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SENSORY PROFILE DESCRIPTION OF MOZZARELLA CHEESE AND ITS RELATIONSHIP WITH CONSUMER PREFERENCE

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ABSTRACT

The aim of this work was to set up the sensory profile and consumer preference test of three different Mozzarella cheeses (from full-fat cow milk, from low-fat cow milk and from full-fat water buffalo milk). The most remarkable difference in composition was the fat content. Nine commercial Mozzarella cheeses (three for each type) were evaluated in triplicate by a trained panel consisting of 10 assessors. Six Mozzarella cheeses (two for each type) out of the nine samples were selected and used for the preference test by 105 consumers. The three different Mozzarella cheeses were sensorially well differentiated. A good discrimination between the Mozzarella cheeses was obtained using the internal preference map method. The combination of cluster analysis and internal preference mapping has lead to a deeper understanding of consumer liking for Mozzarella cheeses.

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INTRODUCTION

Italy is currently one of the largest cheese-consuming countries in the world. Yearly per capita consumption of cheese is ca. 17 kg, after France (21 kg) (Pacifico 1990; Quaglia 1991). Consumer preference is for delicate cheese with little or no ripening in accordance with dietetic requirements. Soft and fresh cheese is the most increasing share according to market estimate (ca. 9 kg yearly per capita consumption). Regarding fresh cheese, Mozzarella cheese plays an essential role: 77% Italian families eat Mozzarella cheese, and 58% at least once a week (Pacifico 1990).

In order to meet current dietetic requirements, a sector of low-fat products has been developed, which has been steadily increasing for some years (Mela 1993). Hence, traditional foods may undergo changes in composition, although their sensory properties should remain unchanged (Drewnowski 1992). Work to understand which fats modify flavors is of considerable interest to the food industry, where it can be exploited to assist in predicting and compensating for the effects of fat-reducing changes in formulation or processing on flavor perception (Mela 1993).

In previous work (Pagliarini and Beatrice 1994) it has been shown that a reduction of Mozzarella fat content (fat = 105 g/kg) changed product characteristics, resulting in a much harder and less watery Mozzarella cheese than the traditional one (fat = 198 g/kg).

There are many studies that have focused on sensory characteristics of cheese, however only a few studies deal with low-fat cheeses (Emmons *et al.* 1980; Banks *et al.* 1989; Marshall 1990; Muir *et al.* 1992; Banks *et al.* 1994), and none are concerned with the typical italian Mozzarella cheese, either traditional and low-fat. Until now there has not been a defined vocabulary for the sensory profiling of Mozzarella cheese. Therefore the aim of this study was to develop a terminology for describing the sensory properties of different types of Mozzarella cheese (from full-fat cow milk, from low-fat cow milk and from full-fat water buffalo milk), to define each attribute and to determine a reference for each characteristic. An increasingly important aspect of sensory analysis is the evaluation of the relationship between preference and sensory properties of samples. This aspect was investigated and the preference of Italian consumers for different types of Mozzarella cheese was defined.

MATERIALS AND METHODS

Products

The nine most popular italian brands of Mozzarella cheese were selected from supermarkets in Milan. Table 1 shows the types of Mozzarella cheeses under

test, the brand code and composition.

In order to minimize within sample variation, all packages of the same brand were supplied from the same batch of production. Samples were purchased one day before each sensory evaluation session and stored at 4C. For assessment, samples were presented as small cubes at room temperature.

TABLE 1.
COMPOSITION OF THE NINE MOZZARELLA SAMPLES INVESTIGATED (RESULTS ARE MEAN VALUES FROM TRIPLICATE ANALYSES)

Brand code	Type	Fat content (%)	Moisture content (%)	Protein content (%)
A	Cow full-fat milk	21.54	57.76	18.43
B	Cow full-fat milk	21.35	58.72	17.69
C	Cow full-fat milk	21.42	55.97	18.83
D	Cow low-fat milk	8.63	68.70	21.84
E	Cow low-fat milk	8.81	68.79	21.09
F	Cow low-fat milk	9.01	68.46	21.15
G	Water buffalo full-fat milk	24.83	57.78	13.77
H	Water buffalo full-fat milk	25.42	58.15	14.62
I	Water buffalo full-fat milk	25.12	58.03	13.91

Sensory Profiling

Ten panelists (5 females and 5 males) participated in 16 training sessions and evaluated the samples. All assessors were trained in sensory profiling, but no one had previously worked on Mozzarella cheese. During a preliminary session the objectives of the experiment were explained in detail. During the first part of the training period assessors attended a number of group sessions in which they tasted 4 of the 9 samples and generated 20 descriptors. The aim of these training sessions was to develop a common vocabulary for the description of the sensory attributes of Mozzarella cheese. Each attribute term was extensively described and explained to avoid any doubt about the relevant meaning. As the panel agreed on descriptors, they began to reference each of them. Samples were evaluated using the descriptors elicited from individual panelists during the 16 following sessions. Analysis of variance was performed for each attribute in order to identify those that were not significant in discriminating among the samples. The final list of descriptors with the relevant definitions and standards

is reported in Table 2.

After the training period the panel evaluated the nine Mozzarella cheeses in triplicate. Three cheeses were evaluated in each session. Within each session the design was balanced for order and carry over effects (Greenhoff and MacFie 1989). Judges were requested to evaluate the intensity of each attribute by assigning a score between 1 (absence of the sensation) and 9 (extremely intense).

Consumer Test

One hundred and five individuals (54 females and 51 males aged between 21 and 45) in the Milan area were recruited, selected on the basis that they consumed Mozzarella cheese regularly. The preference test was carried out on six different Mozzarella cheeses (A, C, D, E, G, H products, see Table 1) representative of the sensory characteristics of the nine samples tested (see below). Subjects were asked to rate each sample using a 9-pt hedonic scale. The design was balanced for order and carry over effects.

Data Analysis

The sensory data for each attribute were submitted to analysis of variance (ANOVA) with samples, judges, replicates and their interactions as effects. The significance of these effects was tested with F tests. The sample means averaged across judges and replicates were submitted to Principal Component Analysis (PCA) in order to interpret sensory differences amongst Mozzarella cheese samples.

Internal Preference Mapping or Multidimensional Preference analysis (MDPREF) (Carroll 1980) was performed on the consumer preference scores for Mozzarella cheeses in order to examine discrimination between the samples and identify different sub-groups in the population. Internal analysis, unlike external preference mapping, provides a multidimensional product space based on the preference scores alone and may be viewed as a variation of PCA, where the products are the objects and the consumers are the variables (Greenhoff and MacFie 1994). PCA involves the computation of linear combinations of the original variables which are both uncorrelated to each other and summarize as much of the original variance in the data as possible. These linear combinations are usually called principal components (PCs) and the coefficients defining the weightings on the original variables are called loadings. For PCA it is common to scale the PCs so that they represent the variance associated with each dimension, with internal preference mapping however, the product coordinates or PCs are scaled to unit length, while the consumer loadings are either scaled so that they lie on the unit circle or according to the variance explained by each dimension. The latter case is the method of choice here. Consumers loadings on any two of the preference dimensions may be plotted on a scatter diagram. Then

TABLE 2.
FLAVOUR VOCABULARY, DEFINITIONS, AND REFERENCES FOR CHEESES

PANEL ATTRIBUTES	DESCRIPTORS	REFERENCES
External appearance		
1. White	Pure white colour	Colorimeter tile nr. 101947 (Y=87.7 x=0.308 y=0.315)
2. Translucent	Amount of paste that is translucent, it depends on the moisture at the surface	Polenghi water buffalo Mozzarella cheese
3. Fibrous	Typical filamentous or fibrillary texture of milk casein after hot water stretching	Mondragone water buffalo Mozzarella cheese
4. Smooth paste	Product surface free from holes and granules	Locatelli Mozzarella cherries
Odour		
5. Milk odour	Characteristic pasteurized whole milk odour	Centrale del Latte - Milano pasteurized whole milk
6. Butter odour	Characteristic butter odour	Galbani butter
7. Yoghurt odour	Characteristic plain whole yoghurt	Yogolat plain whole yoghurt
Flavour during chewing		
8. Acid	One of the four basic flavours caused by water solutions of various substances perceived in the central part of the tongue	Yogolat plain whole yoghurt
9. Bitter	One of the four basic flavours caused by water solutions of various substances perceived in the rear part of the tongue	0.001% quinine sulphate solution
10. Sweet	One of the four basic flavours caused by water solutions of various substances perceived on the tip of the tongue	Centrale del Latte - Milano pasteurized whole milk
11. Salty	One of the four basic flavours caused by water solutions of various substances perceived on the tongue tip and sides	GS Parmesan cheese
12. Milk flavour	Characteristic pasteurized whole milk flavour	Centrale del Latte - Milano pasteurized whole milk
13. Cream flavour	Characteristic fresh cream flavour	Centrale del Latte - Milano fresh cream
Texture during chewing		
14. Firm	Strength required to compress a substance between the molars (for solids) or between the tongue and the palate (for semisolids)	Ferrari Dutch Gouda
15. Elastic	Degree by which the original shape of a product is restored after compression between the teeth	Locatelli Mozzarella cherries
16. Cohesive	Degree of compression obtained between the teeth prior to breaking	Ferrari Fontalpe
17. Rubbery	Density during chewing time required to break up a semisolid food until it is suitable for swallowing	Ferrari Ductch Gouda
18. Juicy	Wet sensation in the mouth caused by a product after compression between the teeth	Polenghi water buffalo Mozzarella cheese
19 Slippery	Degree of oiling perceived on the lips and in the mouth (opposite of adhesive)	Locatelli Mozzarella cherries
20. Flaky	Mouth sensation describing the typical filamentous or fibrillary texture of milk casein after hot water stretching	Mondragone water buffalo Mozzarella cheese

the resulting points may be thought of as end-points of vectors from the origin representing the direction of increasing personal preference for a consumer. These are not exact representations of each individual's product ratings, but are projections onto the preference dimensions demonstrating the best fit to the original data (Greenhoff and MacFie 1994). The length from the origin to the end-point of the vector is in fact the squared correlation between the pattern of (scaled) liking scores by a consumer and the pattern of product scores represented by those dimensions. It provides an indication of how well that individual is represented by the two dimensions plotted. Since the coordinates are correlation coefficients they must all lie inside the unit circle.

To assess how differently Mozzarella cheeses were discriminated from each other, a bootstrapping method (Efron and Tibshirani 1986) was applied to preference mapping in order to obtain 95% confidence regions for the product positions. The respondents are resampled with replacement up to the full size of the original data set. This procedure, which simulates what might happen if the experiment were repeated, can be performed many times over with different random samplings of the original respondents. Here we choose to generate 500 resampled data sets and perform a preference map on each. It should be noted that with preference mapping there is arbitrariness in the sign and the ordering of the dimensions. A method based on Procrustes rotations is therefore applied to correct for this (Milan and Whitaker 1995). Once this is achieved the variation in the product positions across the 500 samples can be assessed and used to build up a picture of the degree of separation of the cheeses. All 500 positions for each cheese could in theory be plotted on the same graph but we choose instead to summarize their location and covariance by plotting a bivariate normal probability ellipse (Altman 1978).

For the purpose of evaluating whether the data of each subject were significantly fitted by the preference mapping model, permutation tests (Edgington 1987) were performed. This procedure randomly rearranges each individual's rating scores to produce new data sets in which the scores no longer correspond to the products to which they had been originally given. Preference maps calculated on 200 such permuted data sets were used to build up an empirical distribution indicating how long an individual's preference vector may be by chance alone. On the original consumer scores plot this distribution may be represented by drawing a critical ellipse at the 95th percentile of the distribution, arranged such that subjects who fall outside can be said to be significantly fitted. Alternatively there is only a 5% probability that such a good fit to these consumers liking scores could have arisen by chance. All statistical analysis was performed using a SAS procedure written at the Institute of Food Research, UK (Wakeling 1996).

The relationship between sensory profile and consumer preference was analyzed both by external preference mapping and by regression of sensory panel

attribute means onto the product coordinates on each preference axis (Greenhoff and MacFie 1994). Average-linkage cluster analysis was also applied to the consumer preference scores which in conjunction with separate internal preference mapping of two sets of clusters led to a much improved interpretation of the data.

RESULTS AND DISCUSSION

Sensory Profile of Mozzarella Cheese

Analysis of variance on sensory data for each attribute indicated a significant effect of samples at a 1% level for all the attributes. F values for replicates and interactions between samples × judges, judges × replicates and samples × replicates were not significant for nearly all the attributes. These results indicated that the mean scores for each Mozzarella cheese given by the panelist for each attribute could be assumed satisfactory estimates of the sensory profile of the samples. As a result, they were averaged across assessors and submitted to PCA.

A multidimensional space based on sensory data was obtained (Fig. 1a and 1b). The variance explained by the first two principal components was 78%.

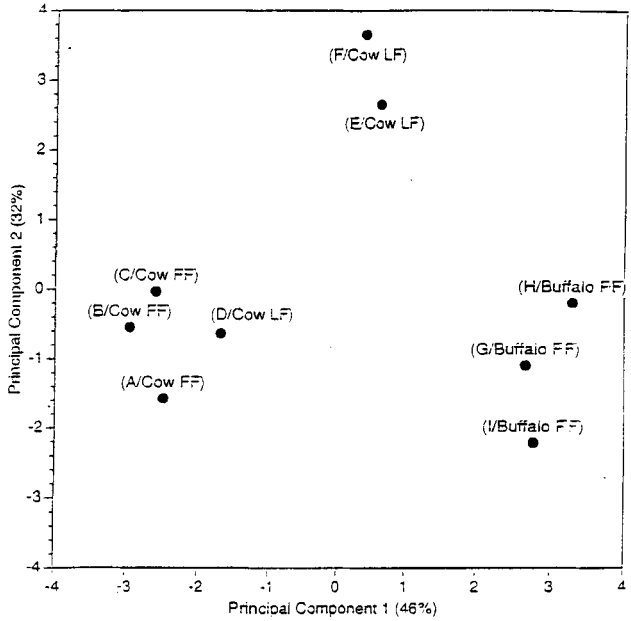

FIG. 1a. PRINCIPAL COMPONENTS PRODUCT SCORES PLOT FROM THE SENSORY ANALYSIS OF MOZZARELLA CHEESES

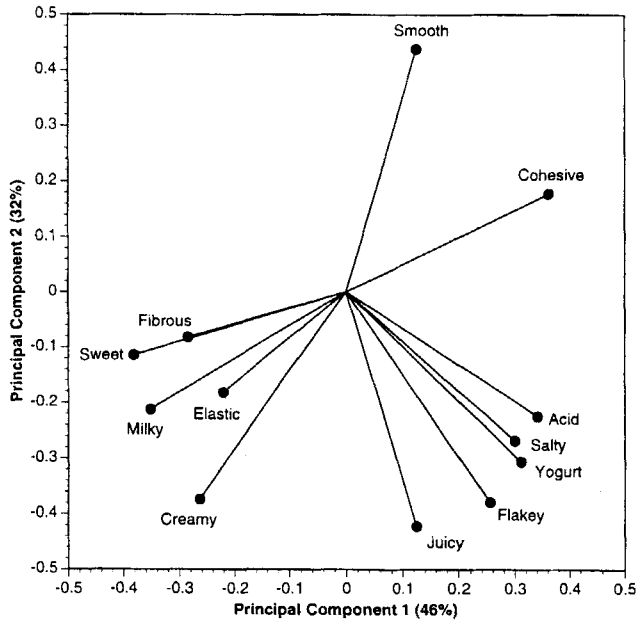

FIG. 1b. PRINCIPAL COMPONENTS ATTRIBUTE LOADINGS PLOT FROM THE SENSORY ANALYSIS OF MOZZARELLA CHEESES

In Fig. 1a (PC1 vs PC2) the Mozzarella cheeses appear to be well separated into three groups. Moving left to right along the first component (explained variance 46%), full-fat cow milk products (A, B, C) and the sample D (low-fat cow milk product) are separated from the water buffalo Mozzarella cheeses (G, H, I). The second component (explained variance 32%) distinguishes the samples E and F (both low-fat cow milk products) from the rest of the products. Principal component loading vectors were examined in order to identify the importance of various attributes in discriminating among the samples. Figure 1b represents the plot of the attributes in the plane defined by the first two components. The buffalo Mozzarella cheese samples on the right of the first component of Fig. 1a receive high scores for the attributes "cohesive", "acid", "salty", "yoghurt odor" and "flaky". The attributes "sweet", "milky", "creamy", "fibrous" and "elastic" discriminate the products A, B, C and D from the others. Among low-fat products only D seems to have a sensory profile comparable with that of full-fat products (A, B, C). Along the second dimension, the samples are separated on "smooth paste", "creamy" and "juicy". It is the low intensity of the attributes

"creamy" and "juicy" that distinguished the low-fat products E and F from the others.

Results from PCA show the sensory profile of water buffalo milk products are very different from cow milk products. In general, the second dimension separates the low and high-fat products, however product D is anomalous as its profile in similar to the full-fat cow's milk products despite being low-fat.

Based on these results, 6 samples were selected to analyze the relationships between sensory properties of products and consumer preference. To this end, a preference test was carried out on the following products: A and C to represent the types of full-fat cow milk Mozzarella cheeses, products D and E to represent the different sensory types of low-fat Mozzarella cheese and on the products G and I as water buffalo milk products.

Consumer Preference for Mozzarella Cheese: the Preference Map

An internal preference map of the 6 Mozzarella cheese products was obtained (Fig. 2a). The variance explained by the model after the first two dimensions was 74.8%. The first dimension accounted for 54.4% of variance, the second for 20.3%. The plot of Fig. 2b was obtained by projecting the subject scores on the two axes. In total, 72 of 105 subjects (68.6%) were significantly fitted.

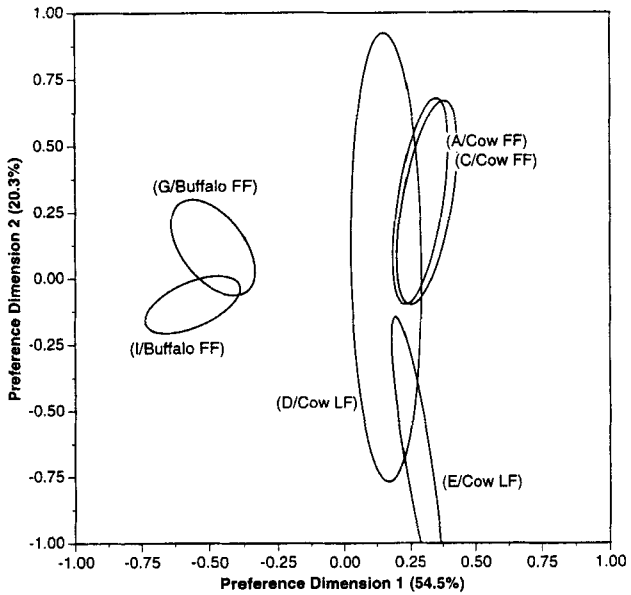

FIG. 2a. INTERNAL PREFERENCE MAPPING OF MOZZARELLA CHEESES (ALL CONSUMERS)

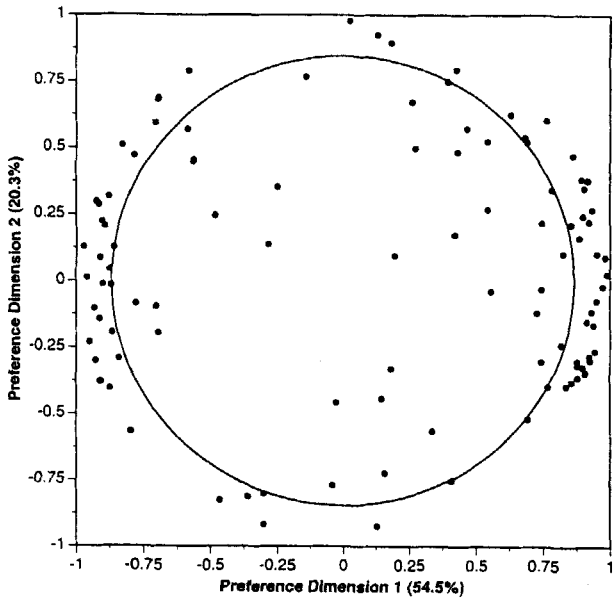

FIG. 2b. INTERNAL PREFERENCE MAPPING OF MOZZARELLA CHEESES: CONSUMER SCORES PLOT FOR ALL CONSUMERS

Comparing the first two dimensions of both product and consumer plots it can be assumed that there is good discrimination between the Mozzarella cheeses and two opposing sub-groups of consumers can be clearly identified by the first dimension. Those consumers on the right of the first dimension are characterized by preferences for cow milk Mozzarella cheeses. Subjects on the left of the first dimension prefer water buffalo milk products and give low scores to all types of cow's milk cheeses. Consumers are spread less widely on dimension 2. Along this dimension the low-fat product E is completely separated from all products apart from D. The 95% confidence regions on the plot suggest that product D is worthy of further investigation since it is many times larger than any of the others. Clearly the large size of this ellipse may be interpreted as considerable uncertainty in the product position. Since the preference map is dominated by the polarization in preference between the buffalo and cow-milks, it was suspected that there was a more subtle segmentation based on the perception of product D that was being lost. To confirm these suspicions a cluster analysis was carried out with the aim of uncovering these segments. Normalized preference scores were subjected to average-linkage cluster analysis which lead to the identification of 6

clusters, whose means scores are reported in Table 3.

An examination of the mean scores for the product D reveals that clusters 1, 3 and 6 generally have a higher liking for product D than clusters 2, 4 and 5. Based on this information, the preference scores for these two sets of clusters were analyzed separately by internal preference mapping.

TABLE 3.
AVERAGE-LINKAGE CLUSTER ANALYSIS: MEAN OF NORMALIZED PREFERENCE SCORES FOR EACH CLUSTER

	Samples					
Cluster	A	C	D	E	G	I
1	0.64	0.79	**0.47**	**-0.04**	-0.77	-1.09
2	0.40	0.77	**-0.63**	**1.14**	-0.66	-1.01
3	-0.86	-0.27	**1.31**	**0.69**	-0.93	0.05
4	-1.01	-0.63	**-0.46**	**1.52**	0.34	0.25
5	-0.55	-0.35	**-0.50**	**-0.69**	1.02	1.06
6	-0.65	-0.08	**1.28**	**-1.39**	0.71	0.13

Figure 3a shows the product plot from the analysis of consumers falling in the clusters 1, 3 and 6 and it can be seen that these consumers generally rate product D close to product E and that generally the three types of cheeses seem to be well separated. Note that here the confidence ellipses are generally larger than those obtained in the full analysis owing to the smaller number of consumers involved.

Almost all the consumers falling in these three groups have positive scores on the first dimension (Fig. 3b) and therefore are those who dislike the buffalo milk products. Dimension 2 is defined by the small groups of consumers near the top right and bottom right of Fig. 3b, and are those people making a strong association between D and E. For these consumers the fat content of the cheese is clearly an important factor in their rating of the products.

Moving on to clusters 2, 4 and 5 the preference map reveals that the dominant feature is again the largest separation of the buffalo and cow's milk products (Fig. 3c). On the corresponding plot (Fig. 3d) the first dimension is defined by a large group of consumers with positive loadings who prefer the buffalo milk products and a smaller group to the left with an opposite preference. Clearly the group on the right will be very similar in membership to the group of consumers on the left of Fig. 3a. The interesting feature is that consumers generally see product E as being distinct from all others as there is very little overlap of its confidence ellipse with other products. Indeed there is a small group of consumers with positive loadings on dimension 2 who prefer this low-fat product to all others.

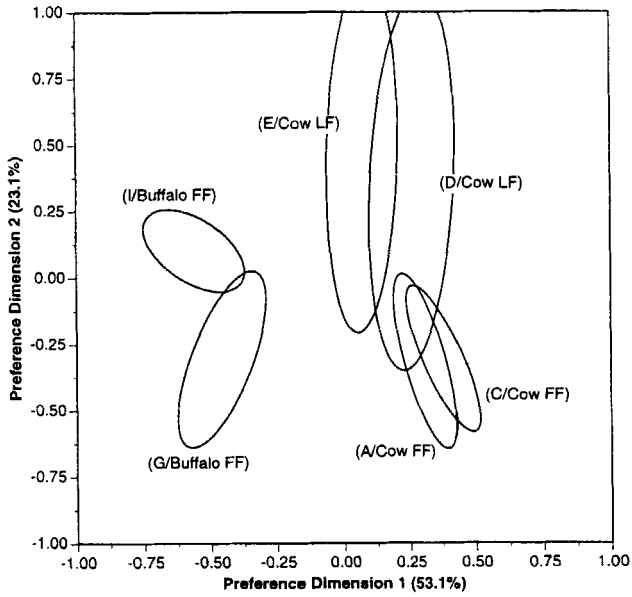

FIG. 3a. INTERNAL PREFERENCE MAPPING OF MOZZARELLA CHEESES: PRODUCT SCORES PLOT FOR CONSUMER CLUSTERS 1,3 & 6 ONLY

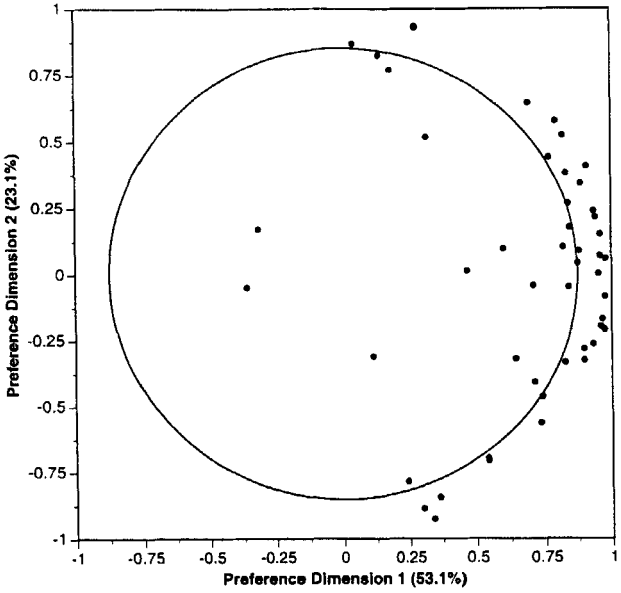

FIG. 3b. INTERNAL PREFERENCE MAPPING OF MOZZARELLA CHEESES: PRODUCT SCORES PLOT FOR CONSUMER CLUSTERS 1, 3 & 6 ONLY

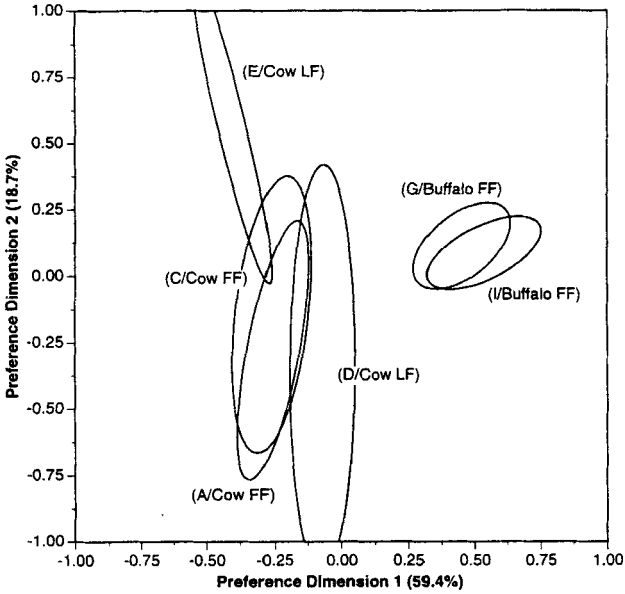

FIG. 3c. INTERNAL PREFERENCE MAPPING OF MOZZARELLA CHEESES: PRODUCT SCORES PLOT FOR CONSUMER CLUSTERS 2, 4 & 5 ONLY

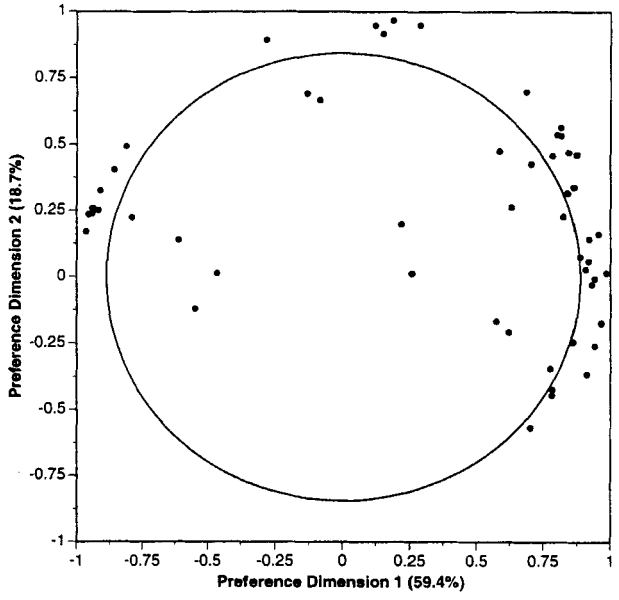

FIG. 3d. INTERNAL PREFERENCE MAPPING OF MOZZARELLA CHEESES: CONSUMER LOADINGS PLOT FOR CONSUMER CLUSTER 2, 4 & 5 ONLY

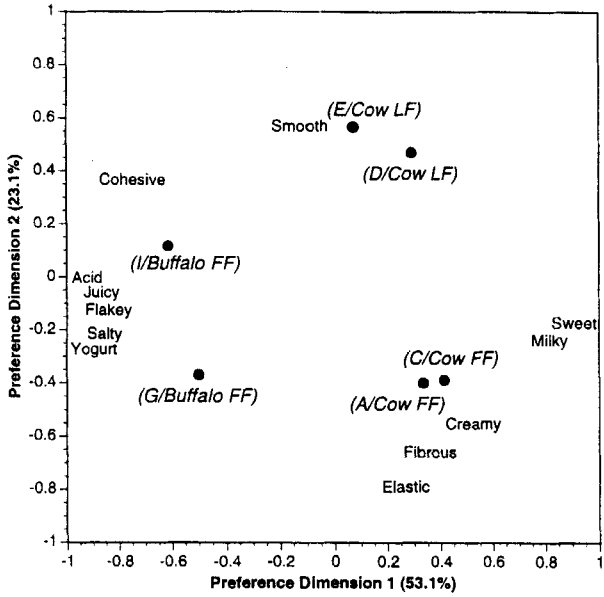

FIG. 4a. INTERNAL PREFERENCE MAPPING OF MOZZARELLA CHEESES: CLUSTERS 1, 3 & 6 WITH PROJECTIONS OF SENSORY PANEL ATTRIBUTE MEANS

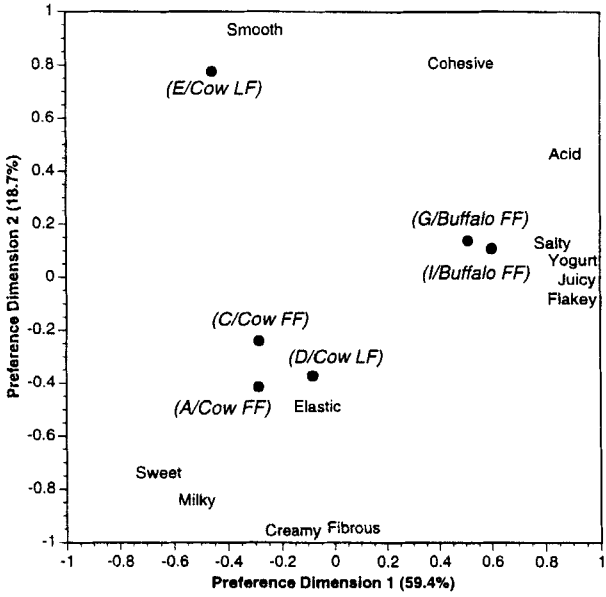

FIG. 4b. INTERNAL PREFERENCE MAPPING OF MOZZARELLA CHEESES: CLUSTERS 2, 4 & 5 WITH PROJECTIONS OF SENSORY PANEL ATTRIBUTE MEANS

In order to bring together the results of the sensory and consumer data in a single analysis, the first approach tried was an external preference mapping projecting the consumers scores onto a 2 dimensional PCA of the sensory data restricted to the subset of 6 products used for the consumer study. The results of this analysis are not shown as very few consumers were significantly fitted. This is not at all surprising considering the low degrees of freedom involved in the regression of each consumer's scores onto the product configuration and the fact that the two subsets of consumers are already known to be acting in different ways and are unlikely to fit to a single map. The preferred approach is to project the sensory panel means onto the two preference maps by regression analysis separately for each preference dimension.

Figure 4a shows the prefmap product positions for clusters 1, 3 and 6 together with the sensory attributes plotted according to their correlation coefficient with the product scores. Comparing this plot with Fig. 3b it can be seen that the majority of consumers are using flavor attributes, namely the juicy, acid, salty and yoghurt odor to sweet and milky dimension to discriminate between the samples. Texture is of lesser importance and is used to separate the high and low-fat cows milk products from one another principally on the basis of their different elasticity and fibrocity.

For clusters 2, 4 and 5 the plot in Fig. 4b should be compared with 3d. Here the situation is more complex. Many consumers both on the right and left of the plot are using just the juicy and yoghurt notes to discriminate between the samples. Note however that the attributes smooth paste and fibrous have much longer vectors when projected onto this second preference map and that the second dimension is strongly associated with the texture of the cheeses. For consumers who fall at the top and bottom right of Fig. 4b, that is those consumers who pay more attention to the texture, find products A, C and D to be similar and clearly see product E as a much smoother and very different product.

CONCLUSIONS

This work allowed us to set up the sensory profile of three different Mozzarella cheeses (from full-fat cow milk, from low-fat cow milk and from full-fat water buffalo milk). It was demonstrated that the three cheeses are sensorially well differentiated. The best sensory descriptors to characterize the three products were also identified. In particular, Mozzarella cheese from cow full-fat milk was identified by sweet, milky, creamy, fibrous and elastic; Mozzarella cheese from water buffalo full-fat milk by cohesive, acid, salty, yoghurt odor and flaky; Mozzarella cheese from cow low-fat milk (samples E and F) by smooth paste and the low intensity of creamy and juicy. It is worth noting that one Mozzarella cheese sample from cow low-fat milk (sample D) appeared in the region of Mozzarella cheese sample from whole milk. This shows that

appropriate production technologies, though based on very different cheese, can simulate traditional products adequately.

Consumer results were processed using the internal preference map method. There is a good discrimination between the Mozzarella cheeses. Consumers who prefer the cow milk Mozzarella cheeses are clearly separated from those who prefer the water buffalo milk products.

The combination of cluster analysis and internal preference mapping has lead to a deeper understanding of consumer liking for Mozzarella cheeses. An interpretation of the cluster analysis alone, leads to the identification of 6 groups of consumers, and provides a more complex picture than is actually necessary. The product confidence regions from the preference mapping however immediately identified the "problem" product, which together with the cluster analysis has lead to the identification of two basically similar product configurations which differ only in the positioning of one of the products.

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