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Research article

Comparison of three sensory characterization methods based on consumer perception for the development of a novel functional cereal-based dessert

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Abstract: Milk can be modified by several processes to yield numerous kinds of food products with specific functional properties besides increasing the food value. This study aimed to evaluate the effect of various concentration of cereal flours (10–16%), inulin (6 and 8%) and sugar (2 and 4%) on sensory characteristic, consumer acceptance and drivers of liking of a new low sugar/fat prebiotic dairy dessert. In this way, descriptive analysis with trained panelists and three consumer profiling techniques were used and the agreement between them was compared. Nine samples of desserts with different concentration of flour, inulin and sugar were formulated using a mixture design. The samples were evaluated by a panel of 120 consumers, randomly divided into three groups of 40, who evaluated sensory characteristics of the desserts using intensity scale, or a check-all-that-apply (CATA questions) or open-ended questions. Results revealed that various concentration of cereal flours, inulin and sugar resulted in significant changes in the sensory properties of the desserts. Adding higher levels of inulin and sugar led to lower intensities in attributes thickness and creaminess. Samples with higher level of flour and lower level of inulin and sugar were liked by consumers and their high intensities in creaminess and thickness drove liking. Results showed that all the three consumer profiling techniques yielded similar information to descriptive analysis with the trained panel. Likewise, sample configurations from the CATA questions were the most similar to those afforded by the panel of trained assessors. These methodologies could be appealing techniques to investigate the relationship between sensory data and consumer description. Moreover, sensory techniques using consumer perception showed to be valuable to develop functional dessert, which is very important in market succession.

Keywords: cereal; check all that apply; intensity scale; open-ended question; prebiotic dessert

1. Introduction

Production of functional foods has become one of the hottest topics in food industries in recent years. The main reason for this trend is the fact that consumers have increasingly identified the relationship between health and diet, hence, are appreciating functional food [1]. Generally, these foods are described as products that provide additional health benefits beyond basic nutrients [2].

Inulin, as a natural constituent of several fruits and vegetables, has a wide range of applications in foods and non-food industries. The widespread use of inulin in food industry is not only due to its nutritional benefits, but also for the sake of its capability as an ingredient in the formulation of novel foods for technological purposes [3]. The technological application of inulin is based on its characteristics as a sugar replace, fat replacer and texturizing factor [4].

Cereal grains contain beneficial constituents such as vitamins, several minerals (especially micronutrients such as iron and zinc), dietary fiber and phytochemicals with antioxidant properties [5]. Multigrain blends of these cereals can offer food products with number of advantages associated with these grains. Mixing different grains enables to maximize their nutritional, functional and sensory properties [6].

Combining cereals and milk provides opportunity to increase the nutritional value of cereal based products [7]. Milk desserts are extensively consumed products worldwide, and are prepared from milk, sugar, modified starch, hydrocolloids, flavorings and colorants; hence, cereal flours can be well incorporated into such desserts to enhance their nutritional values and diversify them. For production of fereni, a well-known traditional cereal-based dessert in Iran, about 4–6% rice flour and 10–12% sugar is added to cold milk; upon heating a thickened and palatable dessert is achieved. Traditionally, dairy desserts in the markets have a large amount of sugar and likely fat. High intake of sugar and fat has been linked to several diseases. The dairy industry must decrease the fat and sugar content of processed foods, which is a main challenge as products have to be reformulated while maintaining their popularity and engaging properties [8]. It has been reported that consumers are hardly willing to compromise on the taste of functional foods for eventual health benefits. In this regard, launching a functional food with desirable sensory characteristics is one of the main challenges [9]. Overall, through the development and improvement of food products, companies should attempt to satisfy consumers' wants and needs, as well as their perception of their food products, so as to guarantee the products' achievement in market [10].

Sensory evaluation is a key step in food product development. Many researchers have studied sensory properties of milk desserts using trained assessor panel [11-13]. The high specialization of descriptive panels permits obtaining very detailed, robust, consistent and reproducible results, stable in time and within a certain sensory space [14]. However, making and maintaining a well-trained calibrated sensory panel can be entirely costly. Small food companies usually cannot tackle it, and it could even mean a significant expense for large companies if they have an extensive variety of products that require various panels working in parallel [14,15]. Furthermore, in order to obtain accurate, discriminating and precise results, checking and monitoring panel performance is essential [16]. It is very noteworthy for food manufacturers to know how consumers describe the sensory characteristics of food products. There is pressure from the industry to develop alternative methods that remove the need to train a sensory panel, as well as to gather sensory information directly from consumers [17]. In this context, a broad range of new methodologies is presented, which allows to carry out sensory characterization in short time frame without the need to train an assessor panel. These methodologies have achieved great popularity in recent years [15,18]. It has been reported that the application of intensity scales for identifying consumer's perception about intensity of various sensory properties could be a good alternative to descriptive sensory method. Recently, the performance of check-all-that-apply (CATA) questions in various food products has been reported. CATA method consists in asking the consumers to select from a list all the attributes that apply to each sample without forcing them to rate the intensity of the attributes. It has been claimed that CATA questions are a simple, quick and easy method to identify determining factors of consumers' acceptance for a given food product [19]. On the other hand, open-ended format is one of the newest forms of questions used to obtain information concerning consumers' perception of sensory properties of foods. In open-ended questions, consumers are allowed to voluntarily express their evaluation and therefore, their responses encompass valuable information that could emphasize and complete quantitative results from trained assessor panels [20]. However, even though many studies have reported application of consumer based test in dairy desserts evaluation, there has not been any research reported on the functional cereal-based dairy desserts.

Taking the above into account, the objectives of the present research were: (a) to determine the drivers of liking of new functional desserts through descriptive profiling and consumer testing, (b) to compare results acquired from the evaluation of a trained assessor panel with consumers' perception.

2. Materials and Methods

2.1. Ingredients and sample preparation

Sugar powder, milk powder, whole wheat flour, corn flour, saffron and rosewater were purchased from the local market. Kappa-Carrageenan was supplied by Robertet (Can, France). Stabilized whole oat flour (inactivated fat hydrolyzing enzymes) was donated by Seed and Plant Improvement Institute (Karaj, Iran). Pure stevia powder (stevioside 80%) which is 100–150 times sweeter than table cane sugar was obtained from Herbo Veda, India. Inulin (Frutafit® TEX!) was obtained from SENSUS (Netherlands) (average chain length ≥ 22 monomers). For preparation of the nine dessert samples, the amounts of milk powder (10%), carrageenan (0.02%), saffron (0.02%), stevia (0.02%), and rosewater (3%) were kept constant. The desserts were formulated by varying the concentration of mixed cereal flours (50% oat flour, 25% wheat flour, 25% corn flour), inulin and sugar, according to mixture design (Table 1). The rest of the formulation consisted of water up to 100%. In order to determine the ranges of variables, pretests were conducted to obtain prebiotic low-sugar desserts with acceptable sensory properties. The samples were produced using a Thermomix food processor (Thermomix TN 31, Wuppertal, Germany) at Doosheh Dairy Research and Development Laboratory (Amol, Iran). In order to reduce the raw flavor of cereal flours based on our tradition in production of fereni, they were soaked in a small amount of recombined milk 24 hours before the preparation of the desserts. The other solid ingredients (except for saffron) were mixed with this suspension and then, the remaining water was added and the mixture was stirred at the highest speed for 20 minutes at 90 ºC in the Thermomix. Then, saffron and rosewater were added and the process was carried out for another 3 minutes under mild agitation. The samples were put into plastic containers, sealed to avoid drying and stored refrigerated (4–6 ºC) for 24 hours, prior to their evaluation.

Table 1. Concentration of cereal flours, inulin and sugar of dessert samples in a mixture design.

Sample	Mixed Cereal Flours (%)	Inulin (%)	Sugar (%)
1	10	6	2
2	10	8	2
3	14	8	4
4	16	8	2
5	10	6	4
6	16	6	4
7	10	8	4
8	16	6	2
9	13	7	3

2.2. Sensory evaluation

2.2.1. The panel of trained assessors

(1) Selection of assessors

A group of 7 panelists (ages ranging from 28–52 years old, 5 males and 2 females) were recruited among staff of Doosheh Dairy Research and Development (Amol, Iran), according to their motivation, discriminating capability and liking of dairy desserts. They were previously trained according to ISO guidelines (ISO 8586: 2012) and were experienced for 3 years in sensory evaluation of dairy products

(2) Development of descriptive terminology and panel training

A modified grid method [21] was used to generate sensory descriptors. The basic about the sensory characteristics of milk desserts has been recently reported and their results were also considered in selection of descriptors [22]. The assessors were presented four dessert samples, showing an extensive range of sensory characteristics. These samples included a commercial sample of a dairy dessert and three commercial samples formulated with different concentration of the above mentioned cereal flours (10, 13 and 18%). After three 1-hour training sessions, 14 descriptive terms were defined through panel discussion and redundant terms were kept out by consensus of all the assessors. Finally, nine sensory attributes covering appearance, aroma, flavor and texture were generated. The best descriptors for describing the sensory properties of the desserts and their definition is presented in Table 2. In order to verify consistent use of terms, training was performed.

For this purpose, during the first session of the training, the assessors were asked to evaluate each of the nine attributes using four commercial dairy desserts and four formulated desserts (containing cereal flour) with different texture and flavor characteristics and score their intensity using a 10-cm unstructured line scale labeled with low and high ends. The response is recorded as the distance of the mark from the lower end of the scale. The assessors reached consensus on the scores for each of the samples via open discussion. During the next training session, the assessors were asked to score the mentioned attributes for five of the nine samples, coded with three-digit numbers. Overall, the panels were trained in five 1-hour training sessions. Assessors who presented different rating tendency were provided with further training. Being familiar with the attributes' definitions, pilot tests were carried out over 2 sessions in order to acquaint the panelists with the scaling method as well as to test the panel consonance. Training was proceeded until results presented good repeatability (data not shown). A variation in the scale of ±1 cm was regarded tolerable [22].

Table 2. Definition of the attributes used by the trained assessors' panel

Attributes	Definition
Thickness	Represents the thickness of the food in the mouth after the food is compressed via up and down motions of tongue palate
Gumminess	Sensation related to the difficulty of disintegrating the sample in the mouth, not mixing easily with saliva
Smoothness	Degree in which the food contains granules detected by moving the tongue parallel to palate
Homogeneity	Extension in which the sample is perceived with a unique texture while mixing with saliva
Creaminess	Range of sensation typically associated with fat content such as full and sweet taste, compact, smooth, not rough, not dry, with a velvety (not oily) coating. Food disintegrates at moderate rate.
Sweetness	Intensity of sweet taste
Floury flavor	Intensity of floury flavor
Off-flavor	Total intensity of non-characteristic flavor in the product
Aftertaste	Intensity of residual flavor after swallowing the product

(3) Evaluation procedure

After the training stage, the samples were evaluated. The seven chosen assessors were presented with 20 g of the dessert samples at a temperature 10 ℃ using closed odorless plastic containers coded with a three-digit random number. The assessors were asked to evaluate each attribute and score their intensity using a 10-cm line scale with an anchor weak on the left and strong on the right. All the 9 samples were presented monadically in random order (simple random method) with two repetitions. The test was carried out in a sensory laboratory designed in accordance with ISO 8589 (2007). The panelists cleansed their palates with mineral water prior to each sample evaluation.

2.2.2. Consumer test

One hundred and twenty consumers aged between 19 to 48 years old were recruited to participate in the dessert test at the sensory service center of Shahid Beheshti University. The participating consumers were among regular consumers of dairy desserts. The participants were randomly divided into three groups of 40 each. Respondents filled out a consent form, then they were presented a direction to the test procedure before beginning of dessert assessments. Firstly, in each group, consumers were asked to evaluate the desserts for overall liking using a 9-point hedonic scale that was ranged from "dislike extremely" (1) to "like extremely" (9). Then, each group evaluated the samples using one of the three methodologies: intensity scales, CATA questions and open-ended questions. The samples were served at 10 ℃ in odorless plastic containers codified with three-digit random numbers. Mineral water was served to rinse the mouth between evaluations of the samples. For all the three methods, 20 g of each of the nine samples was presented to the consumers using a balanced complete block design. Similar to evaluations of the panel of the trained assessors, the testing was performed in a laboratory. Many studies have reported the principle of these tests and two comprehensive reviews have been recently published [23,24]. Therefore, details of the tests have not been reported here. For intensity scale, the consumers were asked to try the desserts and rate the intensity of the sensory characteristics using the 10-cm unstructured line scale anchored with "low" at the left and "high" at the right. The sensory attributes were the same as those used by the panel of the trained assessors [11]. For the CATA test, the consumers had to answer CATA questions applied to describe the samples. For selection of terms used in the CATA questionnaire, descriptors applied in the trained assessors' evaluation were considered, besides recent studies involved in the sensory profile of milk desserts [11,22]. Open-ended questions were used to evoke responses from the consumers in their own words, without any prompting or suggestion as to possible answers. The consumers were asked to describe each of the nine samples in their own words, without any restriction in expression. In all three methodologies, each respondent evaluated the nine dessert samples in a single session. No information about the samples was presented, in order to avoid bias.

2.3. Statistical analysis

Trained assessors panel: Analysis of variance (ANOVA) was used for analyzing the trained assessors' scores using samples, repetition and assessors as sources of variation, followed by a Tukey's test ($p < 0.05$). Moreover, principal component analysis (PCA) was done using a correlation matrix of the attributes' scores averaged across the assessors.

Intensity scales: Regarding the consumers' intensity scores for the evaluated attributes, ANOVA was carried out considering samples and consumers as sources of variation. Also, the Tukey's test was used to compute significant differences ($p < 0.05$). Additionally, ANOVA was performed on consumers' overall liking data. PCA was done using a correlation matrix with the means of the evaluated attributes, and the consumers' overall liking scores were considered as a supplementary variable.

CATA questions: Frequency of use of each of the CATA questions was determined by counting the number of consumers who used that descriptor to describe each sample. Cochran's Q tests were run on the table of assessors × products, independently for each attribute to determine significant differences between the samples for each of the terms included in the CATA questions. In order to obtain a bi-dimensional representation of the samples, correspondence analysis (CA) was used on a matrix where the rows were the desserts (9 lines) and columns were the attributes used by the consumers to describe the samples [11]. The consumers' overall liking scores were considered as a supplementary variable.

Open-ended questions: At the first stage, stop words, auxiliary terms and other irrelevant words were excluded from the data, and spelling mistakes were corrected. Then, words with similar meaning were grouped under one category term by three researchers, considering the words synonymous as specified by a Persian dictionary. The researchers conducted a discussion session in order to reach agreement upon the categorization. Categories mentioned by more than 10% of the consumers were opted and frequency of mentioning of each category was determined by counting the number of consumers who used each category to describe the desserts. A frequency table was formed and analyzed using chi-square test and CA. Chi-square was calculated to evaluate differences in the consumers' perception of the products. Finally, CA was used to obtain a 2-dimentional representation of the samples and attributes.

Comparison of the methodologies: Multiple factor analysis (MFA) was conducted to study the relationship between the consumers' responses to the intensity scales, CATA questions, open-ended questions and trained assessors' data [22]. This technique determines the positioning of the samples in a single sensory map. Similarity between the sensory spaces gained with the four methodologies was assessed using the RV coefficient. Statistical analysis was performed by the XLSTAT software for windows version 2016.

3. Results and Discussion

3.1. Trained assessors panel

Table 3 shows mean score and standard deviation for all the assessed sensory attributes of the nine samples. The samples showed statistical differences in all the evaluated sensory attributes except for off-flavor ($p < 0.05$), suggesting that the assessors were able to find out variation among the samples.

Table 3. Attribute means for each sample of desserts evaluated by the trained assessors' panel using 10-cm lines scale.

Attributes	Samples								
	1	2	3	4	5	6	7	8	9
Sweetness	7.2^{abc} (0.6)	7^{bcd} (0.4)	7.6^{ab} (0.6)	6.8^{cd}(0.6)	7.6^{ab}(0.7)	7.5^{ab} (1)	7.8^{a} (0.3)	6.5^{d} (0.8)	7.3^{abc}(0.7)
Creaminess	4.8^{b} (1.1)	2.9^{c} (0.6)	5^{b} (0.7)	6.9^{a} (0.7)	2.9^{c} (1)	6.6^{a} (1)	2.5^{c} (0.7)	6.2^{a} (0.4)	4.9^{b} (1)
Smoothness	6.5^{ab} (0.7)	7^{a} (0.9)	6.4^{abc}(0.6)	6.1^{bc} (1)	7.2^{a} (0.5)	6^{bc} (1.2)	7^{a} (0.9)	5.6^{c}(0.7)	6.5^{ab}(0.6)
Homogeneity	6.8^{ab} (1)	7^{a} (0.8)	7^{a} (0.7)	6.5^{ab}(0.5)	7.3^{a} (0.6)	6.1^{b}(0.8)	7.2^{a}(0.8)	6.5^{ab}(0.8)	7^{a}(0.8)
Thickness	5.8^{b} (1.1)	2.4^{c} (0.6)	6.1^{b} (0.6)	7.3^{a} (0.4)	2.4^{c} (0.4)	7.2^{a}(0.6)	2.1^{c}(0.3)	7.4^{a} (0.7)	5.8^{b}(0.8)
Gumminess	2.5^{d} (0.4)	2.4^{d}(0.6)	3.1^{c} (0.4)	3.3^{b} (0.7)	2.4^{de}(0.4)	3.8^{a}(0.3)	2^{e}(0.4)	3.8^{a} (0.5)	3^{c}(0.4)
Aftertaste	2.5^{c} (0.4)	2.4^{c} (0.6)	3^{ab} (0.3)	3.3^{a} (0.5)	2.5^{c} (0.4)	3.4^{a}(0.7)	2.4^{c}(0.4)	3.4^{a} (0.9)	2.8^{bc} (0.8)
Off-flavor	1.9 (0.3)	1.2 (0.2)	1.4 (0.3)	1.8 (0.3)	1.7 (0.4)	1.8 (0.4)	1.2 (0.5)	1.8 (0.6)	1.2 (0.3)
Floury flavor	2.2^{d} (0.3)	2.4^{d}(0.4)	3^{c} (0.3)	4^{ab} (0.5)	2.1^{de}(0.4)	3.8^{b}(0.4)	1.5^{e}(0.3)	4.3^{a} (0.4)	2.8^{c}(0.4)

Note: Values are the mean of two replications; different letters in each row indicate significant differences ($p < 0.05$). numbers in brackets show standard deviation.

PCA was performed, and the first and second PC components accounted for 83.95 and 8.97% of the variance of the data set, respectively. Figure 1(a) shows a perceptual map based on descriptive analysis of the desserts. The attributes loaded on the first component indicating strong correlation of the attributes with PC1. PC1 was positively correlated to thickness, creaminess and gumminess and negatively correlated to smoothness and homogeneity. A similar result was reported by Bruzzone et al. [11,22]. Additionally, the PC2 was positively correlated to sweetness and negatively correlated to floury flavor and homogeneity. Examination of the pattern of sample distribution in Figure 1 (b) indicated that the samples 4, 6 and 8 located in right side of PC1 had higher intensity in creaminess, thickness and aftertaste, while they revealed less intensity in smoothness and sweetness. The samples 2, 5 and 7 were suited at the left side of PC1, indicating that these desserts had lower creaminess, thickness, gumminess and aftertaste but higher smoothness and sweetness than the other desserts. As anticipated, intensity of thickness increased with the increment of flour concentration. Previous study revealed that with the increment of starch (main component of flour) concentration, volume fraction of solids in starch dispersion would raise and this resulted in rise in yield stress. This phenomenon could be ascribed to the entanglements brought about by the existence of the highly branched, high molecular weight of amylopectin [25-27].

Lower degree of thickness and creaminess for the samples 2, 5 and 7 could be explained by the fact that concentration of flour (starch) was too low in these samples to create a thick and creamy texture. The sample 7 had the lowest thickness among the desserts. Reason for this unexpected event could be attributed to presence of higher level of sugar. In puddings, starch is applied to give viscosity and a smooth texture. Starch gelatinization brings thickness to the solution. During production of pudding, starch granules swell and are fragmented and solubilized to different level in accordance with the intensity of heating and mechanical shear. Texture, appearance and stability of starch-based desserts are influenced by the distribution of starch between swollen granules, fragmented granules and solubilized polymers. At the same time, presence of other ingredients determines starch granules behavior in food systems. Hydrophilic solutes such as sucrose compete for water, and can slow down and prevent starch swelling. Sugars affect gelatinization onset temperature in connection with their impact on water activity and water volume fraction. Sugar reduces the rate of thickening and enthalpy of gelatinization. It is interesting to note that sugar inhibits starch granules from swelling by competing for water, therefore changing the gelatinization temperature [28]. The temperature change is due to the cross-linking (sugar-bridges) between the sugar molecules and starch swelling is constrained. There are a number of recent studies in the literature studying the effect of inulin addition on rheological and sensory properties of dairy products. Zimeri and kokini (2003) reported that inulin did not synergically interact with starch to constitute a three-dimensional network. This conclusion was confirmed when the apparent viscosity decreased with increasing inulin content, suggesting that inulin acted as a diluent to starch and interfered in the force of the network. Inulin has higher water affinity and this decreases its accessibility for starch gelatinization [29]. Tarrega and Costell (2006) studied the effect of adding 6% long-chain inulin (DP $\geq$ 23) on sensory and rheological properties of fat-free milk based desserts, containing various concentrations of starch (2.5, 3.25 and 4%). The authors reported that the capability of inulin as fat substitute was excellent only in samples with 2.5 and 3.25% starch. In desserts with lower starch concentration (2.5 and 3.25%), there was enough water in the system, so that inulin did not influence the starch granule swelling process. For samples with the higher starch concentration (4%), with part of water bound to the inulin chains, swelling of the starch granules was limited, the volume fraction of swollen particles was lower and the system viscosity decreased [3]. With regard to starch content of cereal grains, dessert samples in present study contain at least 5% starch.

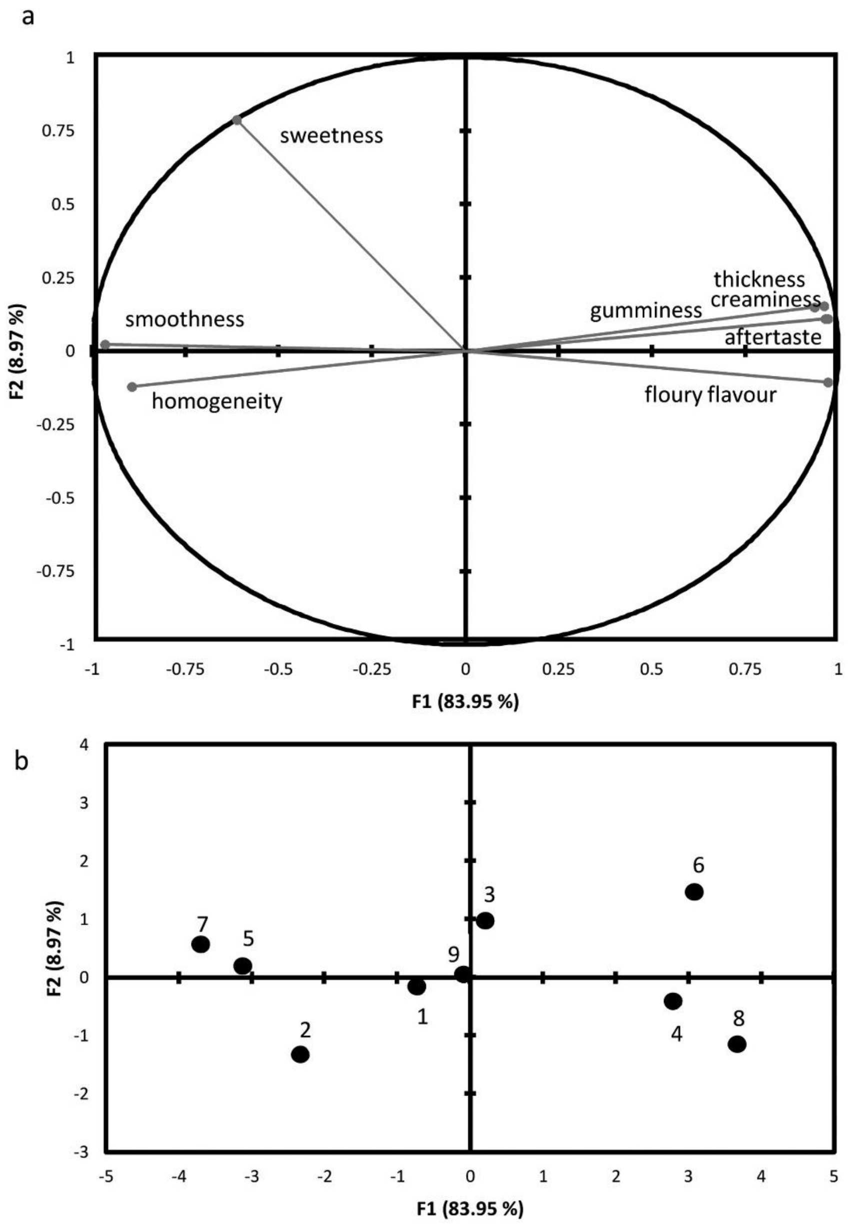

Figure 1. Principal component analysis performed on the correlation matrix of the mean attributes scores of sensory attributes evaluated by the trained assessors' panel: (a) representation of the attributes, (b) representation of the samples.

Lower sweetness perception in samples 4 and 8 can be related to starch concentration. It seems that thicker desserts containing higher level of flour melted slower, coated the mouth more and were perceived to be less sweet than thinner ones.

Therefore, in development of functional dairy desserts, it is important to know to what extent changes in formulation of the product, affect its rheological features and acceptability. By addition of inulin, product structure in particular was influenced, hence, perceived texture were changed. Several investigations have revealed that the prosperous application of inulin as a fat replacer in low-fat dairy desserts depends on the balance of inulin value with the other ingredients present in the formulation [2,3]. In this context, attention must be paid to test different combination of ingredients in formulation in order to attain appropriate combination, so that unfavorable changes which mischaracterize the products are avoided.

Although several studies can be found about creaminess in a wide range of foods in the literature, our understanding is yet restricted. Description of creaminess is difficult and known to be multidimensional [30]. Creaminess was found to depend mainly on smoothness and thickness [31]. In another study, it was found that attributes thickness and smoothness were unrelated, and could not be applied to predict evaluation of creaminess accurately. Conclusion was that creaminess might be more than a combination of smoothness and thickness [32]. In a study about the effect of adding different types of inulin on sensory properties of desserts, it was found that addition of long-chain inulin improved creaminess and consistency of low-fat custards, but reduced smoothness and increased the sensation of roughness [33]. It seems that there is no consensus on topic of creaminess in food products. Creaminess is apparently a complicated attribute and should be seen differently in various food products. Meanwhile, it seems that perception of creaminess relies on consumers' taste and food cultural background and these issues have to be considered in description of sensory attributes of products.

3.2. Intensity scale

The mean score and standard deviation for the intensity of the sensory attributes of each sample are listed in Table 4. According to the results of ANOVA, significant differences were found in all the sensory attributes except for off-flavor ($p < 0.05$). As anticipated, standard deviation was higher for the consumers than for the assessment panel in terms of all the evaluated attributes, ranging from 0.2 to 2.3. This high diversity could be justified by the consumers' lack of training and differences during evaluation [15]. However, contrary to this clear heterogeneity in the consumers' evaluation, the selected attributes were capable to discriminate between the evaluated desserts. It is noteworthy that results of the trained assessment in description of the attributes were almost similar to the consumers' intensity scores. This could be justified considering that, greater number of consumers, as compared with the trained assessors, recompensed the more variability and absence of training of the consumers' panel.

The mean overall liking scores of the evaluated samples ranged from 3.9 to 6.8 as shown in Table 5. Significant differences ($p < 0.05$) were found among the samples' liking scores using the intensity scales as well as the CATA and open-ended questions. The samples 4, 6 and 8 revealed the highest liking score, whereas the samples 2, 5 and 7 revealed the lowest. Generally, overall liking score was greater for the thicker and creamier desserts. Results of overall liking revealed that sample 7 containing 10% flour, 8% inulin and 4% sugar was perceived as the least preferred as compared to the other samples. Producers should emphasize on the descriptors which negatively influence the cereal-based dairy desserts hedonic dimension, because these are possibly the most critical factors for consumer's acceptability and as a result main purpose of buying. Our results revealed that fluid and not creamy make the desserts less pleasant for consumers. Sample 4 containing 16% flour, 8% inulin and 2% sugar was perceived as the most preferred, obtaining the highest mean score values for overall liking.

Table 4. Attribute means for each sample of desserts evaluated by consumers using 10-cm lines scale.

Attributes	Samples								
	1	2	3	4	5	6	7	8	9
Sweetness	7.5^{ab} (1.0)	7.3^{ab} (1.3)	8.0^{a} (2.3)	7.0^{ab} (1.3)	7.5^{ab} (1.8)	6.5^{b} (1.1)	7.4^{ab}(1.7)	6.5^{b} (1.8)	7.8^{a} (1.0)
Creaminess	4.3^{e} (1.1)	2.2^{f} (1.0)	4.5^{cd} (1.5)	6.5^{ab} (1.0)	2.3^{e} (1.4)	6.2^{abc} (1.0)	1.7^{e} (1.1)	6.0^{bcd} (1.0)	4.5^{d} (1.1)
Smoothness	6.9^{bc} (1.3)	7.8^{a} (0.9)	6.8^{bc} (0.6)	6.8^{bc} (1)	8.0^{a} (0.5)	7.0^{ab} (1.2)	7.8^{a} (0.9)	6.4^{bc} (0.7)	6.6^{bc}(0.8)
Homogeneity	7.3^{ab} (1.3)	7.5^{ab} (1.1)	5.5^{c} (0.9)	8.0^{a} (0.9)	7.1^{ab} (1.1)	6.8^{ab} (1.1)	7.5^{ab}(1.1)	6.3^{bc} (1.7)	5.2^{c} (1.7)
Thickness	5.0^{b} (1.6	2.0^{c} (1.3)	5.8^{ab} (1.3)	6.5^{a} (1.7)	2.0^{c} (1.0)	6.3^{a} (0.8)	1.8^{c} (1.0)	6.1^{a} (1.3)	5.0^{b} (0.8)
Gumminess	3.4^{c} (1.3)	3.0^{c} (0.9)	3.9^{bc} (1.2)	4.2^{ab} (1.4)	3.2^{c} (0.9)	4.5^{a} (0.8)	2.9^{c} (0.7)	4.6^{a} (0.8)	3.8^{bc} (0.9)
Aftertaste	2.5^{c} (0.4)	2.9^{cde} (0.7)	3.3^{abcd} (1.0)	3.8^{ab} (1.0)	2.5^{de} (0.8)	3.6^{abc} (0.9)	3.5^{abc} (1.0)	4.1^{a} (1.3)	1.4^{a} (0.3)
Off-flavor	1.9 (0.7)	1.4 (0.2)	1.5 (0.4)	1.5 (0.5)	1.8 (0.4)	2 (0.7)	1.4 (0.5)	1.9 (0.7)	1.4 (0.3)
Floury flavor	2.2^{de}(0.9)	2.3^{e}(0.4)	3.0^{bc}(0.1.1)	2.5^{cde} (0.8)	2.5^{cde} (0.8)	4^{b}(1.4)	1.7^{e} (0.3)	4.5^{a}(1.0)	3.0^{bcd}(0.4)

Note: Values are the mean of 40 consumers' perception; different letters in each row indicate significant differences ($p < 0.05$). numbers in brackets show standard deviation.

The use of intensity scales resulted in an explanation of 77.12% in the variability of the two dimensions of the main components (Figure 2). The samples 4, 6 and 8 were characterized by the attributes including thickness, creaminess, gumminess and aftertaste. The samples 2, 5 and 7 were characterized by the attributes of smoothness and sweetness. Figure 2 (a) also display the relation between overall liking and sensory attributes. It can be seen that customers preferred thicker and creamier samples.

Table 5. Mean consumer liking scores of the evaluated desserts for three methods.

Sample	Overall liking		
	Intensity	CATA	Open-ended
1	5.7^{abc}	5.7^{b}	5.3^{c}
2	5.1^{c}	5.5^{bc}	5.5^{bc}
3	6.0^{b}	6.0^{ab}	5.8^{bc}
4	6.8^{a}	6.5^{a}	6.6^{a}
5	5.0^{c}	4.8^{c}	4.6^{d}
6	6.3^{a}	6.4^{a}	6.5^{a}
7	4.4^{e}	3.9^{d}	3.7^{e}
8	6.1^{ab}	6.4^{a}	6.5^{a}
9	6.1^{ab}	6.2^{ab}	6.0^{ab}

Note: Values in each column are the mean of 40 consumers' perception; different letters in each column indicate significant differences ($p < 0.05$).

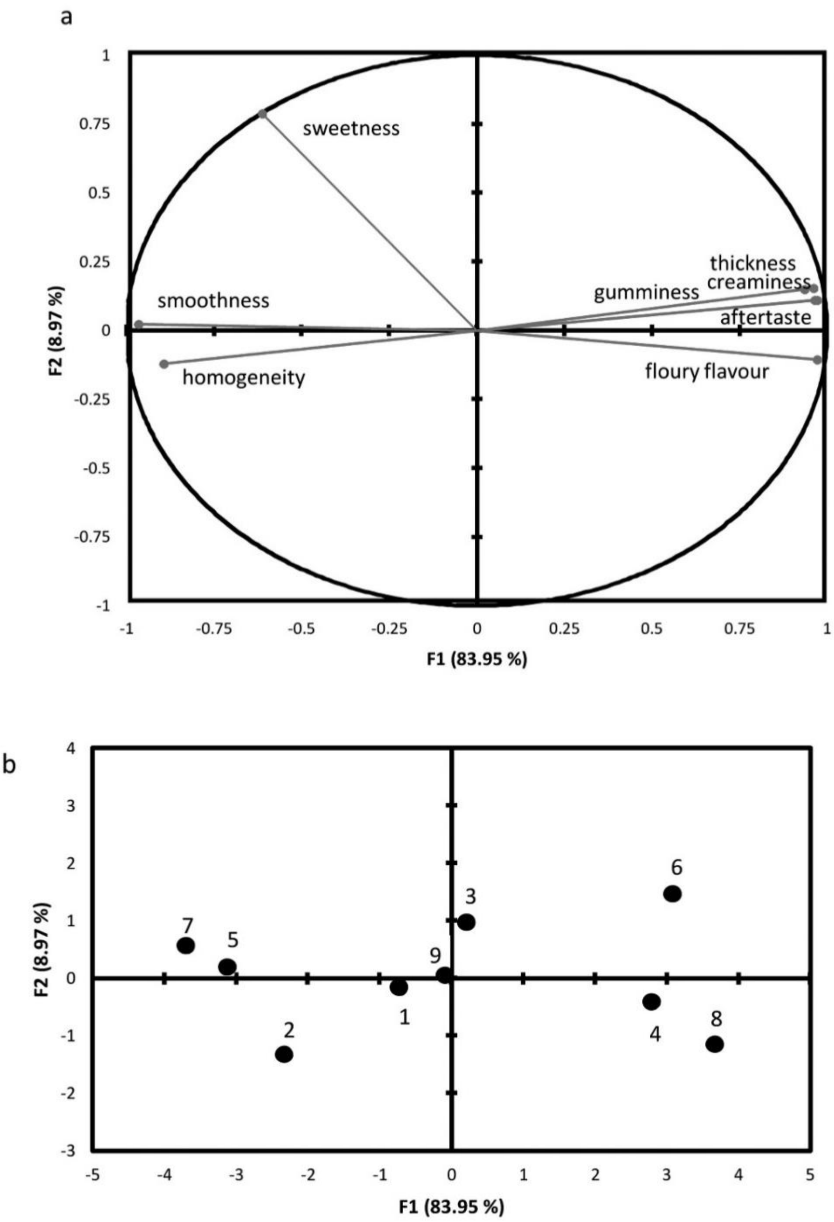

Figure 2. Principal component analysis performed on the correlation matrix of the mean attributes scores of sensory attributes evaluated by consumers: (a) representation of the attributes, (b) representation of the samples.

3.3. CATA questions

Table 6 shows that the terms creamy, sweet, bright color, nice flavor, no floury flavor, smooth and thick displayed the highest frequency of use when the consumers were asked to check sensory characteristics of the desserts. A significant difference was found among the frequencies of most of the attributes using Cochran's Q tests ($p < 0.05$), suggesting that this methodology was able to distinguish the different sensory stimuli provoked by the desserts. Similar results were reported by Bruzzone et al. [11].

Table 6. Frequency of CATA term used to describe nine dessert samples.

Terms	Samples								
	1	2	3	4	5	6	7	8	9
Creamy	14^{bcd}	9^{cd}	15^{bcd}	29^{a}	10^{cd}	26^{ab}	4^{d}	20^{abc}	16^{bcd}
Very creamy	0^{b}	0^{b}	0^{b}	8^{a}	0^{b}	8^{a}	0^{b}	3^{ab}	0^{b}
Not much creamy	12^{bcd}	29^{a}	20^{ab}	3^{b}	29^{a}	2^{d}	32^{a}	5^{cd}	18^{abc}
Sweet	19	19	22	18	23	21	25	18	20
Very sweet	1	1	2	1	2	1	2	0	0
Not very sweet	11	11	8	13	6	9	3	13	7
Bright color	34^{a}	29^{ab}	24^{ab}	21^{ab}	29^{ab}	25^{ab}	30^{ab}	20^{b}	24^{ab}
Dark color	3	4	2	5	4	4	5	8	3
Thick	22^{ab}	7^{c}	24^{a}	34^{a}	8^{bc}	33^{a}	2^{c}	30^{a}	23^{a}
Firm	6^{b}	6^{b}	4^{b}	24^{a}	0^{b}	28^{a}	0^{b}	28^{a}	3^{b}
Fluid	4^{b}	33^{a}	3^{b}	0^{b}	34^{a}	1^{b}	35^{a}	1^{b}	4^{b}
Nice flavor	26	23	29	28	24	29	24	28	30
Bad flavor	5	4	5	6	4	7	3	7	3
Aftertaste	3	3	4	6	3	7	3	7	3
Low floury flavo	4^{b}	6^{b}	6^{b}	12^{a}	4^{b}	14^{a}	4^{b}	15^{a}	4^{b}
High floury flavor	3	3	4	5	3	5	3	6	2
No floury flavor	29^{a}	28^{a}	25^{a}	17^{b}	23^{a}	15^{b}	28^{a}	14^{b}	26^{a}
Smooth	25^{a}	28^{a}	25^{a}	18^{b}	29^{a}	18^{b}	28^{a}	16^{b}	24^{a}
Lumpy	0	2	2	3	0	5	2	4	2
Homogeneous	21^{ab}	25^{c}	25^{ab}	18^{bc}	30^{a}	15^{bc}	28^{ab}	18^{bc}	23^{ab}
Heterogeneous	9^{ab}	7^{ab}	8^{ab}	13^{ab}	5^{b}	14^{ab}	5^{b}	19^{a}	7^{ab}
Gummy	8^{b}	7^{b}	11^{ab}	19^{a}	6^{b}	16^{a}	4^{b}	18^{a}	10^{ab}

Note: different letters in each row indicate significant differences. Numbers with no letter have not significat differnces ($p < 0.05$).

CA was carried out on the contingency table to obtain a sensory map of the samples. The first dimension of the CA explains 71.91% of the variance in the data set and second dimension explains an additional 11.91% of the variance. As indicated in Figure 3 (a), the first dimension of the CA correlated positively with the terms fluid and not creamy and negatively with the terms creamy and thick. According to Figure 3, the samples were categorized into three groups. One group was situated at positive value of the first dimension, including the samples 2, 5 and 7 and described with terms of fluid, not creamy, sweet, bright and not floury flavor. The samples 8, 4 and 6 were situated at negative value of the first dimension and characterized by the terms creamy, thick, heterogeneous and aftertaste. Eventually, the samples 1, 3 and 9 were sorted far from the rest of the samples, and were mainly described by the terms homogeneous, sweet and nice flavor.

It was observed in Figure 3 that the terms thick, creamy and firm were positively correlated to the overall liking. In contrast, the terms fluid and not creamy were negatively correlated to the overall liking, indicating that the consumers might have disliked the samples with these properties. These results are in agreement with previous studies that showed the relevance of thickness and creaminess called “drivers of liking” to be very important to consumers as aspects of a product [18,22].

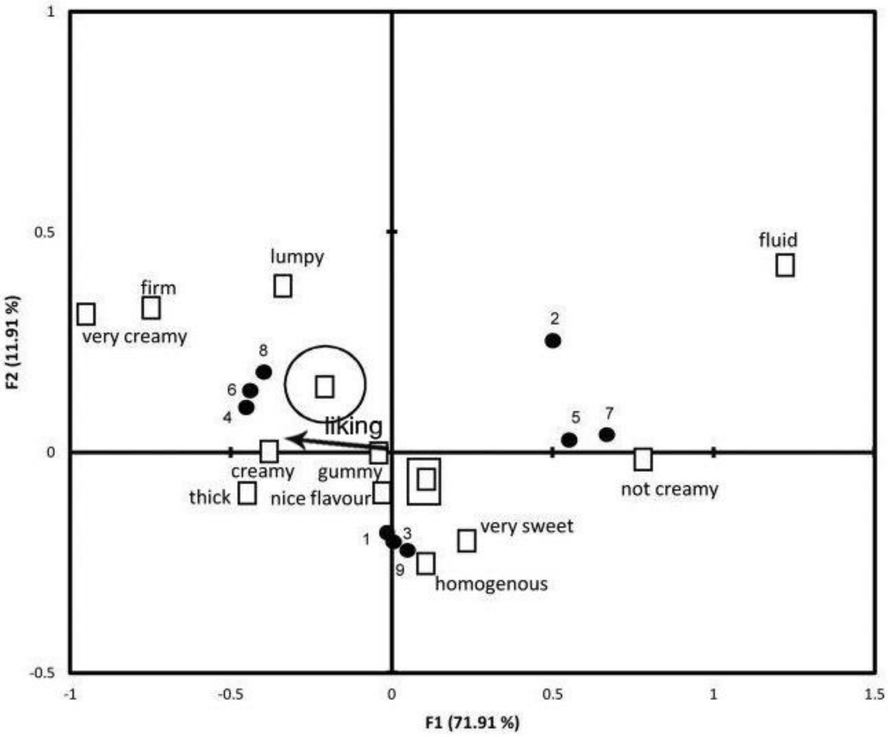

Figure 3: Representation of the samples and the terms in the first and second dimensions of the correspondence analysis of the frequency table of check-all-that-apply question and overall liking. The plot is decluttered. Decluttered attributes (□): sweet, smooth, bright color, not floury flavor. (□): High floury flavor, low floury flavor, bad flavor, dark color, aftertaste, heterogeneous, not sweet.

3.4. Open-ended questions

Table 7 indicates frequency of the consumers and terms they used to describe the evaluated desserts. Significant differences ($p < 0.05$) were detected between the consumers' descriptions of the evaluated desserts, suggesting that the consumers were able to discriminate the samples in their own words. The CA was applied to find out the relationship between the samples and elicited terms. As shown in Figure 4, the first and second dimensions of the CA calculated from the open-ended questions accounted for 89.31 and 4.95% of the variance of the data set, respectively. According to Figure 4 (a) samples were placed into 2 groups. One group consisting of the samples 2, 5 and 7 was characterized by the attributes disgusting and not thick. The samples 4, 6, 8, 1, 3 and 9 were in the other group described as creamy, thick, delicious, well consistent and grainy. Moreover, the words nice flavor and sweet were employed to describe the both groups of samples. Principle coordinate analysis shows that tendency of the consumers is toward the attributes of delicious, thick and creamy (Figure 4). These results are in agreement with the data suggesting the relation of creaminess and thickness as driver of liking of desserts [18,22]. Regarding to results of consumer sensory study, it is interesting to note that, despite the fact that the samples had very low quantity of fat, consumers perceived the most of samples creamy and very creamy, especially samples 4, 6 and 8. This can be attributed to presence of inulin. Addition of long-chain inulin to low-fat starch based dairy desserts modifies the perceived texture in different ways. Characteristic of long-chain inulin to act as fat substitute is based on its capability to generate microcrystal, which interact with each other, thereby forming small aggregates which occlude a great amount of water, forming a fine and creamy texture that gives a mouth sensation similar to that of fat [3]. However, as discussed previously, care should be taken when using inulin, since in desserts with high starch content, inulin could act as diluent, thereby limiting swelling of the starch granules [25].

Table 7. Consumer' responses to open-ended questions. Frequency of occurrence for each of the nine dessert samples.

Category	Examples	Samples								
		1	2	3	4	5	6	7	8	9
Delicious	I like it, delicious, nice, palatable	18^{ab}	17^{ab}	22^{ab}	24^{b}	14^{b}	20^{ab}	8^{a}	21^{ab}	21^{ab}
Disgusting	Disgusting, I don't like it, It's bad	12^{bc}	12^{bc}	4^{c}	4^{c}	20^{ab}	7^{c}	28^{a}	7^{c}	5^{c}
Sweet	Sweet, very sweet	25^{ab}	20^{ab}	25^{ab}	18^{ab}	23^{ab}	26^{a}	23^{ab}	11^{b}	22^{ab}
Creamy	Creamy, very creamy	18^{a}	0^{b}	23^{a}	30^{a}	0^{b}	32^{a}	0^{b}	29^{a}	25^{a}
Grainy	Grainy, not smooth	6	3	9	10	5	11	5	11	9
Nice flavor	Nice flavor, good flavor	11	12	14	11	18	12	17	15	16
Awful flavor	Awful flavor, bad flavor	1	1	0	2	0	2	0	1	0
Floury flavor	Floury, floury flavor	6	4	3	10	5	8	5	8	2
Not very thick	Runny, very runny, fluid, liquid, not thick	14^{b}	31^{a}	11^{b}	2^{b}	30^{a}	1^{b}	34^{a}	0^{b}	13^{b}
Thick	Thick, viscous, consistent	27^{a}	0^{b}	31^{a}	34a	0^{b}	34^{a}	0^{b}	38^{a}	27^{a}
Good consistency	Good consistency, I like it's consistency	8^{ab}	0^{b}	15^{a}	12^{a}	0^{b}	11^{ab}	0^{b}	14^{a}	14^{a}

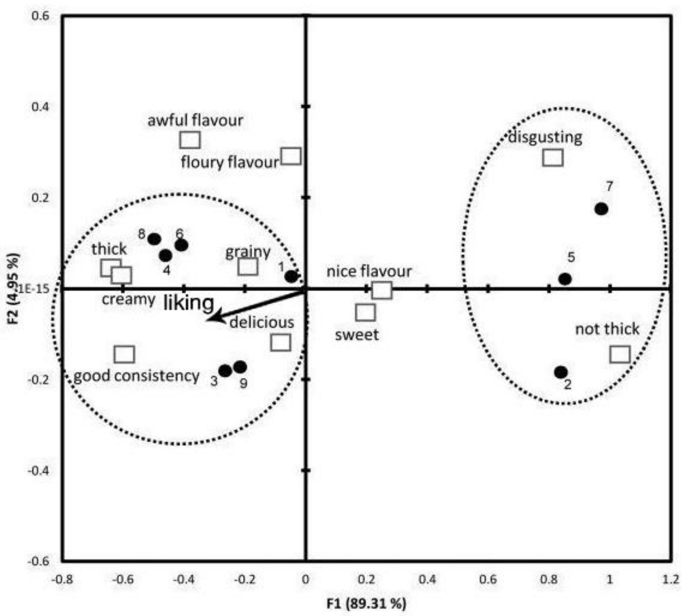

Figure 4. Correspondence analysis of terms used to describe milk desserts from open-ended question and trend of overall liking.

3.5. Comparison of the sensory methods

The MFA was performed to obtain the relationship between the intensity scales, consumers' responses to the CATA, consumers' responses to open-ended questions and trained assessors' data. MFA makes it possible to analyze several tables simultaneously, and to obtain results that allow studying the relationship between the observations, variables and tables [34]. According to results, similar discriminative ability was found in all the four methods used in this research. Results obtained from the consumers' evaluation (the intensity scale, CATA questions and open-ended questions) and trained assessors' data were compared by means of the regression vector (RV) coefficient (Table 8) [35]. RV can be regarded as a correlation coefficient in multidimensional spaces, which lies between 0 and 1, the closer RV is to 1, the more similar the configurations of the two spaces are.

As shown in Table 8, the RV coefficient between the sample configurations from the three consumers' evaluation methodologies was close to 1. Besides, the three consumer profiling methodologies exhibited high correlation to the results obtained by the trained assessors' panel. With respect to similarity between the trained assessment and consumers' responses, the greatest similarities were observed between the CATA and trained assessors' panel. A good correlation was already assumed between the CATA and descriptive analysis; this can be justified by the fact that, CATA uses preselected attributes, while it is based on the evaluation of a distinct product's sensory characteristics. This high resemblance between results from the CATA questions and trained assessors' panel has also been reported by others for the evaluation of various dairy products [9,36,37]. The lower RV coefficient for the open-ended questions than for the CATA questions can be explained by the fact that, the consumers were not able to provide adequately appropriate terms for description of the samples, where as in CATA, a comprehensive list of descriptors was presented and the consumers only had to examine the terms from the questions that were considered suitable for each sample.

Table 8. Regression vector coefficients between sample configurations in the first two coordinates of principal component analysis for the four methodologies.

	Trained assessors	CATA	Intensity	Open-ended	MFA
Trained assessors		0.976	0.938	0.905	0.981
CATA	0.976		0.940	0.891	0.978
Intensity	0.938	0.940		0.921	0.977
Open-ended	0.905	0.891	0.921		0.956
MFA	0.981	0.978	0.977	0.956	

Coordinates of the different data are displayed in Figure 5. The first two dimensions of the MFA accounted for 79.96% of the variance of the experimental data, representing 67.40 and 12.56% of the variance for the first and second dimensions, respectively. We can see on the map that the four methodologies were situated close to each other in the first dimension, while in the second dimension, the intensity scale and open-ended questions were separated from the others, suggesting that CATA method was more similar to trained assessors' evaluation. Figure 6 compares the distribution of the nine cereal milk desserts according to the sensory methodology. This map allows to see how different sensory methodologies influence the position of a given sample. Each sample is displayed by different colors. The different locations show obvious differences among the samples, suggesting that the consumers were able to discriminate between the different desserts. Moreover, points related to the four methods (the intensity scale, CATA, open-ended and trained descriptions) were almost close to one another, indicating that the configurations of the samples were similar for all the four methods. Figure 7 shows superimposed representation of the attributes evaluated by the four methods. This map makes it possible to evaluate relationship between these attributes. It is clear that the attributes “creaminess” and “thickness” obtained from the consumers’ perception were suited close to those evaluated by the trained assessors, suggesting a high correlation among all the four methods. The term "delicious" elicited from the open-ended questions was close to the attributes “creaminess” and “thickness” obtained from the other methods, suggesting that the consumers perceived thick and creamy desserts as delicious. According to this analysis, texture attributes such as creaminess and thickness were recognized as drivers of liking of desserts for consumers. Overall, the terms “creamy”, “very creamy”, “thick”, “firm”, “gummy”, “aftertaste” and “floury flavor” were positively correlated to the first dimensions of the MFA. The term “homogeneous” in the CATA questions was highly correlated to the trained assessors’ evaluation, but not correlated to the attributes “homogeneity” of the intensity scales. This could be explained by the fact that, the samples were very similar concerning their homogeneity, as shown in Table 3. As displayed in the map, the terms related to sweetness were close together in all the methods. In summary, results show that the samples 4, 6 and 8 received high score in a sensory point of view, although these samples were characterized by “aftertaste” and “floury flavor”. Moreover, this is very important to know that these attributes showed the low frequency of use in the CATA and open-ended questions.

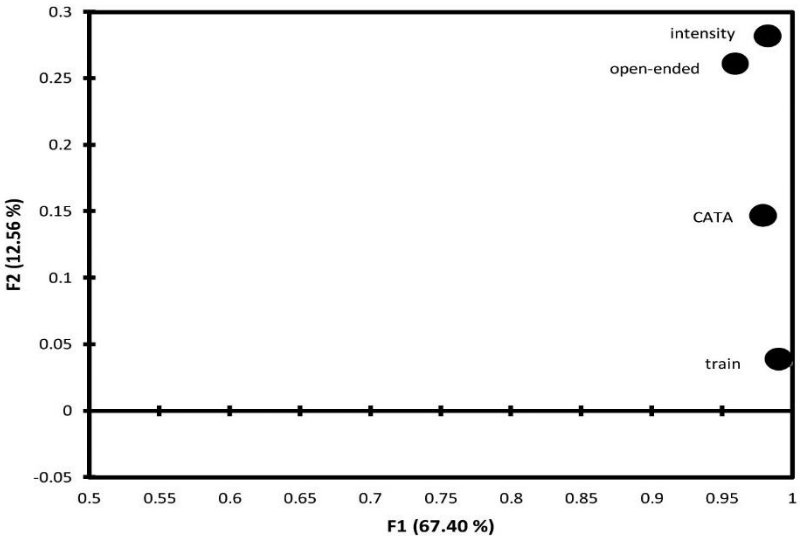

Figure 5. Consensus representation of the methodologies in the multiple factor analysis carried out on consumers’ response to the Check-All-That-Apply (CATA) question, intensity scales, Open-Ended question and trained assessors’ data.

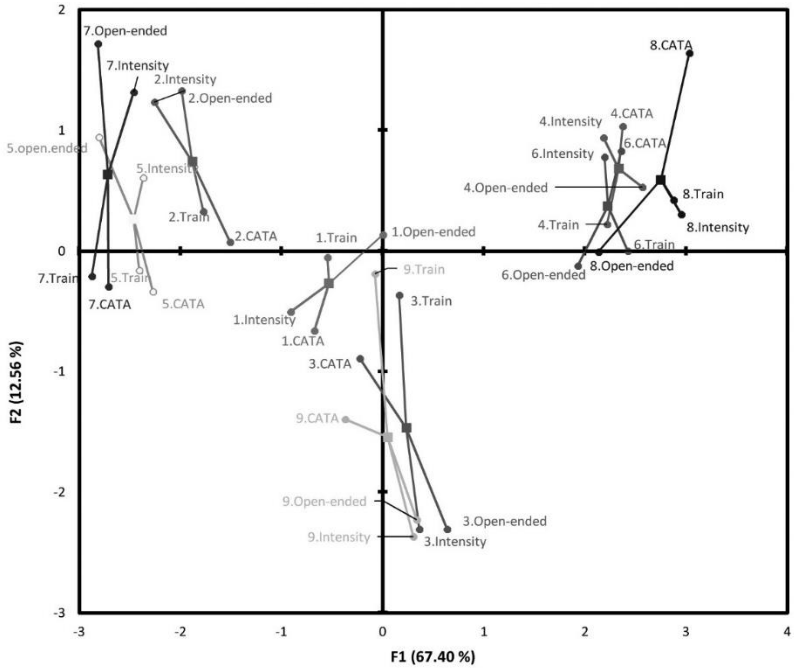

Figure 6. Comparative MFA on individual configurations of CATA, intensity scale, open-ended questions and trained panel. Each dessert is represented using four points corresponding to each method. The mean point of the four methods is the middle point which consider all methodologies.

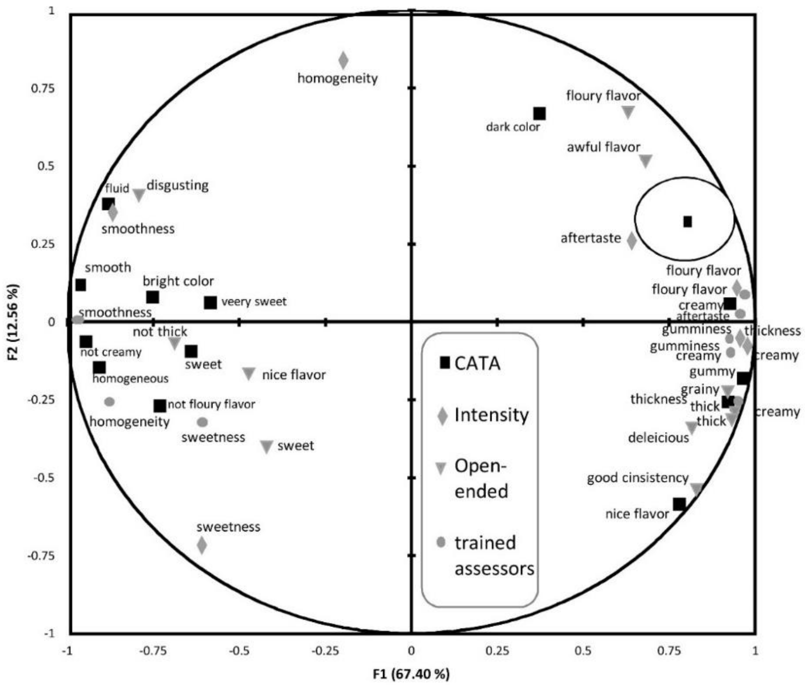

Figure 7: Comparative multiple factor analysis performed simultaneously on data from the four methodologies. The plot is decluttered. Decluttered attributes for CATA method (◻): high floury flavor, low floury flavor, firm, very creamy, bad flavor, aftertaste, heterogeneous, not very sweet, lumpy.

3.6. Limitation of this study

Although it presents important information about acceptability of a new prebiotic healthy dessert, the study also has one limitation. The major limitation of this study was the recruitment of small consumer panel. While some studies use fifty consumers at least, we used just forty people. It was very important in our research that respondents be regular dairy dessert consumers and be interested in sensory evaluation of food products.

4. Conclusions and perspectives

Development of low-fat and low-sugar functional product is an important issue, not only for the food industry, but also for consumers. Quantitative descriptive analysis is still one of the most commonly used methodologies for sensory characterization, providing more detailed and accurate information. Nevertheless, sensory methodologies based at the consumer perception provide the advantage of giving information about the sensory properties of products in short time frames and can be used in the first step of development of food products with numerous sensory characteristics such as prebiotic dairy desserts. In the present work, results obtained from sensory evaluation showed that intensity scale, CATA, and open-ended techniques provided similar information, as compared to the trained assessment for sensory characterization of functional desserts. Rapid descriptive methods are suitable to discriminate differences among products and they can be very useful for obtaining and realizing consumers' perceptions. Thus, they could be considered a valued alternative to obtain information about sensory characteristics of food products for manufacturers who do not have sufficient facilities to train a panel for evaluating a specific product, which is common in many small companies. Further research is needed to study shelf life of these kinds of desserts.

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Conflict of interest

All authors declare no conflicts of interest in this paper.

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