Agronomy Research **18**(S3), 1796–1703, 2020
https://doi.org/10.15159/AR.20.094

The influence of milk quality and composition on goat milk suitability for cheese production

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Abstract. The goat milk production sector is growing in Latvia, therefore detailed studies are required to examine goat milk suitability for cheese production. There is still not enough information about the chemical composition and quality of goat milk, and its connection with milk renneting properties. The objective of this study was to analyse the impact of milk composition and quality on goat milk renneting properties. Fat, protein, lactose, urea content, somatic cell count and freezing point were measured by infrared spectroscopy. The curd firmness was analysed by Texture Analyser TA.HD.plus (Stable Micro Systems, UK). In total, 34 samples, including bulk milk samples (n = 3) were analysed. The analysed breeds included the Latvian Native (n = 9), Saanen (n = 14) and milking crosses (closer to Anglo Nubian) (n = 8). The samples were arranged according to the lactation, somatic cell count and breeds. Obtained fat content varied from 1.72 to 4.67%, and the protein content – from 2.93 to 4.57% in individual goat milk samples. The highest fat to protein ratio was established in the Saanen breed goat milk (0.96), but the lowest – in milking crosses' milk (0.80). The highest somatic cell count was determined in the second lactation goat milk (1421 thous mL^{-1}) and in milking crosses' goat milk (1027 thous mL^{-1}). The somatic cell count influences curd firmness in cheese, and the highest fat to protein ratio was established in the first group samples with lower somatic cell count.

Key words: goat milk, somatic cell count, renneting properties.

INTRODUCTION

Worldwide, goat milk is known as a healthy product, less allergic, with high concentration of bioactive components and excellent digestibility (Albenzio et al., 2012; Jorge et al., 2018). The composition and quality of goat milk has high importance on cheese yield, composition and sensory properties. Contrary to cow milk, the limit of somatic cell count in goat milk has not been established. The breed, parity, stage of lactation, monthly and seasonal variations have major impact on the somatic cell count in goat milk (Sánchez-Macías et al., 2013). These factors should be taken into account when establishing the somatic cell count limits in goat milk. Also, the effect of somatic cell count in goat milk on milk properties, cheese quality, lipolysis and proteolysis is not clear (Sandrucci et al., 2018). Somatic cells contain lysosomal enzymes and elastase which may cause proteolysis and lipolysis in milk as well in cheese. Sánchez-Macías et al. (2013) have reviewed the somatic cell count in goat milk and concluded that it is difficult to determine if somatic cells are responsible for changes in goat milk and cheese quality.

The main characteristics of Latvian goats' milk yield and somatic cell count are summarised in Table 1.

Table 1. Milk yield and somatic cell count (SCC) in different goat breeds in Latvia (Agricultural Data Centre Republic of Latvia, 2019)

Year	Parameter	Breed			All goats
		Latvian Native	Saanen	Milking crosses	
2014	Milk yield, kg	496	614	463	508
	SCC, thous mL^{-1}	1,087	1,316	686	1,202
2015	Milk yield, kg	491	615	505	519
	SCC, thous mL^{-1}	1,011	1,215	908	1,161
2016	Milk yield, kg	499	633	515	539
	SCC, thous mL^{-1}	1,014	1,017	988	978
2017	Milk yield, kg	494	583	532	516
	SCC, thous mL^{-1}	907	1,069	452	1,012
2018	Milk yield, kg	549	552	492	553
	SCC, thous mL^{-1}	966	867	824	804

Saanen breed is the most productive breed in Latvia according to the data of Agricultural Data Centre (2019), but lower somatic cell count is characteristic of milking crosses. The effects of goat breed, the number of lactation, as well as the season on milk renneting properties have not been studied in Latvia before; therefore, the objective of this study was to analyse the impact of milk composition and quality on goat milk renneting properties.

MATERIALS AND METHODS

The study was carried out in August 2019 in one of the largest goat farms in Latvia – the limited liability company Līcīši. Thirty one individual goat milk samples were tested for chemical composition and quality, and fat to protein ratio and curd firmness were measured. Animals were from the second to fourth lactation and represented breeds as followed: the Latvian Native (n = 9), Saanen (n = 14) and milking crosses (closer to Anglo Nubian) (n = 8). Bulk milk samples (n = 3) were studied to establish the average results of goat milk chemical composition and its influence on curd firmness. Samples were divided in 3 groups according to the somatic cell count: 1 = less than 500 thous mL^{-1}, 2 = from 500 to 2,000 thous mL^{-1} and 3 = more than 2,000 thous mL^{-1}. Samples were also arranged according to the lactation (second, third and fourth lactation) and breed (Latvian Native, Saanen and milking crosses). Individual milk samples were taken during morning milking, cooled immediately and stored in refrigerator at 4 °C within 24 hours after collection.

Fat, protein, lactose and urea content was analysed by MilkoScan FT 6000 (Foss, Denmark) and somatic cell count – by Fossomatic FC (Foss, Denmark), but freezing point was detected by MilcoScan Mars^{TM} (Foss, Denmark).

The microbial origin rennet (CHY-MAX 1000 IMCU mL^{-1}, Chr. Hansen, Denmark) was used for determining curd firmness (in Newton's). Rennet was diluted 1:100 (v/v), and 1.0 mL of dilution was added to 50 ml of milk. Milk was heated up to 35 °C then rennet was added and samples were further kept in incubator at 35 °C for 30 minutes. Curd firmness was analysed with TA.HD.plus Texture Analyser (Stable Micro Systems, UK) using compression method for determination of curd firmness (technical data: disc A/BE – d45, test speed 1.0 mm s^{-1}, distance in the depth of curd sample 8 mm) (Petrovska et al., 2017).

Statistical analyses were performed using analysis of variance (ANOVA) and mean comparisons of parameters were carried out by *Descriptive statistics*, *t-test, Shapiro.test, Bartlet.test.* Differences were considered statistically significant with a confidence interval of $P < 0.05$.

RESULTS AND DISCUSSION

The chemical composition of goat milk varies according to season, breed, feed, lactation, animal body condition, etc. (Piliena & Jonkus, 2011; García et al., 2014; Leitner et al., 2016; Marcinkoniene & Ciprovica, 2019). Vacca et al. (2018b) have established that Saanen goat breed is the most productive, but this breed milk has showed insufficient results for cheese production. Data on milk composition and quality are summarised in Table 2.

Table 2. Milk composition and quality indices by goat breeds and lactation

Parameter	Breed			Lactation		
	Latvian Native (n = 9)	Saanen (n = 14)	Milking crosses (n = 8)	Second (n = 13)	Third (n = 13)	Fourth (n = 5)
Fat content, %	2.97 ± 0.71^a	3.30 ± 0.98^b	2.82 ± 0.21^a	2.95 ± 0.50^A	3.12 ± 0.91^{AB}	3.31 ± 1.07^B
Protein content, %	3.27 ± 0.38^a	3.42 ± 0.46^a	3.55 ± 0.38^a	3.49 ± 0.34^A	3.31 ± 0.40^A	3.44 ± 0.66^A
Lactose content, %	4.48 ± 0.27^b	4.54 ± 0.29^b	4.37 ± 0.17^b	4.41 ± 0.19^B	4.51 ± 0.31^B	4.59 ± 0.27^B
Urea content, mg dl^{-1}	46.79 ± 7.64^b	38.00 ± 6.61^c	40.41 ± 6.69^c	41.33 ± 6.39^B	43.02 ± 7.39^B	35.98 ± 10.63^C
SCC, thous mL^{-1}	$1,421 \pm 1,587^a$	$1,100 \pm 879^b$	$1,559 \pm 1,988^a$	$1,421 \pm 1,587^A$	$1376 \pm 1,252^A$	$1,027 \pm 748^B$
Freezing point, °C	-0.486 ± -0.029^b	-0.500 ± -0.023^b	-0.499 ± -0.027^b	-0.495 ± -0.028^B	-0.492 ± -0.027^B	-0.508 ± -0.011^B

Results indicated with the same letter in the lines do not differ significantly ($P > 0.05$).

The mean milk fat content was lower than the protein content, also the analysed milk samples were characterised by reverse ratio of milk fat/protein. Sandrucci et al. (2018) have established that milk fat/protein ratio is significantly influenced by the month of kidding, stage of lactation, herd size, parity and milk production volume. Higher fat and lactose content was established in the Saanen breed goat milk (3.30% and 4.54% respectively), while protein content was higher in milking crosses' milk (3.55%). Estonian researchers have found seasonal differences in fat and protein content in goat milk, where the average fat and protein content was 3.72% and 3.50% in July–September (Tatar et al., 2015). The differences in freezing point have not been observed.

Fat content is rising with lactation and in the fourth lactation it was 3.31%. Also Piliena & Jonkus (2012) have established that the highest fat content in goat milk is in the fourth lactation. Similar characteristics were found in lactose, protein content and freezing point data. Urea content was higher than the range of 28–32 mg dl^{-1} suggested by Brun-Bellut et al. (1984). High urea content could be an indicator of unbalanced feeding or low nitrogen utilisation (Sadrucci et al., 2018).

During the study, the rut started and also grazing season was close to the end, it could be an explanation for the obtained results in comparison to other research data.

Somatic cell count is higher in goat milk (Leitner et al., 2016; Marcinkoniene & Ciprovica, 2019) than in cow milk (Leitner et al., 2016) and somatic cell count data are summarized in Table 3.

Table 3. Somatic cell count in the analysed milk samples

Group	Number of samples	SCC, thous mL^{-1}	Min SCC, thous mL^{-1}	Max SCC, thous mL^{-1}
1	9	< 500	54	480
2	15	500–2,000	527	1,907
3	9	> 2,000	2,034	19,988

In Latvia, milk is still used in cheese production without analysing the somatic cells count and producers therefore cannot ensure adequate cheese quality. They mainly choose to produce soft and acid-milk cheeses that are less demanding than hard and semi-hard cheeses. Similar situation was also observed in the Czech Republic where Michlová et al. (2016) established the same after studying the Saanen goats' milk quality. Some authors (Bagnicka et al., 2011) have indicated that somatic cell count increases with increasing of number of lactation. Jimenez-Granado et al. (2014) noted that the influence of the number of lactation on the somatic cell count depends on the health status of the udder. Our results coincided with this statement, but also the low number of analysed samples should be taken into account. In Latvia, the average somatic cell count was 804 thous mL^{-1} according to milk monitoring results in 2018 (Agricultural Data Centre of the Republic of Latvia, 2019).

Table 4. Goat milk composition by the somatic cell count

Components	Group		
	1 (*n* = 9)	2 (*n* = 15)	3 (*n* = 9)
Fat content, %	3.11 ± 0.36^{a}	3.08 ± 0.54^{a}	2.64 ± 0.25^{b}
Protein content, %	3.24 ± 0.30^{a}	3.38 ± 0.32^{a}	3.31 ± 0.38^{a}
Lactose content, %	4.52 ± 0.14^{b}	4.57 ± 0.24^{b}	4.35 ± 0.15^{c}
Urea content, mg/dl	43.47 ± 8.29^{d}	38.97 ± 8.24^{d}	38.86 ± 10.83^{d}
Freezing point, °C	-0.513 ± -0.008^{e}	-0.497 ± -0.021^{e}	-0.473 ± -0.022^{f}

Results indicated with the same letter in the lines do not differ significantly ($P > 0.05$).

The highest fat content was established in the first group (3.11%), but the lowest – in the third group (2.64%) or in the samples with the highest somatic cell count. Urea content and freezing point were lower in the second and third group samples, but lactose content – in the third group samples (4.35%). No significant differences in protein content and freezing point were found among the groups (Table 4).

Many researchers (Cecchinato et al., 2011; Bittante et al., 2012; Barrón-Bravo et al., 2013; Malchiodi et al., 2014; Leitner et al., 2016) have established that milk firming time and coagulum strength significantly influence the somatic cell count and, correspondingly, cheese quality and yield. High influence on cheese yield and quality is also exerted by coagulation time and curd firmness (Kübarsepp et al., 2005). Fat to protein ratio is another important aspect in cheese production.

The impact of breed on milk quality and renneting properties is summarised in Table 5.

Table 5. Milk composition and curd firmness by goat breeds

Parameter	Breed		
	Latvian Native (*n* = 9)	Saanen (*n* = 14)	Milking crosses (*n* = 8)
Fat to protein ratio	0.92 ± 0.26[a]	0.96 ± 0.25[a]	0.80 ± 0.12[b]
SCC, thous mL^{-1}	1,514 ± 1,260[b]	1,100 ± 879[c]	1,559 ± 1,988[b]
Curd firmness, N	1.57 ± 0.77[c]	1.76 ± 0.59[d]	1.59 ± 0.87[c]

Results indicated with the same letter in the lines do not differ significantly ($P > 0.05$).

The highest fat to protein ratio (0.96) was established in Saanen goat milk and lowest – in milking crosses' milk (0.80). The Latvian Native breed milk showed an average fat to protein ratio (0.92) and curd firmness (1.57 N). The highest curd firmness was in the Saanen breed goat milk (1.76 N) and the lowest – in milking crosses. Saanen goats are very productive in terms of milk yield and for these reasons usually also present higher fat and protein contents compared with the low-producing breeds (Scheepers et al., 2010; Michlová et al., 2016). Saanen breed is an excellent dairy breed but it showed less technological aptitude for cheese production (Pazzola et al., 2018). Crossbreeding and genetic development is an important factor in understanding renneting properties and cheese outcome (Malchiodi et al., 2014). Vacca et al. (2018a) have established that chemical composition, renneting properties and cheese outcome vary among the breeds.

Table 6. The study of milk suitability for cheese production by lactation

Parameters	Lactation		
	Second (*n* = 13)	Third (*n* = 13)	Fourth (*n* = 5)
Fat to protein ratio	0.86 ± 0.20[a]	0.94 ± 0.25[b]	0.96 ± 0.25[b]
SCC, thous mL^{-1}	1,421 ± 1587[c]	1,376 ± 1252[c]	1,027 ± 748[c]
Curd firmness, N	1.84 ± 0.74[d]	1.55 ± 0.63[e]	1.47 ± 0.81[e]

Results indicated with the same letter in the lines do not differ significantly ($P > 0.05$).

Fat to protein ratio in goat milk increases with lactation. There are no significant differences in the somatic cell count in milk. Higher curd firmness results were established in the second lactation goat milk (1.84 N) which could be explained by a higher protein content in the analysed goat milk (Table 6). It was noticed that curd firmness decreases with increasing number of the lactation which could be explained with the differences in chemical composition and higher fat to protein ratio in goat milk. Piliena & Jonkus (2012) have established that milk composition changes with increasing number of lactation. Higher fat content was established in the fifth and older lactation goats and significantly higher protein content was found in the first lactation goats' milk

(Piliena & Jonkus, 2012). Vacca et al. (2018a) have established that the rennet coagulation time becomes shorter at the end of lactation making the coagulum softer.

Table 7. Milk renneting properties by somatic cell count

Parameter	Group		
	1 (*n* = 9)	2 (*n* = 15)	3 (*n* = 7)
Fat to protein ratio	0.97 ± 0.09[a]	0.92 ± 0.18[a]	0.79 ± 0.212[b]
SCC, thous mL^{-1}	248 ± 192[a]	1,095 ± 425[b]	3,262 ± 1,387[c]
Curd firmness, N	1.82 ± 0.54[b]	1.93 ± 0.25[b]	2.18 ± 0.50[b]

Results indicated with the same letter in the lines do not differ significantly ($P > 0.05$).

Analysing milk renneting properties, significant differences were not found among samples with different somatic cell count. Significant differences were found in the somatic cell count among the groups ($P > 0.05$). Fat to protein ratio showed close values and significant differences were observed in the third group samples (0.79). Bagnicka et al. (2011) could not approve their hypothesis that there exists a correlation between lactose content and somatic cell count in goat milk. In our study, milk samples with highest cell count lactose had the lowest somatic and vice versa. It clearly shows that a more detailed study is necessary to understand the limitation of somatic cell count in healthy goats' milk.

Results of chemical composition and quality indices in bulk milk samples are shown in Table 8.

Table 8. Bulk milk composition

Components	Average
Fat content, %	3.48 ± 0.23
Protein content, %	3.54 ± 0.27
Lactose content, %	4.30 ± 0.06
Freezing point, °C	-0.473 ± -0.005
Fat to protein ratio	0.98 ± 0.03
Curd firmness, N	2.18 ± 0.14

Bulk milk showed the highest curd firmness (2.18 N) and fat to protein ratio (0.98). Bulk milk samples were collected from all farm animals (*n* = 154), therefore results significantly differ from individual goat milk data. Analysing milk suitability for cheese production, it is important to evaluate bulk milk to understand the variations in milk chemical composition from different aspects.

CONCLUSIONS

1. The goat breed, number of lactation and season has an impact on the somatic cell count in goat milk.
2. The study results showed a tendency that somatic cell count has impact on curd firmness, also the number of lactation and goat breed significantly influence milk composition.
3. Further studies are necessary to understand the effect of genetics on goat milk quality (especially somatic cell count), curd firmness and cheese outcome.

ACKNOWLEDGEMENTS. The research was supported by the project Strengthening Research Capacity in the Latvia University of Life Sciences and Technologies, contract No. 3.2.-10/2019/LLU/139.

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