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

S. Bayarri*, I. Carbonell, E. X. Barrios and E. Costell

Physical and Sensory Properties Laboratory.

Instituto de Agroquímica y Tecnología de Alimentos, CSIC.

P. O. Box 73, 46100 Burjassot (Valencia) Spain.

** Correspondence should be addressed to:*

Sara Bayarri

Phone: +34-96-3900022

Fax: +34-96-3636301

e-mail: sbayarri@iata.csic.es

Abstract

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

32

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

34 **1. Introduction**

35

36 Growing interest in healthy eating has given rise to a new range of foods and
37 products on the market. An important point to consider is that consumer acceptance
38 of a new healthy product is far from being unconditional. Their benefits may provide
39 added value to consumers but cannot outweigh the sensory properties of foods (Siró,
40 Kàpolna, Kàpolna, & Lugasi, 2008). The acceptance of a product will depend on
41 whether it responds to consumer needs and on the degree of satisfaction it is able to
42 provide. For this reason, consumers' opinions must be taken into consideration, not
43 only to evaluate the acceptance of the final product, but also from the beginning of
44 the process of product development (Drake, Lopetcharat, & Drake, 2009; Van Kleef,
45 Van Trijp, & Luning, 2005). Furthermore, understanding which sensory attributes
46 drive liking is a key issue when developing new products, (Villegas, Tárrega,
47 Carbonell, & Costell, 2010) for product improvement and optimization (Ligget,
48 Drake, & Delwiche, 2008) and for the design of quality control programs (Costell,
49 2002).

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

59 The market offers a number of dairy products of similar appearance, colour, texture
60 and with the same type of packaging, but differing in product name and nutritional
61 information. Theoretically, the criteria a consumer follows when choosing a healthy
62 product cannot always be explained by differences perceived in the sensory quality
63 alone, but also the nutritional characteristics or composition and even its trade name
64 or price play a role. Recently, Pohjanheimo and Sandell (2009) studied the influence
65 of sensory and non-sensory characteristics of drinking yoghurt and concluded that
66 food choice motives (importance of natural content, ethical concern and health)
67 influences liking. In the case of healthy foods, it is logical to think that information
68 on their potential influence on health may affect their acceptance. However, this is
69 not always so. Shepperd, Sparks, Bellier and Raats (1991/92) noted that information
70 on the fat and sugar content did not influence the acceptance of milk beverages. A
71 similar result was obtained by Kähkönen, Tuorila and Lawless (1997) when
72 analyzing the effect of information on the acceptance of non-fat strawberry yoghurt.
73 Behrens, Villanueva and Da Silva (2007) did not detect differences in acceptability
74 of four types of yoghurt-like fermented soymilk between the overall liking rated
75 under blind testing or when the samples were rated with the corresponding nutrition
76 and health claims available. In a previous work, Bayarri, Carbonell, Barrios and
77 Costell (2010) investigated whether the information about product type and
78 nutritional facts affected consumer acceptability of plain yoghurts and fermented
79 milks. We observed that considering the average data for all the consumers,
80 nutritional and product information supplied did not influence acceptability of these
81 product types, yoghurt or fermented milk. The greatest difference in consumer
82 response to sample information was between consumer subgroups with different
83 sensory preference patterns. This attitude may be based on the fact that yoghurt is a

84 familiar product for consumers and the belief that it is beneficial to health is wide-
85 spread (Barrios, Bayarri, Carbonell, Izquierdo, & Costell, 2008; Kähkönen et al.,
86 1997; Newsholme, 2002). In studies about food acceptability a critical question is, to
87 what extent the variation in perceived sensory characteristics influences consumer
88 response. One must accept that variability in perceived intensity of certain attributes
89 by a trained panel or by a group of consumers may not affect acceptability (Costell,
90 Tárrega, & Bayarri, 2010). Therefore the main goal of studies aiming to identify
91 drivers of liking is usually to establish the relationship between the intensity of
92 perceptible attributes evaluated by trained panels and the degree of consumer
93 acceptance (Costell, Pastor, Izquierdo, & Duran, 2000; Tenenhaus, Pages,
94 Ambroisine, & Guinot, 2005). This approach can indicate which sensory attributes
95 most influence consumer acceptance. Validity of the results obtained with this
96 approach mainly depends on the uniformity of the preference criteria of the
97 consumers surveyed. When the individual responses come from consumers with
98 different preference criteria, the average values obtained from the whole population
99 tested do not reflect the actual situation (Young, Drake, Lopetcharat, & McDaniel,
100 2004). Moskowitz (1994) hypothesized that in the consumer population there exist a
101 limited number of basic groups of people and each group exhibits a specified pattern
102 of sensory preferences and suggested that variations in product acceptance in
103 different markets is the result of different distributions of these basic segments. To
104 study individual differences, the average values from the whole group of consumers
105 must be substituted by the analysis of the average values provided by subgroups of
106 consumers. Several techniques can be used to create subgroups of consumers with
107 respect to their individual sensory preferences. Most of them are based on studying
108 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.

125

126 **2. Material and methods**

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128 *2.1. Samples*

129

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

134 leading market brands. The samples, covering the commercial range, were purchased
135 from the local supermarket taking into account the sell-by dates (the same for each
136 brand) and were stored at $5\pm 1^{\circ}\text{C}$ prior to testing. All measurements were performed
137 within the declared shelf-life period of each sample.

138

139 2.2. *Sensory Analysis*

140

141 Tests were conducted in a standard room (ISO, 2007) equipped with nine individual
142 taste booths. Samples (about 15g) were served at $5\pm 1^{\circ}\text{C}$ in white plastic vessels
143 coded with three random digit numbers. Still mineral water was used as palate
144 cleanser. Experimental designs and data acquisition were performed using
145 Compusense® five release 4.6 (Compusense Inc., Guelph, ON, Canada).

146 *Sensory Profile.* For descriptor selection, an initial list of terms was prepared with the
147 information obtained from bibliography (Civille & Lyon, 1996; Hunter & Muir,
148 1993). A group of 10 assessors with previous experience (more than two years) in
149 evaluating sensory differences in various dairy products, were asked to evaluate the
150 suitability of these descriptors to describe the sensory characteristics of the samples
151 according to the checklist method (Damasio & Costell, 1991). Two sessions of two
152 hours were held. In these sessions, the assessors tested the samples and discussed the
153 most suitable attributes. They could also propose new terms. A list, composed of 19
154 terms regarding appearance, odour, flavour and texture of the samples, was finally
155 selected. The same group of 10 assessors was trained in four sessions according to
156 the ISO 8586-1 (1993) guidelines. The first session was held with the panel leader
157 and with all the assessors and was aimed to define the descriptors, to determine the
158 sample evaluation procedures, and establish the definitive scorecard. The final list of

159 descriptors, their definitions and some reference products are shown in Table 2. In
160 the second and third sessions, each assessor evaluated the intensity of the 19
161 previously selected attributes in separate booths on three different commercial
162 samples. The intensity of each attribute was scored on a non-structured 10 cm line
163 scale anchored as “not perceptible” or “weak” at the low end and “intense” at the
164 high end except for two texture attributes: consistency anchored with “thin” and
165 “thick” and structure with “smooth” and “rough”. At the end of each of these
166 sessions the panel leader and the assessors discussed the individual results obtained
167 in order to establish consensus criteria for evaluation. In the last training session,
168 attributes intensity of a reference sample, a commercial plain yoghurt sample not
169 included in the study, were individually scored and a consensus score for each
170 attribute was reached. These consensus scores were marked with “R” on the
171 definitive scorecard.

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

181 *Consumer Test.* Consumers were recruited by a local consumer association
182 (Association of Valencian Consumers and Users-AVACU) through a short
183 questionnaire sent by mail. The participants were selected according to the following

184 criteria: age (from 18 to 65 years), gender (40% men and 60% women) and
185 consumers of yoghurt (minimum intake of one a week). One-hundred-and-twenty
186 participants were selected. Prior to the test, it was confirmed that participants had no
187 allergies to milk or dairy products. The consumers evaluated the overall acceptability
188 of the six samples using a 9-point hedonic scale ranging from 1 (“dislike extremely”)
189 to 9 (“like extremely”). To avoid first position distortions and possible carry-over
190 effects, the samples were served to the consumers monadically according to a
191 balanced design (MacFie et al., 1989). Time lapse between evaluations of two
192 consecutive samples was fixed at 30 seconds.

193

194 2.3. Data Analysis

195

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

205 *Consumer Data.* Initially, mean and standard deviation for each sample was carried
206 out from data obtained from the whole group of consumers. To obtain information
207 about the symmetry and shape of the distributions obtained, frequency histograms,
208 skewness and kurtosis coefficients were calculated for each sample. To test

209 consumer data for normal distribution Kolmogorov-Smirnov test was applied. To
210 identify consumer subgroups with different preferences, the subgroups were
211 segmented based on acceptability scores of the samples by using Cluster Analysis
212 (Clustering Ward Method) (Vigneau & Qannari, 2002). Partial Least Squares
213 regression (PLSR) was applied (Wold, Sjöström & Eriksson, 2001) to model the
214 variance of consumer acceptance data which can be explained by variance in sensory
215 attributes obtained by the trained panel. PLSR was performed for each of the
216 previously identified consumer segments.

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

219

220 **3. Results and discussion**

221

222 *3.1. Descriptive Profile*

223

224 A fixed model of two-way ANOVA (samples and assessors) with interaction (Table
225 3) was applied to the sensory scores obtained for the 19 attributes evaluated.
226 Significant differences between samples ($\alpha=0.05$) were detected, with the exception
227 of one attribute: residual flavour. Assessors were also a significant source of
228 variation ($\alpha=0.05$) in all cases. This was not surprising since it is well known that, in
229 spite of the selection and training of judges, some variability always remains.

230 Variation among assessors can be due to individual differences in the use of scales or
231 to individual differences in sensitivity or motivation and it is very difficult to
232 eliminate completely (Carlucci & Monteleone, 2001; Tomic, Nilsen, Martens, &
233 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 $\times$ assessor interaction provides information about this point. In this case, with regard to the 18 attributes for which the panel found significant perceptible differences ($\alpha=0.05$) among samples, the effect of the sample $\times$ 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 $\times$ 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

259 samples (Y3 and FM2) and the semi-skimmed fermented milk with *bifidobacteria*
260 (FM1) which were in the positive part of this first dimension. The second component
261 explained 26.77% of total variability and was defined mainly by taste attributes. In
262 the upper part, there were the fermented milk samples, FM1, FM2 and FM3, which
263 were perceived as more acidic and slightly saltier than yoghurt samples (Y1, Y2, and
264 Y3). The latter samples, in the lower part of dimension, were clearly perceived as
265 sweeter. Samples FM1 and FM2, in the upper right quadrant, were the only samples
266 perceived as slightly bitter and with higher astringency (Fig. 1a). The third
267 component that explained 10.24% of variability was mainly related with odour and
268 flavour notes. Sample FM1 was perceived as having a more fermented-milk odour
269 and sample FM3 as having a more cooked-milk odour and cooked-milk flavour than
270 the rest of the samples (Fig. 1b). These data show that variability perceived among
271 samples corresponded mainly to texture and taste variability of samples.

272

273 3.2. Consumer Acceptability

274

275 *Whole Consumer Population.* Frequently, to obtain information about the
276 significance of differences among liking scores of samples, the data obtained from
277 whole consumer population are analyzed by analysis of variance. A related problem
278 is that data arising from hedonic scales frequently break the assumptions of
279 normality and homocedasticity (O'Mahony, 1982; Vie, Gulli, & O'Mahony, 1991).
280 Villanueva, Petenate and Da Silva (2000) commented that when a lack of normality
281 is observed in data from hedonic scales, the application of ANOVA may be not
282 suitable. In Table 5, the mean values and standard deviations of yoghurt and
283 fermented milk samples obtained with the hedonic scale from the 120 consumers

284 were presented. The standard deviations indicated that the variances corresponding to
285 the samples evaluated were not homogeneous, showing a certain lack of
286 homocedasticity. When the coefficients of skewness and kurtosis were calculated to
287 obtain information about the symmetry and shape of the distributions corresponding
288 to the different yoghurt and fermented milk samples (Table 5) it was confirmed that
289 deviations occurred from the normal distribution. Positive kurtosis coefficient values
290 for yoghurt samples showed that their distributions were peaked with more data near
291 the mean value than that corresponding to normal distribution. Negative kurtosis
292 coefficients for fermented milk samples indicated flatter distributions. Representing
293 the frequencies of the hedonic acceptability scores given by the whole consumer
294 population can illustrate the characteristics of distributions obtained (Fig. 2). Sharp
295 distributions with one mode and with moderate asymmetry to the left side were
296 observed for the yoghurt samples, while flat distributions with two modes were
297 observed for fermented milk samples. For these last three samples a mode appeared
298 at the lower scale values (2-4) corresponding to non acceptable samples and came
299 from consumers that do not like fermented milk samples. The other mode appeared
300 at higher scale values (6-8) that correspond to acceptable samples and correspond to
301 consumers that like these products. Similar results were obtained by Carbonell,
302 Bayarri, Navarro, Carbonell and Izquierdo (2009) when evaluating the acceptability
303 of fresh mandarin juices of different varieties with the hedonic scale. They concluded
304 that when two modes were observed in data distribution, the individual responses
305 come from consumers with different preference criteria and the average values
306 obtained from the whole population tested do not reflect the real consumers'
307 response. The lack of sample distribution normality was confirmed by the
308 Kolmogorov-Smirnov test. Probability values were clearly significant for all the

309 samples (Table 5). Hence in this situation, the relationships established between the
310 intensity of the sensory attributes and the overall mean hedonic values can fail to
311 predict which sensory attributes are important in defining product acceptability.
312 From the practical point of view, one solution could be to establish such relationships
313 with the average hedonic values provided by subgroups of consumers showing
314 similar preference patterns.

315 *Consumer Segmentation.* When Cluster Analysis was applied to preference data, two
316 segments of consumers were initially detected (Fig. 3). One of them (n=46) did not
317 show clear differences in sample acceptability. The average hedonic score for the six
318 samples varied around 6.5. For the consumers in the second segment (n=74) clear
319 differences in the average hedonic value (from 3.0 to 7.5) were detected among
320 samples. A similar result was observed by Ligget et al. (2008) when Cluster Analysis
321 were applied to hedonic ratings obtained from 101 consumers regarding the flavour
322 of different Swiss cheese samples. They observed two consumer clusters with
323 different responses to samples. One was identified as “nondistinguishers” and the
324 other as “varying responder consumers”. In our case, a more detailed observation of
325 the information obtained by Cluster Analysis (Fig. 3) showed that three distinct
326 clusters of consumers can be identified as components of our second segment of
327 consumers. According these results, one can hypothesize that in the population
328 surveyed there are four groups of consumers with clearly distinguishable sensory
329 preferences: A first group, representing about of 38% of consumers, for whom the
330 variability in intensity of sensory attributes among samples does not affect sample
331 acceptability and a second group formed by three subgroups showing clear
332 differences in acceptability among samples (Fig. 4). A small subgroup (CL1, n=11)
333 representing less than 10% of the total population likes the less sweet and more

334 acidic fermented milk samples (FM1 and FM2) and the other two subgroups (CL2,
335 n=32 and CL3, n=31) like more the sweet and less acidic yoghurt samples (Y1, Y2
336 and Y3). Differences in average acceptability scores of the six samples for the CL2
337 and CL3 subgroups (Fig. 4) showed that the largest difference in acceptability
338 corresponded to fermented milk FM3 which was perceived as having more
339 creaminess and smoothness and less consistency (Fig. 1). This sample was
340 considered highly acceptable by CL2 consumers (average score=7.2) and
341 unacceptable by CL3 consumers (average score=3.5). As the purpose of the study
342 was to identify drivers of product liking/disliking, only the data corresponding to
343 CL1, CL2 and CL3 subgroups of consumer were retained for subsequent analysis.

344

345 *3.3. Relationships between Acceptability and Sensory Attributes*

346

347 Partial least squares regression (PLS) was used to determine the sensory factors
348 driving consumer liking for the different consumer subgroups. Initially, for
349 consumers in CL1, a two component PLSR model ($R^2 = 0.821$) was obtained. The
350 regression explained 82.1% of the mean acceptability scores (Y-data) and 83.9% of
351 the average sensory attribute scores (X-data). However this solution has a $Q^2_{cum} = -$
352 0.064 indicating that the model obtained is poor and does not predict better than
353 chance. Statistical outlier analysis determined FM1 sample to be an outlier. A new
354 model was obtained removing FM1 sample. The new regression explained 99.9% of
355 the mean acceptability scores and 96.4% of the average sensory attribute scores with
356 a $Q^2_{cum} = 0.970$ on three normally distributed components. The standard coefficients
357 for sensory attributes obtained by PLS were considered significant when the variable
358 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 $Q^2_{cum}=0.912$. 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 $Q^2_{cum}=0.814$ (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.

373

374 **4. Conclusions**

375

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

384 consumer population. For an important group of consumers (38%) the variability in
385 intensity of sensory attributes among samples did not affect sample acceptability.
386 They liked all six samples to same extent. For the other three groups, perceptible
387 differences among samples influenced liking in a different way. When PLSR was
388 applied to the data corresponding to each of the these three groups of consumer,
389 results showed that for a small subgroup (10%) liking was driven by saltiness,
390 acidity, bitterness, astringency and cooked milk odour and disliking was driven by
391 sweetness. For the other two subgroups of consumers (52%) results showed that
392 liking was correlated positively with sweetness and negatively with acidity, saltiness,
393 astringency bitterness and cooked-milk flavour although for one of them two textural
394 attributes, consistency and structure, were found to drive product acceptance too.
395 This type of information can be important to predict or to explain the market
396 response to food products and also to select which sensory attributes should be
397 included in a sensory specification or must be considered in product quality control
398 programs.

399

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401

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520 **FIGURE LEGENDS**

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

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

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

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

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

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

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543 Figure 1. Bayarri et al.

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Figure 4. Bayarri et al.

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Fig 5. Bayarri et al.

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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 <i>bifidobacteria</i>	57	0.1	4.0	5.0	150
FM2	Skimmed fermented milk with active bifidus	Skimmed milk, skimmed-milk powder, cream, <i>bifidobacteria</i> , and others starter culture	46	0.4	4.4	5.5	163
FM3	Fermented milk with <i>L. casei imunitass</i>	Milk, sugar, milk proteins, and starter culture (yoghurt starter culture and <i>Lactobacillus casei</i>)	86	2.9	3.8	11.1	116

¹ Declared on label² Y1, Y2, Y3: plain yoghurt samples. FM1, FM2, FM3: plain fermented-milk samples with yoghurt-like structure.

- 1 **Table 2.** Definitions of the descriptors and reference products used in the sensory
2 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.

9 **Table 4.** Mean values of sensory attributes and corresponding Fisher's significant
10 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

11 ¹ Identification of samples in Table 1.

12 ² Means within a row with common superscripts not differ significantly ($\alpha \leq 0.05$)

13 ³ Sample standard error from ANOVA

14 **Table 5.** Mean acceptability values and standard deviations obtained with the
15 hedonic scale (n=120) for yoghurt and fermented-milk samples. Skewness and
16 kurtosis coefficients and *p*-values from Kolmogorov-Smirnov test¹

Sample	Mean	Standard deviation	Skewness	Kurtosis	Kolmogorov- Smirnov test <i>p</i> -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

17 ¹ Identification of samples in Table 1.
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