Short communication: Sensory profile and acceptability of a cow milk cheese manufactured by adding jenny milk

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ABSTRACT

The addition of jenny milk during cheesemaking has been recommended as a viable alternative to egg lysozyme for controlling late blowing defects. However, little is known on the sensory properties of the cheeses made with jenny milk. In this study, the effect of the addition of jenny milk during cheesemaking on sensory properties and consumer acceptability of cheese was evaluated. A sensory profile was carried out by 10 trained panelists on 4 cow milk cheese types. Two types of cheeses were made by adding jenny milk to cow milk during cheesemaking; the cheeses were then left to ripen for 45 and 120 d. The remaining 2 cheese types were made with only cow milk and were also left to ripen for 45 and 120 d. The attributes generated by a quantitative descriptive analysis sensory panel were effective for discriminating the 4 products. Among them, added jenny milk samples aged for 45 d had the highest intensity of some appearance descriptors (structure and color uniformity), as well as the highest intensity of sweetness. The analysis of acceptability data obtained from 89 consumers showed that added jenny milk aged for 45 d was the most preferred type of cheese, whereas no significant differences were found among the other products, which had higher intensity of bitter, salty, acid milk, and so on.
Key words: sensory analysis, consumer acceptability, jenny milk, cheese

Short Communication

In recent decades there has been a renewed interest and research in jenny milk (Guo et al., 2007; Cosentino et al., 2012, 2013, 2015; Fantuz et al., 2012; Martemucci and D'Alessandro, 2012). This interest is first motivated by the chemical composition and nutrient contents of jenny milk, which have made it very similar to human milk (Guo et al., 2007). Besides, jenny milk

is considered as a good replacer for cow milk in feeding children with severe IgE-mediated cow milk protein allergies (Guo et al., 2007; Nazzaro et al., 2010; Galassi et al., 2012). Due to its low lipid content, it is also capable of providing benefits for a low-fat diet plan (Guo et al., 2007; Nazzaro et al., 2010), as well as for the treatment of human immune-related diseases and in the prevention of atherosclerosis (Tafaro et al., 2007).

Another aspect of growing interest is related to the possible use of some components of jenny milk. Among them, the lysozyme contained in jenny milk is of special interest. This bacteriolytic protein is a nonspecific immunoprotective factor, whose powerful antibacterial activity is due to its capacity to catalyze the hydrolysis of the $\beta(1–4)$ glycosidic links between N-acetylmuramic acid and N-acetylglucosamine in the bacterial cell wall polysaccharides, working in synergy with lactoferrin and immunoglobulins (Marseglia et al., 2013). The lysozyme content in jenny milk ranges from 1.0 to 3.7 mg/mL (Zhang et al., 2008; Galassi et al., 2012) and is much higher than in cow (0.18 μg/mL), buffalo (0.15 μg/mL), ewe (0.20 μg/mL), or goat milk (0.25 μg/mL; Kumari and Mathur, 1981; Fratini et al., 2006; Scharfen et al., 2007).

Previous studies have shown that donkey lysozyme can be successfully employed for controlling the growth of the bacteria responsible of late blowing in cheese (Galassi et al., 2012; Cosentino et al., 2013, 2015). For instance, Galassi et al. (2012) compared 2 groups of hard cheeses, one obtained by adding jenny milk (10 L/500 kg) and the other by adding lysozyme from hen egg white (1.6 g/100 kg). Overall, their results showed no significant differences between the groups in terms of technological and sensorial aspects. The effectiveness of jenny milk lysozyme as a substitute of egg lysozyme has been recently confirmed by Cosentino et al. (2013, 2015). In these studies, jenny milk was added to ewe and cow milk during cheesemaking. In both cases, the authors found jenny milk to be an important inhibitor of late blowing in cheese. Moreover, a consumer evaluation found no significant differences between semihard cow cheeses obtained with and without jenny milk (Cosentino et al., 2015).

Table 1. Experimental design for cheese made with (CJ) and without (CC) jenny milk

Code	Cow milk, L	Jenny milk, L	Ripening time, d	Cheeses, n
CJ-45	40	3.2	45	8
CC-45	40	0	45	8
CJ-120	40	3.2	120	8
CC-120	40	0	120	8

The results of previous studies are important not only from a microbiological point of view, but also from a technological one, as they led to the creation of new dairy products made with jenny milk. However, to date, a comprehensive study on the characterization of sensory properties of these products is still not available. In the food industry, sensory analysis is recognized as a standard tool for both the development of new products and in checking and improving their quality. A sensory analysis by an expert panel may be very useful for identifying sensory attributes characterizing the cheese made with jenny milk. By using descriptive profiling techniques, such as quantitative flavor profiling (Stampanoni, 1993), the Spectrum method (Meilgaard et al., 2006), and quantitative descriptive analysis (**QDA**; Stone et al., 2004), several specific sensory profile have been developed for different types of cheeses, such as Scamorza (Braghieri et al., 2015), Caciottina (Papetti and Carelli, 2013), Cheddar (Young et al., 2004), Swiss cheese (Liggett et al., 2008), and so on.

The relationship between sensory profile and consumer acceptability is another crucial factor affecting the success of foods and drinks. Concerning cheese, several studies have been carried out to understand what sensory properties drive consumer liking (Pagliarini et al., 1997; Ritvanen et al., 2005; Ryffel et al., 2008). In the present study, QDA was applied to establish the sensory attributes that characterize the profile of a cow milk cheese manufactured by adding jenny milk and with 2 different ripening times (45 and 120 d). The relationship between sensory attributes and consumer acceptability was investigated to identify those attributes that most affect the liking of this kind of cheese.

Fresh raw cow milk and jenny milk were collected the same day from 2 different farms by a mechanical milking apparatus. After collection, milk samples were immediately refrigerated at 4°C and transported to the laboratory to determine protein, fat, and lactose content according to the International Dairy Federation standard (ISO, 2013), as well as DM and ash content according to AOAC (1990). Cow milk contained, on average, 3.29% protein, 3.69% fat, 4.05% lactose, 11.67% DM, and 0.49% ash content. Jenny milk had the following composition: 1.69% protein, 1.31% fat, 6.43% lactose, 9.62% DM, and 0.42% ash content.

Cow and jenny milk were used to produce cheese according to procedures described by Cosentino et al. (2015). Cow milk was first pasteurized (65°C for 30 min) and then cooled to 37°C. Subsequently, a fixed amount (40 L) of pasteurized cow milk poured into 4 vats. A group of vats was created by adding 3.2 L of raw jenny milk to 2 vats (**CJ**). The remaining 2 vats contained only cow milk and were used as control group (**CC**). Kid rennet (0.2 g/L; activity 1:10,000; Caglio Camoscio CSC 95/75, DMS, Segrate, Italy) was added to the vats of each group. After 50 min, the curds of each vat were cut (diameter of particles = 0.5 cm) and pressed into cylindrical molds (diameter = 14 cm, height = 8 cm). After 24 h of draining, cheeses were salted in containers with sterile brine (200 g/L of NaCl, pH 5.40) for 2 h and then stored at 20°C for 4 d. Finally, both cheese groups were divided into 2 subgroups, each composed of 4 cheeses, which were left in a ripening room (13–15°C, air humidity = 80–85%) for 2 different time periods: 45 and 120 d (Table 1). The whole experiment was repeated twice.

The QDA of the cheeses was carried out by a panel of 10 members (5 male and 5 female, age 22–53 yr) who evaluated the cheeses under the supervision of a leader to generate and agree upon sensory descriptors of odor, flavor, taste, and texture. After training, the panelists developed a final descriptor list composed of 13 descriptive attributes, whose definitions, along with the reference material used to anchor the panel scores, are shown in Table 2. An unstructured line scale was used for rating attribute intensity. The left side of the scale corresponded to the lowest intensity of each attribute (value 0), whereas the right side to the highest intensity (value 100). Triplicate sessions were performed in separate booths equipped with a computerized system and sensory software (FIZZ ver.1.3.1, Biosystèmes, Couternon, France), where the sensory data were recorded directly. Samples were assigned 3-digit codes and their serving orders were randomized by the software. Evaluations took place under red fluorescent lights to mask color differences in the samples, except during the evaluation of cheese appearance, when only fluorescent lighting was used. Pieces of cracker and water were provided for cleansing the palate between samples.

The acceptability of the 4 cheese types [i.e., CJ and CC aged 45 and 120 d (**CJ-45**, **CJ-120**, **CC-45**, and

Table 2. Sensory descriptors, definition, and reference materials used during panel training and quantitative descriptive analysis sessions

Attribute	Descriptor	Definition	Reference materials for anchoring the extreme 2 points of the scale[1]	
			Low	High
Appearance	Color uniformity	Overall uniformity in color, which can be reduced by shades or tones	8-mo ripened Caciocavallo cheese	Fontina PDO[2] cheese
	Structure uniformity	Overall uniformity in structure, which can be reduced by fissures, holes, or cracks	Asiago PDO cheese	Fontina PDO cheese
Odor	Milk	Odor arising from fresh milk	Fontina PDO cheese	Mozzarella cheese
	Cooked milk	Odor associated with cooked milk	UHT milk	Milk brought to boiling point, and then cooled
	Acid milk	Odor of fermented milk products	UHT milk	Low-fat yogurt
	Ripened cheese	Odor associated with the degree of ripening	Ricotta cheese	36-mo ripened Parmigiano Reggiano PDO
Flavor	Cooked milk	Flavor associated with cooked milk	UHT milk	Milk brought to boiling point, and then cooled
	Acid milk	Flavor of fermented milk products	UHT milk	Low-fat yogurt
Taste	Sweet	Fundamental taste associate01d with sucrose or fructose	2% sucrose solution	10% sucrose solution
	Salty	Fundamental taste associated with sodium chloride	2% sodium chloride solution	10% sodium chloride solution
	Bitter	Fundamental taste associated with quinine or caffeine	0.2% caffeine solution	0.8% caffeine solution
	Sour	Fundamental taste associated with citric acid	1% citric acid solution	3% citric acid solution
Texture	Hardness	The force needed by the jaws to bite the sample into two pieces	Mozzarella cheese	36-mo ripened Parmigiano Reggiano PDO

[1]An unstructured scale, whose left side corresponded to the lowest attribute intensity (value 0) whereas the right side to the highest intensity (value 100), was used.

[2]PDO = protected designation of origin.

CC-120, respectively)] was evaluated by 89 habitual consumers (42 male and 47 female, age 22–61 yr) of cheeses. Consumer recruitment was carried out by placing advertisements across the University of Basilicata campus. Cheese slices, identified by random 3-digit codes and served in random order under white fluorescent lighting, were evaluated by using a 9-point hedonic scale (1 = dislike extremely and 9 = like extremely) in individual booths using the software FIZZ (ver.1.3.1, Biosystèmes).

A preliminary 3-factor [1 = cheese (4 levels); 2 = panellists (10 levels); 3 = replications (3 levels)], 2-way ANOVA with interactions was used to evaluate the panel efficiency (Montouto-Grana et al., 2002; Pagliarini, 2002). Based on the ANOVA results, the factor cheese was significant for all descriptors, whereas the other factors, as well as the interactions, were not significant. These results showed a good reliability of the panel's judgments for each sensory descriptor. Both sensory and acceptability data were then subjected to 1-way ANOVA with cheese (4 levels) as factor. Least significant difference (LSD) mean separation test was used to detect significant differences among the cheeses.

Table 3 reports the results of the sensory profile of cheese samples. The factor cheese was significant ($P < 0.001$) on all appearance descriptors. The intensity of color uniformity was not affected by the addition of jenny milk, as no differences were found between CJ and CC samples regardless the ripening time. However, in both groups, the intensity of this appearance descriptor decreased during ripening, probably for the occurrence of shades and tones. Variation in color during ripening has been described in previous studies on different types of cheese (Pompei et al., 1991; Rohm and Jaros, 1996; Buffa et al., 2001; Saldo et al., 2002). In particular, in previous studies a significant decrease in lightness, as well as a change in color to a more yellow-orange color, has been reported during ripening. For the descriptor structure uniformity, the highest mean value (69.97) was observed in CJ-45 cheese samples. This result is related to the lower occurrence of fissures, holes, and cracks in CJ cheese samples, and is consistent with a previous study on the effect of jenny milk addition on the inhibition of late blowing in semihard cheese (Cosentino et al., 2015). In their study, Cosentino et al. (2015) found that adding jenny

Table 3. Means[1] of sensory descriptors that characterized the cheese samples made with (CJ) and without (CC) jenny milk after 45 and 120 d of ripening

Attribute	Descriptor	Cheese			
		CJ-45	CC-45	CJ-120	CC-120
Appearance	Color uniformity	78[a]	77[a]	65[b]	64[b]
	Structure uniformity	70[a]	62[b]	66[c]	49[d]
Odor	Milk	10[a]	10[a]	3[b]	3[b]
	Cooked milk	32[a]	36[b]	10[c]	10[c]
	Acid milk	40[a]	40[a]	44[b]	51[c]
	Ripened cheese	8[a]	10[a]	29[b]	30[b]
Flavor	Cooked milk	27[a]	30[b]	4[c]	5[c]
	Acid milk	34[a]	37[b]	38[b]	43[c]
Taste	Sweet	15[a]	1[b]	6[c]	0[b]
	Salty	58[a]	59[a]	64[b]	69[c]
	Bitter	3[a]	3[a]	9[b]	18[b]
	Sour	34[a]	34[a]	38[b]	45[c]
Texture	Hardness	60[a]	55[b]	68[c]	62[d]

[a–d]Means followed by the same letter in each row are not significantly different at the 5% level according to the Fisher's least significant difference (LSD) mean separation test.

[1]An unstructured scale, whose left side corresponded to the lowest attribute intensity (value 0) whereas the right side to the highest intensity (value 100), was used for each descriptor.

milk during cheese making led to the reduction of the appearance of irregular holes, cracks, and splits within the cow cheese matrix.

A significant ($P < 0.001$) effect of the type of cheese on all odor descriptors was noted. The odor of milk and cooked milk was significantly higher in both CC and CJ after 45 than 120 d. The latter descriptor was also significantly lower in CJ-45 than in CC-45 (32.00 vs. 35.50, respectively). Conversely, the values of ripened cheese and acid milk were significantly the highest in 120-d ripened cheese samples. Flavor descriptors were also significantly ($P < 0.001$) affected by cheese type. In both groups, values of acid milk were lower after 45 d than after 120 d; CJ samples showed the lowest values for this descriptor, regardless of the ripening time. Concerning cooked milk, after 45 d the value was higher in CC than in CJ (29.50 vs. 26.97, respectively), whereas no difference was found between groups after 120 d. According to Gasperi et al. (2012), milk, cooked milk, acid milk, and ripened cheese are among the most common attributes for describing the odor and flavor of cheese. Our results showed that the intensity of some of these attributes changed during ripening, regardless of the addition of jenny milk. For instance, the odor of milk scored higher in less-ripened cheeses; on the contrary, the perception of ripened cheese was higher after 120 d of ripening. With regard to cooked milk, this note has been found in several cheeses with different milk sources, country of origin, processing methods, and ripening times (Drake et al., 2001, 2005a,b; Rétiveau et al., 2005; Koppel et al., 2011). In a study on a Cheddar cheese flavor, Drake et al. (2005b) described cooked milk as a note prevalent in the less-

ripened cheeses. In the present study, the intensity of both odor and flavor of cooked milk was higher in the 45-d-old cheeses, and, comparing the groups at this ripening time, it was higher in CC than in CJ samples. An opposite trend was found for the descriptor acid milk, as its intensity was higher in longer-ripened than in shorter-ripened cheeses; likewise, it was higher in CC than in CJ samples. The perception of acid milk is related to the fermentation of lactose to lactic acid by lactic acid bacteria in the form of starter cultures, or by the microflora naturally present in the raw milk and its environment (McSweeney, 2004; Kongo, 2013). In Cheddar cheese, the amount of lactic acid increased during ripening (Barlow et al., 1989), which, in turn, led to a higher perception of the acid note (Chambers et al., 2005).

Concerning taste descriptors, significant differences were observed among the cheeses ($P < 0.001$). The highest value of sweet was noted in CJ rather than CC samples. This result is related to the presence of lactose in jenny milk. According to Guo et al. (2007), the lactose content in jenny milk is relatively high, with values ranging from 5.8 to 7.4 g/100 g. Residual levels of lactose have been found in the curd of Cheddar, although a great part is lost as lactose in the whey, or as lactate during cheesemaking (Huffman and Kristoffersen, 1984). The highest intensity of sweet found in CJ samples is probably due to a lower loss of lactose compared with CC samples. However, the intensity of this taste descriptor in CJ-120 samples decreased by more than 50% compared with that of CJ-45 samples. This result is probably related to the fermentation of lactose to lactic acid during ripening (McSweeney, 2004;

Kongo, 2013). The differences found among cheeses for the other taste attributes were due to the ripening time rather than the presence of jenny milk. In particular, less-ripened cheeses had lower scores than more ripened cheeses for salty, bitter, and sour descriptors. These results are consistent with previous studies (Barlow et al., 1989; Muir et al., 1995; Freitas and Malcata, 2000), in which a higher intensity of some basic taste intensified as cheese aged.

Texture was also significantly ($P < 0.001$) affected by the type of cheese, with longer-ripened (120 d) cheese samples showing higher hardness compared with 45-d cheese samples. This result is probably due to the decrease of the moisture content of cheeses during ripening. Previous studies (Creamer and Olson, 1982; Amantea et al., 1986; Freitas and Malcata, 2000; Buffa et al., 2001) have reported that the moisture loss led to an increase of cheese firmness during ripening. Based on this explanation, it can be assumed that the decrease in moisture content was probably higher in CJ than in CC samples, as the highest intensity of hardness was found in CJ samples.

Concerning the consumer test, the mean liking scores of the 4 types of cheeses were well above the central point (5 = neither pleasant nor unpleasant) of the 9-point hedonic scale (CJ-45: 6.72; CC-45: 6.07; CJ-120: 5.92; CC-120: 5.74), thus indicating that all the products were appreciated by consumers. However, the differences among the products were statistically significant ($P < 0.05$): the mean overall liking score was significantly higher for CJ-45 cheese samples than for the other cheese samples. As shown in Table 3, the 45-d-old cheese made with jenny milk was characterized by the strongest intensity of structure and color uniformity, as well as by the strongest sweet taste. The acceptability of the other cheeses was quite similar each other, as no significant differences were found among their liking ratings. Our results are consistent with a previous study on semihard cheese made with jenny milk (Cosentino et al., 2015), in which no difference for some sensory parameters (color, odor, flavor, and texture) among 120-d-old cheeses made by adding different aliquots of jenny milk during cheesemaking (from 0 to 7.41%). The lack of significant differences among cheeses found in Cosentino et al. (2015) is probably related to a decrease of the intensity of the sensory descriptors that characterize the 45-d-old cheese made with jenny milk.

In conclusion, our results revealed that adding jenny milk during cheese making led to the creation of cheese characterized by characteristic sensory properties. In particular, the intensity of some sensory attributes was quite different between cheeses made with and without jenny milk and it was also affected by ripening time. By sensory and consumer acceptability data analysis, some descriptors related to appearance and taste attributes were found to be distinctive of the 45-d-old cheese made with jenny milk, which was the most preferred by consumers.

Overall, these results are clearly an important step toward the characterization of cheese manufactured by adding jenny milk. However, to obtain a more comprehensive characterization, further studies are needed to evaluate the effect of the addition of jenny milk on chemical and physical composition of cheese.

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