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UREA CONCENTRATION IN THE MILK OF ALPINE GOATS

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SUMMARY

Nutrition is considered the primary paragenetic factor influencing the milk urea (MU) concentration in ruminants. In addition to diet, various other factors (including season, milk yield, stage of lactation, etc.) have also been shown to affect the urea concentration in ruminant milk. While the physiological concentration of MU has been well-defined for cow's milk, with an optimal range of 15 to 30 mg/dl, such parameters have yet to be established for goat's milk. The objective of this study was to determine the urea concentration in the milk of Alpine goats and to assess its correlation with the daily milk yield and the contents of fat, protein, lactose, and solids-not-fat (SNF). A total of 3,009 samples of Alpine goat milk, collected from two farms in 2021, were analyzed. The average MU concentration was 37.3 ± 8.9 mg/dl, with a range from 13.8 to 110.7 mg/dl. The average daily milk yield was 1.15 ± 0.49 kg, whereas the average milk fat and protein contents were 3.28 ± 0.97% and 3.35 ± 0.50%, respectively. The study found a positive and statistically significant correlation between the MU concentration and the contents of milk fat, protein, and SNF. Conversely, an increase in the MU concentration was negatively correlated with the daily milk yield. Monitoring the MU concentration in dairy goat herds enables the optimization of feed rations, particularly their protein and energy contents, thus improving nitrogen utilization in milk production.

Key words:
milk urea, goat milk, milk fat, protein

INTRODUCTION

In the region of Vojvodina, goat milk production, as a high-quality food source, has been increasing in recent years. Goat's milk is commonly processed on agricultural households into various premium cheeses. The quality of goat's milk depends primarily on the breed, age, health, body condition, and weight of the goats, as well as on nutrition, lactation (duration, parity, stage), and numerous other factors, including production system, housing, milking frequency, number of offspring, dry period length, milking personnel, hygiene, gestation, etc. (Park & Haenlein, 2010; Abbas et al., 2014; Krajinović & Pihler, 2014). The dairy goat farms in Vojvodina exhibit significant variability relative to housing systems, breeds, and nutrition, ranging from intensive systems with dairy breeds (Saanen or Alpine) to semi-intensive or extensive systems (Paskaš et al., 2022). Monitoring the goat milk quality is essential not only for standard cheese production but also for increasing milk yield and reducing production costs, primarily through optimized nutrition. Milk urea (MU) is a normal constituent of milk and other bodily fluids, formed in the digestive system of ruminants (the rumen) as the end product of protein metabolism.
The research by Bed et al. (1997), Cannas et al. (1998), and Schephers & Meijer (1998) found a strong positive correlation between blood urea and milk urea (MU) concentrations. Measuring MU concentrations is simpler than

determining blood urea levels and can be conducted as part of routine monthly milk testing. The MU concentration is influenced by numerous paragenetic factors, with nutrition being the most significant. Proteins are the most costly component of animal feed, and excessive protein intake directly increases feeding costs. Laudadio & Tufarelli (2010) reported that the concentration of MU varies according to the amount of rumen-degradable protein in the diet. Rappettei et al. (2014) observed a significant positive correlation between MU and dietary crude protein content. A high MU concentration indicates an imbalanced diet in terms of protein and energy. Conversely, low MU levels suggest inadequate protein intake and an imbalance between protein and energy (Jonker et al., 1998). The unfavorable protein-to-energy ratio in ruminant rations not only reduces protein utilization efficiency but also increases nitrogen excretion into the environment. Excess nitrogen excretion by both large and small ruminants can contribute to air and groundwater pollution (Santos et al., 2014).

The ecological sustainability of animal husbandry is receiving increasing attention. Livestock production systems, which are important for global food production, must focus more on sustainability and environmental responsibility. Ruminant diets often contain more protein than necessary. By measuring the MU concentration, it is possible to monitor the balance of ruminant rations in terms of energy and protein contents, as well as assess the nutritional and reproductive status of dairy cows (Bed et al., 1997; Bonanno et al., 2008; Giaccone et al., 2007; Bendelja et al., 2011; Čobanović, 2016). The systematic monitoring of MU in the milk of small ruminants is not commonly conducted, as specific criteria for the MU concentration in goat's milk have not yet been clearly established. The urea concentration in goat's milk is influenced by numerous factors, including season, breed, diet, production level, lactation phase, body weight, parity, milk composition, milking time, and more (Goetscha et al., 2011). The research by Bonanno et al. (2008), Laudadio & Tufarelli (2010), and Rapetti et al. (2009) found a wide range of MU concentrations in goat's milk, from 22.0 mg/dl to 62.4 mg/dl. Elevated MU levels can negatively affect the productive and reproductive traits of dairy animals and may also impact the suitability of milk for further processing. Accurately determining the MU concentration is crucial for organizing efficient, economically viable, and environmentally sustainable milk production.

This research aimed to determine the milk urea (MU) concentration in the Alpine goat's milk, and its correlations with the daily milk yield and the contents of protein, fat, lactose, and solids-not-fat (SNF). In objective was to optimize the diet, specifically the protein and energy contents of rations, thus enhancing nitrogen utilization in milk production.

MATERIAL AND METHODS

In 2021, goat milk samples were collected from two goat farms during routine milking, once daily, as part of the regular DHI control, conducted according to the AT4 method (ICAR, 2019). The goats were machine-milked, and samples were taken alternately from morning and evening milking throughout lactation. Production on the controlled farms was organized as a closed housing system with animals fed a consistent, balanced diet year-round, which remained unchanged during lactation. The milk samples were preserved with bronopol, cooled to 4 °C, and transported to the Laboratory for Milk Quality Control at the Faculty of Agriculture, University of Novi Sad.

Goat's milk samples were preserved by bronopol, cooled at 4 °C and transported to the Laboratory for Milk Quality Control at Faculty of Agriculture, University of Novi Sad. The chemical composition of the milk (fat, protein, lactose, and SNF content), as well as the urea concentration, were analyzed using infrared spectrophotometry (ISO 9622:2020) with a MilcoScan FT instrument. The laboratory is certified under ISO 17025:2017 and follows the ICAR guidelines (2020).

A total of 3,009 Alpine goat milk samples were analyzed, with the data on daily milk yield, milk fat, protein, lactose, SNF, and MU collected on the date of testing. The average values and variability of the traits studied, as well as the influence of the farm on MU, milk fat, protein, lactose, SNF, and daily milk yield (DMY), were calculated using the PROC UNIVARIATE and PROC GLM procedures within the Statistica software package version 14.0 (TIBCO Software Inc., Palo Alto, CA, USA). A correlation analysis was conducted between the MU concentration and production variables using the correlation procedure. Model effects were considered significant at $p < 0.01$ for all the parameters.

RESULTS AND DISCUSSION

The mean values for the investigated traits (MU, milk fat, total protein, SNF, lactose, and DMY) are presented in Table 1.

Table 1. Average chemical composition, standard deviation (SD), and coefficient of variation (CV) of the analyzed goat milk samples

Trait	N	Mean	SD	CV (%)
Fat (%)	3,009	3.28	0.97	29.44
Protein (%)	3,009	3.35	0.50	14.87
DMY (kg)	3,009	1.15	0.49	42.64
SNF (%)	3,009	8.52	0.49	5.76
Lactose (%)	3,009	4.36	0.24	5.54
MU (mg/dl)	3,009	37.30	8.86	23.76

Legend: DMY – daily milk yield, SNF – solids-not-fat, MU – milk urea

The urea concentration in goat's milk exhibited significant variability (SD = 8.86 mg/dl), with a mean concentration of 37.3 mg/dl. Brun-Bellut et al. (1991) reported a lower optimal MU level (28-32 mg/dl), whereas Bonanno et al., (2008) also found a lower mean MU concentration (22.5 mg/dl) in goat's milk. Rapetti et al. (2009) and Sandrucci et al. (2019) observed similar MU concentrations (39.7 mg/dl and 39.2–41.2 mg/dl, respectively). Other studies (Todaro et al., 2005; Giaccone et al.,2007; Bendelja-Ljoljić, 2018) reported higher MU concentrations (43.7 mg/dl, 43.6 mg/dl, and 41.4 mg/dl, respectively) in goat's milk. Rapetti et al. (2009) and Sandrucci et al. (2019) also noted considerable variation in the urea concentration in goat's milk (11.9–67.5 mg/dl and 11.40–90.90 mg/dl).

The mean protein content (3.35%) was higher than the mean milk fat content (3.28%). Sandrucci et al. (2019) reported that more than half (51.4%) of 7,000 individual goat milk samples exhibited an inverse relationship between the milk fat and protein contents (3.49% and 3.59%, respectively).

Božanić et al. (2002) and Aroua et al. (2018) observed higher milk fat contents (3.60% and 5.04%, respectively), whereas Čobanović et al. (2019) found a lower milk fat content (3.07%) in goat's milk. Antunac & Samaržija (2000), Božanić et al. (2002), and Čobanović et al. (2019) reported lower protein contents in goat's milk (2.90%, 3.10%, and 2.76%, respectively). In the analyzed goat milk samples, the average SNF content was 8.52%, indicating an average dry mater content of 11.80%. Čobanović et al. (2019) reported a lower average dry matter content in the milk of Saanen goats (10.87%), whereas Božanić et al. (2002) and Aroua et al. (2018) found higher average dry matter contents in goat's milk (11.94% and12.1 ± 1.1%, respectively).

Based on the coefficient of variation (CV) values (Tab. 1), it can be observed that the milk fat content (29.44%) and MU concentration (23.76%) showed the greatest variability, consistent with the findings of Čobanović et al. (2019) (23.40% and 24.52%). Bendelja-Ljoljić (2018) reported similar variability in the MU concentration (24.82%) and lower variability in the milk fat content (14.20%).

Table 2 presents the average chemical composition of milk and urea concentration by farm. On Farm 1, goats were provided with a more concentrated feed containing a higher crude protein content (1.34 kg and 20.94%) compared to Farm 2 (1.1 kg and 16.34%). The results indicate statistically significant differences ($p < 0.01$) between the farms relative to the milk fat content and urea concentration. No statistically significant difference was observed in the protein content of the milk. However, the significant difference in milk urea concentration suggests a possible imbalance in the feed, potentially indicating an excess of crude protein. Kučević et al. (2016) similarly identified a statistically significant effect of farm management on the milk fat content. Paskaš et al (2023) also reported a significant impact of the housing system on the chemical composition of milk, with higher contents of milk fat, protein, lactose, and urea observed in grazing systems compared to indoor systems.

Table 2. Average composition of raw milk by farm

Farm	N	Milk fat (%)	Protein (%)	DMY (kg)	SNF (%)	Lactose (%)	MU (mg/dl)
1	982	3.06^{a}	3.37^{a}	1.16^{a}	8.54^{a}	4.36^{a}	43.65^{a}
2	2,027	3.38^{b}	3.35^{a}	1.14^{a}	8.51^{a}	4.35^{a}	34.23^{b}

Legend: Averages within the same column with different superscripts (a,b) differ significantly ($p < 0.01$)

Based on the results shown in Table 3, the MU concentration exhibited a highly significant positive correlation with the contents of milk fat, protein and SNF, whereas the positive correlation with the lactose content was not statistically significant.

Table 3. Correlation coefficients between the MU concentration, milk components, and daily milk yield

Trait	Milk fat (%)	Protein (%)	DMY (kg)	SNF (%)	MU (mg/dl)
Milk fat (%)	1.0000	0.5296*	-0.2671*	0.5166*	0.0524*
Protein (%)		1.0000	-0.3805*	0.8715*	0.0998*
DMY (kg)			1.0000	-0.3141*	-0.1085*
SNF (%)				1.0000	0.0886*
Lactose (%)					0.0211^{NS}

Legend: Significant differences: * $p < 0.01$, NS – non-significant differences $p > 0.01$

The positive correlation between the MU concentration and protein content was confirmed by Bonnano et al. (2008). The results obtained in this study align with those of Čobanović et al. (2019), except for the correlation between the MU concentration and lactose content, where they reported a statistically highly significant positive correlation ($p < 0.01$). Bendelja et al. (2011) also found a positive correlation between the milk fat content and MU concentration in goat's milk, as well as between the MU concentration and protein content. However, Abdouli et al. (2008), observed a negative correlation between the protein content and milk urea concentration, whereas Rajala-Schultz & Saville (2003) reported no significant correlation. Hojman et al. (2005) attributed the association between higher milk urea (MU) concentrations and increased milk fat content to the higher neutral detergent fiber content in animal feed, which promotes greater protein degradability. Todaro et al. (2005) reported a statistically highly significant positive correlation ($p < 0.001$) between the urea concentration and lactose content in goat's milk. The only negative correlation observed with the MU in this study was with the daily milk yield (DMY). In contrast to these findings (Tab. 3), some authors have reported a statistically highly significant positive correlation ($p < 0.001$) between the urea concentration in goat's milk and DMY (Todaro et al., 2005; Bonanno et al., 2008).

CONCLUSION

The farm, through its general management practices, plays a significant role in the variability of milk urea (MU) concentration in goat's milk, influencing other milk constituents. A positive and statistically significant correlation was observed between the MU concentration and the contents of milk fat, protein, and solids-not-fat (SNF), whereas an increase in the MU concentration negatively impacted the daily milk yield.

To optimize the protein content in goats' diets, farmers should utilize goat milk analysis by monitoring the MU-to-protein ratio. This approach aims to enhance nitrogen utilization for milk production while minimizing its excretion through urine into the environment.

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