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Fatty Acid Composition of Different Breed Goat Milk

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Abstract. The chemical composition of goat milk, especially fatty acid profile is recently renewed due to the role of monosaturated and polyunsaturated fatty acids in human nutrition. These nutrients are important to analysed in connection with the different breeds receiving the same breeding and feed. The aim of this study was to analyse goat milk fatty acid profile in relation to different breeds.

Specimens for fatty acid analyses were collected from individual animals of breeds like Latvian Native (n=5), Saanen (n=5), and crossbreeds (n=5). Bulk milk samples (n=5) were also taken for milk quality testing and fatty acid range determination. Fat content was analysed according to ISO 1211:2011 and fatty acids were measured with the chromatographic method. Protein, lactose, casein and urea concentration was analysed according to ISO 13366-2:2007 and somatic cell count to ISO 9622/IDF141:2013.

The highest fat concentration was determined in crossbreed milk samples (3.81 g 100 g^{-1}) and the lowest (2.96 g 100 g^{-1}) in the Latvian Native breed goat milk samples. The highest butyric acid (0.12 g 100 g^{-1}) and caproic acid (0.12 g 100 g^{-1}) concentration was established in Saanen goat milk samples. Compared to other breeds, the milk of the Latvian Native breed goats is characterised by a higher capric acid (0.20 g 100 g^{-1}) concentration, while a higher concentration of total unsaturated and monounsaturated fatty acids was detected in the samples of crossbreed goat milk. The average fatty acid composition of bulk milk samples was 68% for saturated fatty acids, 23% for monosaturated fatty acids and 4.3% for polyunsaturated fatty acids. In analysed goat milk samples, fatty acids showed the characteristic fatty acid profile of goat milk.

Key words: organic farming, breeds, goat milk, fatty acids, milk composition.

Introduction

Goat milk has an important role in human nutrition (Michlová et al., 2016). Goat milk is less allergenic and has higher nutritional value and digestibility of milk compounds compared to bovine milk (Verruck, Dantas & Prudencio, 2019).

It is known that dietary fat supplements in feed rations affect the concentration of synthesised milk fats and proteins (Martínez Marin *et al.*, 2011). Moreover, LeDoux *et al.* (2002) analysing the fatty acid profile in goat milk established that modification of the dietary forage has a significant effect on capric, lauric, oleic, and linolenic acids. A diet with a high level of forage results in lower capric, lauric and linoleic acids and higher linolenic and oleic acid concentrations in goat milk. Clark & Mora García (2017) have summarised research information on goat milk composition and established that fatty acids had already been studied by Jensen et al. in 1961, and until now have been the subject of research. The fatty acid concentration differs in goat milk; the highest concentration was established for capric, caproic and caprylic acids which contribute to the unique flavour and aroma of goat milk (Clark & Mora García, 2017). Long-chain saturated fatty acids are determined to be unfavourable in high concentrations in human nutrition (Inglingstad *et al.*, 2016). At the same time, goat milk is characterised by a relatively high concentration of medium-chain fatty acids (Mollica *et al.*, 2021). LeDoux *et al.* (2002) have concluded that fatty acids like capric, lauric, palmitic, stearic, myristic and oleic, account for almost 80% of the total fatty acid concentration, while Lopez *et al.* (2019) have noticed that the composition of fatty acids in goat milk is closely related to applied processing techniques as some processes are able to increase the free fatty acid concentration which reduces shelf-life and stability of goat milk products. If the fat globule membrane is disrupted and triglycerides are released,

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the formation of free fatty acids may be developed as the result of lipase activity in the milk serum (Skeie, 2014). It is known that omega-3 and omega-6 fatty acids are irreplaceable in human nutrition (Broka *et al.*, 2016). Mollica *et. al.* (2021) established in their study that special attention should be given to linoleic acid, which contributes to the daily intake of polyunsaturated fatty acids as well as conjugated linoleic acid production in situ.

It is important to know that goat milk supplies consumers with beneficial fatty acids, however, the concentration of long-chain polyunsaturated fatty acids in milk varies depending on the lipid sources in animal feed (Goetsch, Zenh & Gipson, 2011) as well as on breeds.

The aim of this study was to analyse goat milk fatty acid profile in relation to different breeds.

Materials and Methods

The study was carried out from May to July 2021 at the limited liability company Līcīši (Latvia). All animals received the same feeding (hay, carrots, oats, and pasture grass) twice per day. Salt licks and micro- and macro-elements were also available *ad libitum*.

Individual goat milk samples (n=27) were collected for the chemical analyses. Breeds represented in the goat milk composition analyses were the Latvian Native (n=7), Saanen (n=8), and crossbreed (n=12). Animals of each breed represented the same lactation.

Each of the samples was collected upon morning milking, refrigerated instantly and kept in a fridge at 4 °C for 24 hours. The collected samples were analysed with the MilkoScan FT 6000 (Foss, Denmark) according to ISO 13366-2:2007 and protein, casein, lactose, urea concentrations were determined and the somatic cells were counted with the Fossomatic FC (Foss, Denmark) according to ISO 9622/IDF141:2013.

Milk composition and fatty acid analyses were not made at the same time. In total, fifteen individual goat milk samples (Latvian Native breed (n=5), Saanen breed (n=5), and crossbreeds (n=5)) and five bulk milk samples were examined in terms of fatty acid composition and fat concentration according to PN-EN ISO 1211:2011 (fat concentration), for fatty acid profile method PB-365 ed. I of 15.09.2017. Bulk milk samples were collected from all farm animals at the same time as individual milk samples had been taken. Collected samples were frozen and stored in a freezer at -21±1 °C prior to testing. The fatty acids were analysed in J.S. Hamilton Poland Sp.z.o.o. testing laboratory using the chromatographic method.

Only 20 fatty acids were analysed in this study as the rest of the detected fatty acids were lower than <0.1 g 100 g^{-1} of milk and further calculation and data treatment were not made.

The statistical analysis was performed using the ANOVA, and mean comparisons of parameters were made with descriptive statistics and t-test. Differences were proven to be significant with a confidence interval of $p<0.05$.

Results and Discussion

The chemical composition and somatic cell data are summarised in Table 1.

No significant differences were found in the composition of milk samples coming from the different breeds, except for the slight differences in somatic cell count and urea concentration for Latvian native breed goat milk. Milk of the Latvian Native breed showed the lowest protein (2.98%) and casein (2.24%) concentration, while the somatic cell count (3.52 $\log_{10}$ ml^{-1}) and urea concentration (67.4 mg dl^{-1}) were the highest. Barrón-Bravo *et al.* (2013) established that somatic cell count has an influence on milk composition, especially fat concentration which resulted in lower milk fat due to higher somatic cell count. These findings were also established in the current study. The Latvian Native breed goat milk was characterised by the highest somatic cell count (3.52 $\log_{10}$ ml^{-1}) and the lowest fat concentration

Table 1

Different breed goat milk composition

Indicator	Breeds		
	Latvian Native (n=7)	Saanen (n=8)	Crossbreeds (n=12)
Protein concentration, %	2.98±0.41[a]	3.04±0.38[a]	3.11±0.28[a]
Casein concentration, %	2.24±0.30[b]	2.28±0.29[b]	2.34±0.20[b]
Lactose concentration, %	4.29±0.15[c]	4.34±0.23[c]	4.29±0.21[c]
SCC, $\log_{10}$ ml^{-1}	3.52±3.68[c]	3.09±2.90[d]	3.16±3.20[d]
Urea concentration, mg dl^{-1}	67.4±18.2[d]	65.7±13.1[e]	65.2±11.7[e]

Results indicated with the same small letter in the lines do not differ significantly between the breeds (p>0.05).

Table 2

Fatty acid composition in different goat breed milk and bulk milk, g 100 g^{-1}

Fatty acid	Crossbreeds	Latvian Native	Saanen	Bulk milk
Fat content	3.81±0.73^{a}	2.96±0.59^{a}	3.40±1.34^{a}	3.24±0.22^{a}
C4:0 butyric acid	0.10±0.00^{b}	0.10±0.00^{b}	0.12±0.05^{a}	0.10±0.00^{b}
C6:0 caproic acid	0.10±0.00^{b}	0.10±0.01^{b}	0.12±0.05^{c}	0.10±0.00^{b}
C8:0 caprylic acid	<0.10^{c}	<0.10^{c}	0.10±0.00^{d}	0.10±0.00^{d}
C10:0 capric acid	0.26±0.09^{d}	0.20±0.13^{d}	0.18±0.05^{d}	0.20±0.00^{d}
C12:0 lauric acid	0.12±0.05^{efg}	0.10±0.01^{efg}	0.10±0.00^{f}	0.10±0.00^{g}
C14:0 myristic acid	0.26±0.06^{f}	0.22±0.08^{f}	0.24±0.24^{f}	0.24±0.06^{f}
C16:0 palmitic acid	0.96±0.17^{g}	0.74±0.16^{g}	0.92±0.35^{g}	0.82±0.08^{g}
C18:0 stearic acid	0.62±0.13^{h}	0.48±0.10^{h}	0.56±0.26^{h}	0.54±0.06^{h}
C18:1t9 trans-elaidic acid	0.10±0.00^{ijk}	0.10±0.00^{j}	0.10±0.01^{ijk}	0.10±0.00^{k}
C18:1c9 oleic acid	0.90±0.31^{j}	0.68±0.10^{j}	0.80±0.42^{j}	0.70±0.07^{j}
C18:2n6 linoleic acid	0.13±0.05^{k}	0.10±0.00^{k}	0.12±0.05^{k}	0.12±0.05^{k}
Other fatty acids	0.10±0.00^{k}	0.10±0.00^{k}	0.12±0.05^{l}	0.10±0.00^{k}
Total saturated fatty acids (SAFA)	2.52±0.39^{l}	1.96±0.46^{l}	2.28±0.73^{l}	2.20±0.19^{l}
Total monounsaturated fatty acids (MUFA)	1.02±0.35^{m}	0.76±0.10^{m}	0.88±0.42^{m}	0.74`±0.06^{m}
Total polyunsaturated fatty acids (PUFA)	0.12±0.05^{n}	0.10±0.00^{n}	0.12±0.05^{n}	0.14±0.06^{n}

Results indicated with the same small letter (in lines) do not differ significantly between the breeds and bulk milk ($p>0.05$).

(2.96 g 100 g^{-1}, see Table 2). According to the findings of Barrón-Bravo *et al.* (2013), somatic cell count also has a strong correlation with milk yield. At the same time, Piliena & Jonkus (2012) established that fat concentration was higher in the milk of the Saanen breed, but the protein concentration was higher in the Latvian Native breed goat milk. There were no significant differences in protein and urea concentration between the Saanen breed and crossbreeds while remarkable differences in fat and urea concentration were found between the Saanen and Latvian Native breeds' goat milk. Marcinkoniene & Ciprovica (2020) reported that a significant difference was established between the Latvian Native and Saanen breeds' milk in terms of somatic cell count, but no significant differences were in the protein and casein concentration. Lactose concentration was similar in the milk of the studied breeds. The highest fat (3.54%) and lactose (4.34%) concentrations were determined in the Saanen goat milk, but the highest protein concentration (3.11%) was in crossbreeds' milk. Worldwide, the Saanen goats are known as very productive and characterised by high milk yield, fat and protein concentration (Schepers *et al.*, 2010; Michlová *et al.*, 2016; Marcinkoniene & Ciprovica, 2019).

Milk quality is influenced by many factors, like environment, breeding system, genetics, animal health and hygiene standards at the farm (Skeie, 2014; Leitner *et al.*, 2016), which explains the differences between the detected nutrients and the studies. Bittante, Penasa & Cecchinato (2012) discussed the importance of genetic variants of animals and their effect on the concentration of milk protein, especially k-casein.

The herd productivity has been influenced by goat health (Sanchez-Macias *et al.*, 2013; Stuhr *et al.*, 2013). In Latvia there is no adopted regulation on the SCC limitation, therefore this value is highly variable. The somatic cell count in the studied goat milk samples varies to a large extent (3.09 to 3.52 $\log_{10}$ ml^{-1}). As the farm maintains high hygienic standards and the presence of mastitis-causing agents is not detected, increasing somatic cell count in milk alters milk yield and technological properties of milk.

Goat feeding has a crucial effect on the fatty acid profile in milk. If the feed was supplemented with polyunsaturated fatty acids (PUFA), higher milk production yield, protein, and fat concentration were observed in goat milk. Similar changes were found in the study of Sanz Sampelayo *et al.* (2004), where a group of goats was fed with feed additives consisting

of 9% PUFA-rich fats (fish oil). The results showed differences in fatty acid profile, where saturated fatty acid (SFA) concentration decreased and PUFA concentration significantly increased. The situation changed when the PUFA supplements were withdrawn from the feeding ration (Sanz Sampelayo *et al.*, 2004).

The supply of fatty acids to mammary glands is important for high-quality goat milk production (Inglingstad e*t al.*, 2016). Also, Skeie (2014) concluded that feed has an influence on the fat concentration, fatty acid profile, and free fatty acid concentration which resulted in the flavour score of the Norwegian goat breed milk. Feed forage with unsaturated fats (rapeseed oil) is more suitable for goats than feed forage with saturated fats (palm oil), and it ensures a higher concentration of unsaturated (mono- and poly-) fatty acids in milk (Inglingstad *et al.*, 2016). The fatty acid results are shown in Table 2.

In all goat milk samples, fatty acids showed the characteristic fatty acid profile of goat milk. The highest butyric acid (0.12 g 100 g^{-1}) concentration was established in Saanen goat milk. Similar results were found by Park (2009) in his study, where butyric acid concentration was 0.13 g 100 g^{-1}. The concentration of fatty acids and fat concentration differs among the breeds. The Latvian Native breed milk has lower fat and total fatty acid concentration than other studied breeds; the same does not relate to capric acid (0.20 g 100 g^{-1}) concentration. The lowest concentration of capric acid was found in the milk of Saanen goats (0.18 g 100 g^{-1}). Lopez *et al.* (2019) detected significant differences between organic and conventional goat milk in Italy (two low-input system farms: one organic and one conventional, and one high-input system: conventional farm) in relation to the fatty acid pattern. Odd- and branched-chain fatty acid concentration was higher (p<0.05) in the low-input system organic milk (4.7%), followed by the low-input (4.5%) and high-input conventional milk (3.4%). The same situation was also observed with α-linolenic acid concentration. Myristic acid was found in higher concentration in crossbreeds' milk (0.26 g 100 g^{-1}); the same was with palmitic acid (0.96 g 100 g^{-1}) and oleic acid (0.90 g 100 g^{-1}) concentration. Also, monounsaturated fatty acids (MUFA) were detected in higher concentrations in the milk of crossbreeds. Mollica *et al.* (2021) concluded that the amount of saturated fatty acids varied from 59 to 74%, monounsaturated fatty acids from 19 to 36%, and polyunsaturated fatty acids from 2.6 to 5.6% in goat milk. The results of the current study are also within these limits. Fat concentration in bulk milk was 3.24 g 100 g^{-1}, in which saturated fatty acids accounted for 68%, 23% for MUFA and 4.3% for PUFA of the total fat in goat milk. Voblikova *et al.* (2020) established that unsaturated fatty acids, like linoleic acid and oleic acid, have a major role in the protection of organisms from the risk of cardiovascular diseases. Our study showed a higher previously mentioned fatty acid concentration in the milk of crossbreed goats (0.90 and 0.13 g 100 g^{-1} respectively). The polyunsaturated fatty acid concentration is rather low in goat milk; therefore plant-based oils should be added to the feeding forage to increase the beneficial fatty acid concentration in goat milk.

The highest amount of linoleic acid was established for crossbreeds (0.13 g 100 g^{-1}), but elaidic acid was the same concentration for all breeds. Lopez *et al.* (2019) found that goat milk products seem to be richer in linoleic acid, α-linolenic acid, elaidic acid, total omega-3, and omega-6 fatty acid concentration compared to bovine milk products.

Conclusions

1. No significant differences were established in the studied goat breed milk composition, except for the slight differences in somatic cell count and urea concentration for Latvian native breed goat milk.
2. In all goat milk samples, fatty acids showed the characteristic fatty acid profile of goat milk.
3. The differences were mainly imputable to different amounts of some fatty acids, primarily capric, oleic and linoleic acids in Saanen and crossbreeds' goat milk.

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