (CARA); Sweet flavor (SWEF); Milk flavor (MILF); Dulce de leche flavor (DLF); Caramel flavor (CARF); Adhesiveness (ADHE); Firmness (FIR)

Table 4: Mean[1] consumer acceptance scores for the attributes appearance, aroma, flavor, texture and overall impression of dulce de leche from brands A, B, C, D, E and F

Sample	Appearance	Aroma	Flavor	Texture	Overall impression
A	3.33^{d}	4.83^{d}	5.02^{bc}	5.97^{c}	4.69^{c}
B	5.74^{b}	5.78^{c}	5.34^{bc}	4.67^{e}	5.25^{c}
C	4.88^{c}	5.52^{c}	4.52^{c}	5.30^{d}	4.71^{c}
D	5.81^{b}	6.00^{abc}	6.09^{ab}	6.09^{bc}	5.92^{b}
E	6.73^{a}	6.34^{a}	7.45^{a}	7.09^{a}	6.60^{a}
F	6.05^{b}	6.31^{ab}	6.40^{ab}	6.62^{ab}	6.34^{ab}
MSD[2]	0.6364	0.5488	1.4229	0.6235	0.5925

[1]Means±standard deviation in the same line accompanied by the same letter are not significantly different by the Tukey's test ($p \geq 0.05$); [2]MSD: Minimal significant difference; N = 124

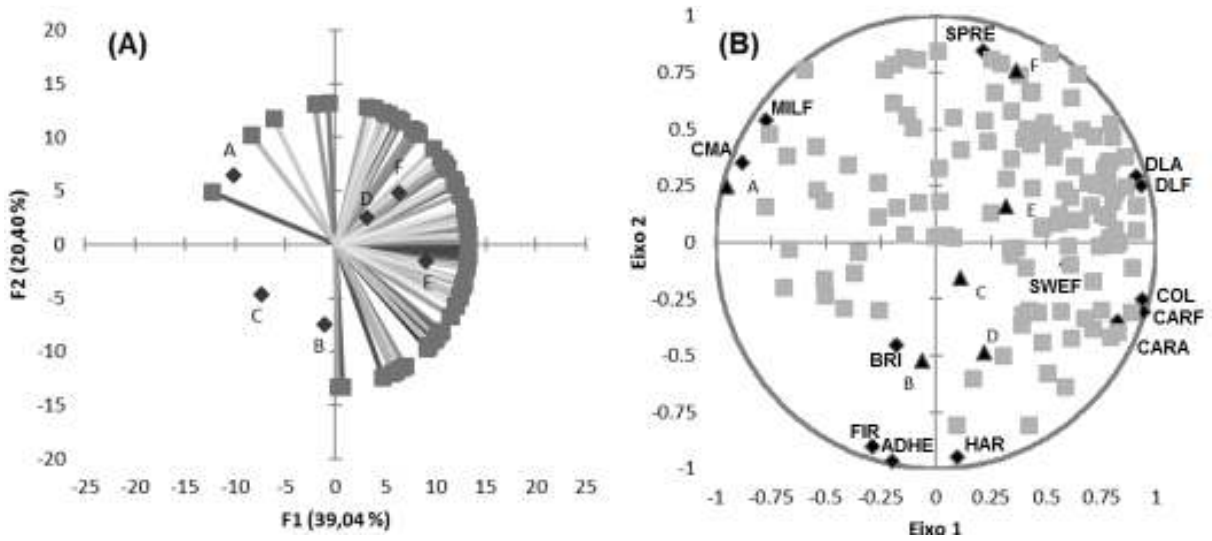

Fig. 3: Internal (A) and external preference maps (B) of commercial dulce de leche samples (A, B, C, D, E and F) considering the individual responses of each consumer.Descriptors:Color (COL); Brightness (BRI); Hardness (HAR); Spreadability (SPRE); Cooked milk aroma (CMA); Dulce de leche aroma (DLA); Caramel aroma (CARA); Sweet flavor (SWEF); Milk flavor (MILF); Dulce de leche flavor (DLF); Caramel flavor (CARF); Adhesiveness (ADHE); Firmness (FIR)

Acceptance tests: Table 4 shows the results of the consumers` acceptance test for the attributes appearance, aroma, flavor, texture and overall impression of the dulce de leche. Regarding the appearance, the sample E differed significantly ($p \leq 0.05$) from the other samples and was the most accepted for this attribute. No significant differences ($p \geq 0.05$) were observed among the samples D, E and F for the aroma and flavor, thus indicating a consumers` preference for these brands. The same was observed for the samples E and F in relation to the texture and overall impression.

An Internal Preference Map (Fig. 3A) was elaborated considering the individual responses of each consumer, which explained 60% of the variability between samples, indicating the consumers` preference for the samples D, E and F rather than A, B and C. In addition, the preference vectors (Fig. 3B) were close to the descriptors dulce de leche aroma, dulce de leche flavor and sweet taste, which best characterized the sample E. This result shows that consumers prefer the samples with aroma and flavor of dulce de leche and higher sweetness.

The samples E and F presented ideal creaminess and sweetness in the consumers' opinion (Fig. 4A and 4B), while the samples B and C were less accepted for these attributes.

Figure 5 shows the results of the consumer's purchase intention of all dulce de leche samples. The highest percentages referring to the descriptions "would probably buy" and "would certainly buy" were found for the samples E and F. These results corroborate with the acceptance test and just-about-right scale for creaminess and sweetness. The highest percentage referring to the description "certainly would not buy" was found for the sample A.

Instrumental color and texture measurements:

Instrumental color: As can be seen in Table 5, significant differences ($p \leq 0.05$) were observed among the brands for the color parameters L, a * and b *, except for the L value of the samples C and F.

The L value represents the brightness and the closer to 100 the greater the luminosity of the sample. The component a* represents the variation from red (-) to green (+) while the component b * represents the

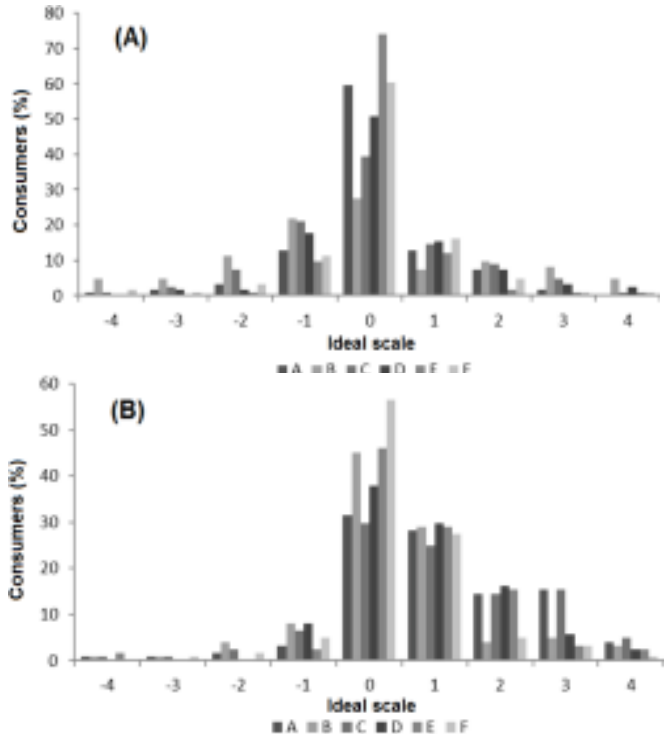

Fig. 4: Frequency distribution of consumers' responses in the just-about-right scale for creaminess (4A) and sweetness (4B) of dulce de leche A, B, C, D, E and F

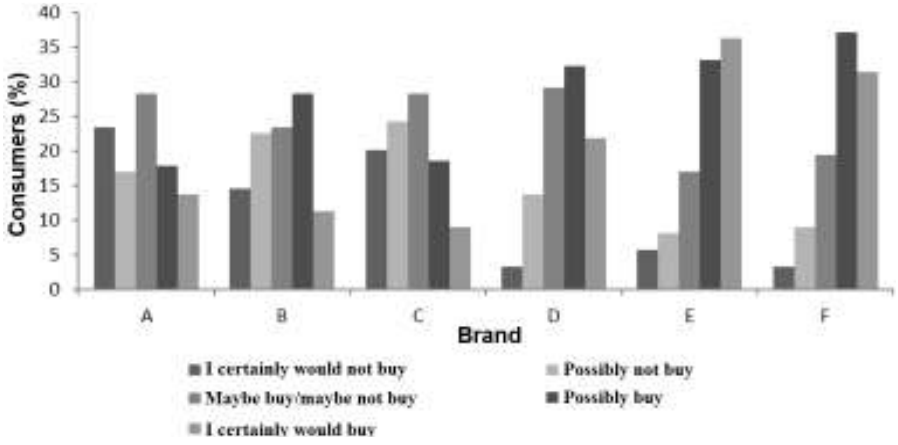

Fig. 5: Frequency distribution of the scores corresponding to the purchase intention of dulce de leche A, B, C, D, E and F

Table 5: Means and standard deviation[1] of the color and the instrumental texture parameters of dulce de leche from brands A, B, C, D and E

Sample	L	a*	b*	Hardness
A	56.20±0.43^{a}	6.433±0.05^{f}	24.61±0.19^{a}	127.44±4.61^{a}
B	45.86±0.005^{b}	10.50±0.17^{d}	20.92±0.28^{c}	145.66±21.02^{a}
C	39.65±0.41^{d}	10.05±0.27^{e}	18.75±0.43^{e}	132.74±13.74^{a}
D	36.63±0.16^{e}	11.01±0.16^{c}	16.26±0.25^{f}	106.39±4.67^{b}
E	43.30±0.30^{c}	12.98±0.12^{a}	23.48±0.05^{b}	112.80±1.61^{b}
F	40.29±0.11^{d}	12.46±0.11^{b}	19.46±0.03^{d}	118.36±7.02^{a}
Sample	Adhesiveness	Cohesiveness	Gumminess	Chewiness
A	-341.68±13.11^{ab}	0.730±0.005^{a}	93.05±3.57^{ab}	85.25±3.00^{ab}
B	-416.07±75.23^{a}	0.703±0.03^{ab}	102.14±12.21^{a}	86.14±6.81^{a}
C	-284.74±44.46^{bc}	0.673±0.02^{b}	89.38±10.99^{ab}	79.81±9.69^{ab}
D	-201.37±22.09^{c}	0.667±0.01^{b}	71.02±4.15^{b}	64.03±3.22^{bc}
E	-264.35±1.45^{c}	0.699±0.004^{ab}	78.83±0.74^{b}	70.58±0.89^{bc}
F	-260.75±11.75^{bc}	0.683±0.006^{b}	80.78±4.60^{b}	72.13±5.12^{abc}

[1]Means±standard deviation in the same line accompanied by the same letter are not significantly different by the Tukey's test ($p \geq 0.05$)

variation from yellow (-) to blue (+) (Ranalli *et al*., 2012).

Sample A was considered the brightest sample, since it presented higher L and b * and lower a* values. Sample D presented lower L and b * values and intermediate a* value, thus being considered the darkest sample. These results confirm those observed in the Qualitative Descriptive Analysis (Table 3), indicating that the instrumental analysis was able to predict the sensory evaluation of the samples of the present study.

As discussed earlier, these differences in color may be due to several factors, including process time and temperature, as well as the ingredients used in the dulce de leche formulations (Gaze *et al*., 2015).

Table 5 presents the results of the instrumental texture of the six dulce de leche samples. The samples D and E presented lower hardness values and were statistically different ($p \leq 0.05$) from the other samples. In addition, sample D was considered the hardest sample in the QDA, while sample E was considered the least hard; therefore, in this case, the instrumental analysis was not able to predict the sensory evaluation.

In contrast, the results of instrumental texture corroborated the sensory evaluation of the sample B, since greater hardness and adhesiveness values were observed for this sample in both analyses, in addition to greater gumminess and chewing. As discussed earlier, the sample B corresponds to a low-fat sample, thus itcontains thickeners, which may lead to changes in texture since these ingredients are used to increase the viscosity of dulce de leche (Ferreira *et al*., 2012; Ranalli *et al*., 2012).

Texture is one of the most important quality attributes in dulce de leche because it defines the characteristics of the product for later applications, especially for pasty products. Texture defects can negatively affect the consumers' acceptance, which is, in general, caused by inadequate manufacturing (Ranalli *et al*., 2012).

The texture of dulce de leche is influenced by the milk constituents, including casein, whey proteins and fat globules to a lesser extent. The increase in consistency is directly proportional to the cooking temperature since high temperatures lead to a higher precipitation of β-lactoglobulin (whey protein) on the casein micelles. This interaction between proteins increases the consistency of the dulce de leche due to the lower mobility of the constituents (Gaze *et al*., 2015; Giménez *et al*., 2008; Oliveira *et al*., 2009).

CONCLUSION

The Quantitative Descriptive Analysis demonstrated a great heterogeneity of descriptors in the sensory profile of commercial dulce de leches. Sample A was significantly different ($p \leq 0.05$) from the others for the attributes milk flavor, dulce de leche flavor, caramel flavor, cooked milk aroma, dulce de leche aroma and caramel aroma, which contributed to the depreciation of the product`s quality. This fact was confirmed by the lower acceptance scores of this sample in the consumers' acceptance tests.

The samples E and F stood out in overall impression ($p \leq 0.05$) and purchase intention, besides ideal creaminess and sweetness, respectively.

The results of instrumental color and texture of the samples A and B, respectively, were similar to those obtained by QDA, which was not observed for the other samples. According to the results of the present study, although the instrumental analysis has proven to be a good tool to evaluate color and texture parameters of dulce de leche, it cannot replace the sensory evaluation.

ACKNOWLEDGMENT

The authors would like to thank the São Paulo Research Foundation (FAPESP) for the awarding a scholarship to B. R. C. LeiteJúnior (grant number 2014/17782-4 and 2016/01425-3) and to M. S. Fernandes (grant number 2010/10507-7). In addition, the authors would like to thank the National Counsel of Technological and Scientific Development (CNPq) for the awarding a scholarship to B. Barone.

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