Impact of sensory differences on consumer acceptability of Yoghurt and Yoghurt-like Products

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Abstract

The aim of this work was to obtain information about how perceptible sensory differences affect consumer acceptability for yoghurt and a yoghurt-like product. Descriptive sensory profiles of six commercial samples, three of plain yoghurt and three of plain fermented milk, were determined using a trained panel (n=10). Sample acceptance was determined by a group of consumers (n=120). Initially, two groups of consumers were identified using Cluster analyses. For one group about 38% of the consumer population, variability in sensory attributes did not affect sample acceptability. For the second group, of around 62% of the population, variability in sensory attributes had a significant effect and three consumer subgroups with different preference criteria were detected. Partial least squares regression was used to determine the sensory factors driving liking/disliking for each consumer subgroups. The information obtained can be important in predicting or explaining the market response to these types of products.

Keywords: yoghurt, fermented milk, consumer acceptance, drivers of liking.

1. Introduction

Growing interest in healthy eating has given rise to a new range of foods and products on the market. An important point to consider is that consumer acceptance of a new healthy product is far from being unconditional. Their benefits may provide added value to consumers but cannot outweigh the sensory properties of foods (Siró, Kàpolna, Kàpolna, & Lugasi, 2008). The acceptance of a product will depend on whether it responds to consumer needs and on the degree of satisfaction it is able to provide. For this reason, consumers' opinions must be taken into consideration, not only to evaluate the acceptance of the final product, but also from the beginning of the process of product development (Drake, Lopetcharat, & Drake, 2009; Van Kleef, Van Trijp, & Luning, 2005). Furthermore, understanding which sensory attributes drive liking is a key issue when developing new products, (Villegas, Tárrega, Carbonell, & Costell, 2010) for product improvement and optimization (Ligget, Drake, & Delwiche, 2008) and for the design of quality control programs (Costell, 2002).

From among the different product sectors, the dairy sector is the one that has undergone greatest change, with many new products claiming healthy characteristics, not all of which are equally successful. In recent years, the market of traditional healthy dairy products, like skimmed dairy products, or those with probiotic characteristics, like yoghurt, has expanded to incorporate an ample range of fermented milks of pre- or probiotic nature, with different active ingredients that offer the consumer an alternative to conventional dairy products (Allgeyer, Miller, & Lee, 2010; Dello Staffolo, Bertola, Martino, & Bevilacqua, 2004; Guggisberg, Cuthbert-Steven, Piccinali, Bütikofer, & Eberhard, 2009; Tárrega, & Costell, 2006;).

The market offers a number of dairy products of similar appearance, colour, texture and with the same type of packaging, but differing in product name and nutritional information. Theoretically, the criteria a consumer follows when choosing a healthy product cannot always be explained by differences perceived in the sensory quality alone, but also the nutritional characteristics or composition and even its trade name or price play a role. Recently, Pohjanheimo and Sandell (2009) studied the influence of sensory and non-sensory characteristics of drinking yoghurt and concluded that food choice motives (importance of natural content, ethical concern and health) influences liking. In the case of healthy foods, it is logical to think that information on their potential influence on health may affect their acceptance. However, this is not always so. Shepperd, Sparks, Bellier and Raats (1991/92) noted that information on the fat and sugar content did not influence the acceptance of milk beverages. A similar result was obtained by Kähkönen, Tuorila and Lawless (1997) when analyzing the effect of information on the acceptance of non-fat strawberry yoghurt. Behrens, Villanueva and Da Silva (2007) did not detect differences in acceptability of four types of yoghurt-like fermented soymilk between the overall liking rated under blind testing or when the samples were rated with the corresponding nutrition and health claims available. In a previous work, Bayarri, Carbonell, Barrios and Costell (2010) investigated whether the information about product type and nutritional facts affected consumer acceptability of plain yoghurts and fermented milks. We observed that considering the average data for all the consumers, nutritional and product information supplied did not influence acceptability of these product types, yoghurt or fermented milk. The greatest difference in consumer response to sample information was between consumer subgroups with different sensory preference patterns. This attitude may be based on the fact that yoghurt is a familiar product for consumers and the belief that it is beneficial to health is wide-spread (Barrios, Bayarri, Carbonell, Izquierdo, & Costell, 2008; Kähkönen et al., 1997; Newsholme, 2002). In studies about food acceptability a critical question is, to what extent the variation in perceived sensory characteristics influences consumer response. One must accept that variability in perceived intensity of certain attributes by a trained panel or by a group of consumers may not affect acceptability (Costell, Tárrega, & Bayarri, 2010). Therefore the main goal of studies aiming to identify drivers of liking is usually to establish the relationship between the intensity of perceptible attributes evaluated by trained panels and the degree of consumer acceptance (Costell, Pastor, Izquierdo, & Duran, 2000; Tenenhaus, Pages, Ambroisine, & Guinot, 2005). This approach can indicate which sensory attributes most influence consumer acceptance. Validity of the results obtained with this approach mainly depends on the uniformity of the preference criteria of the consumers surveyed. When the individual responses come from consumers with different preference criteria, the average values obtained from the whole population tested do not reflect the actual situation (Young, Drake, Lopetcharat, & McDaniel, 2004). Moskowitz (1994) hypothesized that in the consumer population there exist a limited number of basic groups of people and each group exhibits a specified pattern of sensory preferences and suggested that variations in product acceptance in different markets is the result of different distributions of these basic segments. To study individual differences, the average values from the whole group of consumers must be substituted by the analysis of the average values provided by subgroups of consumers. Several techniques can be used to create subgroups of consumers with respect to their individual sensory preferences. Most of them are based on studying the structure of acceptability data with Internal Preference Maps (Greenhoff &

MacFie, 1994), which identifies groups of consumers based on their degree of correlated behaviour or on grouping consumers who prefer the same products using Cluster Analysis. This approach identifies groups of consumers based on the degree of similarity among their hedonic scores (Jacobsen & Gunderson, 1986; Vigneau, Qannari, Punter, & Knoops, 2001). Because of this situation to understand consumer response to food we should identify drivers of liking for subgroups of consumers with similar preference patterns. Application of Partial Least Squares regression (Wold, Sjöstrom, & Eriksson, 2001) can be a good way to model the variance of consumer acceptance data which can be explained by variance in sensory attributes obtained by a trained panel (Liggett et al., 2008; Childs, Yates, & Drake, 2009; Pohjanheimo & Sandell, 2009). The objectives of this work were: a) To obtain information about perceptible differences among plain yoghurts and fermented milks using descriptive analyses and about consumer acceptance using a hedonic scale; b) To detect possible subgroups of consumers with different preference patterns on the consumers population surveyed; and c) To identify sensory drivers of liking for the different subgroups of consumers detected.

2. Material and methods

2.1. Samples

Six commercial samples were analyzed, three plain yoghurts, i.e. without flavouring and colouring ingredients (Y1, Y2, Y3) and three plain fermented milk with a weak gelled, yoghurt-like structure (FM1, FM2, FM3) (Table 1). The selection criteria were based on a previous analysis of commercial product range and identification of leading market brands. The samples, covering the commercial range, were purchased from the local supermarket taking into account the sell-by dates (the same for each brand) and were stored at 5±1ºC prior to testing. All measurements were performed within the declared shelf-life period of each sample.

2.2. Sensory Analysis

Tests were conducted in a standard room (ISO, 2007) equipped with nine individual taste booths. Samples (about 15g) were served at 5±1 ºC in white plastic vessels coded with three random digit numbers. Still mineral water was used as palate cleanser. Experimental designs and data acquisition were performed using Compusense® five release 4.6 (Compusense Inc., Guelph, ON, Canada).

Sensory Profile. For descriptor selection, an initial list of terms was prepared with the information obtained from bibliography (Civille & Lyon, 1996; Hunter & Muir, 1993). A group of 10 assessors with previous experience (more than two years) in evaluating sensory differences in various dairy products, were asked to evaluate the suitability of these descriptors to describe the sensory characteristics of the samples according to the checklist method (Damasio & Costell, 1991). Two sessions of two hours were held. In these sessions, the assessors tested the samples and discussed the most suitable attributes. They could also propose new terms. A list, composed of 19 terms regarding appearance, odour, flavour and texture of the samples, was finally selected. The same group of 10 assessors was trained in four sessions according to the ISO 8586-1 (1993) guidelines. The first session was held with the panel leader and with all the assessors and was aimed to define the descriptors, to determine the sample evaluation procedures, and establish the definitive scorecard. The final list of descriptors, their definitions and some reference products are shown in Table 2. In the second and third sessions, each assessor evaluated the intensity of the 19 previously selected attributes in separate booths on three different commercial samples. The intensity of each attribute was scored on a non-structured 10 cm line scale anchored as “not perceptible” or “weak” at the low end and “intense” at the high end except for two texture attributes: consistency anchored with “thin” and “thick” and structure with “smooth” and “rough”. At the end of each of these sessions the panel leader and the assessors discussed the individual results obtained in order to establish consensus criteria for evaluation. In the last training session, attributes intensity of a reference sample, a commercial plain yoghurt sample not included in the study, were individually scored and a consensus score for each attribute was reached. These consensus scores were marked with “R” on the definitive scorecard.

Descriptive analysis of the six samples was carried out in triplicate over six sessions and each assessor evaluated three samples per session. The reference sample together with the scorecard was presented at the beginning of each session. This process allowed the panellists to create the appropriate context for each scale. The reference sample was removed before sample evaluation. For each sample, odour attributes were evaluated first. Then, assessors were asked to evaluate visual texture, flavour, and finally, in mouth textural attributes. To reduce the influence of serving order, the samples evaluated in each session were served according to a balanced design (MacFie, Bratchell, Greenhoff & Vallis, 1989).

Consumer Test. Consumers were recruited by a local consumer association (Association of Valencian Consumers and Users-AVACU) through a short questionnaire sent by mail. The participants were selected according to the following criteria: age (from 18 to 65 years), gender (40% men and 60% women) and consumers of yoghurt (minimum intake of one a week). One-hundred-and-twenty participants were selected. Prior to the test, it was confirmed that participants had no allergies to milk or dairy products. The consumers evaluated the overall acceptability of the six samples using a 9-point hedonic scale ranging from 1 (“dislike extremely”) to 9 (“like extremely”). To avoid first position distortions and possible carry-over effects, the samples were served to the consumers monadically according to a balanced design (MacFie et al., 1989). Time lapse between evaluations of two consecutive samples was fixed at 30 seconds.

2.3. Data Analysis

Sensory Profile Data. Two-way ANOVA (samples and assessors) with interaction was applied to the sensory data obtained for each attribute. Individual differences among assessors were analyzed by a fixed model, considering assessors as fixed factor. When a significant interaction between assessors and sample was observed for a descriptor, a mixed model ANOVA was performed, considering assessors as random effect (González-Tomás, Bayarri, & Costell, 2009). F_{sample} values were then recalculated taking the average square of the interaction as denominator. Least significant differences (LSD) between samples were determined by Fisher test (α=0.05). Principal Component Analysis (PCA) was also applied to the mean values of attribute intensity.

Consumer Data. Initially, mean and standard deviation for each sample was carried out from data obtained from the whole group of consumers. To obtain information about the symmetry and shape of the distributions obtained, frequency histograms, skewness and kurtosis coefficients were calculated for each sample. To test consumer data for normal distribution Kolmogorov-Smirnov test was applied. To identify consumer subgroups with different preferences, the subgroups were segmented based on acceptability scores of the samples by using Cluster Analysis (Clustering Ward Method) (Vigneau & Qannari, 2002). Partial Least Squares regression (PLSR) was applied (Wold, Sjöstrom & Eriksson, 2001) to model the variance of consumer acceptance data which can be explained by variance in sensory attributes obtained by the trained panel. PLRS was performed for each of the previously identified consumer segments.

All calculations were carried out with XLSTAT Pro software version 2007 (Addinsoft, Paris, France).

3. Results and discussion

3.1. Descriptive Profile

A fixed model of two-way ANOVA (samples and assessors) with interaction (Table 3) was applied to the sensory scores obtained for the 19 attributes evaluated. Significant differences between samples (α=0.05) were detected, with the exception of one attribute: residual flavour. Assessors were also a significant source of variation (α=0.05) in all cases. This was not surprising since it is well known that, in spite of the selection and training of judges, some variability always remains. Variation among assessors can be due to individual differences in the use of scales or to individual differences in sensitivity or motivation and it is very difficult to eliminate completely (Carlucci & Monteleone, 2001; Tomic, Nilsen, Martens, & Naes, 2007). However, it is important to know whether assessor variability may influence the estimation of sample differences. The significance, or not, of the effect of sample x assessor interaction provides information about this point. In this case, with regard to the 18 attributes for which the panel found significant perceptible differences (α=0.05) among samples, the effect of the sample × assessor interaction was not significant for seven of them (vanilla odour, visual consistency, sweetness, saltiness, astringency, consistency and mouthcoating) indicating a good level of concordance among the panel members. For the remaining eleven attributes the sample × assessor interaction was significant, indicating a certain lack of concordance within the panel. In spite of this, the main sample effect for these attributes remained significant except for two attributes (odour intensity and flavour intensity) when a mixed ANOVA model was applied considering assessors as random effect (Table 3). The mean values of the 19 sensory attributes for each sample and the significant differences among them are given in Table 4. It can be observed that, in addition to the attributes for which sensory differences among samples were not significant (odour and flavour intensity and residual flavour) there were two other attributes (caramelized and vanilla odours), for which sensory intensity perceived was very low (<0.8) for all the samples tested. Given this information, Principal Component Analysis was only applied to average scores of the remaining 14 attributes (Fig. 1). PCA results showed that the three first components, with an eigenvalue higher than 1, accounted for 95% of data variability. The first component explained 57.98% of total variability and was mainly related to visual and in mouth texture attributes. In the negative part of the first dimension, the two sugar-sweetened semi-skimmed plain yoghurts (Y1 and Y2) and the sugar-sweetened fermented milk with the bacterium *Lactobacillus casei* (FM3) showed lower consistency, higher creaminess and a smoother structure than the two skimmed samples (Y3 and FM2) and the semi-skimmed fermented milk with *bifidobacteria* (FM1) which were in the positive part of this first dimension. The second component explained 26.77% of total variability and was defined mainly by taste attributes. In the upper part, there were the fermented milk samples, FM1, FM2 and FM3, which were perceived as more acidic and slightly saltier than yoghurt samples (Y1, Y2, and Y3). The latter samples, in the lower part of dimension, were clearly perceived as sweeter. Samples FM1 and FM2, in the upper right quadrant, were the only samples perceived as slightly bitter and with higher astringency (Fig. 1a). The third component that explained 10.24% of variability was mainly related with odour and flavour notes. Sample FM1 was perceived as having a more fermented-milk odour and sample FM3 as having a more cooked-milk odour and cooked-milk flavour than the rest of the samples (Fig. 1b). These data show that variability perceived among samples corresponded mainly to texture and taste variability of samples.

3.2. Consumer Acceptability

*Whole Consumer Population***.** Frequently, to obtain information about the significance of differences among liking scores of samples, the data obtained from whole consumer population are analyzed by analysis of variance. A related problem is that data arising from hedonic scales frequently break the assumptions of normality and homocedasticity (O’Mahony, 1982; Vie, Gulli, & O’Mahony, 1991). Villanueva, Petenate and Da Silva (2000) commented that when a lack of normality is observed in data from hedonic scales, the application of ANOVA may be not suitable. In Table 5, the mean values and standard deviations of yoghurt and fermented milk samples obtained with the hedonic scale from the 120 consumers were presented. The standard deviations indicated that the variances corresponding to the samples evaluated were not homogeneous, showing a certain lack of homocedasticity. When the coefficients of skewness and kurtosis were calculated to obtain information about the symmetry and shape of the distributions corresponding to the different yoghurt and fermented milk samples (Table 5) it was confirmed that deviations occurred from the normal distribution. Positive kurtosis coefficient values for yoghurt samples showed that their distributions were peaked with more data near the mean value than that corresponding to normal distribution. Negative kurtosis coefficients for fermented milk samples indicated flatter distributions. Representing the frequencies of the hedonic acceptability scores given by the whole consumer population can illustrate the characteristics of distributions obtained (Fig. 2). Sharp distributions with one mode and with moderate asymmetry to the left side were observed for the yoghurt samples, while flat distributions with two modes were observed for fermented milk samples. For these last three samples a mode appeared at the lower scale values (2-4) corresponding to non acceptable samples and came from consumers that do not like fermented milk samples. The other mode appeared at higher scale values (6-8) that correspond to acceptable samples and correspond to consumers that like these products. Similar results were obtained by Carbonell, Bayarri, Navarro, Carbonell and Izquierdo (2009) when evaluating the acceptability of fresh mandarin juices of different varieties with the hedonic scale. They concluded that when two modes were observed in data distribution, the individual responses come from consumers with different preference criteria and the average values obtained from the whole population tested do not reflect the real consumers' response. The lack of sample distribution normality was confirmed by the Kolmogorov-Smirnov test. Probability values were clearly significant for all the samples (Table 5). Hence in this situation, the relationships established between the intensity of the sensory attributes and the overall mean hedonic values can fail to predict which sensory attributes are important in defining product acceptability. From the practical point of view, one solution could be to establish such relationships with the average hedonic values provided by subgroups of consumers showing similar preference patterns.

Consumer Segmentation. When Cluster Analysis was applied to preference data, two segments of consumers were initially detected (Fig. 3). One of them (n=46) did not show clear differences in sample acceptability. The average hedonic score for the six samples varied around 6.5. For the consumers in the second segment (n=74) clear differences in the average hedonic value (from 3.0 to 7.5) were detected among samples. A similar result was observed by Ligget et al. (2008) when Cluster Analysis were applied to hedonic ratings obtained from 101 consumers regarding the flavour of different Swiss cheese samples. They observed two consumer clusters with different responses to samples. One was identified as “nondistinguishers” and the other as “varying responder consumers”. In our case, a more detailed observation of the information obtained by Cluster Analysis (Fig. 3) showed that three distinct clusters of consumers can be identified as components of our second segment of consumers. According these results, one can hypothesize that in the population surveyed there are four groups of consumers with clearly distinguishable sensory preferences: A first group, representing about of 38% of consumers, for whom the variability in intensity of sensory attributes among samples does not affect sample acceptability and a second group formed by three subgroups showing clear differences in acceptability among samples (Fig. 4). A small subgroup (CL1, n=11) representing less than 10% of the total population likes the less sweet and more acidic fermented milk samples (FM1 and FM2) and the other two subgroups (CL2, n=32 and CL3, n=31) like more the sweet and less acidic yoghurt samples (Y1, Y2 and Y3). Differences in average acceptability scores of the six samples for the CL2 and CL3 subgroups (Fig. 4) showed that the largest difference in acceptability corresponded to fermented milk FM3 which was perceived as having more creaminess and smoothness and less consistency (Fig. 1). This sample was considered highly acceptable by CL2 consumers (average score=7.2) and unacceptable by CL3 consumers (average score=3.5). As the purpose of the study was to identify drivers of product liking/disliking, only the data corresponding to CL1, CL2 and CL3 subgroups of consumer were retained for subsequent analysis.

3.3. Relationships between Acceptability and Sensory Attributes

Partial least squares regression (PLS) was used to determine the sensory factors driving consumer liking for the different consumer subgroups. Initially, for consumers in CL1, a two component PLSR model (R^2 = 0.821) was obtained. The regression explained 82.1% of the mean acceptability scores (Y-data) and 83.9% of the average sensory attribute scores (X-data). However this solution has a Q^2cum= -0.064 indicating that the model obtained is poor and does not predict better than chance. Statistical outlier analysis determined FM1 sample to be an outlier. A new model was obtained removing FM1 sample. The new regression explained 99.9% of the mean acceptability scores and 96.4% of the average sensory attribute scores with a Q^2cum=0.970 on three normally distributed components. The standard coefficients for sensory attributes obtained by PLS were considered significant when the variable importance in the projection (VIP) was greater than 0.8 (Wold et al., 2001) and only significant attributes were retained as possible drivers of liking. For CL1 consumers liking was driven by saltiness, acidity, bitterness, astringency and cooked milk odour and disliking was driven by sweetness. For the consumer segment included in CL2, a good result was obtained with a two component PLSR model (Fig. 5). The regression explained 97.4% of the mean acceptability scores and 83.2% of the average sensory attribute scores with a Q^2cum=0.912. Considering only the attributes with VIP value greater than 0.8, liking for CL2 consumers was driven by sweetness and the attributes that significantly influenced disliking were acidity, saltiness, astringency, bitterness, oral and visual consistency and rough structure. When PLS was applied to consumer data corresponding to CL3, a three-component regression model explained 98.8% of the mean acceptability scores and 94.3% of the average sensory attribute scores with a Q^2cum=0.814 (Fig. 6). Drivers of liking for CL3 consumers were sweetness and fermented milk odour and disliking for this group was driven by acidity, saltiness, bitterness, astringency and cooked milk flavour.

4. Conclusions

The six samples (yoghurt and fermented milk) evaluated were differentiated by 14 of 19 sensory attributes. As consumer population surveyed showed that the individual responses came from consumers with different preference criteria, the average values obtained from the whole population tested did not reflect the real consumers' response. One way to predict which sensory attributes are important in defining product acceptability could be to establish relationships using the average hedonic values provided by different subgroups of consumers. Cluster Analysis identified four basic groups of consumers with different preference patterns within the whole consumer population. For an important group of consumers (38%) the variability in intensity of sensory attributes among samples did not affect sample acceptability. They liked all six samples to same extent. For the other three groups, perceptible differences among samples influenced liking in a different way. When PLSR was applied to the data corresponding to each of the these three groups of consumer, results showed that for a small subgroup (10%) liking was driven by saltiness, acidity, bitterness, astringency and cooked milk odour and disliking was driven by sweetness. For the other two subgroups of consumers (52%) results showed that liking was correlated positively with sweetness and negatively with acidity, saltiness, astringency bitterness and cooked-milk flavour although for one of them two textural attributes, consistency and structure, were found to drive product acceptance too.

This type of information can be important to predict or to explain the market response to food products and also to select which sensory attributes should be included in a sensory specification or must be considered in product quality control programs.

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References

Allgeyer, L. C., Miller, M. J., & Lee, S.-Y. (2010). Drivers of Liking for Yogurt Drinks with Prebiotics and Probiotics. *Journal of Food Science, 75*, S212-S219.

Barrios, E.X., Bayarri, S., Carbonell, I., Izquierdo, L., & Costell, E. (2008). Consumer attitudes and opinions toward functional foods: A focus group study. *Journal of. Sensory Studies, 23*, 514-525.

Bayarri, S., Carbonell, I., Barrios, E. X., & Costell, E. (2010). Acceptability of yoghurt and yoghurt-like products. Influence of product information and consumer characteristics and preferences. *Journal of Sensory Studies*, *25,* 171-189.

Behrens, J. H., Villanueva, N. D. M., & Da Silva, M. A. A. P. (2007). Effect of nutrition and health claims on the acceptability of soyamilk beverages. *International Journal of Food Science and Technology,42*, 50-56.

Carbonell, L., Bayarri, S., Navarro, J. L., Carbonell, I., & Izquierdo, L. (2009). Sensory profile and acceptability of juices from mandarin varieties and hybrids. *Food Science and Technology International, 15*, 375-385.

Carlucci, A., & Monteleone, E. (2001). Statistical validation of sensory data: a study on wine. *Journal of the Science of Food and Agriculture, 81*, 751-758.

Childs, J. L., Yates M. D., & Drake M. A. (2009). Sensory properties and consumer perception of wet and dry cheese sauces. *Journal of Food Science, 74*, 205-218.

Civille, G. V., & Lyon, B. G. (1996). *Aroma and Flavor. Lexicon for sensory evaluation. Terms, definitions, references, and examples.* American Society for Testing and Materials (ASTM) DS 66 (158 p.). West Conshohocken, P.A., U.S.A.

Costell E., Tárrega A., & Bayarri, S. (2010). Food acceptance: The role of consumer perception and attitudes. *Chemosensory Perception, 3*, 42-50.

Costell, E. (2002). A comparison of sensory methods in Quality Control. *Food Quality and* Preference*, 13*, 341-353.

Costell, E., Pastor, M. V., Izquierdo, L., & Duran, L. (2000). Relationships between acceptability and sensory attributes of peach nectars using internal preference mapping. *European Food Research and Technology, 211*, 199-204.

Damasio, M. H., & Costell, E. (1991). Análisis sensorial descriptivo: Generación de descriptores y selección de catadores. *Revista de Agroquímica y Tecnología de Alimentos, 31*, 165-178.

Dello Staffolo, M., Bertola, N., Martino, M., & Bevilacqua, A. (2004). Influence of dietary fiber addition on sensory and rheological properties of yogurt. *International Dairy Journal, 14*, 783-789.

Drake, S. L., Lopetcharat, K., & Drake, M. A. (2009). Comparison of two methods to explore consumer preferences for cottage cheese. *Journal of Dairy Science*, *92,* 5883-5897.

González-Tomás, L. M., Bayarri, S., & Costell, E. (2009). Inulin-enriched dairy desserts. Physicochemical and sensory aspects. *Journal of Dairy Science*, *92*, 4188-4199.

Greenhoff, K., & MacFie, H. J. H. (1994). Preference mapping in practice. In H. J. H. MacFie, & D. M. H. Thompson (Eds.). *Measurements of food preferences* 1^{st} edn. (pp.137-166). Blackie Academic and Professional, Glasgow, U. K.

Guggisberg, D., Cuthbert-Steven, J. Piccinali, P., Bütikofer, U., & Eberhard, P. (2009). Rheological, microstructural and sensory characterization of low-fat and whole milk set yoghurt as influenced by inulin addition. *International Dairy Journal, 19*, 107-115.

Hunter E. A., & Muir, D. D. (1993). Sensory properties of fermented milks: Objective reduction of an extensive sensory vocabulary. *Journal of Sensory Studies*, *8*, 213-227.

ISO 8586-1. (1993). Sensory Analysis. General guidance for the selection, training and monitoring of assessors. Part I. Selected assessors. Geneva. Switzerland.

ISO 8589. (2007). Sensory Analysis. General guidance for the design of test rooms. Geneva. Switzerland.

Jacobsen, T., & Gunderson, R. W. (1986). Applied clusters analysis. In J. R. Piggot (Ed.). *Statistical Procedures in Food Research* (pp. 361-408). Elsevier, Glasgow, Scotland, U. K.

Kähkönen, P., Tuorila, H., & Lawless, H.T. (1997). Lack of effect of taste and nutrition claims on sensory and hedonic responses to a fat-free yogurt. *Food Quality and Preference, 8*, 125-130.

Ligget, R. E., Drake, M. A., & Delwiche, J. F. (2008). Impact of Flavor Attributes on Consumer Liking of Swiss Cheese. *Journal of Dairy Science, 91*, 466-476.

MacFie, H. J., Bratchell, N., Greenhoff, K., & Vallis, L.V. (1989). Designs to balance the effect of order of presentation and first-order carry-over effects in Hall Tests. *Journal of Sensory Studies, 4*, 129-148.

Moskowitz, H. R. (1994). Sensory segmentation and product design. In *Food concepts and products. Just-in-time development* (pp. 233-291). Food and Nutrition Press, Trumbull, Connecticut, U. S. A.

Newsholme, H. C. (2002). *Consumer awareness of and attitudes towards functional foods*. (45 p.) R & D No. 162. Campden & Chorleywood Food Research Association Group.

O'Mahony, M. (1982). Some assumptions and difficulties with common statistics. *Food Technology, 36*, 75-82.

Pohjanheimo, T., & Sandell, M. (2009). Explaining the liking for drinking yoghurt: The role of sensory quality, food choice motives, health concern and product information. *International Dairy Journal, 19*, 459-466.

Shepherd, R., Sparks, P., Bellier, S., & Raats, M. M. (1991/1992). The effects of information on sensory ratings and preferences: the importance of attitudes. *Food Quality and Preference, 3*, 147-155.

Siró, I., Kàpolna, E., Kàpolna, B., & Lugasi, A. (2008). Functional food. Product development, marketing and consumer acceptance. A review. *Appetite, 51*, 456-457.

Tárrega, A., & Costell, E. (2006). Effect of inulin addition on rheological and sensory properties of fat-free starch-based dairy desserts. *International Dairy Journal, 16* (9), 1104-1112.

Tenenhaus, M., Pages, J., Ambroisine, L., & Guinot C. (2005). PLS methodology to study relationships between hedonic judgements and product characteristics. *Food Quality and Preference, 16*, 315-325.

Tomic, O., Nilsen, A., Martens, M., & Naes, T. (2007). Visualization of sensory profiling data for performance monitoring. *LWT- Food Science and Technology, 40,* 262-269.

Van Kleef, E., Van Trijp, H. C. M., & Luning, P. (2005). Consumer research in the early stages of new product development: a critical review of methods and techniques. *Food Quality and Preference, 16*, 181-201.

Vie, A., Gulli, D., & O'Mahony, M. (1991). Alternative hedonic measures. *Journal of Food Science*, 56, 1-5.

Vigneau, E., Qannari, E. M., Punter, P. H., & Knoops, S. (2001). Segmentation of a panel of consumers using clustering of variables around latent directions of preference. *Food Quality and Preference, 12*, 359-363.

Vigneau, E., & Qannari, E.M. (2002). Segmentation of consumers taking account external data. A clustering of variables approach. *Food Quality and Preference*,13, 515-521.

Villanueva, N. D. M., Petenate, A. J., & Da Silva, M. A. A. P. (2000). Performance of three affective methods and diagnosis of the ANOVA model. *Food Quality and Preference, 11*, 363-370.

Villegas, B., Tárrega, A., Carbonell, I., & Costell, E. (2010). Optimising acceptability of new prebiotic low-fat milk beverages. *Food Quality and Preference, 21*, 234-242.

Wold, S., Sjöstrom, M., & Eriksson, L. (2001). PLS-regression: a basic tool of chemometrics. *Chemometrics and Intelligent Laboratory Systems, 58*,109-130.

Young, N. D., Drake, M., Lopetcharat, K., & McDaniel, M. R. (2004). Preference Mapping of Cheddar Cheese with Varying Maturity Levels. *Journal of Dairy Science, 87*, 11-19.

FIGURE LEGENDS

Figure 1. Principal Component Analysis biplots of the yoghurt and fermented milk samples. a) Principal Components 1 and 2; b) Principal Components 1 and 3. Identification of samples in Table 1.

Figure 2. Frequencies of acceptability scores given by 120 consumers to yoghurt and fermented milk samples. Identification of samples in Table 1.

Figure 3. Consumer segmentation (n = 120) by Cluster Analysis.

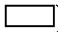
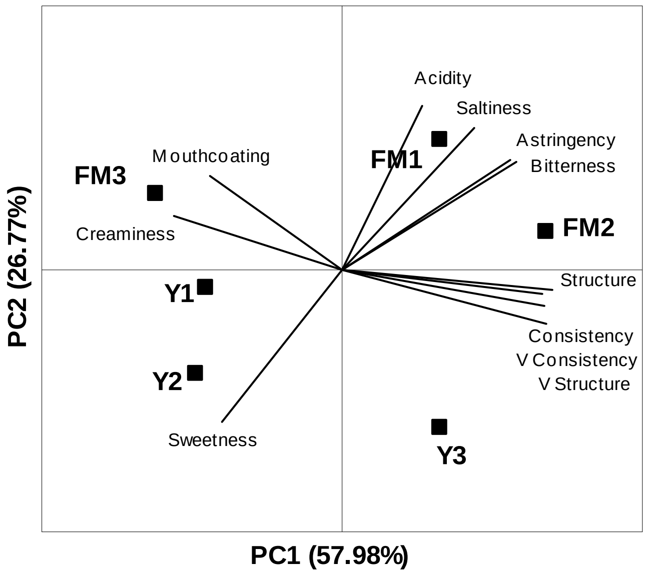
Figure 4. Mean acceptability scores of samples for the three considered consumers' segments (Cluster 1 = ; Cluster 2 = ; Cluster 3 = ).

Figure 5. Partial Least Squares correlation biplot of Cluster 2 (n = 32). Attributes that significantly contributed ($p<0.05$) to acceptability are represented by solid bars.

Figure 6. Partial Least Squares correlation biplot of Cluster 3 (n = 31). Attributes that significantly contributed ($p<0.05$) to acceptability are represented by solid bars.

a)



b)

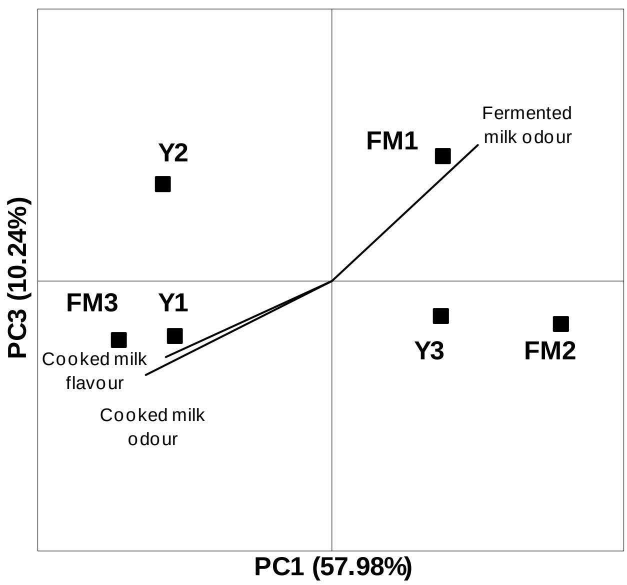


Figure 1. Bayarri et al.

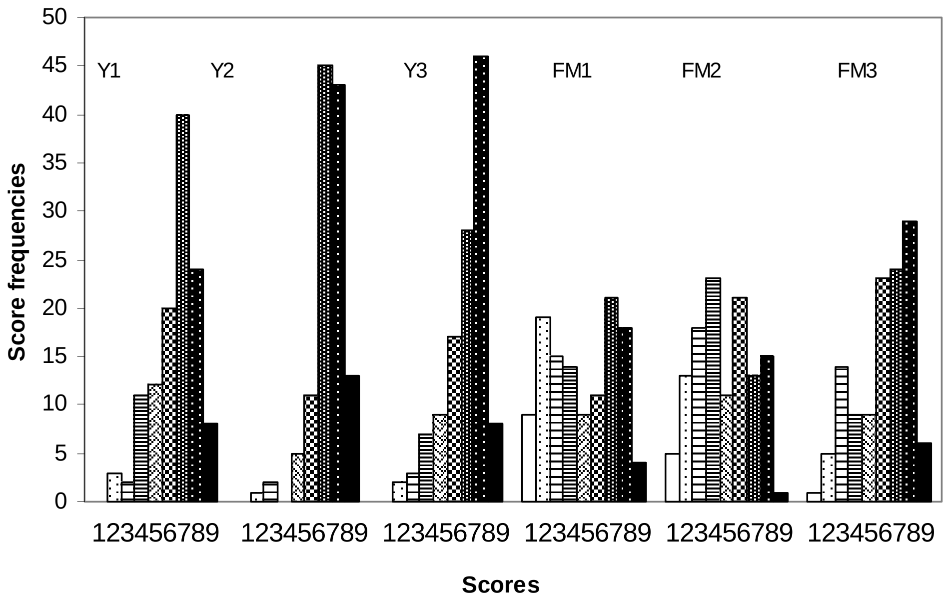


Figure 2. Bayarri et al.

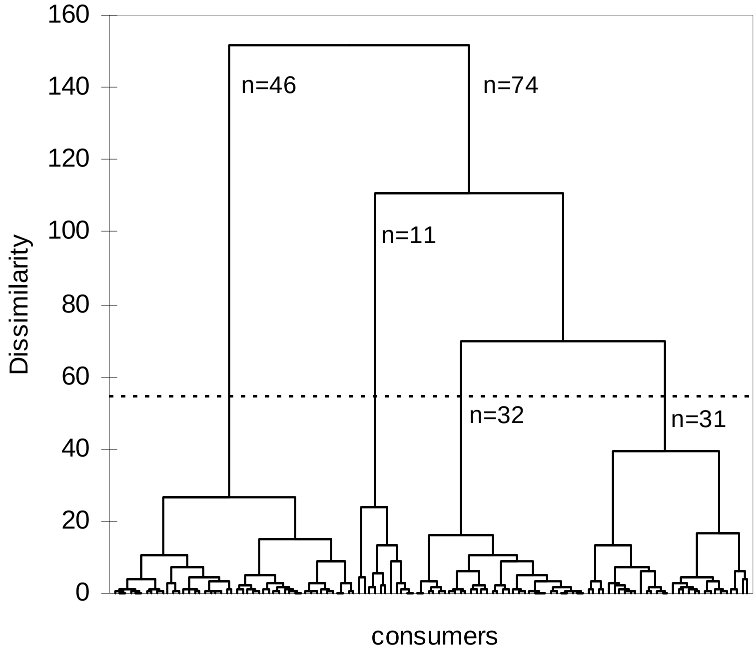


Figure 3. Bayarri et al.

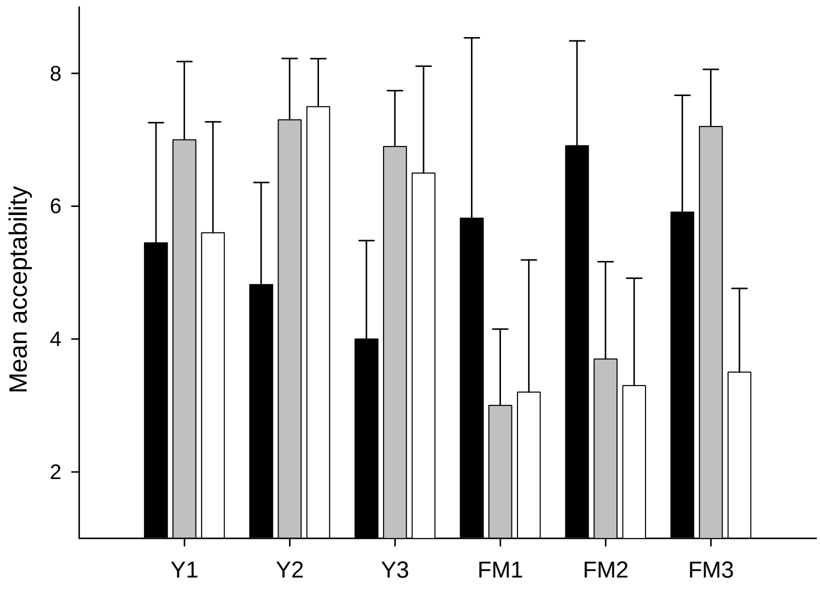


Figure 4. Bayarri et al.

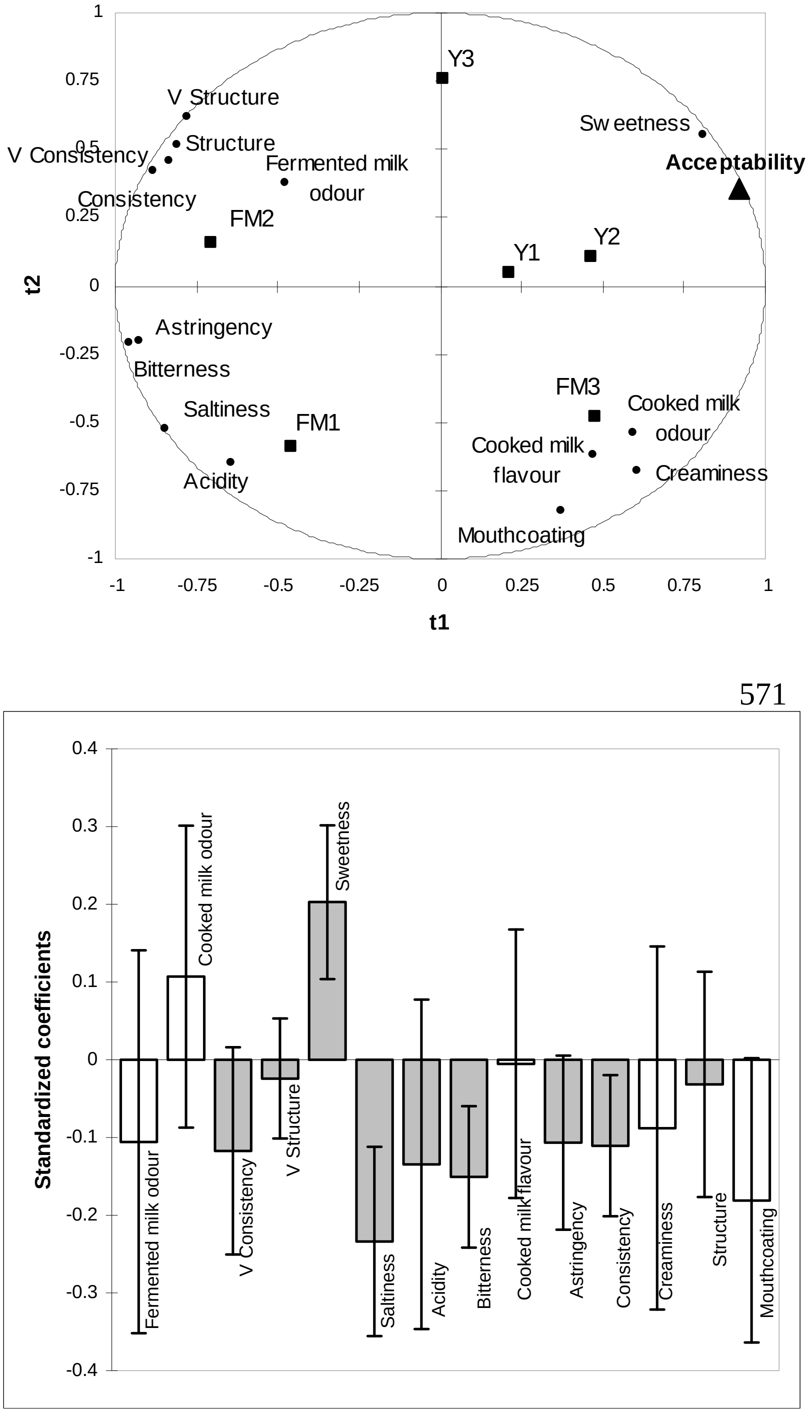


Fig 5. Bayarri et al.

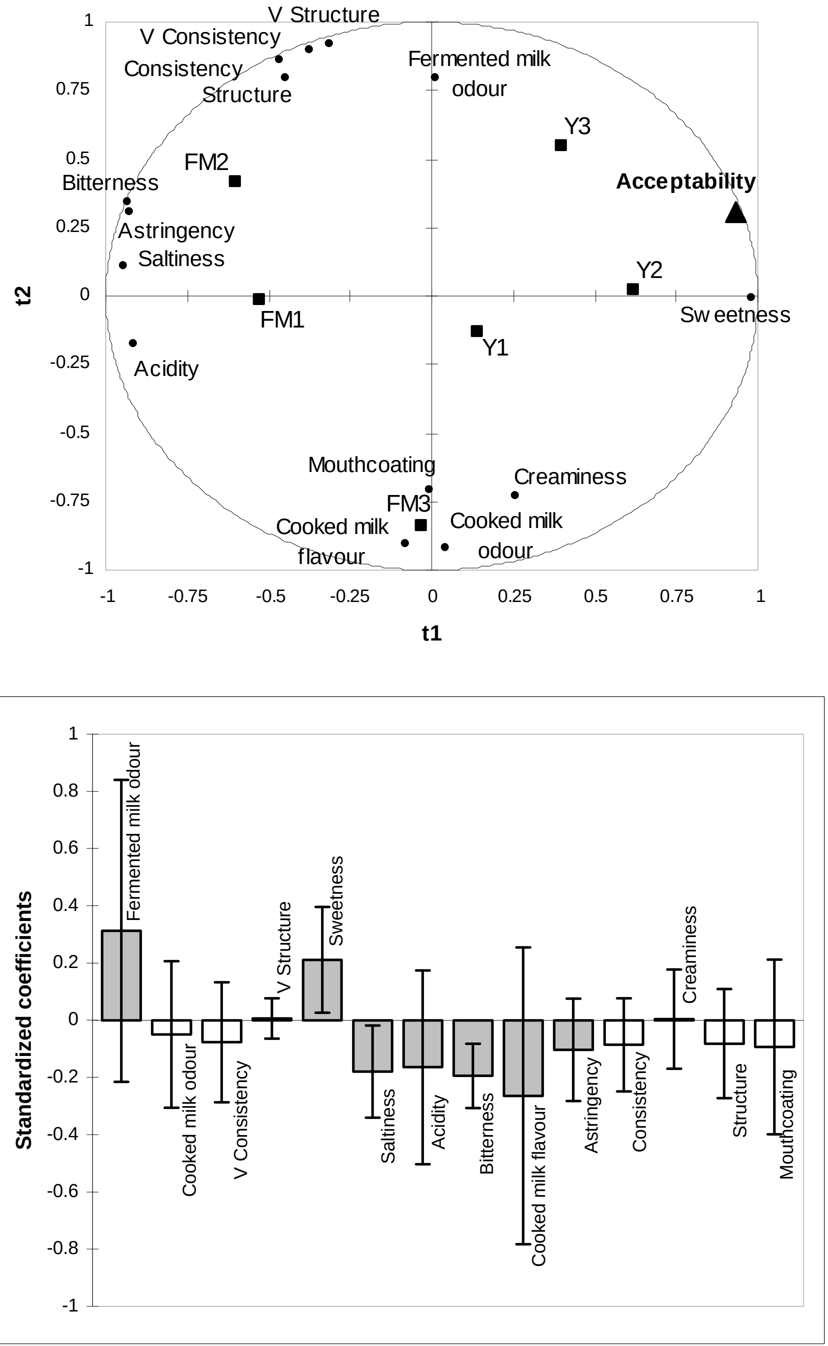


Fig 6. Bayarri et al.

Table 1. Sample description and nutritional facts of commercial yoghurt and fermented-milk samples[1,2]

Code	Sample	Main ingredients	Energetic value (Kcal/100g)	Fat content (g/100g)	Protein content (g/100g)	Carbohydrate content (g/100g)	Calcium content (mg/100g)
Y1	Sweetened yoghurt with calcium	Semi-skimmed milk, sugar, glucose syrup, yoghurt starter culture, calcium and milk proteins	87	1.8	3.2	14.4	96
Y2	Sweetened yoghurt	Semi-skimmed milk, sugar, skimmed-milk powder, and yoghurt starter culture	86	1.9	3.1	13.4	127
Y3	Sweetened skimmed yoghurt rich in calcium	Skimmed milk, yoghurt starter culture, calcium and sweeteners (acesulfame K and aspartame)	40	2.1	4.3	5.2	140
FM1	Fermented milk with active bifidus	Semi-skimmed milk, starter culture, and *bifidobacteria*	57	0.1	4.0	5.0	150
FM2	Skimmed fermented milk with active bifidus	Skimmed milk, skimmed-milk powder, cream, *bifidobacteria*, and others starter culture	46	0.4	4.4	5.5	163
FM3	Fermented milk with *L. casei imunitass*	Milk, sugar, milk proteins, and starter culture (yoghurt starter culture and *Lactobacillus casei)*	86	2.9	3.8	11.1	116

[1] Declared on label

[2] Y1, Y2, Y3: plain yoghurt samples. FM1, FM2, FM3: plain fermented-milk samples with yoghurt-like structure.

Table 2. Definitions of the descriptors and reference products used in the sensory evaluation of yoghurt and fermented milk products.

Attribute	Definition	Reference product
ODOUR		
Intensity	Magnitude of the odour perceived	
Fermented milk	Odour associated with the acid lactic	Yoghurt
Cooked milk	Odour sensation associated with the heated milk	Heated milk
Caramelized	Aromatic sweet sensation typical of the burnt sugar	Caramelized sugar
Vanilla	Sweet odour, with toasted, floral, or spicy notes	Vanilla stick
VISUAL TEXTURE		
Consistency	Speed of fall of the product from a spoon	Condensed milk
Structure	Geometric property related to the perception of the size and form of the particles (lumps)	Cottage cheese
FLAVOUR		
Intensity	Magnitude of the flavour perceived	
Sweetness	Elemental taste produced by aqueous solutions of sugar and different sweeteners	Sucrose solution
Saltiness	Elemental taste produced by aqueous solutions of sodium chloride	Sodium chloride solution
Acidity	Elemental taste produced by aqueous solutions of most acid substances (e.g. citric, tartaric)	Citric acid solution
Bitterness	Elemental taste produced by aqueous solutions of substances such as quinine or caffeine	Caffeine solution
Cooked milk	Flavour sensation associated with the heated milk	Heated milk
Astringency	Trigeminal sensation of drying, drawing, puckering of the mouth surfaces	Khaki, some red wines
Residual	Flavour perceived when the product has been swallowed, different from the one perceived when it was in the mouth	
TEXTURE IN MOUTH		
Consistency	Mechanical property perceived when compressing the product between the tongue and the palate	Condensed milk
Creaminess	Combined perception of fat, smoothness, and viscosity	Condensed milk, whipped cream
Structure	Geometric property related to the perception of the size and form of the particles	Cottage cheese
Mouthcoating	The mouthfeel of the product, once swallowed, consists in the perception of a thin layer covering the palate	

Table 3. Two-way ANOVA of sensory attributes scores of yoghurt and fermented milk samples (10 assessors, 6 samples, 3 replicates). *F* ratio values.

Attribute	Sample[1]	Assessor	Sample x Assessor	Sample[2]
ODOUR				
Intensity	3.72*	8.22*	1.68*	2.21[ns]
Fermented milk	13.21*	16.07*	1.91*	6.93*
Cooked milk	17.01*	16.31*	4.86*	3.50*
Caramelized	8.14*	6.29*	1.74*	4.68*
Vanilla	3.17*	2.08*	1.26[ns]	
VISUAL TEXTURE				
Consistency	87.95*	3.05*	1.10[ns]	
Structure	200.58*	4.16*	2.60*	77.22*
FLAVOUR				
Intensity	2.38*	7.22*	2.75*	0.87[ns]
Sweetness	131.47*	7.74*	1.44[ns]	
Saltiness	19.53*	13.22*	0.99[ns]	
Acidity	32.36*	7.37*	2.58*	12.56*
Bitterness	4.19*	8.50*	1.52*	2.76*
Cooked milk	33.93*	8.18*	3.60*	9.44*
Astringency	17.12*	16.42*	1.15[ns]	
Residual	0.56[ns]	3.39*		
TEXTURE IN MOUTH				
Consistency	32.67*	3.10*	1.41[ns]	
Creaminess	24.27*	3.33*	1.68*	14.43*
Structure	200.25*	7.61*	2.62*	76.3*
Mouthcoating	7.27*	7.97*	1.22[ns]	

[1] Calculated using the mean square error as denominator.
[2] Calculated using the mean square of interaction term as denominator.
* Significant at $\alpha \leq 0.05$; ns = not significant.

Table 4. Mean values of sensory attributes and corresponding Fisher's significant difference for samples[1,2]

Attribute	Samples						Standard error[3]
	Y1	Y2	Y3	FM1	FM2	FM3	
ODOUR							
Intensity	4.5^{a}	4.9^{a}	3.9^{a}	4.2^{a}	4.6^{a}	3.4^{a}	1.3
Fermented milk	3.8^{c}	5.2^{a}	4.3^{bc}	4.6^{ab}	4.9^{ab}	2.2^{d}	1.3
Cooked milk	2.2^{b}	1.8^{bc}	1.1^{d}	1.3^{cd}	1.6^{cd}	3.0^{a}	0.8
Caramelized	0.3^{b}	0.1^{bc}	0.03^{c}	0.02^{c}	0.1^{bc}	0.8^{a}	0.5
Vanilla	0.2^{ab}	0.02^{b}	0.03^{b}	0.03^{b}	0.02^{b}	0.4^{a}	0.4
VISUAL TEXTURE							
Consistency	4.1^{c}	4.6^{c}	7.7^{a}	6.9^{b}	7.9^{a}	2.7^{d}	1.0
Structure	3.5^{d}	3.1^{d}	7.4^{b}	4.6^{c}	8.5^{a}	0.8^{e}	0.9
FLAVOUR							
Intensity	7.4^{a}	6.8^{a}	7.1^{a}	7.4^{a}	6.8^{a}	6.8^{a}	0.9
Sweetness	6.1^{b}	7.4^{a}	7.4^{a}	1.3^{d}	1.0^{d}	4.6^{c}	1.1
Saltiness	1.2^{b}	1.0^{b}	0.9^{b}	3.1^{a}	2.9^{a}	1.5^{b}	1.0
Acidity	6.2^{bc}	3.4^{d}	3.9^{d}	7.7^{a}	6.7^{b}	5.7^{c}	1.3
Bitterness	0.7^{b}	0.3^{b}	0.7^{b}	1.2^{a}	1.3^{a}	0.6^{b}	0.8
Cooked milk	1.3^{bc}	1.6^{b}	0.8^{c}	1.4^{b}	1.4^{b}	3.8^{a}	0.8
Astringency	4.2^{b}	2.3^{c}	3.4^{bc}	5.7^{a}	6.6^{a}	3.4^{bc}	1.5
Residual	3.8^{a}	4.2^{a}	4.4^{a}	4.3^{a}	4.1^{a}	3.8^{a}	1.5
TEXTURE IN MOUTH							
Consistency	4.6^{c}	4.7^{c}	7.1^{ab}	6.6^{b}	7.8^{a}	3.6^{d}	1.3
Creaminess	7.0^{b}	7.8^{a}	5.7^{c}	7.8^{a}	4.9^{d}	7.8^{a}	1.1
Structure	1.7^{d}	1.4^{d}	5.2^{b}	2.9^{c}	7.3^{a}	0.9^{e}	0.8
Mouthcoating	4.6^{b}	5.5^{a}	4.1^{b}	5.7^{a}	4.2^{b}	5.6^{a}	1.3

[1] Identification of samples in Table 1.
[2] Means within a row with common superscripts not differ significantly ($\alpha \leq 0.05$)
[3] Sample standard error from ANOVA

Table 5. Mean acceptability values and standard deviations obtained with the hedonic scale (n=120) for yoghurt and fermented-milk samples. Skewness and kurtosis coefficients and *p*-values from Kolmogorov-Smirnov test[1]

Sample	Mean	Standard deviation	Skewness	Kurtosis	Kolmogorov-Smirnov test *p*-values
Y1	6.5	1.59	-0.756	0.224	<0.0001
Y2	7.3	1.20	-1.482	3.929	<0.0001
Y3	6.9	1.56	-1.082	0.688	<0.0001
FM1	4.9	2.44	-0.031	-1.391	0.002
FM2	4.8	2.07	0.036	-1.078	0.012
FM3	6.0	1.99	-0.591	-0.716	0.001

[1] Identification of samples in Table 1.