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MAIN FACTORS AFFECTING THE CONSUMER ACCEPTANCE OF ARGENTINEAN FERMENTED SAUSAGES

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ABSTRACT

Microbiological, physicochemical and sensory characteristics of most popular Argentinean fermented sausages were evaluated in order to detect drivers of consumer liking. As a first step, a detailed description of instrumental parameters and consumer liking for fermented sausages was carried out. Furthermore, two multivariate mappings were performed: (1) cluster analysis to identify accepted fermented sausages based on overall acceptance and liking of appearance, aroma, taste and texture and (2) standard discriminant analysis to graphically recognize instrumental parameters that better described acceptance clusters. From these results, three fermented sausages groups with different acceptance patterns were segmented; taste and texture emerged as key sensory parameters and water activity, lightness, total protein, molds and enterococci among the physicochemical and microbiological variables were correlated with consumer liking.

PRACTICAL APPLICATIONS

Getting insight into the factors involved in the consumer liking is a relevant task for food scientists who want to establish official standards in terms of sensory quality. From the results obtained herein, instrumental parameters linked to consumer acceptance can be proposed as quality criteria. These guidelines could be profited by manufacturers and technologists to improve fermented sausage production.

INTRODUCTION

There is renewed interest in traditional fermented meat products as witnessed by the recent abundant literature, which is particularly remarkable in Europe where they have a strong significance and economic weight (Conter *et al.* 2008; Vignolo *et al.* 2010). Differences in raw materials, formulations and manufacturing processes led to the existence of a wide range of fermented meat products, most of them registered under Protected Designation of Origin or Protected Geographic Indication (Lebert *et al.* 2007; Conter *et al.* 2008; Vignolo *et al.* 2010). In Argentina, no official quality standards exist; in fact, the characteristics that different types of fermented sausages should meet have not been established. Despite the differences due to raw material availability and environmental conditions in different geographical regions, the manufacturing of fermented meat products has followed Spanish and Italian traditions, hence dry fermented sausages such as salami and fuet type are the most commonly produced in the country (Vignolo *et al.* 2010). On the other hand, due to the high accessibility and optimal price/quality ratio of Argentinean beef (Schor *et al.* 2008), fermented-dry sausages are usually manufactured using beef in their formulation. Nevertheless, the need for quick income often leads to meat products of variable quality (usually they are early sold before ripening has been completed) compared with the European products. Studies conducted on traditional meat products showed that hygienic shortcomings may lead to product loss with high economic consequences, so in order to improve hygienic and sensory properties, functional starter cultures are usually applied (Vignolo and Fadda 2007). However, many artisanal fermented sausages, in particular those manufactured in small-scale processing units, are produced without starter cultures and consequently a lack of consistency among different production batches as well as hygienic safety failures can occur.

Fermented sausages are defined as meat products made of a mixture of mainly pork and beef meat, pork fat, salt curing agents, sugar and spices while starter cultures are not always added. Essential sequential steps for the manufacture of dry and semidry fermented sausages were described by Vignolo *et al.* (2010). The typical taste and aroma are due to nonvolatile and volatile compounds, originated from metabolic and/or chemical reactions derived from carbohydrates, proteins, lipids and added spices. Two microbiological reactions occur simultaneously and interdependently during fermentation: a decrease in meat batter pH via glycolysis by lactic acid bacteria (LAB) and nitric oxide production for red color formation by gram-positive, catalase-positive cocci (GCC) through nitrate reduction (Stahnke 2002; Vignolo *et al.* 2010).

Analysis of consumer acceptability toward foodstuffs constitutes a challenging task, especially in fermented sausages that are biochemically and microbiologically dynamic undergoing changes during ripening. A number of statistical tools are used to model, analyze and understand the relationships between product characteristics and consumer preferences (Deliza and Macfie 1996; Helgesen *et al.* 1998; Guinard *et al.* 2001). A specific method employed to graphically communicate these relationships is preference mapping, which refers to a group of multivariate statistical techniques designed to develop a deeper understanding of consumer liking of goods. Besides their application to a wide range of marketing problems, they are frequently used for the purpose of product improvement (van Kleef *et al.* 2006). In fact, the generation of maps for product attributes and/or consumer liking ratings in a two-dimensional space allows relating liking to sensory attributes with the purpose of explaining intrinsic characteristics of the product which drive consumer preference (McEwan *et al.* 1998; Gomes *et al.* 2011). Recently Yenket *et al.* (2011) compared different mapping techniques highlighting the importance of supportive underlying findings from the original data and basic analyses when interpreting preference maps to avoid misleading results. Multivariate mapping procedures have been used to identify product components creating differences across products (Bom *et al.* 2005; Allgeyer *et al.* 2010) and as a segmentation tool for products or consumers (Tenehaus *et al.* 2005; Onwezen and Bartels 2011). The aim of this study was to define the Argentinean fermented sausages characteristics (sensory, microbiological and physicochemical) that might explain consumer acceptance as a first attempt to establish quality guidelines for these products.

MATERIALS AND METHODS

Sausage Samples

The fermented sausages (FS1 to FS10) used in this study represent nine commercial brands produced in different regions of Argentina. They were purchased in supermarkets located in Tucumán, Argentina. Although cultural traditions background among regions are known to be different, country population basically access, in supermarkets, to similar range of food product brands as well as the same nationwide advertising. Therefore, it can be hypothesized that acceptability patterns would be similar for consumers from different regions as previously stated by Martinez *et al.* (2002). Table 1 shows sausages' plant localization and their nutritional composition as declared by the labels.

Microbiological Analysis

Ten grams of each sausage were mixed with 100 mL of sterile 0.1% peptone water (Britania, Buenos Aires, Argentina) and homogenized for 8 min in a stomacher machine (Lab blender 400, Seward medical, London, U.K.). Appropriate decimal dilutions of the samples were prepared and plated in duplicate onto selective media to enumerate the microbiota. The following media and incubation conditions were used: (1) plate count agar for total aerobic bacteria (30C; 48 h); (2) De Man Rogosa & Sharpe agar (Britania) for LAB (30C; 48 h); (3) mannitol salt agar (Britania) for GCC (30C; 48 h); (4) Mc Conkey agar (Britania) for total enterobacteria (37C; 24–48 h); (5) Slanetz & Bartley

TABLE 1. INFORMATION OF FERMENTED SAUSAGES AS DECLARED ON THE LABEL

	FS*1	FS2	FS3	FS4	FS5	FS6	FS7	FS8	FS9	FS10
Manufacture origin	Santa Fe	Buenos Aires	Córdoba	Tucumán	Santa Fe	Buenos Aires	Santa Fe	Santa Fe	Santa Fe	Santa Fe
Product type	Salami	Fuet	Salami	Salami	Salami	Fuet	Salami	Salami	Salami	Salami
Sodium (%)	1.69	1.48	ND	0.45	1.42	1.65	1.45	1.57	1.45	1.69
Total fat (%)	36.00	37.50	ND	27.50	27.50	40.00	32.50	32.50	27.5	36.00
Saturated fat (%)	13.00	13.75	ND	12.25	10.00	18.25	15.00	14.25	10.5	13.00
Proteins (%)	19.00	24.75	ND	15.50	20.25	25.00	18.00	17.00	19.25	19.00
Lean meat (%)	83.91	83.52	ND	88.54	87.58	82.35	85.55	85.43	87.55	83.91
Meat type	Beef/pork	Pork	Beef/pork	Beef/pork	Beef/pork	Pork	Beef/pork	Beef/pork	Beef/pork	Beef/pork
Colorant addition†	ND	D	ND	ND	ND	D	ND	ND	ND	ND

* Fermented sausage samples.
† Cochineal carmine (INS120).
ND, not declared; D, declared.

(Oxoid, Basingstoke, U.K.) for enterococci (37C; 48 h); (6) Baird Parker medium (Oxoid) with egg yolk telluride emulsion (Oxoid) for *Staphylococcus aureus* (*S. aureus*) (37C; 24–48 h); and (7) yeast and mold agar (Britania) for yeasts and molds (25C; 48–72 h). Analysis was carried out on sausages from three different batches. Results were expressed as logarithm of colony-forming units/gram (log cfu/g). After counting, means and standard deviations were calculated. Analysis of variance (ANOVA) was used to search significant differences between means. Comparison between samples was performed using the Tukey's test ($P < 0.05$).

Physicochemical Analysis

The pH values were obtained by directly inserting the tip of the probe (Meat pHmeter, Hanna Instruments Argentina, Buenos Aires, Argentina) into different portions of sausage samples. Water activity (a_w) was determined on 5-mm sausage slices using an Acqua Lab instrument (Decagon Devices, Inc., Pullman, WA) and drying at 104C (AOAC 1995) was carried out for moisture determination. Total nitrogen was determined by Kjeldahl method (Slack 1987) and protein was calculated as total $N \times 6.25$ (%). Amino acid and peptide content were determined using the *o*-phtaldialdehyde (OPA) spectrophotometric assay (Church *et al.* 1983). On each sausage sample, two independent measurements were carried out; means and standard deviations were calculated. Instrumental color analysis was performed using a Minolta spectrocolorimeter (Chroma meter CR-300, Osaka, Japan) on the surface of sausage slices as described by Marcos *et al.* (2007). Due to the typical coarse-cut fat and lean particle dispersion, color measurements were taken in fat-free areas of sausages with a minimum of six readings per sample and the results were averaged. L^* (lightness), a^* (redness) and b^* (yellowness) values were determined by the CIE Lab system. The colorimeter was calibrated before each set of measurements using a white tile. The significant differences for each parameter between samples were determined with ANOVA and the means were compared using Tukey's test ($P < 0.05$).

Consumer's Behavior Survey

In order to select nontrained judges who were regular consumers of fermented sausages, a behavior survey was sent to the whole staff from Scientific Technological Center, CONICET, Tucumán (Argentina), consisting of 120 persons from 25 to 65 years old. The questionnaire included identification of consumer, socioeconomic status (age, gender, educational level, job category) and purchasing/consumption habits (main purchasing place, number of consumed slices and preferred brands). From 72 received responses, the surveyed persons that affirmed to have a daily, weekly and fortnightly consumption were considered as regular consumers; these 48 people were invited for the sensory study (Jaeger *et al.* 1998). In addition, behavior survey results allowed to adapt the sensory analysis design to the consumer habits of the studied population and to select the preferred brands for this study.

Sensory Analysis

Exploratory Evaluation. In order to get information about questionnaire understanding and to achieve an accurate statistical analysis, two preliminary evaluations of six fermented sausage samples randomly presented to five people (not included in further studies) were performed. The first test allowed an estimation of response variations among panelists and the expected effects among sausage samples, these being useful to improve forms and testing conditions. For the second preliminary assessment, an independent sensory evaluation of samples was established. The obtained data were analyzed by Infostat Statistical Software (2010 version, Universidad Nacional de Córdoba, Córdoba, Argentina) (treatments' number: 10; maximal common variance among treatments: 1.1; α error: 0.05; minimal difference: 1; β error: 0.1) and a panel size with a minimum of 45 members was calculated.

Acceptance Test. The study was carried out in a conditioned room with normal light and fresh air, frequently used for lunch as recommended by Espinosa Manfugás (2007). Fermented sausages were purchased and stored at 4C 1 day before sensory evaluation. Consumers tasted samples identified at random with three-digit codes, in two different sessions, following a balanced incomplete experimental block design (Olivares *et al.* 2010). The first session consisted of samples FS1, FS2, FS6, FS7 and FS8 while in the second, samples FS3, FS4, FS5, FS9 and FS10 were included. For each session, two slices (5 mm thick) of the five different sausages were first equilibrated (1 h at room temperature) and covered with aluminum foil (to prevent loss and/or merge of sample flavors). Samples were supplied to the panelists in a same plate to be tasted in a randomized order. To minimize any residual effect, judges were instructed to rinse their mouth with water, to eat cookies without salt between samples and to take a sufficient time to score the samples. The consumer likings, evaluated by the nontrained judges, were appearance, aroma, taste and texture (numeric scale from 1: disliked to 5: liked very much). Overall acceptance was also asked by a seven-level hedonic scale and further translated to a numeric scale (Pedrero and Pangborn 1989). Data from sessions were collected and analyzed by ANOVA and Fisher test ($P < 0.05$). Before applying multivariate analysis (cluster analysis

[CA]), mean values of liking variables for each sample were standardized (mean = 0; standard deviation = 1) to allow comparisons between the two different scales, using Infostat Statistical Software.

Statistical Analysis

Principal Component Analysis (PCA) based on sensory variables (aroma, appearance, taste, texture and overall acceptance) was performed considering individual responses of each judge. Further, to establish acceptance categories of fermented sausage samples, a CA using data from hedonic questions was carried out by applying the Ward method (Rencher 2002) and Euclidean distances. Using standardized arithmetic averages of consumer acceptance responses (mean: 0; variance: 1) a heat map was generated by R Statistical Software to visualize samples and sensory variables. Heat maps are visual representations of quantitative data on two axes; the x-axis generally reflects individual samples and the y-axis consists of groups of measured parameters. The field between the axes is comprised of an array of contiguous boxes color coded to reflect quantitation. In this study, basic data structure underlying the heat map is comprised of independent variables (fermented sausage samples) and dependent variables (overall acceptance, appearance, aroma, taste and texture). In addition, on the basis of physicochemical/microbiological data and acceptance groups, a standard discriminant analysis (SDA) was performed to determine the microbiological and physicochemical variables contributing to the categorization of the analyzed fermented sausages. These parameters (group mean values) were used to evaluate each acceptance group by ANOVA and Tukey's test ($P < 0.05$). Infostat Statistical Software was used for data analysis.

RESULTS AND DISCUSSION

Microbiological and Physicochemical Analysis

Microbial contents of the assayed Argentinean fermented sausages are shown in Table 2. Despite their different origins, it was possible to detect a predominance of LAB in all analyzed sausages, their counts ranging between 6.67 ± 0.24 (FS2) and 8.46 ± 0.14 (FS7) log cfu/g. Enterococci and GCC loads were found to be the second and/or third largest microbiota, cell counts ranging from 4.51 ± 0.06 (FS5) to 7.29 ± 0.06 (FS4) and 3.54 ± 0.71 (FS6) to 7.16 ± 1.27 (FS5) log cfu/g, respectively. The obtained viable counts showed the principal role played by LAB and GCC during ripening as widely acknowledged in the literature (Fontana *et al.* 2005; Aquilanti *et al.* 2007; Cocolin *et al.* 2009). Even when high levels of enterococci

TABLE 2. MICROBIAL COUNTS OF FERMENTED SAUSAGES

	FS*1	FS2	FS3	FS4	FS5	FS6	FS7	FS8	FS9	FS10
Total aerobic	7.04 ± 0.71^{a}	6.81 ± 0.47^{a}	7.92 ± 0.39^{bc}	8.16 ± 0.14^{bc}	8.41 ± 0.18^{c}	8.45 ± 0.38^{c}	8.46 ± 0.30^{c}	7.96 ± 1.31^{bc}	7.42 ± 0.18^{ab}	6.63 ± 0.17^{a}
LAB	7.21 ± 0.63^{c}	6.67 ± 0.24^{a}	7.83 ± 0.39^{e}	8.11 ± 0.04^{f}	8.44 ± 0.13^{g}	8.22 ± 0.06^{f}	8.46 ± 0.14^{g}	7.16 ± 0.63^{ab}	7.46 ± 0.13^{d}	6.84 ± 0.30^{b}
GCC	5.26 ± 1.62^{abcd}	4.83 ± 0.30^{abc}	3.81 ± 0.78^{a}	6.66 ± 0.26^{cd}	7.16 ± 1.27^{d}	3.54 ± 0.71^{a}	6.89 ± 0.29^{cd}	6.40 ± 0.10^{bcd}	4.79 ± 1.65^{abc}	4.46 ± 0.58^{ab}
Enterococci	6.59 ± 0.16^{g}	6.51 ± 0.02^{f}	6.83 ± 0.07^{h}	7.29 ± 0.06^{i}	4.51 ± 0.06^{b}	ND^{a}	5.44 ± 0.29^{c}	4.53 ± 0.04^{e}	6.55 ± 0.08^{fg}	6.21 ± 0.02^{d}
Yeast	4.53 ± 0.06^{cd}	4.43 ± 0.92^{bc}	3.99 ± 0.13^{a}	4.86 ± 0.87^{e}	5.65 ± 0.18^{g}	4.77 ± 0.12^{de}	5.49 ± 0.13^{fg}	4.23 ± 0.15^{ab}	5.33 ± 0.17^{f}	4.43 ± 0.41^{bc}
Molds	3.60 ± 0.25^{d}	4.00 ± 0.20^{f}	2.27 ± 0.20^{b}	2.40 ± 0.32^{b}	3.20 ± 0.35^{c}	4.83 ± 0.15^{g}	3.72 ± 0.36^{de}	ND^{a}	3.87 ± 0.06^{ef}	4.90 ± 0.37^{g}

Values are expressed as means of logarithm of colony-forming units per gram of sample (log cfu/g) ± standard deviations. Data within the same row with different letters are different ($P < 0.05$) (Tukey's test).

* Fermented sausage samples.

LAB, lactic acid bacteria; GCC, gram-positive, catalase-positive cocci; ND, not detected in 10 g of sample.

were determined in some salami-type sausages, both fuet-type samples differed in this microbial group, FS2 exhibiting counts of 6.51 ± 0.02 log cfu/g while a total absence of enterococci was found for FS6 sample (Table 2). Variations in LAB and *Enterococcus* loads may be assigned to their different provenance; the type and number of developed microorganisms are often closely related to the indigenous microbiota resulting from the raw materials, the manufacture environment as well as the ecological diversity present in the different regions (Lebert *et al.* 2007). Concerning GCC counts, they showed to be in the range of previously reported data by Fontana *et al.* (2005) for traditional Argentinean sausages with the exception of FS4–FS5 and FS7–FS8 salami samples whose numbers were higher than 6.00 log cfu/g. These results are in coincidence with Talon *et al.* (2007) who reported that GCC constitute the second microbiota at the end of ripening; these organisms play a major role in sensory property development by reduction of nitrates to nitrite for cured color achievement and the production of flavor and aroma compounds (Søndergaard and Stahnke 2002). Yeasts were detected in all fermented sausages while molds were present in nine samples out of 10; yeast trends found in this study are in agreement with those previously reported (Fontana *et al.* 2005; Aquilanti *et al.* 2007). Regarding the hygienic status of the analyzed sausages, neither enterobacteria nor *S. aureus* were detected (data not shown), indicating that good manufacture practices must have been applied.

Microbial trends found in the analyzed fermented sausages have significantly influenced the pH of the final product as shown in Table 3. All the samples were characterized by a pH ranging from 5.14 ± 0.01 to 6.03 ± 0.03. Samples FS2, FS6 and FS9 including both fuet-type sausages, exhibited the highest pH values (around 6.00), this being in accordance with those reported for slightly acid fermented sausages (Spaziani *et al.* 2009). The remaining samples (salami-type) showed pH between 5.14 ± 0.01 and 5.66 ± 0.13 which are similar to values found for Italian, Spanish and French fermented sausages (Vignolo *et al.* 2010). When a_w was analyzed, fermented sausages showed a variation from 0.76 (FS9) to 0.94 (FS1) while the moisture: protein ratio was below 2.00 with the exception of FS1 sample. According to Vignolo *et al.* (2010) and based on both physicochemical parameters, FS samples may be classified as dry sausages while FS1 may be considered a semidry product. Regarding total protein contents of fermented sausages and considering the declared information by the label (Table 1), all the samples contained between 82.35 and 88.54% of lean meat, both fuet-type samples exhibiting the highest protein percentages (24.75 and 25%). Although total protein values determined in this study were not closely correlated with those declared by the label, a similar trend was found (Table 3). As was expected, amino acid

TABLE 3. PHYSICOCHEMICAL ANALYSIS OF FERMENTED SAUSAGES

	FS*1	FS2	FS3	FS4	FS5	FS6	FS7	FS8	FS9	FS10
pH	5.14 ± 0.01^{a}	6.03 ± 0.03^{d}	5.17 ± 0.13^{ab}	5.43 ± 0.06^{bc}	5.32 ± 0.02^{ab}	6.00 ± 0.05^{d}	5.60 ± 0.11^{c}	5.66 ± 0.13^{c}	6.00 ± 0.03^{d}	5.31 ± 0.10^{ab}
a_w	0.94 ± 0.02^{f}	0.79 ± 0.00^{cba}	0.79 ± 0.00^{cba}	0.93 ± 0.01^{fe}	0.90 ± 0.01^{fe}	0.80 ± 0.01^{bcd}	0.86 ± 0.00^{cde}	0.87 ± 0.00^{def}	0.76 ± 0.00^{a}	0.77 ± 0.00^{ab}
M	36.31 ± 0.72^{a}	28.75 ± 1.77^{a}	30.66 ± 1.13^{a}	48.70 ± 1.84^{a}	40.32 ± 5.81^{a}	28.28 ± 2.76^{a}	46.12 ± 5.56^{a}	38.03 ± 10.17^{a}	44.26 ± 4.25^{a}	36.52 ± 11.17^{a}
P	17.47 ± 0.13^{a}	24.81 ± 0.44^{e}	18.69 ± 0.35^{ab}	20.16 ± 0.49^{b}	22.75 ± 0.62^{cd}	26.81 ± 0.35^{f}	24.72 ± 0.58^{de}	22.56 ± 0.17^{c}	27.72 ± 0.48^{f}	19.97 ± 0.93^{b}
M : P	2.08	1.16	1.64	2.42	1.77	1.05	1.87	1.69	1.60	1.83
Aa	10.29 ± 0.62^{a}	14.78 ± 0.22^{ab}	18.14 ± 1.15^{bcd}	21.60 ± 0.23^{cde}	19.43 ± 1.26^{bcde}	20.14 ± 0.63^{bcde}	25.12 ± 1.08^{e}	16.18 ± 0.89^{abc}	35.47 ± 3.49^{f}	22.59 ± 2.67^{de}
L^*	54.75 ± 2.37^{d}	48.58 ± 0.94^{c}	48.79 ± 0.84^{c}	39.94 ± 1.89^{b}	46.55 ± 3.96^{c}	48.01 ± 1.60^{c}	52.36 ± 1.31^{cd}	47.79 ± 1.58^{c}	32.22 ± 2.24^{a}	39.88 ± 3.11^{b}
a^*	19.74 ± 1.60^{abcd}	26.57 ± 1.70^{e}	22.61 ± 0.66^{de}	20.80 ± 1.65^{bcd}	16.63 ± 0.10^{a}	20.91 ± 0.55^{bcd}	17.23 ± 0.21^{ab}	21.71 ± 1.37^{cd}	17.05 ± 1.07^{ab}	18.25 ± 3.04^{abcd}
b^*	10.47 ± 2.29^{abcd}	15.91 ± 1.33^{e}	14.12 ± 1.67^{cde}	12.53 ± 3.24^{abcde}	12.20 ± 1.31^{bcde}	11.23 ± 1.10^{abc}	13.48 ± 2.56^{abcde}	14.60 ± 2.11^{de}	7.30 ± 1.87^{ab}	6.42 ± 1.56^{a}

Significant differences ($P < 0.05$) between samples are indicated by letters (Tukey's test). Values are expressed as means ± standard deviations.

* Fermented sausage samples.

a_w, water activity; M, moisture %; P, total protein % (N × 6.5); M : P, moisture : protein ratio; Aa, amino acids (mM leucine/g); L^*, lightness; a^*, redness; b^*, yellowness.

content in the fermented sausages were not always in accordance with the determined protein content, which may be assigned to a variable contribution of endogenous/bacterial enzymes to beef and pork protein degradation during ripening. In fact, a correlation between total protein and amino acid content was observed for salami-type FS9, both parameters showing the highest values (27.72 ± 0.48 and 35.47 ± 3.49, respectively). However, in fuet-type (FS2 and FS6) samples that exhibited similar protein contents (24.81 ± 0.55 and 26.81 ± 0.35%, respectively), no correlation with released amino acids (14.78 ± 0.22 and 20.14 ± 0.63 mM leucine/g, respectively) was found (Table 3).

Color formation during sausage fermentation and ripening is known to be strongly dependent on pH decrease and oxygen depletion (Møller and Skibsted 2007). Changes occurring during this process involve a decrease of lightness (L^*) as a result of drying, an increase of redness (a^*) due to the typical red-cured nitrosomyoglobin development and a decrease in yellowness (b^*) values (Perez-Alvarez *et al.* 1999). In this study, color results for salami-type samples were similar or slightly higher to those reported for traditional Spanish and Italian fermented sausages, respectively (Gimeno *et al.* 2000; Casaburi *et al.* 2007); an influence of beef presence in the formulation which is characterized by higher myoglobin contents, should not be discarded. Regarding fuet-type samples, color parameters showed to be higher than those reported for Spanish low-acid fermented sausages (Marcos *et al.* 2007); the presence of red colorant in the formulation of this samples as declared by the label, may explain their higher a^* values (Table 1).

Consumer's Behavior Survey and Exploratory Evaluation

Behavior trends toward fermented sausages were investigated hypothesizing a population with similar products availability in supermarkets and exposure to nationwide advertisements than in other cities of the country (Martinez *et al.* 2002). Results indicated that 39% of the surveyed people declared to be a weekly fermented sausages consumer, 21% consumed fermented sausages once every 15 days and only the 5% affirmed that it was a daily habit. In addition, consumers that answered "almost never" and "monthly" represented 35% of surveyed persons. Regarding the purchasing habits, 85% answered to acquire fermented sausages at supermarkets, but not at butcher shops or other specific markets, this practice being widespread in Argentina urban areas. Moreover, even when a 60% of respondents exhibited no particular purchasing preferences for fermented sausages, the remaining 40% declared to prefer a specific product, from which 76% purchased renowned nationwide brands from Buenos Aires and Santa Fe (Argentina) included in this study. On the other hand, assay conditions for acceptance analysis were optimized and 46 panelists (regular consumers) were recruited from Scientific Technological Center staff. Although the number of consumers is an important issue for the design of sensory acceptability studies, it was stated to be variable (Hough *et al.* 2006). In fact, less than 100 nontrained judges, including students and/or employees of the same institute, to perform similar analyses were reported (Papadima *et al.* 1999; Soukoulis *et al.* 2010).

Sausage Segmentation by Consumer Liking

The affective method test was carried out to identify highly accepted fermented sausages and to investigate the hedonic variables driving consumer liking. Although sausage samples were separated in two sessions, no effect of session was found by variance analysis (data not shown). Regarding acceptance questions, ANOVA and Fisher test showed FS1 and FS2 to exhibit minimum and maximum scores, respectively for each query (Table 4). On this basis, by using the standardized data, a segmentation of Argentinean sausage samples was done based on CA. Indeed, three fermented sausage segments with different acceptance levels were defined: *accepted* (Group A) including samples FS2, FS3, FS5 and FS6; *intermediately accepted* (Group I) corresponding to samples FS7, FS9 and FS10, and *nonaccepted* (Group NA) integrated by FS1, FS4 and FS8 samples, as shown in the heat map graph (Fig. 1). Similarities and dissimilarities may be distinguished from the heat map in which the mean values of sensory attributes are in accordance with a color scale. As such, heat maps are a flexible visualization tool for grouping data and exploring patterns (Wilkinson and Friendly 2008; Pleila *et al.* 2011). In coincidence with those previously stated (Table 4), the lowest and highest rates for each sensory parameter were obtained for FS1 and FS2, clearly emerging as the worst and the best FS samples (Fig. 1). Furthermore, acceptance variable clustering showed a strong association between overall acceptance with taste and texture, suggesting that these aspects might modify the consumer choice, so these attributes must be particularly considered for fermented sausage appreciation. Notably, fuet-type samples (FS2, FS6) formulated exclusively with pork meat and salami-type samples (FS3, FS5) elaborated with beef/pork meat constituted the Group A, this suggesting that meat type would not greatly affect taste and texture as key factors for fermented sausage acceptance. Based on the homogeneity of consumer preference data among panelists arising from PCA (data not shown), the two-dimensional visual mapping (heat map) could be successfully applied. Although preference mapping to evaluate consumer liking is often used, a certain degree of

TABLE 4. ACCEPTABILITY OF FERMENTED SAUSAGES

	FS*1	FS2	FS3	FS4	FS5	FS6	FS7	FS8	FS9	FS10
Overall acceptance	3.46 ± 1.39^{a}	5.52 ± 1.24^{d}	5.16 ± 1.30^{d}	3.89 ± 1.71^{ab}	5.00 ± 1.61^{cd}	5.22 ± 1.28^{d}	4.11 ± 1.35^{b}	3.80 ± 1.59^{ab}	4.09 ± 1.71^{b}	4.39 ± 1.46^{bc}
Appearance	2.07 ± 0.88^{a}	3.98 ± 1.06^{d}	3.70 ± 0.79^{d}	2.66 ± 0.99^{bc}	2.93 ± 0.87^{c}	3.67 ± 0.84^{d}	2.70 ± 0.84^{bc}	2.54 ± 1.05^{b}	2.80 ± 0.88^{bc}	2.73 ± 1.00^{bc}
Aroma	2.50 ± 1.03^{a}	3.65 ± 0.99^{f}	3.16 ± 0.99^{cde}	2.80 ± 1.13^{abc}	3.27 ± 0.85^{def}	3.37 ± 1.14^{ef}	2.70 ± 1.05^{ab}	2.87 ± 0.96^{abcd}	3.07 ± 1.19^{bcde}	2.82 ± 0.90^{abc}
Taste	2.35 ± 1.04^{a}	3.63 ± 0.95^{f}	3.36 ± 0.99^{ef}	2.55 ± 1.09^{abc}	3.39 ± 1.15^{ef}	3.20 ± 1.15^{de}	2.83 ± 0.85^{bcd}	2.43 ± 0.89^{ab}	2.70 ± 1.23^{abc}	2.93 ± 0.87^{cd}
Texture	2.41 ± 0.98^{a}	3.83 ± 0.93^{g}	3.41 ± 1.00^{efg}	2.73 ± 1.13^{abc}	3.27 ± 1.06^{def}	3.59 ± 0.98^{fg}	3.07 ± 0.95^{cde}	2.57 ± 1.00^{ab}	2.93 ± 1.09^{bcd}	2.98 ± 0.95^{bcd}

Overall acceptance was evaluated with a hedonic scale of seven (7) levels and translated to a numeric scale. For other parameters, a numeric scale from 1 to 5 was used. Analysis of variance and Fisher test were applied. Means ± standard deviation are shown and significant differences ($P < 0.05$) between samples are indicated by letters.

* Fermented sausage samples.

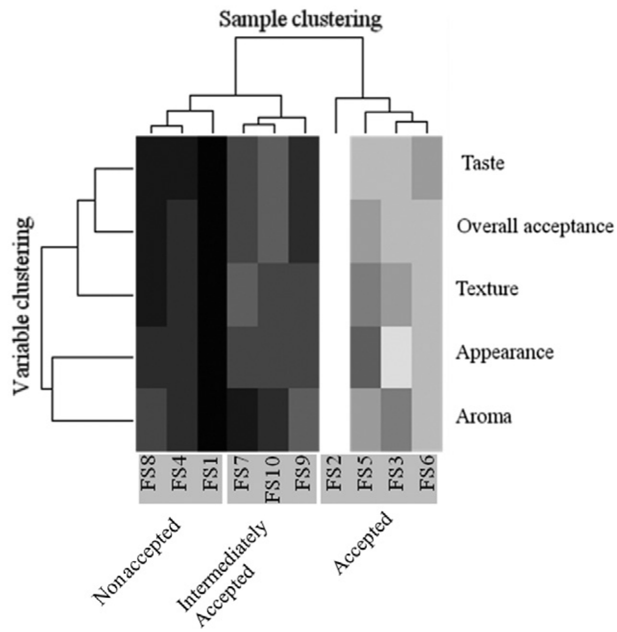

FIG. 1. HEAT MAP OF SENSORY STUDY OF ARGENTINEAN FERMENTED SAUSAGES BASED ON SCORE MEANS FOR EACH VARIABLE ASSIGNED BY CONSUMER JUDGES

Sample clustering is shown at the top and variable clustering on the left. Preference groups of fermented sausages are separately highlighted. Color legend: from white (highest mean scores) to black (lowest mean scores).

heterogeneity among consumer preferences may occur (Berna *et al.* 2005; Sinesio *et al.* 2010). However, as stated by Yenket *et al.* (2011), owing to consumer data homogeneity obtained in this study, any method/program to create a preference map could be implemented.

Instrumental Parameters Related to Consumer Acceptance

An SDA was then performed in order to find the most useful microbiological and physicochemical parameters for differentiation of sausage groups (A, I and NA). Variables and samples represented on two axes (Fig. 2) showed that the first discriminant function was clearly the most important; this accounting for 85.81% of the explained variance, while the remaining 14.19% was explained by the second function. Thus, an accurate discrimination was obtained because 100% of sausage samples matched with the *a priori* clustering. The larger the measure of variable plots, the greater the contribution to samples discrimination, in particular considering function 1 (horizontal axe). Accordingly, a_w, L^*, mold counts, total protein and enterococci population allowed discriminating among A, I and NA sausage groups. Results obtained from the combination of CA and

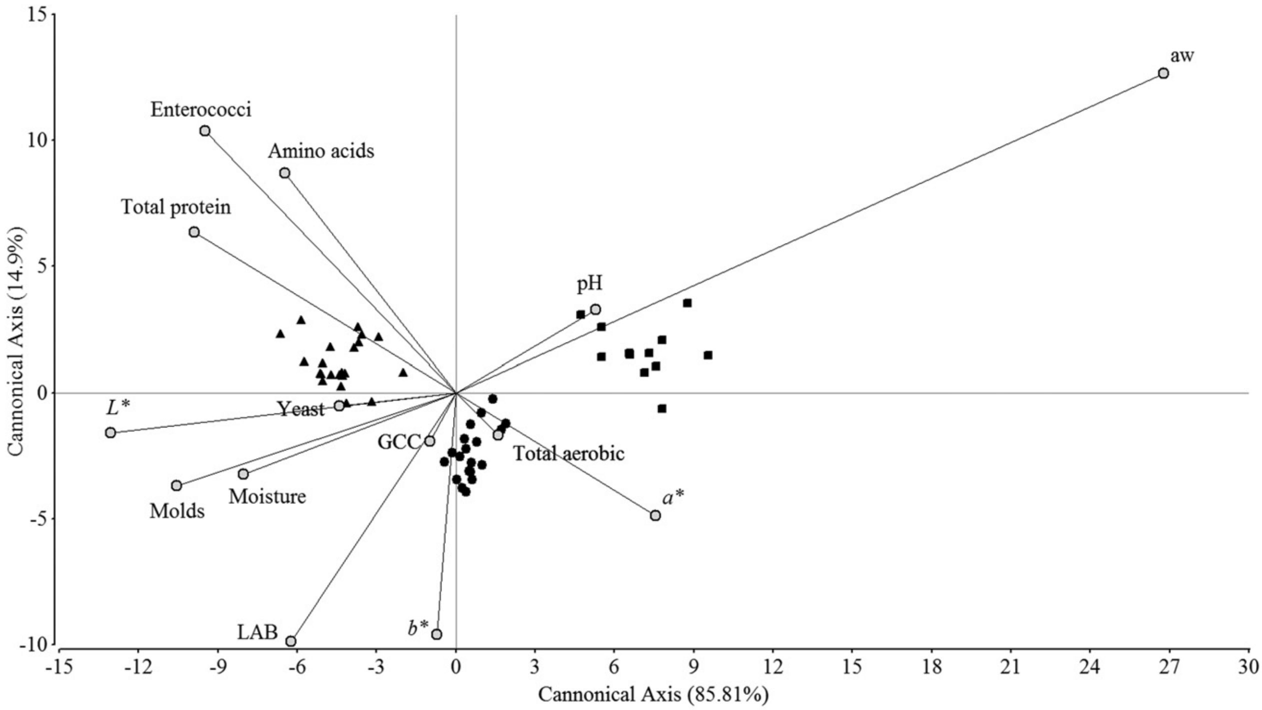

FIG. 2. SDA PLOT PERFORMED ON MICROBIOLOGICAL AND PHYSICOCHEMICAL DATA FOR FERMENTED SAUSAGES SEGMENTATION BASED ON CONSUMER ACCEPTANCE

Each determination of microbiological and physicochemical variables expressed in the canonical axis is represented as (•) for Accepted, (▲) for Intermediately Accepted and (■) for Non Accepted fermented sausages. SDA, standard discriminant analysis.

SDA may still be considered satisfactory, because a reduced number of variables allowed to differentiate three acceptance levels for Argentinean fermented sausages. Similarly, by applying discriminant analysis, Bianchi *et al.* (2007) were able to distinguish between two different geographical origins for Northern Italy dry sausages on the bases of volatile compounds analysis. To describe each group, ANOVA of discriminant variables (Table 5) revealed that sausages involved in both A and I group showed lower a_w and enterococci counts but higher mold counts and protein content mean values when compared with NA group; I group diverged from A and NA groups due to its lower L^* value. Although not fully matching of some individual values in terms of a_w and protein content (Table 1), with SDA calculated means (Table 5) occurred, 100% of samples were accurately classified according to the *a priori* CA group (Fig. 2). Similarly, Ambrosiadis *et al.* (2004) by using SDA were able to relate fresh sausages flavor with microbiological and physicochemical traits as affected by storage time. In the study presented herein, a positive correlation between consumer acceptance and satisfactory sausage ripening may be inferred. In fact, *accepted* Argentinean fermented sausages (Group A) exhibited low a_w and enterococci counts as well as high protein content mean values as expected for an optimal fermentation and ripening process (Talon *et al.* 2002).

TABLE 5. MEAN VALUES OF DISCRIMINANT VARIABLES FOR FERMENTED SAUSAGES GROUPS BASED ON CONSUMER ACCEPTANCE

Variables	Group A	Group I	Group NA
a_w	0.81 ± 0.05^a	0.80 ± 0.04^a	0.91 ± 0.03^b
L^*	48.06 ± 1.75^b	41.71 ± 8.36^a	47.79 ± 6.61^b
Molds (log cfu/g)	3.47 ± 1.02^b	4.18 ± 0.58^b	2.00 ± 1.58^a
Enterococci (log cfu/g)	4.82 ± 2.71^a	6.09 ± 0.47^{a,b}	6.76 ± 0.41^b
Total protein (%)	22.85 ± 3.22^a	23.98 ± 3.37^a	20.06 ± 2.18^b

Significant differences ($P < 0.05$) between samples are indicated by letters (Tukey's test).
a_w, water activity; L^*, lightness; Group A, *accepted* group; Group I, *intermediately accepted* group; Group NA, *nonaccepted* group.

CONCLUSIONS

Factors affecting acceptance for Argentinean fermented sausages by regular consumers were established by different approaches. Liking of texture and taste were both important drivers of consumer acceptance, in addition, a limited number of microbiological and physicochemical characteristics, namely a_w, lightness (L^*), total protein, molds and enterococci counts were able to define fermented sausages segmentation. The preference mapping approach constitutes a valuable tool for relating groups of consumers with different acceptance profiles to data generated by instrumental techniques (microbiological and physicochemical analyses). Argentinean liking trends for fermented sausages might be related to products satisfactorily fermented and ripened. To the best of our knowledge; this constitutes the first attempt to establish quality standard criteria for Argentinean fermented sausages.

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