J. Dairy Sci. 96:2792–2800
http://dx.doi.org/10.3168/jds.2012-6273

Composition and sensory profiling of probiotic Scamorza ewe milk cheese

M. Albenzio,*[1] A. Santillo,* M. Caroprese,* A. Braghieri,† A. Sevi,* and F. Napolitano†
*Department of the Sciences of Agriculture, Food and Environment (SAFE), University of Foggia, Via Napoli, 25, 71100 Foggia, Italy
†Scuola di Scienze Agrarie, Forestali, Alimentari ed Ambientali, University of Basilicata, Via dell'Ateneo Lucano 10, 85100 Potenza, Italy

ABSTRACT

The present study aimed to assess the effect of the addition of different usually recognized as probiotic bacterial strains on chemical composition and sensory properties of Scamorza cheese manufactured from ewe milk. To define the sensory profile of Scamorza cheese, a qualitative and quantitative reference frame specific for a pasta filata cheese was constructed. According to the presence of probiotic bacteria, cheeses were denoted S-BB for Scamorza cheese made using a mix of *Bifidobacterium longum* 46 and *Bifidobacterium lactis* BB-12, and S-LA for Scamorza cheese made using *Lactobacillus acidophilus* LA-5. The designation for control Scamorza cheese was S-CO. Analyses were performed at 15 d of ripening. The moisture content of Scamorza ewe milk cheese ranged between 44.61 and 47.16% (wt/wt), showing higher values in S-CO and S-BB cheeses than in S-LA cheese; the fat percentage ranged between 25.43 and 28.68% (wt/wt), showing higher value in S-LA cheese. The NaCl percentage in Scamorza cheese from ewe milk was 1.75 ± 0.04% (wt/wt). Protein and casein percentages were the highest in Scamorza cheese containing a mix of bifidobacteria; also, the percentage of the proteose-peptone fraction showed the highest value in S-BB, highlighting the major proteolysis carried out by enzymes associated with *B. longum* and *B. lactis* strains. Texture and appearance attributes were able to differentiate probiotic bacteria-added cheeses from the untreated control product. In particular, S-BB and S-LA Scamorza cheeses showed higher color uniformity compared with S-CO cheese. Furthermore, the control cheese showed higher yellowness and lower structure uniformity than S-BB. The control product was less creamy and grainy than S-BB; conversely, the inclusion of probiotics into the cheese determined lower adhesivity and friability in S-BB and S-LA than in S-CO. This study allowed the definition of the principal composition and sensory properties of Scamorza ewe milk cheese. The specific quantitative vocabulary for sensory analysis and reference frame for assessor training also established in this study should be implemented to systematically monitor the quality of this new typology of ewe milk cheese.
Key words: pasta filata ewe milk cheese, probiotic bacteria, chemical composition, Scamorza sensorial profile

INTRODUCTION

Pasta filata cheeses encompass a wide range of cheese varieties such as Mozzarella (fresh cheese), Scamorza (short-ripened cheese), Provolone, and Caciocavallo (medium- and long-ripened cheese), which originated primarily in the northern Mediterranean region (Italy, Greece, the Balkans, and Turkey) and are obtained from cow milk or buffalo milk, or both.

Pasta filata cheese is produced by a thermizing and texturizing process that occurs when the curd is dipped in hot water and worked mechanically into a plastic consistency, followed by molding into a desired shape and size. The thermal treatment influences the microbiological, biochemical, physicochemical, and functional characteristics of the cheese, which, in turn, markedly affects the sensory properties of these products. For its peculiarity, pasta filata cheese has been traditionally grouped as a distinct cheese category (Kindstedt et al. 2010).

Cheese may be a good alternative for delivery of probiotic bacteria into human gut compared with more acidic fermented dairy products such as yogurt and it has been the subject of various marketing and research studies in recent years (Gomes da Cruz et al., 2009). In fact, cheese creates a buffer against the high acidic environment in the gastrointestinal tract, thus producing a more favorable environment for probiotic bacteria survival throughout gastric transit (Karimi et al., 2012). Nevertheless, probiotics in cheese may have positive effects on health; it is important that their incorporation should not affect the main sensory properties (flavor, texture, and appearance) of this product.

Previous studies suggest that the inclusion of probiotics does not markedly change the sensory profile of cheese (Champagne et al., 2005; Santillo and Albenzio,

Received October 16, 2012.
Accepted February 7, 2013.
[1]Corresponding author: m.albenzio@unifg.it

2008). However, ripening may determine an increasing accumulation of microbial metabolism products, with possible effects on the cheese sensory profile (Gomes da Cruz et al., 2009). In particular, lactic acid bacteria can transform carbon compounds into lactic acid and sugars into other organic products (Even et al., 1999), whereas bifidobacteria are able to produce high amounts of acetic acid (Grattepanche et al., 2008). As a consequence, the inclusion of probiotic bacteria may contribute to distinct flavor and texture characteristics (Urala and Lähteenmäki, 2004), thus changing perceived cheese liking (Buriti et al., 2005a). However, if the sensory profile does not match the costumer expectations, the product will fail in the market.

Differently from other more standardized foods, sensory evaluation of animal products may have intrinsic pitfalls, including variability among animals within the same farming conditions, among breeds, among farming conditions, and among process characteristics within the same category of products. Therefore, a specific training program is needed to standardize evaluation practices among assessors (Braghieri et al., 2012). A valid assessor-training program needs qualitative and quantitative frames of reference (Muñoz and Civille, 1998). For other food products, a list of reference descriptors is produced by presenting a variety of chemicals, ingredients, spices or products, covering the entire sensory spectrum to be described (Rainey, 1986). Nonfood materials possessing sensory stimuli, such as grass for grassy or red cards for color standards, may also be used. Subsequently, assessors clarify the meaning of each descriptor using concrete examples representing the qualitative frame of references for the panel (Muñoz and Civille, 1998).

However, in the case of pasta filata cheese a standardized quantitative frame of reference is lacking. Furthermore, for complex attributes, such as texture or flavor of cheese, panelists may be unable to generalize sensory concepts to products unrelated with the category under evaluation (Murray and Delahunty, 2000), whereas a quantitative reference frame related to the product can improve performances of panelists (Meilgaard et al., 1979; Noble et al., 1987).

The use of ewe milk to produce pasta filata cheese containing probiotic bacteria could represent a further chance to promote dairy sheep enterprises by differentiating into innovative products. The present study aimed to assess the effect of the addition of different probiotic strains on chemical and sensory properties of Scamorza cheese from ewe milk. To achieve the sensory profile of Scamorza cheese, the definition of a qualitative and quantitative reference frame specific for a pasta filata cheese was performed.

MATERIALS AND METHODS

Scamorza Cheese Production

Probiotic Scamorza cheese production was performed following the protocol reported in Albenzio et al. (2013), which is summarized in Figure 1. The peculiar phase of the production protocol provided for inoculation of thermized ewe milk with 1% commercial starter of *Streptococcus thermophilus* (Lyofast, ST 044; Sacco, Como, Italy) and 2% fresh cells of heat-adapted *Lactobacillus acidophilus* LA-5 (Chr. Hansen SpA, Milan, Italy), or a mix (1:1) of *Bifidobacterium longum* BL-46 (DSM14583) and *Bifidobacterium lactis* BB-12 (Chr. Hansen SpA). Probiotic bacteria strains were grown for 48 h at 37°C in de Man, Rogosa, and Sharpe broth (**MRS**; Oxoid, Milan, Italy) for *Lb. acidophilus* or in MRS + 0.05% cysteine (Sigma-Aldrich, Milan, Italy) (cMRS) for bifidobacteria. After reaching the stationary phase of growth, the probiotic strains were heated in a water bath at 65°C for 30 min to induce heat adaptation; 6 heat treatments (65°C for 30 min were performed on each probiotic strain tested, adapted from the method described in Minervini et al. (2012). Cell cultures (30 mL) were centrifuged at 1,200 × *g* for 10 min; then, the supernatant was discarded and 30 mL of sterile distilled water added to the pellet. To test cell recovery after heat adaptation treatment, the harvested cells were plated on the selective medium, previously reported; cell counts of *Lb. acidophilus* and *B. longum* and *B. lactis* ranged between 8.5 and 9.0 log cfu/mL.

Three Scamorza cheesemaking trials were performed in triplicate in an industrial dairy plant. According to the presence of probiotics, cheeses were denoted **S-BB** for Scamorza cheese made using a mix of *B. longum* and *B. lactis*, **S-LA** for Scamorza cheese made using *Lb. acidophilus* as probiotic strain, and **S-CO** for control Scamorza cheese with no addition of probiotics. Analyses were performed at 15 d of ripening. Probiotic cell loads in Scamorza cheese at 15 d of ripening were determined on specific media: the mean value of *Lb. acidophilus* was 7.55 ± 0.07 $\log_{10}$ cfu/g of cheese detected on MRS agar (Sigma-Aldrich) acidified to pH 5.0 and incubated at 37°C for 48 to 72 h under anaerobic conditions; the mean value of the mix of *B. longum* and *B. lactis* was 9.9 ± 0.04 $\log_{10}$ cfu/g of cheese detected on MRS agar + 0.5% cysteine and nalidixic acid, paromycin sulfate, neomycin sulfate, and lithium chloride (NPNL), as reported by Vinderola and Reinheimer (1999), incubated at 37°C for 2 to 4 d under anaerobic conditions. Counts of *Lb. acidophilus* and bifidobacteria were confirmed through microscopic examination using light/contrast phase microscopy (400×; Axioskop 20; Carl Zeiss SpA, Milan, Italy) to assess colony mor-

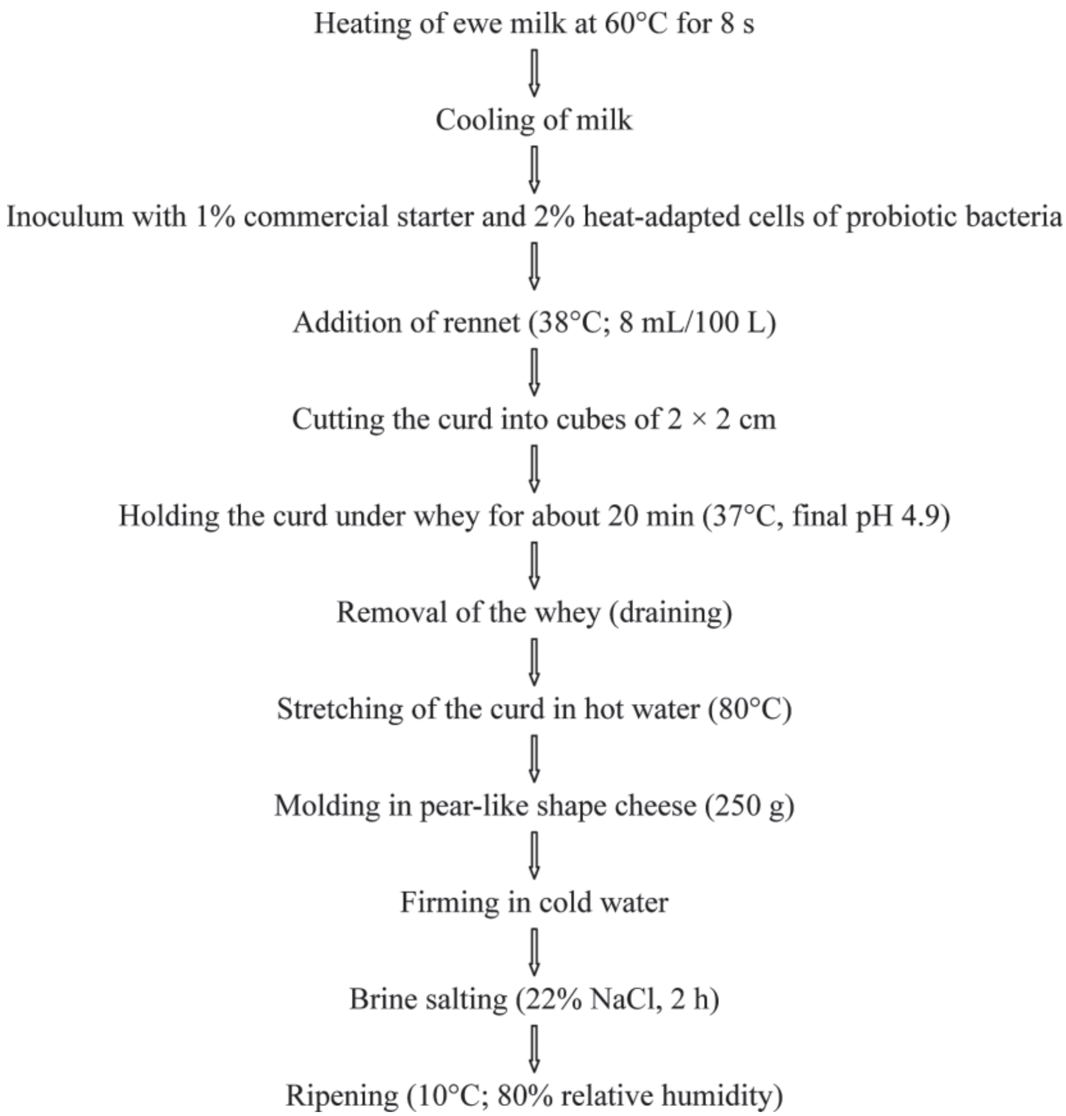

Figure 1. Protocol for the production of Scamorza ewe milk cheese.

phology. Furthermore, DNA was extracted from some representative strains, and analyzed through repetitive sequence-based PCR and internal transcribed spacer PCR as reported by Bevilacqua et al. (2010).

Chemical Characteristics

The pH value, DM, and NaCl contents of the cheese were determined according to standard International Dairy Federation procedures [IDF (1989), IDF (1986), and IDF (1988), respectively]. Total nitrogen (**TN**) and NPN concentrations were determined as described by Gripon et al. (1975); water-soluble nitrogen (**WSN**) concentration was determined as proposed by Stadhouders (1960). Casein nitrogen concentration was calculated by subtracting WSN from TN; the peptone fraction concentration was calculated by subtracting the NPN from WSN. Fat concentration was determined by the Soxhlet method using ethyl ether according to AOAC International (1995). All cheeses were analyzed at 15 d of ripening.

Sensory Analysis

Panel Selection and Training. Ten panelists (7 males and 3 females; between 25 and 40 yr of age) were selected on the basis of their capacity for identification of the 4 (sourness, sweetness, bitterness, and saltiness) basic tastes (Jellinek, 1985). For this purpose, sucrose (sweetness), sodium chloride (saltiness), citric acid (sourness), and quinine hydrochloride (bitterness) solutions (filtered, deionized water at room temperature

Table 1. Descriptive attributes and definitions used to evaluate Scamorza ewe milk cheese

Descriptor	Definition
Odor/flavor	
Milk	Odor/flavor arising from milk at room temperature
Butter	Odor/flavor arising from butter at room temperature
Taste	
Acid	Fundamental taste associated with citric acid
Sweet	Fundamental taste associated with sucrose
Bitter	Fundamental taste associated with quinine
Salty	Fundamental taste associated with sodium chloride
Seasoned	Taste associated with the degree of seasoning
Texture	
Tenderness	Minimum force required to chew cheese sample: the lower the force, the higher the tenderness
Creaminess	Formation of a creamy bulk during mastication
Grainy	Perception of course particles in mouth
Adhesivity	Force required to remove the mouth coating layer of cheese: the higher the force, the higher the adhesivity
Moisture	Moisture released by the product in the mouth during early mastication (dry: saliva is absorbed by the product; humid: liquids are released during mastication)
Friability	Extent to which cheese fragments are increasingly perceived during mastication
Appearance	
Color uniformity	Overall uniformity in color: presence of either shades or tones reduces uniformity
Structure uniformity	Overall uniformity in structure: presence of either fissures or holes reduces uniformity
Yellowness	Overall intensity of the yellow color

as diluent) were used. Three concentration levels (basic, high, and low concentrations) of sodium chloride (1.5, 3, and 1 g/500 mL of solution), citric acid (0.5, 0.75, and 0.375 g/L of solution), quinine hydrochloride (0.375, 0.75, and 0.037 g/L of solution), and sucrose (5, 6.5, and 4 g/L of solution) were prepared. The taste of each basic concentration was overtly indicated to the panelists. Then, a 10-mL quantity of high and low concentration for each taste solution was served in clean glasses. Between tests, the panelists rinsed their mouths with filtered, deionized water, which was also used as blanks. All taste solutions and blanks (totaling 10 samples) were presented in random order. The panelists were asked to identify, in blind conditions, the intensity (low and high) of each taste solution. The inability to recognize 8 out of the 10 taste solutions was used as the cut-off point for selection purposes.

Subsequently, panelists were trained for the scale use (Stone and Sidel, 2004). During preliminary sessions, the assessors, on the basis of available literature (Muir et al., 1995; Adhikari et al., 2003), developed and then agreed on a consensus list of attributes and their definitions. A single score card containing 2 odor/flavor, 5 taste, 6 consistency, and 3 appearance descriptors was compiled, representing the consensus profile of sensory characteristics (Table 1). Subsequently, a reference frame for assessor training was developed (Table 2). Standard reference products specific to each identified attribute were sought. Under the guidance of the panel leader, the assessors determined which of the proposed references were most suitable to represent the previously identified sensory attributes. The identification of reference standards required 2 sessions of 2 h. For a reliable evaluation, at least 2 points of the scale were anchored to the reference material during the panel training.

Quantitative Descriptive Sensory Analysis. A quantitative-descriptive analysis method (Murray et al., 2001) was used to assess the 3 products. Cheese cube samples (1 cm^3) were coded with 3-digit randomized numbers and served in random order according to sample, replicate, and assessor. Panelists were asked to eat a slice of apple between samples to try to make the palate conditions similar for each sample. Attributes were rated on the basis of 100-mm unstructured lines with anchor points at each end (0 = absent; 100 = very strong). The intensity of the descriptors was expressed as low (0–35 points), moderate (36–70 points), and high (71–100 points). The panelists evaluated 3 replications of each cheese product. Tests were performed at about 1000 h in a controlled sensory analysis laboratory (ISO, 1988) equipped with individual booths and under red lighting to mask color differences in the samples, except during the evaluation of cheese appearance, when only white fluorescent lighting was used. The panelists were not provided with any information regarding the samples to be tasted. To avoid sensory fatigue due to the number of samples, 3 samples were evaluated in each session. The interval between samples was approximately 10 min. Three sessions were performed to analyze cheese.

Statistical Analyses

All the variables were tested for normal distribution using the Shapiro-Wilk test (Shapiro and Wilk,

Table 2. Reference frame used for assessor training

Descriptor	Reference intensity
Odor/flavor	
Milk	Low: 120 g of Fontina cut in blocks of about 1 cm^2 cross-sectional area
	High: 120 g of Mozzarella cheese cut in blocks of about 1 cm^2 cross-sectional area
Butter	Low: 120 g of melted Ricotta cheese
	Medium: 20 g of butter mixed with 100 g of Ricotta cheese
	High: 80 g of butter mixed with 40 g of Ricotta cheese
Taste	
Seasoned	Low: 20 g of Ricotta cheese
	Medium: 20 g of Asiago cheese
	High: 20 g of Parmesan cheese seasoned 36 mo
Texture	
Tenderness	Low: 30 g of Parmesan cheese seasoned 36 mo
	Medium: 30 g of Emmental cheese
	High: 30 g of Mozzarella cheese
Creaminess	Low: 30 g of Parmesan cheese seasoned 36 mo
	Medium: 30 g of Fontina cheese
	High: 30 g of Taleggio cheese
Grainy	Low: 30 g of Asiago cheese
	Medium: 30 g of Emmental cheese
	High: 30 g of Parmesan cheese seasoned 36 mo
Adhesivity	Low: 30 g of Mozzarella cheese
	Medium: 30 g of Fontina cheese
	High: 30 g of Taleggio cheese
Moisture	Low: 30 g of Parmesan cheese seasoned 36 mo
	Medium: 30 g of Asiago cheese
	High: 30 g of Ricotta cheese
Friability	Low: 30 g of Taleggio cheese
	Medium: 30 g of Emmental cheese
	High: 30 g of Caciocavallo cheese seasoned 6 mo
Appearance	
Color uniformity	Low: 30 g of Caciocavallo cheese seasoned 6 mo
	High: 30 g of Fontina cheese
Structure uniformity	Low: 30 g of Asiago cheese
	High: 30 g of Fontina cheese
Yellowness	Low: 30 g of Asiago cheese
	Medium: 30 g of Fontina cheese
	High: 30 g of Caciocavallo cheese seasoned 6 mo

1965). Data on chemical composition were processed by ANOVA using PROC GLM of SAS (SAS Institute, 2011). The tested effect was probiotic bacterial addition. Sensory profile data were subjected to ANOVA using assessor (10), replication (3), product (3), and the interactions as factors. Results are presented as least squares means and the variability of the data is expressed as the standard error of the mean response throughout the whole trial. Significant differences were considered at $P < 0.05$. When significant effects were found (at $P < 0.05$), the Tukey test was used as a post-hoc test.

RESULTS AND DISCUSSION

Chemical Characteristics of Scamorza Ewe Cheese

Scamorza cheeses were produced by using ewe milk obtained from the Gentile di Puglia ovine breed; this milk is particularly suitable for cheese making because of its high protein and fat content. However, the peculiar technique of pasta filata cheese production has a profound effect on the chemical composition of the cheese; in particular, the stretching and molding phases affect moisture and fat losses in the fresh curd (Kindstedt et al., 2010).

The pH value and principal composition of Scamorza cheese from ewe milk after 15 d of ripening is reported in Table 3. The moisture content of Scamorza ewe milk cheese ranged between 44.61 and 47.16% (wt/wt), showing higher values in S-CO and S-BB cheeses than in S-LA cheese and the fat percentage ranged between 25.43 and 28.68% (wt/wt), showing higher value in S-LA cheese. It is worth noting that moisture content in fresh Scamorza cheese curd displayed a mean value of 56.24 ± 0.48% (wt/wt) and no differences were found among cheeses. The NaCl percentage in Scamorza cheese from ewe milk was 1.75 ± 0.04% (wt/wt) and no differences were detected among cheeses, demonstrating high repeatability in brining procedures in terms of residence time in the brine and brine concentration, which are key parameters that affect total

Table 3. Least squares means of pH value and principal composition of Scamorza ewe milk cheese

	Scamorza cheese[1]				Effect (P-value)
Parameter	S-CO	S-BB	S-LA	SEM	Probiotic
pH	4.98[b]	4.92[a]	4.90[a]	0.01	**
Moisture (% by wt)	46.09[b]	47.16[b]	44.61[a]	0.58	*
Protein (% by wt)	24.64[a]	26.24[b]	25.44[a]	0.08	*
Casein (% by wt)	21.74[a]	22.77[b]	21.77[a]	0.08	*
Peptone/TN[2] (% by wt)	14.99[a]	17.71[b]	14.74[a]	0.40	***
Fat (% by wt)	25.62[a]	25.43[a]	28.68[b]	0.98	*

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

[1]S-CO = control Scamorza cheese; S-BB = Scamorza cheese containing the mix of *Bifidobacterium longum* BL-46 and *Bifidobacterium lactis* BB-12; S-LA = Scamorza cheese containing *Lactobacillus acidophilus* LA-5.

[2]TN = total nitrogen.

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

salt uptake. Moisture and NaCl contents are strictly related both to milk and to cheese-making procedures and represent basic features of the cheese; therefore, the standardization of these parameters is useful to define cheese identity. Few data are reported in literature for Scamorza cheese composition and they refer to cheese obtained from cow milk with a moisture percentage higher than 50% (wt/wt; Rankin et al., 2006) and fat and protein percentages of 25 and 24% (wt/wt), respectively (Kindstedt, 2003). The comparison between data on chemical composition of Scamorza cheese from cow and ewe milk derives from milk species composition, which is regarded as one of the main factors able to influence cheese composition. No data are available on cheese composition of Scamorza cheese from ewe milk; therefore, data reported in this study could represent a reference range for this cheese typology.

Proteolysis is a fundamental process in cheese ripening and leads to the hydrolysis of the casein matrix into small soluble peptides and free amino acids responsible for cheese sensory and texture profiles. This process is ruled by milk endogenous enzymes, milk coagulant, and enzymes associated with starter and nonstarter bacteria. Protein and casein percentages showed a similar trend, both being highest in Scamorza cheese containing a mix of bifidobacteria. The casein nitrogen fraction represented almost the total of protein nitrogen, due to the limited proteolysis occurring during the short time of Scamorza cheese ripening. However, the percentage of peptones/TN, which is reported as an index of casein degradation, showed the highest value in S-BB, highlighting a different proteolytic process among cheeses and confirming the major proteolysis carried out by enzymes associated to *B. longum* BL-46 and *B. lactis* BB-12 strains.

Sensory Properties of Scamorza Cheese

The interactions product × replication and product × assessor were not significant. These results about panel performances are fundamental for subsequent analyses and interpretations, as they demonstrate high reliability of the panel by showing that the products were consistently evaluated both in different replications and by different assessors. Therefore, both the reference frame and assessor training proved to be appropriate for Scamorza cheese sensory evaluation purposes.

Results concerning sensory analysis are reported in Table 4. Within taste attributes only "seasoned" was affected by the inclusion of probiotics; it can be hypothesized that *B. longum* BL-46 and *B. lactis* BB-12, unlike *Lb. acidophilus* LA-5, produced specific metabolites affecting the attribute "seasoned". The effect of probiotic bacteria on flavor characteristics of cheese is mainly dependent on the species and strains added. Also, it depends on the metabolic activity of the strains during cheese production and storage. Cheese flavor is very complex and hundreds of compounds (volatile and nonvolatile) are involved, as a result of proteolysis, lipolysis, and glycolysis. The enzymes of probiotic bacteria can interfere with these biochemical processes and contribute to cheese odor and flavor (Drake et al., 1996; Ong and Shah, 2009). For instance, incorporation of lactobacilli enhanced bitterness and sour-acid flavor (Lynch et al., 1999; El Soda et al., 2000) of Cheddar cheese. The authors related these effects to the complex peptidase system possessed by lactobacilli. The slight modifications usually induced on flavor by probiotics may have an effect, albeit minor, on consumer liking (Liggett et al., 2008).

Numerous investigations indicate that addition of probiotic bacteria to cheese in a suitable culture composition and formulation does not markedly change the flavor and (or) other sensory characteristics of the final product compared with the control. Dinakar and Mistry (1994) reported that bifidobacteria added to Cheddar cheese did not exhibit vigorous metabolic activity and did not affect the flavor, texture, or appearance through 24 wk of storage. In particular, cheeses with

Table 4. Intensity levels of Scamorza ewe milk cheese sensory attributes as affected by inclusion of probiotics

	Scamorza cheese[1]				Effect (P-value)
Parameter	S-CO	S-BB	S-LA	SEM	Probiotic
Odor/flavor					
Butter	55.37	52.33	56.33	3.55	NS
Milk	22.67	28.17	27.70	3.49	NS
Taste					
Sweet	42.07	35.83	36.83	3.17	NS
Salty	34.13	36.93	35.87	2.32	NS
Acid	48.23	42.97	43.07	3.92	NS
Bitter	57.27	65.37	62.93	4.14	NS
Seasoned	60.57[b]	48.30[a]	63.57[b]	2.94	**
Texture					
Tenderness	34.01	31.57	33.67	2.94	NS
Creamy	29.01[a]	39.80[b]	35.90[ab]	3.11	*
Grainy	67.10[a]	81.57[b]	75.60[ab]	3.23	**
Adhesivity	38.83[b]	22.83[a]	32.30[ab]	3.29	**
Moisture	73.20	73.03	73.70	3.38	NS
Friability	30.07[b]	19.43[a]	21.83[a]	3.11	*
Appearance					
Color uniformity	45.30[a]	65.40[b]	63.07[b]	3.20	***
Yellowness	20.43[b]	11.67[a]	13.80[ab]	2.89	*
Structure uniformity	43.01[a]	52.17[b]	47.83[ab]	2.59	*

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

[1]S-CO = control Scamorza cheese; S-BB = Scamorza cheese containing the mix of *Bifidobacterium longum* BL-46 and *Bifidobacterium lactis* BB-12; S-LA = Scamorza cheese containing *Lactobacillus acidophilus* LA-5.

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

added bifidobacteria had higher concentrations of acetic and lactic acids compared with the control (Ong et al., 2007), but the sensory differences were unchanged (Gobbetti et al., 1998). Buriti et al. (2005b) observed that besides increasing proteolysis during storage, the addition of *Lb. acidophilus* to Minas fresh cheese had no influence on flavor and preference compared with a control cheese. In addition, the incorporation of the *Lb. acidophilus*, when producing the previously mentioned fresh cheese, conferred sensory stability during storage of the product for up to 14 d, particularly in cheese produced with the addition of the probiotic in co-culture with *Strep. thermophilus* (de Souza et al., 2008).

Most of the texture and appearance attributes differentiated probiotic cheeses from the untreated control product. In particular, S-BB and S-LA cheeses showed higher color uniformity compared with S-CO cheese ($P < 0.001$). In addition, the S-CO cheese showed higher yellowness and lower structure uniformity than S-BB and tended to show higher yellowness and lower structure uniformity than S-LA ($P < 0.10$ and $P < 0.20$, respectively). Appearance attributes are important drivers of consumer liking, as they can affect choice behavior (Wadhwani and McMahon, 2012). Often, pasta filata cheeses such as Scamorza are sold under the form of portioned products; therefore, color intensity and color and structure uniformity are clearly visible, thus playing a central role in orienting consumer preferences and purchase decision. Previous studies on consumer preference mapping showed that some groups prefer less-colored and more-uniform cheeses (Murray and Delahunty, 2000).

As to texture, the control product was less creamy and grainy than S-BB cheese and tended to be less creamy and grainy than S-LA cheese ($P < 0.10$ and $P < 0.20$, respectively). Conversely, the inclusion of probiotics into the cheese determined lower friability in S-BB and S-LA cheeses than in S-CO cheese, whereas adhesivity was lower in S-BB, intermediate in S-LA, and higher in S-CO cheeses. Accordingly, Buriti et al. (2005a) found that the inclusion of *Lactococcus* spp. in cheeses significantly influenced texture parameters, leading to more fragile cheeses, in addition to the intense reduction of pH and increase in titratable acidity due to the production of lactic acid and other organic acids. Lower pH levels were also observed in the present study in probiotic Scamorza cheeses (4.90 ± 0.02 in S-BB and S-LA cheeses vs. 4.98 ± 0.02 in S-CO cheese) at 15 d of ripening. The modification of the textural properties of cheese, due to the probiotic incorporation, in fact, may be related to the effect of these bacteria on the acidification rate of cheese. Heller et al. (2003) stated that the rate and extent of acidification have a major effect on cheese texture via demineralization of the casein micelles. The more intense the production of lactic acid by probiotic microorganisms, the higher the decrease in calcium bound to casein and the more brittle the texture of cheeses (Fox and McSweeney, 1998). Texture characteristics comprise an important set of sensory cheese characteristics, affecting product overall quality and consumer liking according to different sensory segments. These characteristics also play a central role in the differentiation of cheese products and varieties (Foegeding et al., 2003). Furthermore, Scamorza cheese containing *B. longum* BL-46 and *B. lactis* BB-12 was perceived as less seasoned, which could be associated with the high creaminess and low friability.

CONCLUSIONS

Milk from the Gentile di Puglia ovine breed was suitable for Scamorza cheese production and this cheese type may enable expansion of the market offering of ewe milk cheese. Sensory analysis was able to differentiate the 3 products: control Scamorza and Scamorza cheeses containing a mix of *B. longum* BL-46 and *B. lactis* BB-12 or *Lb. acidophilus* LA-5, based on texture and appearance characteristics. Probiotic Scamorza cheese showed higher structural uniformity and lower friability, and was more creamy and grainy than the control Scamorza cheese. In particular, the incorporation of bifidobacteria determined the greatest differences compared with the control product, whereas the incorporation of *Lb. acidophilus* LA-5 produced intermediate characteristics. This study also allowed the definition of a specific quantitative vocabulary for Scamorza cheese sensory analysis and a specific reference frame for assessor training, which should be implemented to systematically monitor the quality of this new typology of ewe milk cheese. Further studies are needed to verify whether the modifications induced by the addition of probiotics and the use of ewe milk to manufacture Scamorza cheese have an effect on consumer liking (either positive or negative).

ACKNOWLEDGMENTS

The present work is part of the research program titled "Innovative strategies for quality and safety in ovine production," financially supported by the Italian Ministry of Agricultural, Food and Forestry Policies (MIPAAF, Rome, Italy).

REFERENCES

Adhikari, K., H. Heymann, and H. E. Huff. 2003. Textural characteristics of low fat, full fat and smoked cheeses: Sensory and instrumental approaches. Food Qual. Prefer. 14:211–218.

Albenzio, M., A. Santillo, M. Caroprese, D. Ruggieri, F. Napolitano, and A. Sevi. 2013. Physicochemical properties of Scamorza ewe milk cheese manufactured with different probiotic cultures. J. Dairy Sci. 96:2781–2791. 10.3168/jds.2012-6218.

AOAC International. 1995. Official Methods of Analysis. 16th ed. AOAC International, Washington, DC.

Bevilacqua, A., C. Altieri, M. R. Corbo, M. Sinigaglia, and L. I. I. Ouoba. 2010. Characterization of lactic acid bacteria isolated from Italian Bella di Cerignola table olives: Selection of potential multifunctional starter culture. J. Food Sci. 75:M536–M544.

Braghieri, A., N. Piazzolla, A. Carlucci, E. Monteleone, A. Girolami, and F. Napolitano. 2012. Development and validation of a quantitative frame of reference for meat sensory evaluation. Food Qual. Prefer. 25:63–68.

Buriti, F. C. A., J. S. da Rocha, E. G. Assis, and S. M. I. Saad. 2005a. Probiotic potential of Minas fresh cheese prepared with the addition of *Lactobacillus paracasei*. Lebenson. Wiss. Technol. 38:173–180.

Buriti, F. C. A., J. S. da Rocha, and S. M. I. Saad. 2005b. Incorporation of *Lactobacillus acidophilus* in Minas fresh cheese and its implications for textural and sensorial properties during storage. Int. Dairy J. 15:1279–1288.

Champagne, C. P., N. J. Gardner, and D. Roy. 2005. Challenges in the addition of probiotic cultures to foods. Crit. Rev. Food Sci. Nutr. 45:61–84.

de Souza, C. H. B., F. C. A. Buriti, J. H. Behrens, and S. M. I. Saad. 2008. Sensory evaluation of probiotic Minas fresh cheese with *Lactobacillus acidophilus* added solely or in co-culture with a thermophilic starter culture. Int. J. Food Sci. Technol. 43:871–877.

Dinakar, P., and V. V. Mistry. 1994. Growth and viability of *Bifidobacterium bifidum* in Cheddar cheese. J. Dairy Sci. 77:2854–2864.

Drake, M. A., T. D. Boylston, K. D. Spence, and B. G. Swanson. 1996. Chemical and sensory effects of a *Lactobacillus* adjunct in Cheddar cheese. Food Res. Int. 29:381–387.

El Soda, M., S. A. Madkor, and P. S. Tong. 2000. Adjunct cultures: Recent developments and potential significance to the cheese industry. J. Dairy Sci. 83:609–619.

Even, S., C. Garrigues, P. Loubiere, N. D. Lindley, and M. Cocaign-Bousquet. 1999. Pyruvate metabolism in *Lactococcus lactis* is dependent upon glyceraldehydes-3-phosphate dehydrogenase activity. Metab. Eng. 1:198–205.

Foegeding, E. A., J. Brown, M. Drake, and C. R. Daubert. 2003. Sensory and mechanical aspects of cheese texture. Int. Dairy J. 13:585–591.

Fox, P. F., and P. L. H. McSweeney. 1998. Dairy Chemistry and Biochemistry. Blackie Academic & Professional, London, UK.

Gobbetti, M., A. Corsetti, E. Smacchi, A. Zocchetti, and M. de Angelis. 1998. Production of Crescenza cheese by incorporation of bifidobacteria. J. Dairy Sci. 81:37–47.

Gomes da Cruz, A., F. C. A. Buriti, C. H. Batista de Souza, J. A. Fonseca Faria, and S. M. I. Saad. 2009. Probiotic cheese: Health benefits, technological and stability aspects. Trends Food Sci. Technol. 20:344–354.

Grattepanche, F., S. Miescher-Schwenninger, L. Meile, and C. Lacroix. 2008. Recent developments in cheese cultures with protective and probiotic functionalities. Dairy Sci. Technol. 88:421–444.

Gripon, J. C., M. J. Desmazeaud, D. Le Bars, and J. L. Bergere. 1975. Etude du rôle des micro-organismes et des enzymes au cours de la maturation des fromages. II.—Influence de la présure commercial. Lait 548:502–515.

Heller, K. J., W. Bockelmann, J. Schrezenmeir, and M. deVrese. 2003. Cheese and its potential as a probiotic food. Pages 203–225 in Handbook of Fermented Functional Foods. E. R. Farnworth, ed. CRC Press, Boca Raton, FL.

IDF (International Dairy Federation). 1986. Cheese and processed cheese products. Determination of dry matter. IDF Standard No. 4. FIL-IDF, Brussels, Belgium.

IDF (International Dairy Federation). 1988. Determination of dry salt content. IDF Standard No. 12B. FIL-IDF, Brussels, Belgium.

IDF (International Dairy Federation). 1989. Determination of pH. IDF Standard No. 115A. FIL-IDF, Brussels, Belgium.

ISO (International Organization for Standardization). 1988. Sensory analysis: General guidance for the design of test rooms. ISO 8589. ISO, Geneva, Switzerland.

Jellinek, G. 1985. Sensory Evaluation of Food. Ellis Horwood International Publisher in Science and Technology, Chichester, UK.

Karimi, R., A. M. Mortazavian, and A. Amiri-Rigi. 2012. Selective enumeration of probiotic microorganisms in cheese. Food Microbiol. 29:1–9.

Kindstedt, P. S. 2003. Pasta-filata cheeses. Pages 286–391 in Encyclopedia of Dairy Sciences. H. Roginski, J. W. Fuquay, and P. F. Fox, ed. MPG Books Ltd., Bodmin, Cornwall, UK.

Kindstedt, P. S., A. J. Hillier, and J. J. Mayes. 2010. Technology, biochemistry and functionality of pasta filata/pizza cheese. Chapter 9 in Technology of cheesemaking. B. A. Law and A. Y. Tamime, ed. Blackwell Publishing Ltd., Singapore.

Liggett, R. E., M. A. Drake, and J. F. Delwiche. 2008. Impact of flavor attributes on consumer liking of Swiss cheese. J. Dairy Sci. 91:466–476.

Lynch, C. M., D. D. Muir, J. M. Banks, P. L. H. McSweeney, and P. F. Fox. 1999. Influence of adjunct cultures of *Lactobacillus paracasei* ssp. *paracasei* or *Lactobacillus plantarum* on Cheddar cheese ripening. J. Dairy Sci. 82:1618–1628.

Meilgaard, M. C., C. E. Dalgleish, and J. F. Clapperton. 1979. Beer flavour terminology. J. Inst. Brew. 85:38–42.

Minervini, F., S. Siragusa, M. Faccia, F. Dal Bello, M. Gobbetti, and M. De Angelis. 2012. Manufacture of Fior di Latte cheese by incorporation of probiotic lactobacilli. J. Dairy Sci. 95:508–520.

Muir, D. D., E. A. Hunter, J. M. Banks, and D. S. Horne. 1995. Sensory properties of hard cheese: Identification of key attributes. Int. Dairy J. 5:157–177.

Muñoz, A. M., and G. V. Civille. 1998. Universal, product and attribute specific scaling and the development of common lexicons in descriptive analysis. J. Sens. Stud. 13:57–75.

Murray, J. M., and C. M. Delahunty. 2000. Mapping consumer preference for the sensory and packaging attributes of Cheddar cheese. Food Qual. Prefer. 11:419–435.

Murray, J. M., C. M. Delahunty, and I. A. Baxter. 2001. Descriptive sensory analysis: Past, present and future. Food Res. Int. 34:461–471.

Noble, A. C., R. A. Arnold, J. Buechsenstein, E. J. Leach, J. O. Schmidt, and P. M. Stern. 1987. Modification of a standardized system of wine aroma terminology. Am. J. Enol. Vitic. 38:143–146.

Ong, L., A. Henriksson, and N. P. Shah. 2007. Chemical analysis and sensory evaluation of Cheddar cheese produced with *Lactobacillus acidophilus*, *Lb. casei*, *Lb. paracasei* or *Bifidobacterium* sp. Int. Dairy J. 17:937–945.

Ong, L., and N. P. Shah. 2009. Probiotic Cheddar cheese: Influence of ripening temperatures on proteolysis and sensory characteristics of Cheddar cheeses. J. Food Sci. 74:S182–S191.

Rainey, B. A. 1986. Importance of reference standards in training panelists. J. Sens. Stud. 1:149–154.

Rankin, A., C. M. Chen, D. Sommer, D. Sommer, and A. Esposito. 2006. Mozzarella and Scamorza cheese. Chap. 150 in Handbook of Food Science, Technology, and Engineering. Vol. 4. Y. H. Hui, ed. CRC Press, Taylor & Francis Group, Boca Raton, FL.

Santillo, A., and M. Albenzio. 2008. Influence of lamb rennet paste containing probiotic on proteolysis and rheological properties of Pecorino cheese. J. Dairy Sci. 91:1733–1742.

SAS Institute. 2011. SAS/STAT User's Guide: Statistics. Version 9.2. SAS Inst. Inc., Cary, NC.

Shapiro, S. S., and M. Wilk. 1965. An analysis of variance test for normality. Biometrika 52:591–611.

Stadhouders, J. 1960. The hydrolysis of protein during ripening of Dutch cheese. The enzymes and bacteria involved. Neth. Milk Dairy J. 14:83–110.

Stone, H., and J. L. Sidel. 2004. Sensory Evaluation Practices. 3rd ed. Elsevier Academic Press, London, UK.

Urala, N., and L. Lähteenmäki. 2004. Attitudes behind consumers' willingness to use functional foods. Food Qual. Prefer. 15:793–803.

Vinderola, C. G., and J. A. Reinheimer. 1999. Culture media for the enumeration of *Bifidobacterium bifidum* and *Lactobacillus acidophilus* in the presence of yoghurt bacteria. Int. Dairy J. 9:497–505.

Wadhwani, R., and D. J. McMahon. 2012. Color of low-fat cheese influences flavor perception and consumer liking. J. Dairy Sci. 95:2336–2346.