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Improvement of the Sensory Characteristics of Goat Milk Yogurt

Diana De Santis , Giuseppina Giacinti, Giulia Chemello, and Maria Teresa Frangipane

Abstract: The sensory characteristics of goat yogurt could be greatly improved by integrating to a culture typical of yogurt starters, *Streptococcus thermophilus*, *Lactobacillus delbrueckii* spp. *bulgaricus*, with cultures of *Leuconostoc lactis*. The addition of *L. lactis* requires the use of the definition of “fermented milk” to the product, although it is prepared according to the same technology. The experimental plan has designed the use of inoculation with a bacterial concentration of at least 10^9 , for each microbial species considered, with the aim of increasing the probiotic effect of yogurt and fermented milk. Descriptive analysis of the samples was conducted using the profile sheet obtained applying the consensus profiling method (UNI EN ISO 13299:2010) by a trained panel. The acceptability of our products was evaluated by 62 consumers through 7-points hedonic scale. The results of this study indicated that the addition of *L. lactis* to the traditional yogurt starter produced a noticeable improvement to the sensory characteristics of fermented goat milk.

Keywords: goat milk, fermented milk, quality, sensory profile, yogurt

Practical Application: To improve the sensory characteristics of goat's yogurt to make it more acceptable to the consumer and increase market demand we tested the integration of *Leuconostoc lactis* to typical starter cultures. The experimentation carried out tested different combinations of fermenting microorganisms with the aim of developing a better flavor as compared to that of traditional yogurt, which is often unpleasant to consumers. The addition of *L. lactis* to the starter culture of the goat's milk results in less aggressive aromatic notes and greater appreciation as confirmed by consumers who tested the product.

Introduction

Yogurt is an important dairy product consumed worldwide and appreciated for its sensory characteristics, obtained by the proto-symbiotic fermentation of milk using a live and active cultures of *Lactobacillus delbrueckii* spp. *bulgaricus* and *Streptococcus thermophilus* (Aryana & Olson, 2017; Esmerino et al., 2017a,b). In recent years, the production of fermented milk (FM) and yogurt has increased significantly, reaching 35.5 million tons in 2015, with a growth of 20% over the previous 5 years (World Yogurt Market Report, 2016).

Yogurt is traditionally made with cow's milk. However, over the years, milk from other sources has been used to make yogurt. Goat's milk, is particularly suitable for the production of yogurt, due to its composition, as well as providing numerous health benefits (Verruk, Dantas, & Prudencio, 2019).

Indeed, many studies on the chemical composition of goat's milk have amply demonstrated its nutritional value higher than cow's milk (Costa et al., 2014, 2015). The increase in interest for dairy goat's milk products is due to the constant worldwide production of goat's milk, which reached almost 18 million tons in 2017, earning the third place as milk produced in the world, behind cow's milk and buffalo (FAO STAT, 2018; Pulina et al., 2018).

Therefore, fermented goat's milk products could represent a good opportunity to increase the supply of dairy products with greater nutritional value (Atamian, Olabi, Baghdadi, & Toufeili, 2014; Eissa, Mohamed Ahmed, Yagoub, & Babiker, 2010; Eissa, Babiker, & Yagoub, 2011; Ribeiro & Ribeiro, 2010).

Furthermore, the goat milk is also an excellent substrate for the growth of probiotic cultures (Mituniewicz-Malek, Zielińska, & Ziarno, 2019), defined as “live microorganisms which, when administered in adequate quantities, confer a benefit to the health on the host” (Hill et al., 2014) and offers the advantage of a great digestibility and tolerance (Champagne, Cruz, & Daga, 2018; Verruck, Dantas, & Prudencio, 2019).

However, consumer acceptance of goat yogurt is low due to its “goaty” flavor (Uysal-Pala, Karagul-Yuceer, Pala, & Savas, 2006) resulting from high levels of caproic, caprylic, and capric fatty acids compared to other ruminant species (Costa, Beltrão Filho, De Sousa, Cruz, & Queiroga, 2016; Gamage et al., 2016; Kesenkaş, Karagözlü, Yerlikaya, Özer, Akpınar, & Akbulut, 2017).

Considering the importance of sensory perception and prospects for inclusion in the market, our work was developed with the goal of improving the characteristics of fermented goat's milk, by testing the addition of *Leuconostoc lactis* to traditional culture starter.

The *Leuconostoc* strains, in fact, can influence the characteristics of dairy products, for the many actions carried out, as shown by several researchers in their studies.

Nieto-Arribas, Seseña, Poveda, Palop, and Cabezas (2010), in agreement with other authors (Buffa, Morais, Jimenez-Belenguer, Hemández-Giménez, & Guamis, 2005; Perez, Cardarell, & Zarate, 2002), verified that no lipolytic activity was present on the 23 *Leuconostoc* strains, isolated from Manchego cheese.

JFDS-2018-2070 Submitted 11/13/2018, Accepted 5/17/2019. Authors De Santis, Chemello, and Frangipane are with DIBAF, Department for Innovation in Biological, Agro-Food and Forest Systems, University of Tuscia, Viterbo, Italy. Author Giacinti is with National Reference Centre for Ovine and Caprine Milk and Dairy Products Quality (CRELDOC), Istituto Zooprofilattico Sperimentale del Lazio e della Toscana, “M. Aleandri” Via Appia Nuova 1411, 00178, Rome, Italy. Direct inquiries to author De Santis (E-mail: desdiana@unitus.it).

This feature is an undeniable advantage in the aromatic development of dairy products, and goat product in particular, as it reduces the free fatty acids that can favor the appearance of an unpleasant rancid flavor.

In addition, some studies (Hemme & Foucaud-Scheunemann, 2004; Vedamuthu, 1994) have shown that *Leuconostoc* isolated from goat's milk, was able to produce dextrans that increase the viscosity and improve the consistency of soft cream products.

The advantageous result of the presence of dextrans and other exopolysaccharides, in the production of FM, has long been recognized (de Vuyst & Degeest, 1999; Duboc & Mollet, 2001), since they stabilize the casein network favoring the bond with water and reducing syneresis.

Furthermore, as evidenced by several researchers (Franciosi, Settanni, Cavazza, & Poznanski, 2009; Garibal, Rodriguez-Alonso, & Centeno, 2008; Nieto-Arribas et al., 2010), the genus *Leuconostoc* is able to positively influence the aroma of FM, producing pleasant aromas of butter and yogurt, only in mixed cultures.

In fact, the pure cultures of *Leuconostoc* spp. do not produce diacetyl from the metabolism of citrate, but pyruvate is converted into lactate and acetyl phosphate (via acetylCoa). Instead, in mixed cultures, *Leuconostoc* is able to produce diacetyl and acetoin, since the optimum pH for this reaction is reached (Cogan, 1985; Cogan & Hill, 1993; Fox, Lucey, & Cogan, 1990; Hugenholtz, 1993; Mcsweeney & Sousa, 2000).

Based on these findings, we tested the suitability of adding *L. lactis*, to conventional microbial cultures of goat yogurt (*Bifidobacterium animalis* sup. *lactis* BB-12 and *Lactobacillus acidophilus* LA-5), to improve the flavor of goat milk yogurt, in order to make it more attractive to consumers.

It is supposed that our goal can be achieved because, the "goaty" character, could be attenuated by at least three related *Leuconostoc* actions, such as the reduction of free fatty acids (lower lipolysis), the formation of pleasant aromatic notes of butter (diacetyl production) and an improved palatability due to the creamy consistency (dextrans synthesis).

Chemical composition, microbiological, and sensory properties of fermented goat milk and yogurt produced in this study were analyzed.

Materials and Methods

Starter cultures

All the microorganisms used for experimentation came from the collection of the National Reference Center for Ovine and Caprine Milk and Dairy Products Quality (CRELDOC), Rome, Italy. *S. thermophilus* (LAB 42 strain) and *L. delbrueckii* spp. *Bulgarius* (LAB 43 strain) were isolated from goat's milk yogurt and *L. lactis* from raw buffalo milk. Starter cultures were prepared from cryopreserved strains through the revitalization of broth culture, MRS broth (de Mann, Rogasa and Shape-Oxoid) for *L. delbrueckii* and BHI broth (Brain Heart Infusion Broth-Oxoid) for *S. thermophilus* and *L. lactis*. All bacteria has been incubated under aerobic conditions except *L. delbrueckii*, which was incubated in anaerobic jars (Anaero Gen TM, Oxoid) at 37 °C for 48 hr. Revitalized strains were isolated on MRS agar for *L. delbrueckii* and M17 agar (Oxoid) for *S. thermophilus* and *L. lactis* MRS agar have been incubated at 37 °C for 72 hours and M17 at 37 °C for 48 hr.

Yogurt (Y) and FM preparation

To standardize the production of yogurt and fermented milk, using a raw material with homogeneous composition and sensory

characteristics, it decided to work with UHT caprine milk from the same production lot. For each microbial species considered, a solution with a bacterial concentration of about 10⁹ cfu/mL was prepared.

S. thermophilus and *L. delbrueckii* spp. *bulgarius* in a 1:1 ratio used for yogurt while for FM was added also *L. lactis* in a 1:1 ratio.

Flasks containing 100 mL of milk heated to 40 °C were inoculated with the cultures at a concentration of 20 mL/L and 30 mL/L for yogurt and FM respectively defined according to previous testing to ensure a final count minimum of about 6 log CFU/mL, and finally were incubated at 41.5 ± 1 °C in a controlled temperature thermostat.

The coagulation of milk was monitored for pH during the incubation period until a pH of 4.50 ± 0.05 (pH end). When the pH end was achieved, the yogurt and the FM were immediately cooled at 4 ± 1 °C and stored at the same temperature for 28 days.

Physicochemical, microbiological, and sensory analyses were conducted on milk and on milk products after 24 hr from production and after 7, 14, 21, and 28 days of conservation. Analyses physicochemical and microbiological were performed in triplicate.

Physicochemical analysis

Yogurt and FM were evaluated for fat, protein, total solids, and humidity by: FoodScan (Foss-Electric PD, Italy), according to ISO 21543/IDF 201:2006 (Milk products—Guidelines for the application of near infrared spectrometry), while the lactose content was determined by MilkoScan (FT 6000 Foss-Electric PD, Italy).

The pH was determined using a pH meter (Mettler Delta 345) with a standardized glass electrode in the range 7.0 to 4.0. Four consecutive measurements were made on dairy products at a temperature of 21 ± 1 °C.

Microbiological analysis

The enumeration of *S. thermophiles*, *L. lactis*, and *L. delbrueckii* were determined by the same conditions as described above. Yeast and mold enumeration was carried out on YEDCA agar plates, incubated at 25 °C for 5 days while contaminating microorganisms were determined by spread plate techniques on Blood Agar and incubated at 37 °C for 24 hr.

Sensory analysis

The purpose of sensory analysis was to define the sensory profile of the yogurt and the FM using a descriptive test.

Sensory profile: The analyses were carried out in the sensory laboratory at Tuscia University, equipped according to the specifications reported in UNI ISO 8589: 2007. The panel comprised of 10 expert sensory assessors (UNI EN ISO 8586-2: 2008) (eight women and two men, aged 25–57 years), by staff and students of the Tuscia University, with particular experience in sensory profile development. They were asked to evaluate eight goat yogurt products commercially available to identify sensory attributes related to appearance, taste, flavor, and texture.

Development of the descriptor set: four open roundtable tasting sessions were conducted to specifically develop a list of detailed terms to evaluate the sensory characteristics of goat yogurt and FM (UNI EN ISO 13299: 2010), 36 descriptors were identified by the panel. A first skimming eliminated the repetitive and redundant terms and led to the selection of 28 attributes (Table 1). In order to reduce the number of descriptors and determine the most significant of these, judges were asked to assess the intensity of perception for each identified descriptor, measured on a scale from 0 to 7, (0 = absence of perception; 7 = very strong perception).

Table 1—Weight percentage of the attributes selected by panel.

	Attributes	Weight%
1	Creamy	38.54
2	Filante	23.40
3	Gluey	28.11
4	Sour	59.87
5	Salty	45.44
6	Sweet	35.92
7	Bitter	3.30
8	Umami	12.65
9	Mineral	27.04
10	Lemon	36.99
11	Lactic	38.64
12	Cooked milk	35.25
13	Stable	8.28
14	Goaty	36.48
15	Wool	5.54
16	Animal	6.64
17	Buttery	35.08
18	Cookies	19.57
19	Floury	16.63
20	Vinegar	9.53
21	Rancid butter	35.62
22	Yeast	9.85
24	Astringency	45.16
25	Density	27.21
26	Fat	35.37
27	Viscosity	39.57
28	Cohesion	28.50

The weight percentage of each descriptor was measured using the geometric mean (M) which is the square root of the product of the frequency (F) of the citations and the relative intensity (I) for each attribute (ISO 11035: 1994). Of the descriptors identified, only those with a weight percentage above 35% were selected.

In this way, the results of the definitive list consisted of 13 sensory attributes, as highlighted in bold in Table 1.

Panel training

In order to confirm the sensory attributes identified by the judges, the most appropriate reference standards were selected for each of them (Table 2). The search for reference standards required two 1-hour sessions. For a reliable evaluation, at least two points of the scale were anchored to the reference material during the panel training. Each descriptor was measured using a discrete reference scale from 0 (no perception) to 7 (high perception). The panel training with the described standards on the same yogurt used to develop the descriptor set took three 1-hour sessions.

Table 2—Sensory attributes definition and reference standards used for goat yogurt and fermented milk adapted by ISO 22935-1 (2009).

Attribute	Definition	Reference
Creamy	Thick and smooth, like cream	Whipping cream
Sour	Gustatory complex sensation, generally due to the presence of organic acids. Fermented milk	0.35 g and 0.83 g lactic acid/L
Salty	Fundamental taste sensation of which NaCl is typical	0.25 and 0.60 g NaCl/100 g
Sweet	Fundamental taste sensation of which sucrose is typical	0.5% and 2% sucrose in water
Citrusy (lemon type)	The sour, sweet, floral aromatics associated with lemon	Real lemon juice
Lactic	Cow milk flavor	Full fat milk
Cooked milk	Boiled milk flavor	Milk eat to 85 °C for 45 min
Goaty	Goat fresh cheese flavor	Goat fresh cheese
Buttery/Fat	Butter flavor/Greasy film in the mouth after swallowing	Butter
Rancid butter	Rancid butter flavor	Oxidized butter
Astringency	Rough sensation on the tongue's surface	0.1% Tannic acid powder in water
Viscosity	Rated at which sample flows on the tongue	Creamy yogurt

Descriptive analysis

The samples for each sensory test were taken simultaneously from separate production lines to have a direct comparison between the two production lines and five retention times (0, 7, 14, 21, and 28 days).

An aliquot (30 mL) of each sample was put into odorless disposable shorts (50 mL) of polystyrene, coded with a random three-digit number and immediately covered with a plastic cover. The samples were given to the judges immediately, in the sensory lab booths, with tasteless and odorless bottled spring water to rinse the mouth between samples, and the profile card tests were conducted in duplicate on the samples presented in a complete random block design.

Judges received the 10 samples in pairs of two (yogurt and FM) for five different storage times, and evaluating the intensity of each attribute recognized in the samples.

The panelist was asked to take a 15-min break after completing five pairs of samples, and the next five pairs were presented after the break. The panelist took approximately 10 mL of each sample at a time and assessed the intensity of sensory attributes using a 7-point scale. First, the overall appearance was evaluated. Second, taste and smell descriptors were evaluated. Finally, tactile sensation descriptors in the mouth were evaluated. The whole test was replicated after 2 days.

Consumer test

Sensory acceptance tests were developed utilizing the hedonic scale, with 62 volunteer untrained adult tasters of both genders, aged between 20 and 60 years, possessing educational levels from undergraduate to graduate, and being accustomed to the frequent consumption of yogurt based on cow's milk, recruited from students, administration staff and professors of the Tuscia University, Viterbo, Italy. Before the experiments began, participants were provided with information on hygiene and safety of goat yogurt and FM samples offered to them and then were given oral instructions on how to conduct the experiment.

The tests were conducted in individual booths, where consumers received an evaluation sheet to evaluate the products, using a balanced 7-point hedonistic verbal scale ranging from 1 (dislike extremely) to 7 (liked extremely), suitable to consumers involved in the preference test on our products (Cardello, 2017; Karagül-Yüceer & Drake, 2013; Lim, 2011; Masamba & Ali, 2013; Suriasih, Hartawan, Sucipta, Lindawati, & Okarini, 2014).

Note that 30 mL of each sample encoded with a three-digit number were randomly distributed to the judges in a 50 mL

Table 3—Sensory profile card used to define the sensory profile of the yogurt and the fermented milk.

Sample	Name	Data
Descriptors of appearance		Score from 0 to 7
Creamy	Dense egg cream (7)	
Descriptors of flavor		
Sour		
Salty		
Sweet		
Fermented milk		
Citrusy (lemon type)		
Lactic (pasteurized milk)		
Goaty		
Buttery		
Rancid butter		
Descriptors of body and texture		
Astringency	Rough sensation on the tongue's surface	
Fat	Greasy film in the mouth after swallowing	
Viscosity	Sliding resistance during the suction	

disposable cup. Consumers have evaluated the samples in pairs (yogurt and FM at each time of storage) presented simultaneously.


It was also given bottled water odorless and tasteless to cleanse the palate between samples.

Statistical analysis

The results of the analysis performed triplicate on all samples were averaged and the standard deviation calculated.

One-way analysis of variance (ANOVA) was carried out on sensory data in order to find significant difference among samples. When differences were observed at a significance level of $P < 0.05$, a multiple comparison of means was performed using the Fisher's least significant difference (LSD).

To highlight the relationships between all the attributes and the samples of our study, a principal components analysis (PCA) was conducted using the matrix with 10 lines, linked to samples and 8 columns associated with statistically significant attributes ($P < 0.05$).

The PCA was performed using Unscrambler® v.9.7 (Camo Software A 

Results and Discussion

Physical-chemical analyses

The starting milk used for testing displayed the following contents: fat 3.74%, protein 3.47%, lactose 3.92%, pH 6.91. Results concerning the physicochemical characteristics after fermentation and during refrigerated storage of yogurt and FM are summarized in Table 4. Overall, the mean values of lactose, proteins, and pH were statistically different ($P < 0.05$) in two products, while no difference was observed for fat, total solid and humidity. Compared to the initial content, the lactose reduced ($P < 0.05$) during

Table 4—Mean value (\pm SE) of composition (%) and pH during storage of yogurt (Y) and fermented milk (FM) at 4 °C.

Storage time, d	Total solid		Humidity		Fat	
	Y	FM	Y	FM	Y	FM
0 (24 hours)	11.29 \pm 0.06 ^{Aa}	11.27 \pm 0.11 ^{Aa}	88.71 \pm 0.06 ^{Aa}	88.73 \pm 0.11 ^{Aa}	3.59 \pm 0.06 ^{Aa}	3.62 \pm 0.01 ^{Aa}
7	11.37 \pm 0.13 ^{Aa}	11.39 \pm 0.13 ^{Aa}	88.63 \pm 0.13 ^{Aa}	88.61 \pm 0.13 ^{Aa}	3.78 \pm 0.16 ^{Aa}	3.70 \pm 0.15 ^{Aa}
14	11.46 \pm 0.03 ^{Aa}	11.26 \pm 0.10 ^{Aa}	88.54 \pm 0.03 ^{Aa}	88.74 \pm 0.10 ^{Aa}	3.70 \pm 0.14 ^{Aa}	3.65 \pm 0.14 ^{Aa}
21	11.58 \pm 0.09 ^{Aa}	11.26 \pm 0.07 ^{Ab}	88.42 \pm 0.09 ^{Aa}	88.74 \pm 0.07 ^{Ab}	3.59 \pm 0.18 ^{Aa}	3.62 \pm 0.15 ^{Aa}
28	11.41 \pm 0.15 ^{Aa}	11.40 \pm 0.08 ^{Aa}	88.59 \pm 0.15 ^{Aa}	88.60 \pm 0.08 ^{Aa}	3.60 \pm 0.10 ^{Aa}	3.61 \pm 0.11 ^{Aa}
Mean value	11.42 \pm 0.05 ^a	11.34 \pm 0.03 ^a	88.58 \pm 0.05 ^a	88.68 \pm 0.03 ^a	3.65 \pm 0.04 ^a	3.64 \pm 0.02 ^a
Storage time, days	Proteins		Lactose		pH	
	Y	FM	Y	FM	Y	FM
0 (24 hours)	3.80 \pm 0.11 ^{Aa}	2.56 \pm 0.11 ^{Aa}	2.56 \pm 0.11 ^{Aa}	7.65 \pm 0.12 ^{Aa}	4.35 \pm 0.11 ^{Aa}	4.52 \pm 0.06 ^{Ab}
7	3.76 \pm 0.06 ^{Aa}	2.53 \pm 0.24 ^{Aa}	2.53 \pm 0.24 ^{Aa}	7.69 \pm 0.05 ^{Aa}	4.31 \pm 0.07 ^{Aa}	4.46 \pm 0.07 ^{Aa}
14	3.72 \pm 0.08 ^{Aa}	2.49 \pm 0.18 ^{Aa}	2.49 \pm 0.18 ^{Aa}	7.61 \pm 0.03 ^{Aa}	4.33 \pm 0.08 ^{Aa}	4.43 \pm 0.04 ^{Aa}
21	3.74 \pm 0.10 ^{Aa}	2.51 \pm 0.23 ^{Aa}	2.51 \pm 0.23 ^{Aa}	7.64 \pm 0.22 ^{Ab}	4.34 \pm 0.06 ^{Aa}	4.47 \pm 0.04 ^{Aa}
28	3.65 \pm 0.06 ^{Aa}	2.50 \pm 0.24 ^{Aa}	2.50 \pm 0.24 ^{Aa}	7.79 \pm 0.07 ^{Aa}	4.33 \pm 0.10 ^{Aa}	4.49 \pm 0.08 ^{Aa}
Mean value	3.73 \pm 0.02 ^a	2.51 \pm 0.01 ^a	2.51 \pm 0.01 ^a	7.67 \pm 0.03 ^a	4.33 \pm 0.01 ^a	4.47 \pm 0.01 ^b

^AMeans in column with the same letters are not significantly different from each other at $P < 0.05$.

^{a,b}Means in row with the same letters are not significantly different from each other at $P < 0.05$.

Table 5—Mean value (\pm SE) of lactic bacteria viable count (\log_{10} CFU/g) grown in M17 Agar (*S. thermophilus*, *L. lactis*) and MRS agar (*L. delbrueckii* spp. *bulgaricus*), during storage of yogurt (Y) and fermented milk (FM) at 4 °C.

Storage time, days	M17		MRS		M17 + MRS	
	Y	FM	Y	FM	Y	FM
0	6.84 \pm 0.56 ^{Aa}	8.43 \pm 0.43 ^{Ab}	8.22 \pm 0.31 ^{Aa}	8.29 \pm 0.31 ^{Aa}	8.35 \pm 0.22 ^{Aa}	8.68 \pm 0.37 ^{Aa}
7	6.49 \pm 0.61 ^{Aa}	8.44 \pm 0.30 ^{Ab}	8.05 \pm 0.46 ^{Aa}	7.80 \pm 0.48 ^{Aa}	8.27 \pm 0.25 ^{Aa}	8.54 \pm 0.33 ^{Aa}
14	6.58 \pm 0.57 ^{Aa}	8.29 \pm 0.57 ^{Ab}	7.61 \pm 0.48 ^{Aa}	7.53 \pm 0.78 ^{Aa}	7.92 \pm 0.28 ^{Aa}	8.38 \pm 0.60 ^{Ab}
21	6.38 \pm 0.62 ^{Aa}	8.22 \pm 0.55 ^{Ab}	7.90 \pm 0.62 ^{Aa}	7.44 \pm 0.64 ^{Aa}	8.24 \pm 0.28 ^{Aa}	8.32 \pm 0.56 ^{Aa}
28	6.23 \pm 0.71 ^{Aa}	8.58 \pm 0.49 ^{Ab}	7.37 \pm 0.84 ^{Aa}	7.53 \pm 0.62 ^{Aa}	7.95 \pm 0.37 ^{Aa}	8.63 \pm 0.50 ^{Ab}

^AMeans in column with the same letters are not significantly different from each other at $P < 0.05$.

^{a,b}Means in row with the same letters are not significantly different from each other at $P < 0.05$.

the fermentation process by approximately 35% in yogurt and 26% in the FM; In addition, there was a further reduction of 1.52% and 0.25% during storage for the yogurt and fermented milk, respectively. The FM showed greater lactose content than the yogurt, as a function of time (Table 4) showing significant differences between the two products ($P < 0.05$) to 14 and 28 days of storage. These differences may be attributable to the fermenting bacteria used, as previously reported (Kneifel, Jaros, & Erhard, 1993).

Protein content increased more yogurt than the FM (3.73% compared with 3.63%). This finding may be due to the higher amount of inoculum in FM causing a higher dilution in preparation, therefore reducing the total protein amount.

The pH values in FM was on average higher than yogurt, showing a significant difference ($P < 0.05$) at time 0. This could be explained by the fact that the acid pH stimulates the metabolism of the citrate in *L. lactis* with the production of acetaldehyde, diacetyl, and acetoin (Starrenburg & Hugenholtz, 1991), leading to medium deacidification that partly counteracts the increase in acid production (Hache et al., 1999) in the FM.

Microbiological analyses

In the yogurt and FM prepared in this study, no yeast, mold, or contaminating bacteria were detected in any of the samples.

The results of the viable counts of the starter bacteria inoculated in yogurt (*S. thermophilus* and *L. delbrueckii* spp. *bulgaricus*) and in FM (*S. thermophilus*, *L. delbrueckii* spp. *Bulgaricus*, and *L. lactis*) during refrigerated storage are presented in Table 5. As shown, the maximum viable counts of the bacterial cultures were observed at 24 hours, except for the counts in M17 for FM at 28 days where the higher value was found. The addition of *L. lactis* did not have a negative effect on the counts of *S. thermophilus* and *L. delbrueckii* spp. *bulgaricus* in FM, suggesting that the activities of *L. lactis* did not interfere with those of the lactic starters. Even though during storage there were no significant changes in the counts in all the samples, in FM the viable counts were subject to less variability than yogurt. This could be due to the best resistance of *L. lactis* to an acid pH (Cogan, 1985; Moon et al., 2015). In addition, some authors (Moon et al., 2015) found in *L. lactis* promising probiotic attributes, like resistance against acid bile salts, absence of transferable genes for antibiotic resistance, broad utilization of prebiotics.

Descriptive analysis

The geometric means, in accordance with ISO 11035: 1994, allowed the selection of the descriptors that represent the sensory profile of the two products. Table 1 illustrates the list of descriptors with an M value that exceeded the defined threshold, used for the profile sheet.

In a recent article (Megale mou et al., 2017) that compared yogurt derived from different types of milk, the sample of goat yogurt was significantly higher for the attribute of "sour" for taste, the attributes of "persistent," "intense," and "goaty" for the aftertaste and the attributes of "velvety," "smooth," and "fluid" for the texture.

This confirms what detected through the descriptive analysis carried out in our study, for which, the strong "caprine" feature of goat yogurt (Y), is well characterized and different from the FM, by the selected descriptors (Table 6) of the sensory profile.

The selected attributes, significantly discriminating for the samples, were one for appearance (creamy), three for taste (sour, salty, and sweet), three for flavor (goaty, butter, and rancid butter) and one for texture (viscosity). Furthermore, the data show that the

Table 6—Changes in sensorial attributes of goat yogurt and fermented milk during storage.

Parameter	Storage period, days													
	0			7			14			21			28	
	Y0	FM0	Y7	FM7	Y14	FM14	Y21	FM21	Y28	FM28				
Creamy	1.80 ± 0.25 ^a	2.00 ± 0.19 ^a	1.00 ± 0.30 ^a	1.83 ± 0.18 ^b	0.80 ± 0.28 ^a	1.40 ± 0.30 ^b	0.20 ± 0.02 ^a	1.20 ± 0.27 ^b	0.20 ± 0.03 ^a	1.20 ± 0.28 ^b				
Sour	3.33 ± 0.38 ^a	2.33 ± 0.28 ^b	4.20 ± 0.32 ^a	2.20 ± 0.41 ^b	3.80 ± 0.11 ^a	2.20 ± 0.09 ^b	3.80 ± 0.34 ^a	2.20 ± 0.18 ^b	4.00 ± 0.42 ^a	1.60 ± 0.30 ^b				
Salty	3.17 ± 0.20 ^a	1.67 ± 0.22 ^b	2.60 ± 0.31 ^a	0.80 ± 0.51 ^b	2.60 ± 0.24 ^a	1.20 ± 0.32 ^b	2.40 ± 0.18 ^a	0.80 ± 0.09 ^b	2.60 ± 0.33 ^a	0.80 ± 0.25 ^b				
Sweet	0.83 ± 0.09 ^a	1.70 ± 0.30 ^b	1.20 ± 0.15 ^a	1.80 ± 0.22 ^b	0.67 ± 0.11 ^a	1.50 ± 0.28 ^b	1.00 ± 0.11 ^a	1.80 ± 0.22 ^b	1.00 ± 0.09 ^a	1.80 ± 0.10 ^b				
Goaty	3.40 ± 0.18 ^a	1.60 ± 0.28 ^b	3.00 ± 0.30 ^a	1.17 ± 0.38 ^b	1.80 ± 0.41 ^a	1.00 ± 0.35 ^b	1.40 ± 0.22 ^a	1.40 ± 0.29 ^b	1.40 ± 0.50 ^a	0.00 ± 0.00 ^b				
Butter	0.33 ± 0.09 ^a	1.50 ± 0.18 ^b	0.60 ± 0.08 ^a	1.80 ± 0.18 ^b	0.80 ± 0.09 ^a	1.60 ± 0.15 ^b	0.60 ± 0.04 ^a	1.40 ± 0.31 ^b	0.80 ± 0.09 ^a	1.60 ± 0.30 ^b				
Rancid butter	0.83 ± 0.18 ^a	0.50 ± 0.08 ^a	1.60 ± 0.08 ^a	0.20 ± 0.08 ^b	1.60 ± 0.30 ^a	0.20 ± 0.05 ^b	1.20 ± 0.30 ^a	0.20 ± 0.08 ^b	1.20 ± 0.20 ^a	0.20 ± 0.02 ^b				
Viscosity	0.83 ± 0.15 ^a	1.00 ± 0.30 ^a	1.00 ± 0.15 ^a	1.60 ± 0.16 ^b	1.00 ± 0.27 ^a	1.60 ± 0.33 ^a	1.10 ± 0.16 ^a	1.50 ± 0.12 ^b	1.20 ± 0.09 ^a	1.60 ± 0.12 ^b				

Value are means of three independent determinations. Mean values having different superscript letters in a row are significantly different in pairs (Y/FM) ($P \leq 0.05$).

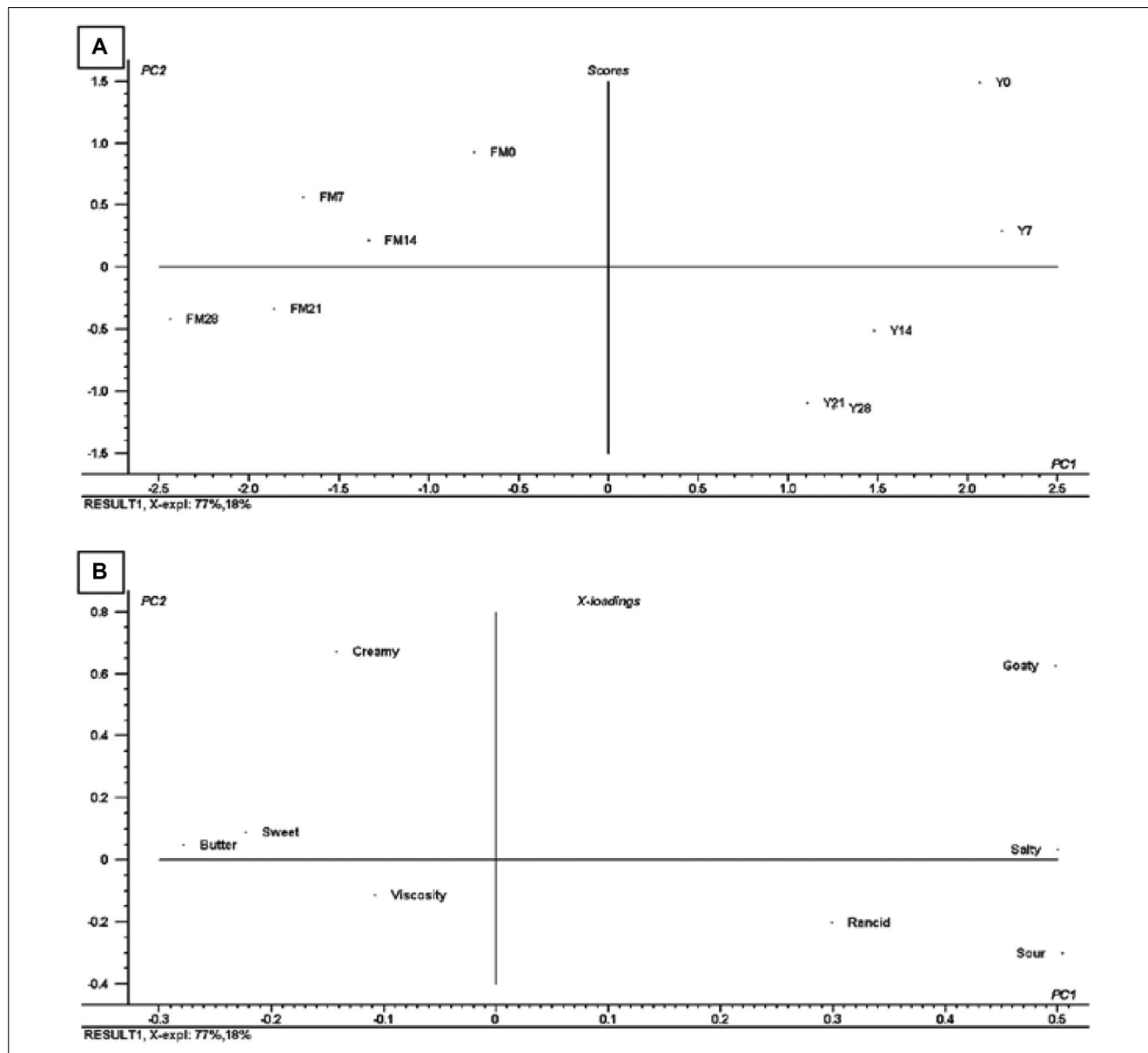


Figure 1—Score (A) and loading (B) plots of the PC analysis.

sample of goat yogurt (Y) is characterized by higher acidity, salinity and goaty aroma, while the FM sample is more creamy, sweeter, more buttery and has a lower intensity for all aggressive features linked to goat's milk (sour, salty, goaty).

The opposite result was observed by Pimentel, Cruz, and Prudencio (2013), for whom the addition of probiotics (*Lactobacillus paracasei* ssp. *Paracasei*) did not change the sensory profile of low-fat yoghurt from cow's milk. This result suggests the possibility of attributing sensory changes, perceived in FM compared to Y, to the specific probiotic strain used or to goat milk. Both hypotheses could be further examined.

Recently, many researchers have focused their attention on the possibility of incorporating fruit juices and pulp or other natural sweeteners such as honey with goat yogurt to improve taste (Machado et al., 2017; Ranadheera, Evans, Adams, & Baines, 2012; Silva et al., 2017). In fact, the sweet taste mitigates the goat flavor that makes these products not always particularly pleasing to the customer. The addition of components extraneous to the

product, made these formulations susceptible to interfere with the fermentative activity.

Our proposal, to add the *L. lactis* to the goat yogurt starter culture, enhance the product's acceptability, without the use of other ingredients and does not interfere with the fermentation process.

Consumer test

The results of the preference tests clearly showed that FM always obtained the highest score compared to conventional yogurt (Y), as shown in Table 7.

If to consider an acceptable product, the average value of the preference, must be at least 70% of the maximum value of the hedonistic scale used in the tests (Gularte, 2002), then, for our products, the threshold had to be about 5.

The Table 7 shows that the FM sample scored an average value equal to 5.72 ± 0.19 , higher than the threshold of acceptability.

Table 7—Mean acceptability values preference test of goat's yogurt (Y) and fermented milk (FM) samples.

	Y	FM
0	3.85 ± 0.80 ^a	5.62 ± 0.65 ^b
7	3.84 ± 0.62 ^a	5.52 ± 0.48 ^b
14	4.02 ± 0.58 ^a	5.74 ± 0.66 ^b
21	4.73 ± 0.45 ^a	5.72 ± 0.51 ^b
28	4.71 ± 0.72 ^a	6.00 ± 0.53 ^b
Mean	4.23 ^a	5.72 ^b

Values are means of 62 determinations. Means values having different superscript letters in a row are significantly different ($P \leq 0.005$).

Table 8—Factor loadings for each principal components and communalities.

	PC 1 (77%)	PC 2 (18%)	Communalities
Creamy	-0.143	0.672	0.472
Sour	0.504	-0.302	0.345
Salty	0.500	0.034	0.251
Sweet	-0.223	0.089	0.058
Goaty	0.498	0.627	0.641
Butter	-0.279	0.049	0.080
Rancid	0.299	-0.202	0.130
Viscosity	-0.108	-0.113	0.024
Eigenvalue	2.31957	0.53205	

The preference scores at all storage times for goat yogurt are significantly lower ($P < 0.005$) than those of fermented goat milk studied in our work.

These results suggest that the addition of the *L. lactis* to traditional initial culture had a positive impact on the acceptability of the FM compared to traditional goat yogurt (Y) and confirms that the differences found by the group of experts are indeed perceived by consumers.

Our proposal, validated by this result, could probably represent a possible solution to increase the consumption of goat's milk products.

Principal component analysis

The PCA is the most widely used technique to display concealed relevant information in a data matrix, and this approach allows you to evaluate the clustering of samples in the class who seem to have the greatest similarity (Granato et al., 2018a).

According to the Kaiser criterion (Kaiser, 1960) reported by Granato, Santos, Escher, Ferreira, and Maggio (2018b), the optimal number of PCs is defined by the sum of the eigenvalues higher than 1, therefore we considered the first two PCs, which explained about 95% of the total variance, assuring a good discrimination of the samples.

Table 8 shows that the two PCs accounted for 77% and 18% of the variance, respectively.

The score plot (Figure 1A) showed good separation between samples, depending on the different type of inoculum (FM and Y) and the storage time.

In addition, the loading plot (Figure 1B) indicated the main sensory attributes responsible in the discrimination between the FM and Y samples.

As shown in Table 8, the PC1 explained 77% of the variance and differentiated the samples according to the values of sour, salty, and goaty, resulting mainly linked to the fermentation process (Y and FM).

Instead, the PC2 clarified a further 18% of the variation of the data and distributed the samples according to the values of

creaminess and goaty, relative to the storage time, which clearly mitigated these aspects in the samples.

It is interesting to note that based on the distribution of samples, according to the PCA, the attributes that justify the good acceptability of the FM samples by the consumer, in the hedonic test, are presumably four: creamy, salty, goaty, and sour, according to the Communalities (CM) values reported in the Table 8.

Conclusions

In order to encourage the consumption of dairy products from goat's milk, various proposals have been made to improve the sensory qualities (flavor and texture feel) characterized by a strong unpleasant goaty flavor. The most promising results seem to be related to the addition of probiotic strains to the traditional starter yogurt culture. As highlighted by Mituniewicz-Malek et al. (2019), the selection of the strain is fundamental for the improvement of the sensory features of the final product.

Furthermore various authors (Benyoucef et al., 2017; Ranadheera, Naumovski, & Ajlouni, 2018), have revealed that the composition of goat's milk is particularly suitable for the development and long-term survival of the probiotic flora. This property has allowed the addition of *L. lactis* to traditional microbial yogurt starter culture, greatly improving the sensory characteristics of the product. The objective achieved with the addition of *Leuconostoc* is linked to the metabolism of this microorganism which, as previously explained, can modify the sensory profile of dairy products. The low lipolytic activity, the production of dextran and diacetyl, under specific operating conditions, allow *Leuconostoc* to significantly mitigate the unpleasant characteristics of goaty in goat's milk yogurt.

The use of natural culture microorganisms enhances the aromatic characteristics of the goat's FM, without adding sweeteners or other ingredients, which might create interference with fermentation activity.

The diminution of the less pleasant sensory attributes, such as sour, salty and the feeling of goat, combined with an increase in positive attributes such as sweetness and creaminess enhanced the sensory profile of fermented goat's milk, increasing its acceptability.

This improvement can help to stimulate the consumption of products made from goat milk with a consequent positive effect on health.

Author Contributions

D. De Santis conceived the presented idea, developed the sensory analysis, supervised the findings of this work, and the writing of the manuscript. G. Giacinti and G. Chemello performed the microbiological analysis. M.T. Frangipane contributed to the implementation of the research and to the analysis of the results. All authors discussed the results and contributed to the final manuscript.

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