




External preference map to evaluate the acceptance of light and diet yogurt prepared using natural sweeteners

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ABSTRACT: Owing to the high demand for healthier foods, the food industry has been marketing diet and light yogurts. The present study aimed to sensorially evaluate yogurts prepared using natural sweeteners through a simple centroid mixture design with three repetitions at the central point using the preference map methodology. Different formulations were processed using stevia, xylitol, and sucrose in delimited proportions based on the sweetness of the sweetener. A team of tasters was recruited to survey the sensory attributes of the formulations using the check-all-that-apply (CATA) methodology. A product acceptance analysis was also conducted in which 50 consumers evaluated the formulations using a 9-point hedonic scale. After assessing the acceptance, consumers completed the CATA questionnaire. Internal and external preference maps were built using the obtained results. We found high acceptance means (xylitol:stevia:sugar) for F7 (1.0:0:0), F1 (0.5:0:0), and F2 (0:0.5:0.5), which were characterized by a sweet taste, creamy texture, strawberry flavor, fermented milk flavor, and light pink appearance. Formulations with the lowest scores were F6 (0:1.0:0), F3 (0.33:0.33:0.33), and F4 (0.5:0.5:0), which were characterized by a residual and bitter taste, astringent sensation, and inconsistent texture.

Key words: principal components analysis, sensory analysis, fermented milk.

Mapa de preferência externo para avaliar aceitação de iogurte light e diet elaborados com edulcorantes naturais

RESUMO: Devido à grande procura por alimentos mais saudáveis, as indústrias alimentícias vêm introduzindo no mercado os iogurtes diet e light. O presente estudo teve como finalidade avaliar sensorialmente iogurtes produzidos com edulcorantes naturais através de delineamento de mistura centroide simples com três repetições no ponto central pela metodologia Mapa de preferência. Foram elaboradas diferentes formulações utilizando estêvia, xilitol e sacarose em proporções delimitadas considerando o poder adoçante do edulcorante. Uma equipe de provadores foi selecionada para levantamento dos atributos sensoriais dos iogurtes por meio da metodologia Check-All-That-Apply (CATA). Foi ainda efetuada a análise de aceitação do produto em que cinquenta consumidores avaliaram as formulações usando escala hedônica de nove pontos. Após avaliação da aceitação, os consumidores preencheram a ficha do questionário CATA. Com os resultados obtidos foram montados mapas de preferência: interno e externo. Constatou-se maiores médias de aceitação das amostras F7 (1,0:0:0; xilitol:estêvia:açúcar), F1 (0,5:0:0,5; xilitol:estêvia:açúcar) e F2 (0:0,5:0,5; xilitol:estêvia:açúcar) que apresentaram características como gosto adocicado, gosto doce, textura cremosa, sabor polpa de morango, aroma bebida láctea, aparência rosa claro, e as amostras com menores cores foram as F6 (0:1,0:0; xilitol:estêvia:açúcar), F3 (0,33:0,33:0,33; xilitol:estêvia:açúcar) e F4 (0,5:0,5:0; xilitol:estêvia:açúcar) apresentaram características como sabor residual, gosto amargo, sensação adstringente, texturas em consistência.

Palavras-chave: análise de componentes principais, análise sensorial, leite fermentado.

INTRODUCTION

In Brazil, diet and light food products are classified and regulated into different categories; therefore, they have different purposes. For products to be considered light, according to the provisions of Ordinance SVS/MS N 27/98, they must satisfy the low or light attributes for absolute nutrient content (energy value, sugars, etc.). Diet foods are those intended for patients wanting to consume diets with restricted nutrients. Light foods have a minimum reduction of 25% in terms of caloric value or the content of some

nutrients when compared to a similar one. For products to be considered dietary, they must also comply with the provisions of Ordinance SVS/MS N 29/98. Dietary products can be classified as follows: nutrient-restricted foods, carbohydrate-restricted foods, fat-restricted foods, protein-restricted foods, sodium-restricted foods, and other foods intended for specific purposes. Stevia and xylitol are natural sweeteners that are used as an alternative to sugar in diet and light food products (MUSSATTO & ROBERTO, 2002; REIS, 2007).

Stevia leaf extract is approximately 300 times sweeter than sucrose (FREITAS, 2002). Besides

being highly soluble in water and alcohol, non-fermentable, and physically and chemically stable, stevia has several industrial applications, mainly in the food industry. Xylitol is extracted from fruits and vegetables, mainly cereals. Because it has a sweetening power and volume similar to that of sucrose, it is preferentially used as a substitute for sucrose; thus, xylitol can be substituted at the same proportion to reach the desired sweetness without affecting the food mass balance. Further, xylitol contains only 2.4Kcal/g and does not have an unpleasant residual taste (MUSSATTO & ROBERTO, 2002).

The addition of sweeteners to produce diet or light yogurt having sensory characteristics similar to those of traditional yogurt should be conducted with caution owing to the diverse chemical structures or conditions of consumption and storage and their interaction with different food properties. Most sweeteners not only have sweetening properties but also other sensory characteristics that are considered undesirable by consumer, such as a persistent sweet taste, bitter taste, and persistent or non-residual taste (REIS, 2007). Substitution of sucrose by other natural sweeteners requires the application of appropriate sensory techniques. For example, it is necessary to determine the concentration of the sweetener to obtain an equivalent sweetness; it is also important to identify which sweetener has sensory characteristics similar to those of the product being developed (ESMERINO et al., 2015).

Several advanced techniques in sensory analyses, such as time intensity analysis, parallel factor analysis, principal component analysis, comment analysis, and check-all-that-apply (CATA) methodology, are being implemented in the development of new products by the food industry. These techniques are being used to elaborate internal and external preference maps along with attributes generated by the consumer, which reduces the time and cost for the development of new products (ESMERINO et al., 2017).

Some recent studies have applied these techniques, for example, in evaluating the addition of prebiotics and sweeteners in the development of a chocolate dairy dessert (MORAIS et al., 2014). The formulation was developed using a 9-point hedonic scale for appearance, aroma, flavor, texture, and global acceptance attributes, and a parallel factor analysis and principal component analysis to build the internal preference map. Optimization of the milk dessert formulation simultaneously facilitated the evaluation of consumer acceptance of several sensory attributes.

Sensory analysis techniques that use an elaborated product profile have quickly gained acceptance in the food industry. Techniques that

use a direct analysis of the terms generated by the consumer itself are considered easy, do not require any training, and also include information of how a consumer perceives the product. As an example, researchers evaluated different brands of ice cream (FONSECA et al., 2016). Central pivot techniques and comment analysis were effective in characterizing the different chocolate ice cream samples using consumer perception, which had high correlation results. However, they observed that the comment analysis was intuitively performed by the consumers, whereas the central pivot technique presented high analytical and discriminative power, even using consumers, proving this to be a promising technique for routine applications.

The CATA method can be used by consumers to characterize products and to understand the hedonic and sensory characteristics of food products. For each sample, a pre-defined list of sensory descriptors is presented and participants are instructed to select all that apply, which is considered an easy and less time consuming method for the tasters (ARES et al., 2014). Three techniques were used for the characterization of sensory attributes of Greek yogurt: central pivot, CATA, and map of projection (ESMERINO et al., 2017); the authors verified that the techniques used to characterize the product with consumers were efficient.

Application of CATA and intensity scale techniques allowed Minas Frescal cheese to be described in a study aiming to improve products based on consumer perception (OLIVEIRA et al., 2017). Samples of whole cheese (in terms of fat content), low fat cheese, and low lactose content cheese were used. The data obtained were used to reformulate the product based on the consumer's perceptions. The CATA questionnaire identified that only flavor was important for the various cheeses evaluated. Results showed that these techniques used should be considered by cheese producers so that they can adjust the manufacturing based on consumer preference.

In an evaluation of six dairy products in the category of cream and processed cheese (traditional, with the addition of starch, and with the addition of starch and vegetable fat), the CATA technique was used to obtain descriptive attributes (TORRES et al., 2017). The authors concluded that the technique is an alternative method to elaborate on the sensory profile of the product and that the technique was similar to a descriptive and discriminant analysis.

Among the methods used to identify a product's acceptability, most evaluations provide acceptance averages, which do not identify consumers

or individual segments (RODRIGUES et al., 2013). As such, the importance of elaborating on preference maps is realized, which makes the evaluation of taster behavior in relation to each sample possible.

A preference map can be divided into two categories as follows: internal (when acceptance data are derived from results obtained by affective tests) and external (when a descriptive analysis is provided by a team of trained judges related to acceptance data and the preference of evaluated products)(SILVA; DUARTE; CAVALCANTI-MATA, 2010). As the external preference map enables a comprehensive and detailed explanation of consumer preferences, it becomes an important tool to visualize the behavior of each taster to the analyzed sample(RODRIGUES et al., 2013). The present study applies an external preference mapping methodology to evaluate the effect of the addition of natural sweeteners (stevia and xylitol at different proportions) in the acceptance of liquid yogurts using the CATA technique for evaluating the sensory descriptors of formulations.

MATERIALS AND METHODS

Preparation of yogurt formulations

Yogurts were processed with the addition of different sweeteners (sucrose, stevia, and xylitol) at different proportions according to a single centroid blend design with three replicates at the center point, as shown in table 1 (NETO & SCARMINIO; BRUNS, 2003). Yogurts were prepared following the method proposed by the yeast manufacturer. Sugar (at a proportion of 8%) was added to the milk (2L) in

Table 1 - Design of simple centroid mixing with three replicates at the central point.

Assay	Sucrose	Xylitol	Stevia
F1	0.500	0.500	0.000
F2	0.500	0.000	0.500
F3	0.333	0.333	0.333
F3	0.333	0.333	0.333
F3	0.333	0.333	0.333
F4	0.000	0.500	0.500
F5	1.000	0.000	0.000
F6	0.000	0.000	1.000
F7	0.000	1.000	0.000

Zero indicates absence and 1 is the maximum amount of the ingredient (80g xylitol, 80g sucrose, or 91g stevia).

the formulations before heat treating the raw material at 80°C for 30 min. After cooling to 40°C, yeast (RICA NATA) was added in a lyophilized form along with a lactic culture of *Streptococcus thermophiles* and *Lactobacillus delbruecki* subsp. *Bulgarius*. The milk was fermented for approximately 12h in a thermal box until the acidity of the dough was between 72°D and 75°D. The mass was broken, the strawberry preparation (5%) of the PROREGI brand and the sweeteners were added (xylitol and stevia at different proportions based on the initial milk volume). The obtained product was then manually packed in polyethylene bottles and stored at 8°C.

Microbiological analysis

Microbiological analyses were performed following the method described by SILVA et al. (2017). Coliforms at 35°C and 45°C were evaluated using the most probable number (MPN) technique. Three series of three tubes were used for sample dilutions of 10⁻¹, 10⁻², and 10⁻³ and results were expressed as MPN.mL⁻¹. For molds and yeasts, the surface plating method was used with a potato dextrose agar culture medium and Drigalsky's handle; one milliliter of the yogurt sample was seeded, followed by incubation at 25°C for 5d. All experiments were performed in duplicate. Results were expressed as colony forming units (CFUs), mL⁻¹.

Sensory analysis

Sensory analysis was performed with regular consumers of yogurt; students and employees of the Instituto Federal do Sudeste de Minas, Campus Barbacena, who showed an interest in participating were enrolled. Samples were identified by random three digits and were served in plastic containers that were free of any odor.

Acceptance testing

The formulations were evaluated with 50 tasters in complete blocks balanced following the method of BRASIL (2005) and the overall impression according to the hedonic 9-point scale according to BELSITO et al. (2017). Approximately 20g of each formulation was served at 12°C. Water was served to the consumers to wash their palate between testing of each sample. The analyses were conducted once the free and informed consent of the tasters was obtained.

Sensory attributes

A pre-selection was performed with 30 consumers following the method described by MINIM (2010). The triangular test was applied in three sessions in which three samples of yogurt

were offered, two being equal and one being different. Consumers were asked to identify the different sample. Criterion used to select tasters was minimum 60% accuracy for all tests applied.

Descriptive thermology was developed by the Network method (MOSKOWITZ, 1983) with pre-selected tasters aged between 20 and 42 years (10 women and 2 men). In this section, samples of light and traditional yogurts were acquired from local commerce followed by a list of possible attributes. A list of descriptive sensory terms (flavor, taste, aroma, texture, and color) that characterized the sample was prepared. The team, tasters, and a mediator met and, through an open discussion, chose by consensus the most appropriate and important sensory terms that actually described the yogurt samples. The terms were used to compile the CATA form. Approximately 20g of the formulations at 12°C, which were under study, were presented to 50 consumers. Water was served to consumers to wash their palate between each sample. All consumers were asked to record all possible flavor, aroma, texture, taste, and color attributes according to the CATA test sheet (Figure 1) to describe the evaluated product (ARES et al., 2014). The sample presentation order was balanced.

Statistical analysis

The acceptance test results were evaluated using analysis of variance (ANOVA) and a regression

analysis using the MINITAB 15® software. The attributes chosen by the trained team were used to elaborate the internal and external preference maps through the SENSOMAKER® software. For the preparation of the internal preference map, the samples were used as the abscissa (X axis) and the consumers' scores were used as the ordinate (Y axis) in SENSOMAKER®. The software preprocesses the data using a correlation matrix. The plot was a vector type. For the preparation of the external preference map, the formulations were used as the X axis and the frequency of the descriptors obtained with the CATA method were used as the Y axis. Data were pre-processed by SENSOMAKER® through a correlation matrix and plotting vector-type graphs using $\alpha=0.20$, in agreement with the consumers.

RESULTS AND DISCUSSION

Microbiological analysis

The nine samples evaluated presented satisfactory results when compared to the limits established by current legislation (BRASIL, 2007), which limits values for indicative samples: Total Coliform less than 100MPN.mL⁻¹, Coliform at 45°C was lower than 10MPN.mL⁻¹ and Yeasts lower than 200CFU.mL⁻¹ for indicative sample.

Sensory analysis

Twelve tasters matched >60% of the applied tests and were selected to participate in the

Name: _____ Date: _____

Indicate with X, the most appropriate characteristics to describe this yogurt sample.

Sample code _____

Attribute Appearance	Attribute Aroma	Attribute Texture	Attribute Taste	Attribute Flavor
<input type="checkbox"/> Pink salmon	<input type="checkbox"/> Fermented milk	<input type="checkbox"/> No consistency	<input type="checkbox"/> Sweet	<input type="checkbox"/> Strawberry pulp
<input type="checkbox"/> Light pink	<input type="checkbox"/> Artificial strawberry	<input type="checkbox"/> Creamy	<input type="checkbox"/> Bitter taste	<input type="checkbox"/> Residual Sweetener Flavor
<input type="checkbox"/> Presence of strawberry pulp		<input type="checkbox"/> Consistent with strawberry pulp	<input type="checkbox"/> Acid	<input type="checkbox"/> Astringent
<input type="checkbox"/> Absence of strawberry pulp				<input type="checkbox"/> Sweetish

Figure 1 - Datasheet specified in the check-all-that-apply test.

attribute survey. The terms that best characterized the yogurt samples were selected by the team after discussion and consensus (Figure 1). A new results for processed yogurts in which the regression model was statistically significant ($\alpha=0.05$) are presented in table 2. Results of *t*-test of the coefficients at the 5% probability level were also significant (Table 3). The mathematical model used was as follows: equation (1)

The coefficients of Eq. (1) indicated that acceptance of the yogurt is better when high proportion of sugar and xylitol is used. As the stevia ratio increases, product acceptance decreases. Results of the evaluation of samples sensory acceptability are graphically represented in Figure 2. Use of xylitol did not promote rejection by the consumers and was within the range of acceptance, unlike the sample with stevia that had a higher index for a minor addition.

Figure 3 graphically represents the internal preference map, high light in the behavior of BRASIL (2007) tasters in relation to sample acceptance for the overall impression attribute. Consumers are Figure 3 graphically represents the internal preference map. Consumers are represented by the vectors and samples are the squares. The closer the vectors and squares, the greater the acceptability of the samples; a greater distance between them indicates a greater rejection by tasters. Samples with a lower proportion of stevia presented a greater acceptance, except for F2 (0.5:0:0.5), which was accepted but was further away from the vectors.

Table 4 shows the absolute frequency of each CATA term used by the tasters to describe the yogurt samples. Data obtained by the CATA method for each descriptor term together with acceptance data of the yogurts were evaluated by means of an external preference map. For the external preference map, we used a vector model considering $\alpha=0.20$ with 32 consumers out of a total of 50, which resulted in a correlation coefficient of $R^2=0.7975$. This justifies the change that occurred in the acceptance of samples F2 and F4. The first two principal components

Table 2 - Analysis of variance of the global acceptance of yogurts

Source	Degrees Freedom	Mean Square	F	p
Regression	2	3.2060	6.27	0.034
Linear	2	3.2060	6.27	0.034
Residue	6	0.5117		
Lack of fit	4	0.7459	17.21	0.056
Pure error	2	0.0433		
Total	8			

Table 3 - Coefficient of regression of the global acceptance of yogurts.

Predictor	Coefficient	P
Sucrose	7.836	0.00
Xylitol	7.516	0.00
Stevia	4.916	0.00

$R^2 = 0.676$.

(PC1 and PC2) explained 64.29% of experimental data variance (37.81% and 26.48%, respectively).

The attributes of a light pink appearance (APRC), sweetish (GAD), milk flavor aroma (ABL), strawberry flavor (SMOR), sweet taste (GDC), consistency with strawberry pulp (TPM), and creamy texture were identified in the formulations F1, F5, and F7. Sample F4 stood out as having the creamiest texture (TCR). Sample F6 was separated from the vectors; it presented a residual flavor (SRES), bitter taste (GAM), and texture without consistency (TSC). Sample F3 was classified as astringent (SADST) and F2 had an acid taste (GAC) and an artificial strawberry aroma (AMAT), (Figure 4).

CICCONE; DAMY-BENEDETTI (2017) verified acceptance in relation to sweetness, residual taste, overall acceptance, and preference of cola-type soft drinks in the zero, light, and stevia versions. Stevia version comprised 50% sugar and 50% stevia and had an acceptance value of seven (moderately liked) for all attributes analyzed. This finding is similar to the acceptability of our F2 formulation.

MAIA et al. (2008) elaborated on and evaluated consumer preference for ice cream formulations (cream, strawberry, and chocolate) sweetened with sucrose and xylitol. Ice cream sweetened with sucrose was preferred over xylitol; however, the acceptability of xylitol was considered high for the general appearance of the ice creams. YUYAMA et al. (2008) developed a "cubiu" (*Solanum sessiliflorum* Dunal) jelly sweetened with xylitol and observed that its acceptability had similar results.

REIS (2007) studied the elaboration of strawberry light yogurts with different sweeteners, such as sucralose, aspartame, aspartame and acesulfame-k mixture, cyclamate and saccharin mixture, cyclamate, and saccharin and stevia mixture, using the internal preference mapping methodology. Similar product acceptance results were reported for processed yogurt with cyclamate, saccharin, and stevia, which presented with an initial and final bitter taste as the main characteristic and was the least accepted by consumers. BARBOSA (2009) reported similar results regarding the acceptance of light

Table 4 - Frequency of citation of the descriptor terms used to characterize the yogurt evaluated by the CATA method.

Attributes	Sigla	Formulations						
		F1	F2	F3	F4	F5	F6	F7
Light pink appearance	APRS	19	14	33	31	20	3	24
Light pink appearance due to presence of strawberry pulp	APRCM	9	14	10	4	7	6	8
Pink salmon appearance	APRS	10	12	11	5	10	8	11
Aroma of fermented milk	ABL	40	33	53	39	40	33	44
Artificial strawberry aroma	AMAT	10	33	22	10	9	17	6
Texture without consistency	TSC	6	4	17	6	1	11	2
Creamy texture	TCR	32	26	47	28	39	29	33
Consistent with strawberry pulp	TPM	12	20	10	15	10	9	15
Sweetish	GAD	31	19	29	24	17	6	26
Sweet taste	GDC	15	25	6	16	30	5	20
Bitter taste	GAM	2	6	25	8	0	31	0
Acid taste	GAC	2	45	15	2	3	8	3
Residual sweetener flavor	SRES	10	10	28	16	2	38	5
Strawberry flavored pulp	SMOR	36	37	24	25	45	5	39
Astringent sensation	SADST	3	2	22	6	3	6	5

F1, xylitol/sucrose; F2, sucrose/stevia; F3, sucrose/stevia/xylitol; F4, xylitol/stevia; F5, sucrose; F6, stevia; and F7, xylitol.

yogurt with stevia. UMBELINO (2005) reported the behavior of concentrated mango juice and frozen mango pulp, both reconstituted and sweetened with different sweeteners. A similar sensory characteristic

was observed when using stevia as the sweetener; it presented significantly higher attribute averages for residual bitterness, bitterness, and acidity. BRITO (2009) evaluated the sensory behavior of

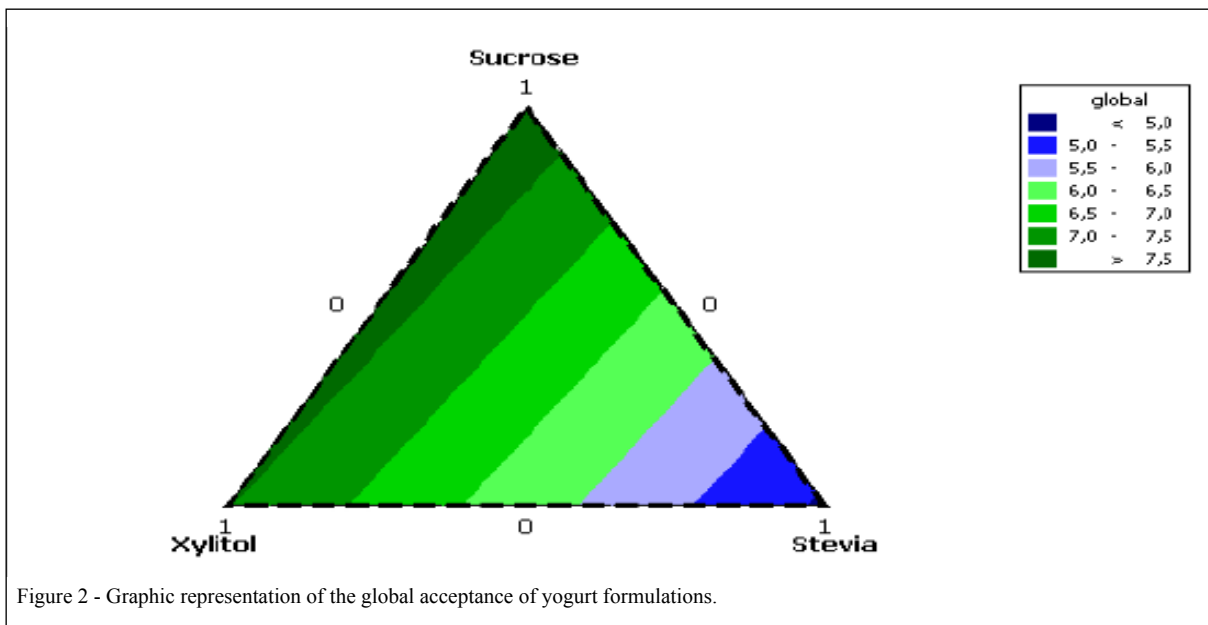
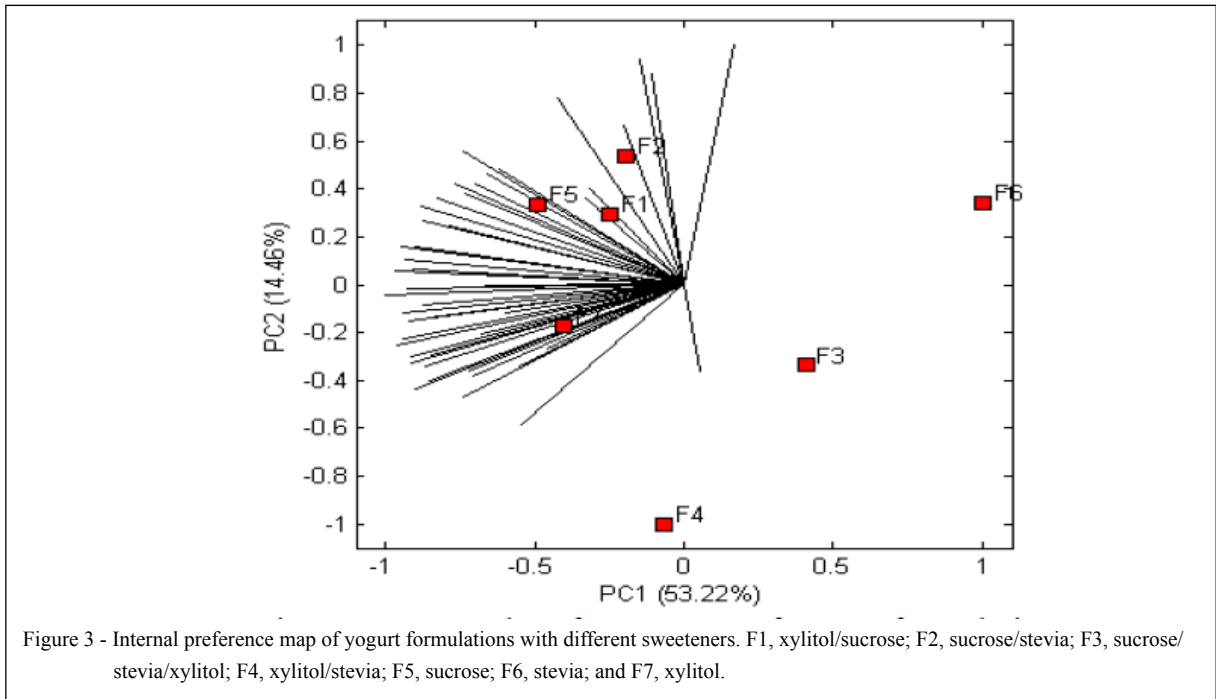


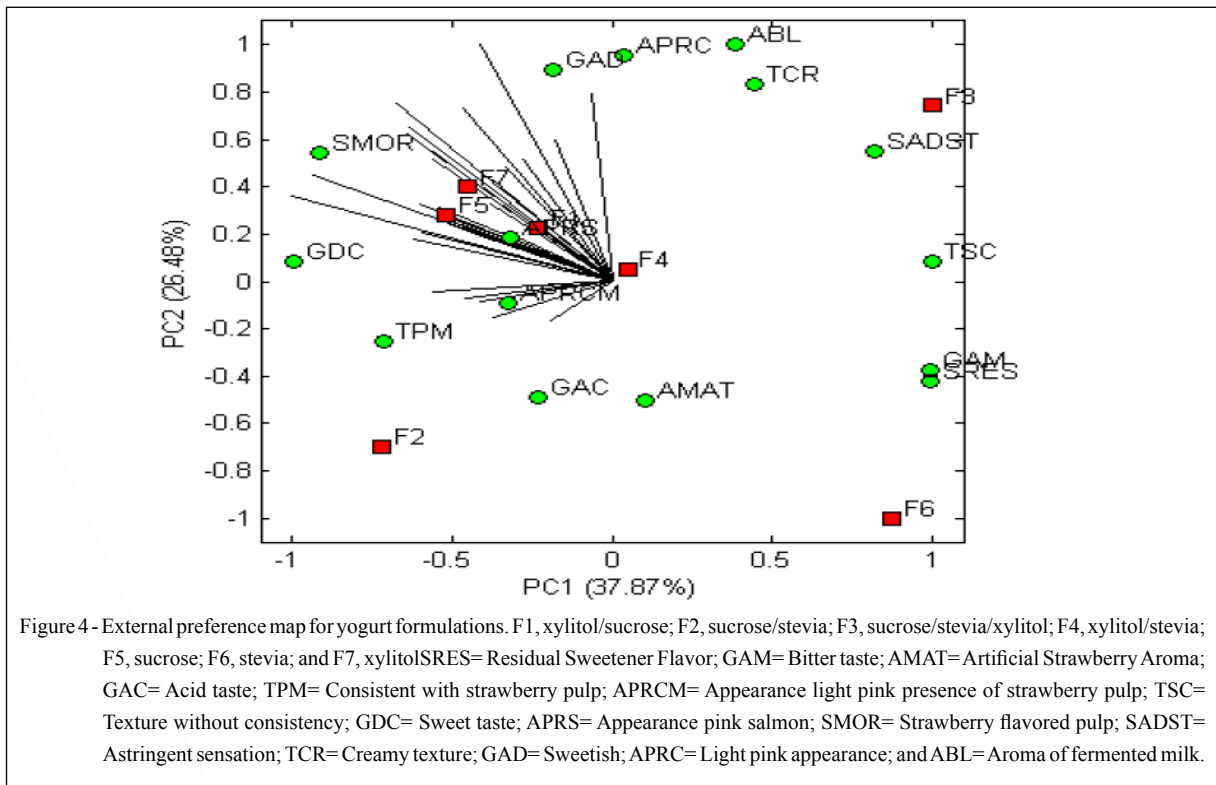
Figure 2 - Graphic representation of the global acceptance of yogurt formulations.



different sweeteners in a guava pulp light drink (guava nectar) using different sweeteners. Stevia has a distinct behavior, presenting with a sweet taste, bitter taste, residual sweetness, residual bitterness and aroma, and a characteristic herb

flavor, thereby resulting in a lower acceptance rate.

The use of the simple centroid mixture design with three replicates at the central point allowed us to define the sensory attributes of the formulations; together with the CATA technique,



it elucidates how these attributes affect product acceptance. At the same time, the procedure allows to define the proportions of the sweetener mixtures for product acceptance. Results obtained reinforced the evaluation of the sweetening power of sweeteners conducted by ESMERINO et al. (2013), PAIXÃO et al. (2014), and ESMERINO et al. (2015).

Multivariate statistical techniques are very useful for analyzing complex data obtained from consumers or trained tasters. Advanced sensory techniques allow acquisition of relevant information about sensory attributes from the consumer. It is worth mentioning that the descriptors obtained from the consumer depend on several factors, because they are complex interactions between the product and the consumer, including consumer personality and previous familiarity and experience with the product (GAZE et al., 2015; JANIASKI et al. 2016).

The CATA methodology is a technique that has been used to gather information about the perception of consumers regarding the sensory characteristics of a product. The CATA questionnaire format allows consumers to choose all possible attributes to describe the product from a list. The terms in the list can be generated by a panel of trained evaluators or by a group of consumers. As the method responses are directly linked to the consumer's perception of product characteristics, these responses can be used to optimize product acceptance. The CATA methodology is efficient for describing and discriminating among products, and its main advantages are the simplicity and speed at which the analyses are conducted. Studies comparing its efficiency with the use of trained evaluators report high correlations among the evaluations, which evidenced that consumers are able to evaluate sensory attributes in a similar way. The main limitation is that the attribute intensity is not quantified, i.e., it is not possible to select a lower power of discrimination when the samples have small differences in attribute intensity (ALCANTARA; FREITAS-SÁ, 2018).

CONCLUSION

Formulations F1 (0.5:0:0.5) and F7 (1.0:0:0) had high acceptance scores, which presented characteristics of sweet taste, creamy texture, strawberry pulp flavor, dairy drink aroma, and light pink appearance. Formulations F6 (0:1.0:0) and F3 (0.33:0.33:0.33) were less accepted because of their characteristics of residual flavor, bitter taste, astringent mouth feel, and inconsistent texture. Formulations containing xylitol are best suited for the manufacture of strawberry diet and light yogurts, because the sensory profile was the one that most approached traditional yogurt.

ETHICS COMMITTEE

This study was approved by the Human Research Ethics Committee of Instituto Federal do Sudeste de Minas Gerais (Opinion No. 2,104,000).

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DECLARATION OF CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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