Sensory properties and acceptance of Uruguayan low-fat cheese "queso magro"

Patricia Arcia, Ana Curutchet, Elvira Costell & Amparo Tárrega

Dairy Science & Technology
Official journal of the Institut National de la Recherche Agronomique (INRA)Formerly 'Le Lait'

ISSN 1958-5586

Dairy Sci. & Technol.
DOI 10.1007/s13594-013-0109-6

Dairy Sci. & Technol.
DOI 10.1007/s13594-013-0109-6

ORIGINAL PAPER

Sensory properties and acceptance of Uruguayan low-fat cheese "queso magro"

Patricia Arcia · Ana Curutchet · Elvira Costell · Amparo Tárrega

Received: 29 June 2012 / Revised: 17 January 2013 / Accepted: 18 January 2013

Abstract Due to health and overweight concerns, there is an increasing interest of consumers for low-fat food. The objective of this work was to study the differences in sensory properties of a Uruguayan low-fat cheese "queso magro" and to establish whether there is a relationship with its acceptability. Six samples of this type of cheese from different commercial brands were studied. The sensory properties of these cheeses were evaluated by a trained panel and subsequently sample acceptability was evaluated by 84 consumers. Uruguayan low-fat cheeses were characterized by having a soft odor and taste, intermediate firmness, medium–high elasticity, and low friability. Samples mainly differed in their texture attributes, firmness, and elasticity though slight variations were observed for flavor attributes. Consumers' liking scores varied widely among samples. The analysis of the relationship among sensory properties and acceptance revealed that flavor attributes like odor and taste intensity, bitterness and aftertaste were those that dictated the differences in acceptance. According to that, in the manufacture of Uruguayan low-fat cheese, to develop a product highly accepted by consumers, efforts should be directed mainly to improve odor and flavor.

Keywords Low fat · Cheese · Sensory profile · Acceptability

1 Introduction

Fat reduction in the diet is important based on scientific evidence linking high-fat diets to coronary heart disease and certain types of cancer (Woteki and Thomas

P. Arcia · E. Costell · A. Tárrega (✉)
Physical and Sensory Properties Laboratory, Instituto de Agroquímica y Tecnología de Alimentos, CSIC, Avda Agustín Escardino, 746980 Paterna, Valencia, Spain
e-mail: atarrega@iata.csic.es

P. Arcia · A. Curutchet
Laboratorio Tecnológico del Uruguay, Av. Italia 6201, 11500 Montevideo, Uruguay

Published online: 27 February 2013

1993). This association has led to increasing consumer awareness and an important increase in the supply of, and demand for, low-fat foods, including low-fat cheeses. The concept of low-fat cheese manufacture is not a new idea; the emphasis on controlling caloric intake, especially in developed countries, has largely been responsible for the growth in low-fat cheese markets in the past 20 years (Mistry 2001). Although low-fat cheese helps reduce fat and calorie intake, the removal of fat causes changes in cheese flavor and texture. Originally, low-fat cheeses, launched in the early 1990s, were met with general dissatisfaction and consumers were not willing to sacrifice the cheese flavor they desired to avoid a few grams of fat (Drake and Swanson 1995). Furthermore, cheese texture is strongly affected by fat reduction (Drake and Swanson 1995; Yates and Drake 2007). Gwartney et al. (2002) reported that the majority of reduced-fat cheeses were characterized by having higher chewiness, hardness, waxiness, fracturability, and springiness. Brown et al. (2003) and Yates and Drake (2007) confirmed these findings and showed that reduced-fat cheeses were firmer and springier and displayed lower adhesiveness and cohesiveness compared with full-fat cheeses.

The low hedonic expectation generated in consumers by fat reduction has been the major obstacle to the success of low-fat versions of already well-known cheese varieties (Mistry 2001). However, the strategies consumers adopt to reduce fat in their diets are not straightforward and, rather than derivatives of existing products, consumers prefer low-fat products considered "new" or start to consume products traditionally known as having low-fat content. This is the case of "queso magro" in Uruguay, which is a semi-soft cheese ripened for 1–2 months and with low-fat content (10–25% by dry matter, according to RBN Decree No. 315/94) and, due to both health and overweight concerns, there is an increasing demand for this product. This presents an interesting opportunity for manufacturers to launch a potentially successful product, provided they develop a low-fat cheese with the sensory properties consumers want. Therefore, it is important to know how the variations in sensory properties affect acceptability and to determine which sensory characteristics drive consumer liking of this product (ten Kleij and Musters 2003). The most usual procedure to do this is to relate acceptance ratings with the sensory profile of samples. While trained assessors are necessary to objectively provide a quantitative description of the perceived sensory characteristics of a product (Jellinek 1985), acceptance is evaluated by naïve consumers.

The objective of this work was to study the variability in sensory properties of Uruguayan commercial low-fat cheeses and to establish how this related to its acceptability.

2 Materials and methods

2.1 Samples

Six Uruguayan commercial low-fat cheeses (coded from A to F) were evaluated. The samples were selected to represent the range of commercial products (based on a preliminary study of differences among commercial products). The samples were purchased from the market, taking into account expiry dates, and were stored under refrigeration (4±1 °C) until analyzed. Samples were evaluated at the same time frame from production, approximately 2 months.

2.2 Chemical analysis

The fat content of samples was analyzed using the Van Gulik method (ISO 2008). The moisture content of cheeses was determined using the oven method (9 h at 102 °C; ISO 2004). The protein content of cheeses was determined using the Kjeldahl method (ISO 2001). Salt content (sodium chloride) of cheese samples was measured using potentiometric titration method (ISO 2006). Two replicates of each sample were analyzed.

2.3 Instrumental texture analysis

Texture profile analysis (TPA) was performed on the six samples, using a TA-XT2i (Stable Micro Systems Ltd., Godalmingel, UK). For the tests, samples at 4±1 °C were cut and equilibrated at room temperature (20±1 °C) for 30 min before measurements were taken. For TPA analysis, samples were cut into cylindrical pieces of 17 mm in diameter and 20 mm in height and were compressed using two uniaxial compression cycles. Test conditions were: P/75 aluminum cylinder probe (75 mm diameter); pre-test speed, 5 $mm.s^{-1}$; test speed, 5 $mm.s^{-1}$; post-test speed, 5 $mm.s^{-1}$; compression (strain), 35%; time pause, 5 s. From the force/time curves, firmness, springiness, cohesiveness, chewiness, and resilience were obtained. For this analysis, three replicates of each sample were analyzed. Data collection and calculations were done using the Texture Expert Exceed Version 2.52. (Stable Micro Systems Ltd., Godalmingel, UK)

2.4 Sensory analysis

Sensory properties of cheeses were evaluated by a trained panel and the acceptability of samples was evaluated by consumers. Both analyses were carried out in a standardized test room (ISO 8589 ISO 2007). Cheese samples were cut into sticks with approximate dimensions of 1.5×1.5 and 5 cm in height, served in transparent plastic dishes, coded with three digit random numbers. Samples were served at 15 °C (temperature of consumption=17±2 °C). Mineral water was provided for mouth-rinsing.

2.4.1 Selection and training of assessors

Sixteen candidates, between 28 and 50 years old (nine women and seven men) participated in the selection and training of the cheese sensory panel. Assessors were selected following the ISO 2009 guidelines. The assessors' discrimination ability for the four basic tastes (acid, salt, sweet, and bitter) were evaluated in preliminary triangle tests and ranking tests in two different medium (water and ricotta cheese) (Gallerani et al. 2000). All assessors achieved high percentages of success in all these tests. In the next stage, they were trained to recognize the cheeses attributes. Texture and flavor descriptors were considered in separate sessions. An initial list with descriptors used by other authors (Montero et al. 2005; Lavanchy et al. 1993) was presented to the assessors. By open discussion among panel leader and assessors the final list of terms was established (Table 1). Reference products were used to fix the

Table 1 List of attributes, definition, and anchors used during training sessions

Attribute	Definition	Scale level	Reference product and intensity
Odor intensity	Strength of the stimulus perceived above the serving of cheese, either directly as we approach it, or when we break into two near the nose	Not detected to high	Water=0, Colonia cheese[a]=4, and semi-hard cheese=6
Firmness tactile	Resistance of the sample to be compressed by the forefinger	Weak to high	Watermelon=1, olive=4, and candy/carrot=7
Firmness in mouth	Resistance of the samples to a very slight opening and shutting of the jaws	Weak to high	Watermelon=1, olive=4, and carrot=7
Elasticity	Ability of a cheese sample to rapidly regain its initial shape after its compression and deformation.	Low to high	Soft butter/raw carrot=0, olive=4, and frankfurter=7
Friability	Capacity of a sample to break up into numerous pieces from the beginning of mastication	Low to high	Hardboiled egg white=1, muffin=4, and shortbread/ Alfajor de maizena)=7
Solubility	A sensation which emerges when the sample melts extremely fast in the saliva	Low to high	Muffin=3, hardboiled egg yolk=5, and meringue=7
Impression of Humidity	Perception of the degree of humidity in the sample in the mouth	Dry to watery	Meringue/Gofio=1, frankfurter=5, and tangerine =7
Adhesivity	The effort needed for the tongue to detach a product stuck to the palate	Low to high	Hardboiled egg white=1, hardboiled egg yolk=4, and melted mozzarella/dulce de leche=7
Taste intensity	Strength of the stimulus perceived retronasal when the cheese is placed in the mouth.	Low to high	Low-fat cheese without salt added=1, Colonia cheese[a]=4, and semi-hard cheese=6
Sweetness	Describes the taste produced by aqueous solutions of substances such as sucrose	Low to high	Colonia cheese[a]=4
Bitterness	Describes the taste produced by dilute aqueous solutions of various substances, such as quinine and caffeine	Not detected to high	Blue cheese=5
Salty	Describes the taste produced by aqueous solutions of substances such as sodium chloride.	Not detected to high	Low-fat cheese without salt added=0 and semi-hard cheese=6
Acidity	Describes the taste produced by dilute aqueous solutions of most acids bodies	Low to high	Cream cheese=5

Table 1 (continued)

Attribute	Definition	Scale level	Reference product and intensity
Spicy	Describes the trigeminal sensation manifested in the mouth in the form of itching	Not detected to high	Semi hard cheese/Gruyere cheese=6
Aftertaste	Smell taste sensation that appears after the elimination of the product and differs from the sensations perceived when it was in the mouth	Low to high	Colonia cheese[a]=4 and semi-hard cheese=6

[a] Colonia cheese is a semi-hard cheese, typical of Uruguay

anchors on the scale (Lavanchy et al. 1993; ISO 2009; Bourne 2002). The following six sessions were used to train assessors in the use of a 0–7 unstructured line scale for all attributes (Table 1). In these sessions assessors evaluated three cheese samples. At the end of each session, the panel leader and the assessors discussed the individual results obtained in order to recognize deviations and correct them. Finally, three sessions were performed to evaluate discrimination capability and repeatability of assessors. To do so, they evaluated four cheese samples in triplicate and a two-way ANOVA (sample and session) for each attribute and each assessor was used. An assessor was considered to be repeatable for an attribute if $F_{session}$ value was not significant ($p>0.05$) and was considered to discriminate among samples if F_{sample} was significant ($p<0.5$). According to these criteria, twelve assessors with good discriminatory capacity (F_{sample} not significant for less than four attributes) and adequate repeatability ($F_{session}$ not significant in more than five attributes) were considered to be part of the final panel.

2.4.2 Sensory profile

The six commercial low-fat cheeses were profiled in duplicate by the trained panel over four sessions, evaluating three samples per session. The order of sample presentation was established according to a William design for three samples. Each of the assessors evaluated the intensity of the fifteen attributes for each cheese sample using the 0–7 unstructured line scale

2.4.3 Consumer acceptance

Eighty-four consumers (54% women and 46% men) between 18 and 66 years of age that regularly consumed low-fat cheese (at least once a week) participated in this part of the study. They evaluated the overall acceptability of the six samples in one session using a 9-point hedonic scale (1="I dislike extremely", 9="I like extremely"). The order of sample presentation was established according to a William design for six samples (MacFie et al. 1989).

2.5 Data analyses

One-way analysis of variance (ANOVA) was performed on chemical and texture parameters in order to study the variability among cheese samples. Relationships between cheese composition and instrumental parameters were established by partial least square (PLS) regression. On acceptability data, a mixed model of ANOVA was applied. Significance of differences between samples was determined by Tukey's test ($\alpha \leq 0.05$). Data from the evaluation of the six cheeses (12 assessors, 15 attributes, 6 samples, and 2 replicates) were analyzed for each attribute with two-way ANOVA (assessors and samples) with interaction. Concordance for each assessor was studied analyzing the interaction effect. In order to identify the assessors with low concordance with the rest of the panel, the approach proposed by Carbonell et al. (2007) was followed, consisting of estimating the contribution of each panelist to the total sum of squares of the interaction (SSI). According to the increasing contribution values, rank orders were assigned to each panelist, and for each of them the sum of rank orders of the fifteen attributes was computed. Principal component analysis (PCA) was applied to the correlation matrix of the average values of the sensory attributes for low-fat cheese samples. Relationships between the sensory attributes and consumer acceptability were established by PLS regression. Analyses were performed using XLSTAT Version 2011 (Addinsoft 1995–2010, France).

3 Results and discussion

3.1 Cheese characterization: composition and mechanical properties

Moisture, fat, sodium, and protein content for each cheese sample are shown in Table 2. The values of all these parameters significantly varied among samples ($p \leq 0.05$). In accordance with the National Bromatological Regulation of Uruguay (1994), cheeses can only be considered as "queso magro" if they

Table 2 Mean values (n=2) for the chemical composition of cheeses

Sample	Moisture (%)	Fat[a] (%)	Sodium (mg/100 g)	Protein (%)
A	51.1^{c}	13.8^{c}	306^{c}	29.4^{b}
B	54.9^{a}	11.5^{e}	422^{b}	28.2^{c}
C	52.3^{b}	10.5^{f}	368^{b}	30.9^{a}
D	50.5^{c}	13.0^{d}	556^{a}	30.9^{a}
E	45.4^{e}	21.5^{a}	425^{b}	28.0^{c}
F	47.8^{d}	16.3^{b}	575^{a}	30.7^{a}

For each parameter, values not sharing similar lowercase letters are significantly different (p=0.05)

[a] Percentage of fat on dry basis

have a fat content between 10% and 24.9% expressed in dry weight. Although the cheese samples in this study showed an important variation in fat content (from 10.5% to 21.5%), all of them complied with the interval defined by this regulation.

Data obtained from TPA allowed cheese samples to be characterized in terms of firmness, springiness, cohesiveness, chewiness and resilience. For all parameters, the values varied significantly among samples (Table 3). Firmness and chewiness showed the most important differences among samples while springiness, cohesiveness and resilience values varied only slightly among samples. PLS regression was performed to find the possible relationships among cheese texture and composition. Two first dimensions explained 81% of total variability in TPA parameters (Fig. 1). Firmness and chewiness of cheeses was positively related with protein to moisture ratio and salt content. Sample F with higher protein to moisture ratio and high salt content was the firmest. These results agreed with previous studies that explained the effect of both factors on cheese firmness by its influence on the strength of the protein network. Walstra and van Vliet (1982) showed that increasing the ratio of moisture to protein in cheese decreased firmness because protein network became weaker as the volume fraction of the protein decreased. Pastorino et al. (2003) studied the role of salt on the structure of cheeses and showed that the increase in hardness with salt content was due to the ionic strength increase that favored solvation of proteins and altered protein interactions. Cohesiveness appeared in the PLS plot positively related with moisture content and negatively related to fat content. Sample B with high moisture and low-fat content was the most cohesive while samples E and F with low moisture and high-fat content were the less cohesive.

3.2 Sensory profile of cheeses

Twelve assessors evaluated the intensity of the fifteen attributes in the six cheese samples. Concordance among assessors in sample evaluation can be estimated from the interaction sample×assessor. The results of the two-way ANOVA (assessor and sample) showed that interaction effect was significant in many attributes (eight out

Table 3 Texture parameters of cheeses samples obtained from TPA analysis

Sample	TPA				
	Firmness (N)	Springiness	Cohesiveness	Chewiness (N)	Resilience
A	22.7^{c}	0.92^{b}	0.87^{abc}	18.1^{c}	0.43^{ab}
B	7.1^{d}	0.98^{a}	0.89^{a}	6.2^{d}	0.45^{ab}
C	7.6^{d}	0.94^{ab}	0.88^{ab}	6.3^{d}	0.42^{b}
D	30.6^{b}	0.95^{ab}	0.88^{ab}	25.7^{b}	0.48^{a}
E	29.4^{b}	0.92^{b}	0.85^{c}	23.1^{b}	0.41^{b}
F	43.8^{a}	0.95^{ab}	0.86^{bc}	35.9^{a}	0.44^{ab}

For each parameter, values not sharing similar superscript letters are significantly different (p=0.05)

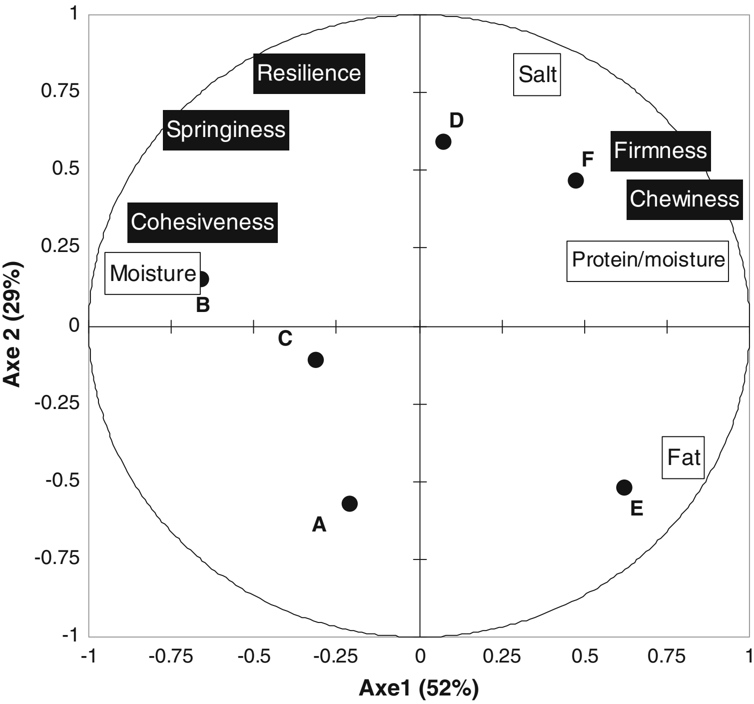

Fig. 1 PLS regression analysis of cheese composition (*X* variables) and instrumental texture (*Y* variables)

the fifteen attributes assessed indicating a lack of agreement between assessors in their evaluation of these attributes. The contribution of each panelist to the total SSI was calculated and the sum of rank orders of the fifteen attributes was computed for each assessor. The two-way ANOVA performed without considering data from the two assessors that contributed most to the interaction showed that the number of attributes showing a significant interaction effect was reduced from eight to three (solubility, impression of humidity, and adhesiveness). Accordingly, data from these two assessors were not considered in further analysis.

A mixed model ANOVA was performed on the data of the sensory attributes scored across the six samples. According to results, the sample effect was significant ($p=0.05$) for all attributes, even in those for which the effect of assessors×sample interaction had been found significant.

Table 4 shows the mean value of each attribute for each cheese sample and the significant differences among samples. According to the results, tactile firmness of the studied cheeses ranged from 2.6 to 4.0 on the 0–7 intensity scale. Samples B and C presented significantly lower firmness than the remaining samples, which showed intermediate firmness. In the case of firmness evaluated in mouth, data followed the same trend as for tactile firmness. The values obtained for elasticity (4.4 to 5.1), indicated that in general all the studied samples showed a marked elastic quality, although differences in elasticity were perceived among samples. Sample C was the most elastic, while samples D and F showed the lowest elasticity. For friability and solubility, variation among samples followed a similar trend within a narrow range between 2.2 and 2.8. These values indicate that both friability and solubility in these

Table 4 Means values of each attribute for each cheese sample (A–F)

Attributes	A	B	C	D	E	F
Firmness tactile	3.72[a]	2.69[b]	2.57[b]	3.98[a]	3.77[a]	3.82[a]
Firmness in mouth	3.72[ab]	2.60[c]	2.54[c]	4.01[a]	3.65[ab]	3.57[b]
Elasticity	4.56[c]	4.99[ab]	5.11[a]	4.38[c]	4.66[bc]	4.39[c]
Friability	2.82[a]	2.42[bc]	2.17[c]	2.54[ab]	2.45[bc]	2.71[ab]
Solubility	2.83[a]	2.47[bc]	2.18[c]	2.61[ab]	2.45[bc]	2.72[ab]
Impression of humidity	3.58[ab]	3.79[a]	3.91[a]	3.13[c]	3.63[a]	3.16[bc]
Adhesiveness	2.49[a]	2.58[a]	2.44[ab]	2.03[b]	2.38[ab]	2.33[ab]
Odor intensity	2.23[a]	1.77[b]	1.67[b]	1.92[ab]	1.86[ab]	1.69[b]
Taste intensity	2.59[a]	1.88[bc]	1.72[c]	2.22[ab]	1.89[bc]	2.30[a]
Sweetness	0.72[ab]	0.74[ab]	0.57[ab]	0.59[ab]	0.81[a]	0.49[b]
Salty	1.98[a]	1.31[b]	0.92[b]	1.74[a]	1.30[b]	1.89[a]
Bitterness	1.14[b]	0.92[b]	1.84[a]	0.94[b]	0.90[b]	0.82[b]
Acidity	1.32[ab]	1.12[ab]	0.94[b]	1.47[a]	1.23[ab]	1.40[a]
Spicy	0.84[a]	0.54[abc]	0.28[c]	0.57[abc]	0.50[bc]	0.62[ab]
Aftertaste	1.84[a]	0.98[b]	1.25[b]	1.33[b]	1.10[b]	1.26[b]

Within each row, mean values not sharing similar letters are significantly different ($p \leq 0.05$)

cheese samples were quite low. Within the range, sample A was the most friable and soluble, whereas sample C was the least. With respect to the impression of humidity, the values varied from 3.1 to 3.9 and seemed to be related with firmness. The softest samples (C and B) corresponded with the highest values for impression of humidity, while the hardest sample (D) had the lowest value for impression of humidity. The adhesiveness was low for all samples, barely varying from 2 and 2.6.

With respect to flavor (Table 4), the Uruguayan low-fat cheeses presented low values for all flavor attributes, indicating that this type of cheese is characterized by not being very tasty. For overall odor and taste intensity, the values barely varied among samples from 1.7 to 2.2 and from 1.7 to 2.6, respectively. For both attributes, the highest intensity was found in sample A, while sample C corresponded to less intense taste. Sweetness and spiciness presented values lower than 1 and can be considered as attributes that are not characteristic of these cheese samples. Acidity of samples varied in a narrow range from 0.9 to 1.5. The intensity of saltiness differed among samples, varying from 0.9 to 2.0. The salty taste was significantly more intense in samples A, D and F than in samples B, C and E. Although NaCl content in sample A (Table 2) was significantly lower than the rest of the samples, the intensity of salt perceived was similar to those samples with a higher NaCl content. This result suggests that the intensity of the perceived salty taste does not only depend on NaCl concentration. As stated in previous studies (Kilcast and Rider 2007; Ritvanen et al. 2010), differences in sample texture and the presence of other substances (fat, aroma, and other taste compounds) may also be responsible for the variation in saltiness perceived. Regarding bitterness, sample C (1.8) significantly differed from the other samples for which the difference was not significant, with an average value of 0.94. The aftertaste was in general low, varying from 1.0 to 1.8. The most intense aftertaste corresponded to sample A.

In order to study the sensory differences among cheese samples, taking into account all sensory attributes, a PCA was performed. The first two principal components (PCs) were calculated and accounted for 88% of the variability in the cheese. The first principal component explained 74% of the variance and was mainly related to texture attributes. It was positively correlated with firmness (tactile and in mouth) and negatively correlated with elasticity, impression of humidity, adhesiveness and also with bitterness. The second principal component explained 14% of the variance and was mainly correlated with flavor attributes. According to its position on the map shown in Fig. 2, the main characteristics that differed among samples could be identified. So, major differences among samples corresponded to differences in texture attributes. Sample B and C proved more elastic and less firm than the other samples. Also, sample C showed more impression of humidity and more bitterness than the others. Sample A was characterized by having a stronger aftertaste, odor intensity, taste intensity and saltiness, and an intermediate firmness. Samples D, E, and F were less adhesive and firmer than the remaining samples.

3.3 Relationship between acceptance and sensory properties

Acceptance of the low-fat cheeses was evaluated by eighty-four consumers. Analysis of variance showed that the acceptability significantly varied among samples (F= 22.3, p<0.0001). Consumers' liking scores differed greatly for the commercial Uruguayan low-fat cheeses. Sample A was the most liked (mean value of 6.8) while sample C was clearly disliked by consumers (mean value of 3.9). Samples B, D, E, and F did not differ significantly from each other, with an intermediate liking score (mean values of 6.1, 5.9, 5.7, and 5.4, respectively).

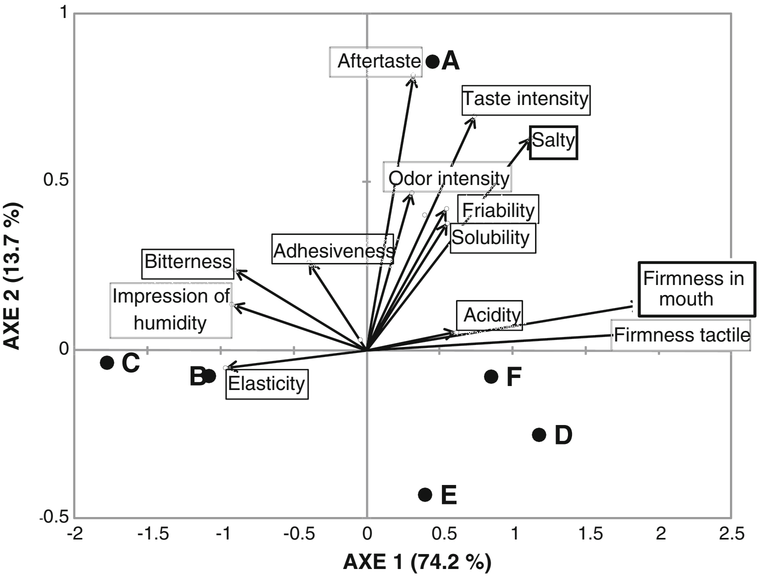

Fig. 2 PC plot of cheese samples and sensory attributes

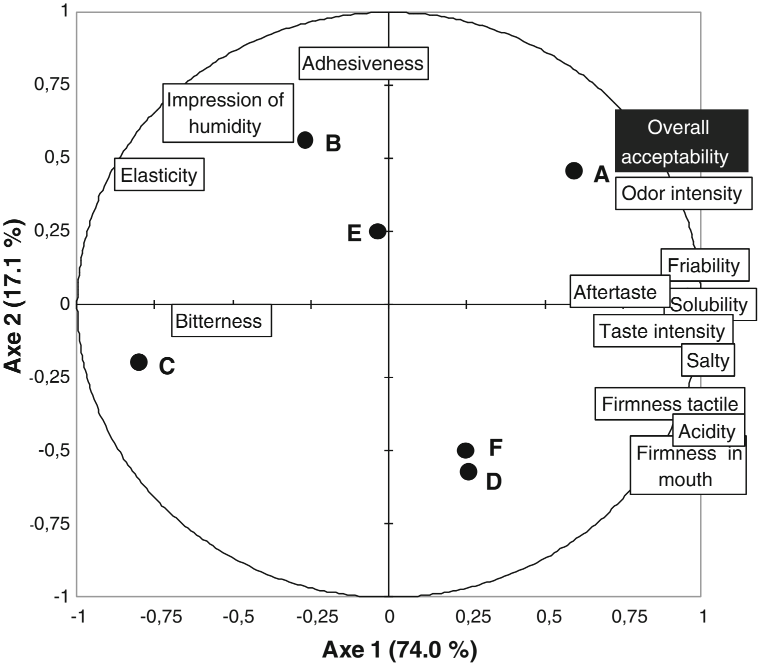

Fig. 3 PLS regression analysis of cheese sensory attributes (*X* variables) and acceptability (*Y* variables)

In order to explain which differences in sensory properties were responsible for the differences in acceptance of the Uruguayan low-fat cheese samples, data were subjected to a PLS regression. The model obtained explained 91.1% of the variability in cheese acceptability. In the PLS plot (Fig. 3), the relationship between acceptance and sensory variables can be observed. Acceptance of this type of cheeses was mostly closely correlated with odor and taste intensity, aftertaste and bitterness, while others parameters like texture attributes and acid and salty taste were shown not to be correlated with acceptability. Sample A, with the most intense overall odor, overall taste and aftertaste, was the sample preferred the most. Conversely, sample C with the highest bitterness but very low odor and taste intensity was the least preferred sample. Results showed that even if differences in texture among cheeses were more evident that differences in flavor, the later ones dictated the differences in preference among consumers.

4 Conclusions

In this work, the sensory properties of Uruguayan low-fat cheese "queso magro" have been described. According to the sensory profile of commercial samples, the cheeses are characterized by having a soft odor and taste, intermediate firmness, medium–high elasticity, and little friability. The commercial low-fat cheeses mainly differed in their texture attributes, firmness, and elasticity. However, flavor attributes were those that dictated the important differences in acceptance among the samples.

Acknowledgments The financial support of MICINN, Spain (Tarrega's contract within the Juan de la Cierva Programme) and financial support of LATU, Uruguay for Arcia's stay at IATA, are all gratefully acknowledged.

References

Bourne MC (2002) Food texture and viscosity: concept and measurement, 2nd edn. Academic, New York

Brown JA, Foegeding EA, Daubert CR, Drake MA, Gumpertz M (2003) Relationships among rheological and sensorial properties of young cheeses. J Dairy Sci 86:3054–3067

Carbonell L, Izquierdo L, Carbonell I (2007) Sensory analysis of Spanish mandarin juices. Selection of attributes and panel performance. Food Qual and Pref 18:329–341

Drake MA, Swanson BG (1995) Reduced- and low-fat cheese technology: a review. Trends Food Sci Technol 6:366–369

Gallerani G, Gasperi F, Monetti A (2000) Judge selection for hard and semi-hard cheese sensory evaluation. Food Qual and Pref 11:465–474

Gwartney EA, Foegeding EA, Larick DK (2002) The texture of commercial full-fat and reduced-fat cheese. J Food Sci 67:812–816

ISO (2001) FIL 20–2:2001: milk—determination of nitrogen content—block-digestion method. Standard No. 8968-2. International Organization for Standardization, Geneva, Switzerland

ISO (2004) FIL 4:2004: cheese and processed cheese—determination of the total solid content. Standard No. 5534. International Organization for Standardization, Geneva, Switzerland

ISO (2006) FIL 88:2006: cheese and processed cheese products—determination of chloride content—potentiometric titration method. Standard No. 5943. International Organization for Standardization, Geneva, Switzerland

ISO (2007) Sensory analysis: general guidance for the design of test rooms. Standard No. 8589. International Organization for Standardization, Geneva, Switzerland

ISO (2008) FIL 222:2008: Cheese - Determination of fat content - Van Gulik method. Standard no: 3433. International Organization for Standardization, Genova, Switzerland

ISO (2009) IDF 99-1: 2009: milk and milk products. Sensory analysis. Part 1: general guidance for the recruitment, selection, training and monitoring of assessors. Standard No. 22935-1. International Organization for Standardization, Geneva, Switzerland

Jellinek G (1985) Sensory evaluation of food: theory and practice. Ellis Horwood Ltd, West Sussex

Kilcast D, Rider C (2007) Sensory issues in reducing salt in food products. In: Guinee TP, O'Kennedy BT (eds) Reducing salt in foods: practical strategies. CRC Press, Boca Raton

Lavanchy P, Berodier F, Zannoni M, Noël Y, Adamo C, Squella J, Herrero L (1993) L' évaluation sensorielle de la texture des fromages á pate dure ou semidure. Étude interlaboratoires. Lebensm.-Wiss. Technol 26:5–68

MacFie HJ, Bratchell N, Greenhoff K, Vallis LV (1989) Designs to balance the effect of order of presentation and first-order carry over effects in Hall Tests. J Sens Stud 4:129–148

Mistry VV (2001) Low fat cheese technology. Int Dairy J 11:413–422

Montero H, Aranibar G, Cañameras C, Castañeda R (2005) Metodologías para la caracterización sensorial de quesos Argentinos. Jornadas de Análisis Sensorial (JASLIS 2005), 6 al 8 de septiembre, Buenos Aires

Pastorino AJ, Hansen CL, McMahon DJ (2003) Effect of salt on structure–function relationships of cheese. J Dairy Sci 86(1):60–69

Reglamento Bromatologico del Uruguay (1994) Decreto N 315/994, 2nd edn. Dirección Nacional de Impresiones y Publicaciones Oficiales, Montevideo, Uruguay, pp 149–151

Ritvanen T, Lilleberg L, Tupasela T, Suhonen U, Eerola S, Putkonen T, Peltonen K (2010) The characterization of the most-liked reduced-fat Havarti-type cheeses. J Dairy Sci 93:5039–5047

Ten Kleij F, Musters PAD (2003) Text analysis of open ended survey responses: a complementary method to preference mapping. Food Qual and Pref 14:43–52

Walstra P, van Vliet T (1982) Rheology of cheese. Int Dairy Fed Bull Doc 153:22–27

Woteki CE, Thomas PR (1993) In eat for life. Harper Collins, New York

Yates MD, Drake MA (2007) Texture properties of gouda cheese. J Sens Stud 22:493–506