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Chemical Composition and Physical Properties of Milk in Norduz Sheep

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ABSTRACT The objective of this study was to uncover the milk composition traits of Norduz sheep, which are bred in the Gürpınar district of the Van province, during the mid-term lactation period. The chosen ewes exhibited no signs of clinical or subclinical mastitis. A total of 104 sheep milk samples were meticulously collected to undergo comprehensive milk composition analysis. The chemical and physical attributes of Norduz sheep milk were methodically determined utilizing a milk autoanalyzer. The mean values for various milk constituents were as follows: milk fat (%), 2.48±0.11; solids-not-fat (SNF) (%), 10.76±0.08; milk protein (%), 5.09±0.04; lactose (%), 4.79±0.04; pH, 6.93±0.02; conductivity (mS/cm), 4.41±0.04; freezing point (°C), -0.602±0.80; salt (%), 0.8035±0.66; and density (kg/m^3), 1039.73±0.39. Noteworthy negative and statistically significant correlations were observed between milk fat and protein (r=-0.36, p<0.001), milk fat and SNF (r=-0.32, p<0.001), as well as milk fat and lactose (r=-0.36, p<0.001). Conversely, positive and significant correlations emerged between SNF and milk protein (r=0.90, p<0.001), SNF and salt (r=0.87, p<0.001), and SNF and lactose (r=0.90, p<0.001). In summation, the protein content of Norduz sheep's milk exceeded that of the majority of sheep breeds reared in Türkiye. These findings carry the potential to make a valuable contribution to enhancing the milk composition of Norduz sheep.

Keywords: *Sheep, Lactation, Milk, Milk protein.*

ÖZ

Norduz Koyunlarında Sütün Kimyasal Yapısı ve Fiziksel Özellikleri

Bu çalışmada, Van ili Gürpınar ilçesinde yetiştirilen Norduz koyunlarının orta laktasyon döneminde süt kompozisyon özelliklerinin ortaya konulması amaçlanmıştır. Koyunlar klinik ve subklinik mastitis yönünden değerlendirilmiş ve örnekler yalnızca sağlıklı koyunlardan toplanmıştır. Bu amaçla toplam 104 koyun sütü örneği toplandı. Norduz koyun sütünün kimyasal ve fiziksel özellikleri, süt otoanalizörü kullanılarak belirlenmiştir. Çalışmada Norduz sütünde süt yağı (%), 2.48±0.11; yağsız kuru madde (SNF) (%), 10.76±0,08; süt proteini (%), 5.09±0.04; laktoz (%), 4.79±0.04; pH, 6.93±0.02; iletkenlik (mS/cm), 4.41±0.04; donma noktası (°C),-0.602±0.80; tuz (%), 0.8035±0.66; ve yoğunluk (kg/m^3), 1039.73±0.39 olarak belirlenmiştir. Süt yağı ile protein (r=-0.36, p<0.001), süt yağı ile SNF (r=-0.32, p<0.001) ve süt yağı ile laktoz (r=-0.36, p<0.001) arasında negatif ve istatistiksel olarak anlamlı korelasyonlar gözlenmiştir. SNF ile süt proteini (r=0.90, p<0.001), SNF ile tuz (r=0.87, p<0.001) ve SNF ile laktoz (r=0.90, p<0.001) arasında ise pozitif ve anlamlı ilişkiler belirlenmiştir. Özetle, Norduz koyun sütünün protein içeriği Türkiye'de yetiştirilen koyun ırklarının çoğunluğunun protein içeriğinden yüksek olduğu tespit edildi. Bu bulgular Norduz koyunlarının süt bileşiminin arttırılmasına değerli bir katkı yapma potansiyeli taşımaktadır.

Anahtar Kelimeler: *Koyun, Laktasyon, Süt, Süt proteini.*

INTRODUCTION

Sheep are versatile animals, raised for their meat, milk, skin, and fleece. They are predominantly raised in developing countries across Asia and Africa. Türkiye stands out as a significant country in Asian sheep breeding (Aysondu et al. 2022). Based on current statistics, Türkiye boasts a sheep population of 44.6 million, encompassing various breeds (TUIK 2022). The majority of these breeds comprise indigenous breeds such as Akkaraman, Morkaraman, and Awassi. Due to its large sheep population, Turkey holds the second position in terms of sheep milk production after China (Mohapatra et al. 2019).

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Sheep milk holds significant nutritional value. The content of total solids and other components of sheep milk are higher than cow's milk. This characteristic allows for the utilization of smaller quantities of sheep milk in the production of dairy products (Wendorff and Haenlein 2017). The composition of sheep milk can be influenced by various factors, including genetic factors (breeds and genotypes), management practices, and the lactation stage. Studies indicate that there are variations in milk composition among the native sheep breeds of Türkiye (Yılmaz et al. 2004; Şahan et al. 2005; Ocak et al. 2009; Kiper and Alkan 2016; Koyun et al. 2021; Turgut et al. 2023).

The Norduz sheep breed is predominantly bred within the Gürpınar region of the Van province, primarily by smallholder farms. The population of Norduz sheep is recorded at 13,900 individuals (Dayan and Bingöl 2008). These sheep are recognized as a variant of the Akkaraman sheep breed. As a versatile breed, Norduz sheep are raised for their meat, milk, and wool production, so they are a crucial source of income for local breeders. The anticipated milk yield per lactation for Norduz sheep is approximately 137.2 kg, with a lactation period lasting roughly six months (Ocak et al. 2009). Notably, a substantial portion of Norduz sheep milk is used in the production of Van herbed cheese and butter (Yıldız and Aygün 2021). Nevertheless, limited information is available regarding the chemical composition and physical properties of Norduz sheep milk (Yılmaz et al. 2004; Ocak et al. 2009).

In light of these circumstances, the present study aimed to investigate the chemical composition and certain physical attributes of Norduz sheep milk during the mid-term lactation phase.

MATERIAL AND METHODS

This study was approved by Van Yuzuncu Yil University Animal Experiments Local Ethics Committee (Approval no: 2023/08-02).

Collection of Milk Samples

This study conducted the assessment of a total of 104 Norduz sheep milk samples. Milk samples were taken from sheep that were not found to have clinical or subclinical mastitis. The collection of milk samples was carried out using 50 ml sterile tubes prior to the morning milking routine. These samples were collected from a flock situated within the Gürpınar district of the Van province. Throughout the milk collection process, the sheep were provided with pasture-based feeding. In addition, each animal was fed 0.35 kg of barley and 0.50 kg of hay daily. The collected milk samples were transported to the laboratory at a temperature of +4 °C to facilitate the subsequent analysis.

Analysis of Milk Samples

The milk samples underwent analysis through the utilization of a ultrasonic milk analyzer (Lactoscan SA Milkanalyzer, Nova Zagora, Bulgaria). Device were calibrated for sheep milk. For the analysis, a total of 15 ml of milk sample was used. Each sample was subjected to analysis twice, and the outcomes were recorded. The analysis encompassed the determination of various components including milk fat (%), solids-not-fat (SNF) (%), milk protein (%), lactose (%), pH, conductivity (mS/cm), freezing point (°C), salt (%), and density (kg/ m^3). Deviation of the device for fat, SNF, density, protein, lactose, freezing point and salts were ±0.06 (%), ±0.15 (%), ±0.3 kg/m^3, ±0.20 (%), ±0.005 °C, ±0.05 (%) respectively. The results of milk autoanalyzer were also verified, using methods described by Association of Official Analytical Chemists (AOAC). Total solids in milk assessed by AOAC Official Method 925.23 Solids (Total) in Milk. Protein content of in milk was determined by AOAC official method (Kjeldahl's method) (Barbano et al. 1990). Fat in raw milk was assessed by Gerber method (Kleyn et al. 2001). Following verification, the results of milk autoanalyzer were used for statistical analysis.

Statistical Analysis

Descriptive statistics were computed to summarize the distribution for each parameter of milk composition separately. To report the central tendency and variation of the collected milk samples, mean±SE values were used with median (Q1-Q3). Minimum and maximum values of each measurement were also reported for better interpretation of results. Pearson's correlation analysis was performed to examine the possible correlations between milk composition traits. A critical value of $p<0.05$ was considered as a criterion of significance and all analyses were conducted by using The Statistical Package for the Social Sciences (SPSS 26.0, IBM) software package.

RESULTS

The mean values for the various milk components were as follows: milk fat (%), 2.48±0.11; solids-not-fat (SNF) (%), 10.76±0.08; milk protein (%), 5.09±0.04; lactose (%), 4.79±0.04 (Table 1); pH, 6.93±0.02; conductivity (mS/cm), 4.41±0.04; freezing point (°C), -0.602±0; salt (%), 0.8035±0.66; and density (kg/m^3), 1039.73±0.39 (Table 2).

Table 1: Descriptive statistics showing milk components of Norduz sheep.

	N	Mean±SE	Median (Q1-Q3)	Min.	Max.
Fat (%)	104	2.48±0.11	2.4 (1.8-2.9)	0.53	8.60
SNF (%)	104	10.76±0.08	10.8 (10.4-11.2)	7.92	12.60
Protein (%)	104	5.09±0.04	5.1 (4.9-5.3)	3.49	5.96
Lactose (%)	104	4.79±0.04	4.9 (4.6-5)	3.30	5.64
Salt (%)	104	0.8035±0.66	0.81 (0.78-0.84.3)	0.54	0.95

Table 2: Descriptive statistics showing physical properties of Norduz sheep.

	N	Mean±SE	Median (Q1-Q3)	Min.	Max.
Density (kg/m^3)	104	1039.73± 0.39	40.3 (38.6-42.3)	21.77	48.24
Conductivity (mS/cm)	104	4.41±0.04	4.4 (4.1-4.7)	3.54	5.97
pH	104	6.93±0.02	6.9 (6.8-7)	5.95	7.80
Freezing point (°C)	104	-0.602±0	-0.6 (-0.6--0.6)	-0.71	-0.40

Significant and negative correlations were observed between milk fat and protein ($r=-0.36$, $p<0.001$), milk fat and SNF ($r=-0.32$, $p<0.001$), as well as milk fat and lactose ($r=-0.36$, $p<0.001$). Conversely, positive and significant correlations were identified between SNF and milk protein ($r=0.90$, $p<0.001$), SNF and salt ($r=0.87$, $p<0.001$), and SNF and lactose ($r=0.90$, $p<0.001$). The correlation coefficients between the various milk characteristics are presented in Table 3 and Figure 1.

Table 3: Correlations between milk characteristics.

		Fat (%)	SNF (%)	Density (kg/m³)	Protein (%)	Conductivity (mS/cm)	Lactose (%)	pH
SNF (%)	Pearson's r	-0.32***	—					
Density (kg/m³)	Pearson's r	-0.522***	0.894***	—				
Protein (%)	Pearson's r	-0.36***	0.902***	0.936***	—			
Conductivity (mS/cm)	Pearson's r	-0.026	-0.161	-0.26**	-0.267**	—		
Lactose (%)	Pearson's r	-0.366***	0.907***	0.94***	0.96***	-0.281**	—	
pH	Pearson's r	0.04	0.014	-0.052	-0.096	-0.191	-0.077	—
Salt (%)	Pearson's r	-0.436***	0.87***	0.947***	0.928***	-0.213*	0.928***	-0.075

Note: * p <0.05, ** p <0.01, *** p < 0.001.

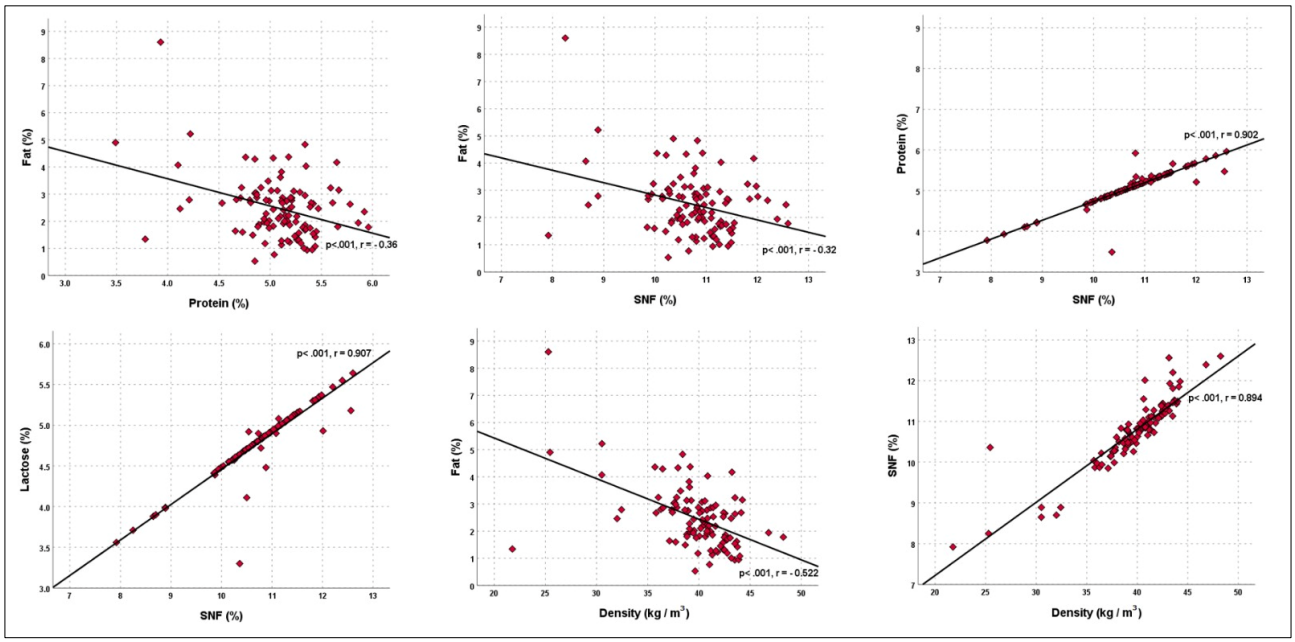

Figure 1: A scatter plot depicting the correlation between various milk characteristics.

DISCUSSION AND CONCLUSION

The current study revealed the milk composition of Norduz sheep during mid-term lactation. The milk composition of Norduz sheep has been investigated in a variety of studies. Previous research by Ocak et al. (2009) documented percentages of milk fat, SNF, and protein as 4.00±1.00, 10.56±1.50, and 7.4±0.69 during the early stage of lactation. In another study, percentages of milk fat, protein, and lactose were reported as 6.49±0.07, 6.11±0.08, and 5.07±0.17 (Yılmaz et al. 2004). This study, however, found notably lower milk fat percentages in Norduz sheep when compared to these other investigations. It's important to note that the stage of lactation significantly influences milk composition in sheep. Typically, a negative correlation exists between daily milk yield and milk composition (Pulina et al. 2005). Koncagül et al. (2012) elucidated that Norduz sheep exhibit a distinctive lactation curve, differing from other sheep breeds (Komprej et al. 2012; Kahraman et al. 2020). According to their findings, the daily milk yield of Norduz sheep peaks during the mid-term of lactation and subsequently decreases. Considering that the milk samples for this study were collected during the mid-term of lactation, it's plausible that the lower percentages of milk fat and protein in Norduz sheep could be attributed to their peak lactation phase. This distinctive timing may account for the observed disparities in milk composition when compared to previous studies in Norduz sheep.

Various studies have delved into the milk composition of native sheep breeds in Turkey, yielding diverse findings. For instance, in Awassi sheep, Şahan et al. (2005) documented percentages of milk fat, SNF, protein, and lactose as 6.61±1.33, 10.93±0.44, 5.68±0.47, and 4.34±0.27, respectively. Meanwhile, in Akkaraman sheep, the reported percentages of milk fat, protein, and lactose were 4.69±0.2, 4.76±0.07, and 5.58±0.08, respectively. In the case of Morkaraman sheep, Türkyılmaz et al. (2018) identified percentages of milk fat, SNF, protein, and lactose as 7.19±0.35, 9.67±0.26, 3.18±0.09, and 5.55±0.15, respectively. Moving to crossbreed Hamdani sheep, Turgut et al. (2023) observed percentages of milk fat, SNF, protein, and lactose as 7.49±0.15, 8.69±0.08, 4.13±0.04, and 3.89±0.04, respectively. Notably, comparisons between Norduz sheep and other breeds reveal higher milk fat percentages in Karayaka (Kiper and Alkan, 2016) and Tuj (Türkyılmaz et al. 2018) sheep. On the other hand, Slovenian Bovec and Istrian Pramenka dairy sheep breeds exhibited milk fat and protein percentages of 6.59±1.60, 5.53±1.14, and 7.20±1.62, 5.63±0.90, respectively (Komprej et al. 2012). Meanwhile, in Sarda sheep, the percentages of milk fat and protein were 6.70 and 6.09. Comparable values were reported in Chios sheep, with milk fat and protein percentages of 6.60 and 6.05 (Pulina et al. 2016).

The composition of sheep milk is significantly influenced by nutritional factors. Generally, milk composition tends to be more favorable in dairy sheep breeds subjected to intensive management practices (Pulina et al. 2005). However, in Turkey, sheep primarily graze on pastures,

with only a small quantity of hay and grains added to their diet, a practice observed in Norduz sheep as well. Within the Gürpınar district of the Van province, sheep predominantly rely on pasture feeding, particularly during the plant-rich spring season. It has been proposed that the elevated protein percentage in Norduz sheep milk could be attributed to the plant composition prevalent in the region (Ocak et al. 2009). This study further supports the findings of Ocak et al. (2009), revealing that during the mid-term lactation phase, the milk protein percentage of Norduz sheep surpasses that of other native Turkish sheep breeds. Thus, it can be inferred that the plant composition of the region significantly impacts the milk composition of Norduz sheep. Additionally, these outcomes underscore the suitability of Norduz sheep milk for cheese production due to its elevated protein content.

This study revealed noteworthy correlations among milk components. A significant negative correlation ($r=-0.36$, $p<0.001$) was identified between milk fat and protein percentages, and a similar negative correlation ($r=-0.366$, $p<0.001$) observed between milk fat and lactose percentages. This observation aligns with findings by Turgut et al. (2023) in crossbreed Hamdani sheep, where a negative and significant correlation between milk fat and protein as well as milk fat and lactose content was noted, akin to the current study. However, Pavić et al. (2002) reported a contrasting outcome, revealing a positive and significant correlation between milk fat and protein percentages. Additionally, this study unveiled positive correlations between solids-not-fat (SNF) and milk protein and lactose content. This can be attributed to the fact that protein, lactose, and minerals constitute the primary constituents of SNF, rendering the observed positive correlations between SNF and protein and lactose content plausible.

Across diverse native sheep breeds of Türkiye, including Norduz sheep, the pH range of milk typically falls between 6.5 and 6.9 (Şahan et al. 2005; Akdağ et al. 2018; Koyun et al. 2021; Turgut et al. 2023). In accordance with these previous findings, the present study established a milk pH of 6.93, corroborating similar reports. The density of sheep milk serves as a significant indicator for assessing milk components. Prior research indicated sheep milk density values of 1.030 kg/m^3 in Morkaraman, Tuj, and Awassi sheep (Türkyılmaz et al. 2018). In alignment with these results, the current study's findings revealed a sheep milk density of 1.039, which closely mirrors the reports in Norduz sheep by Ocak et al. (2009).

Indeed, the density of sheep milk tends to decrease with higher fat content due to the lower density of milk fat molecules. This phenomenon has been highlighted by Turgut et al. (2023), who suggested that such a relationship could result in a negative correlation between milk fat and density in crossbred Hamdani sheep. Similarly, in the present study, a negative correlation ($r=-0.522$) that holds statistical significance ($p<0.001$) was observed between milk fat and density. This aligns with the anticipated trend stemming from the milk composition.

It's important to emphasize that milk composition is notably influenced by genetic factors. Particularly, genetic variations within genes associated with milk traits can exert a significant impact on milk composition (Koyun et al. 2021). Given this consideration, the exploration of genetic variations tied to milk composition through molecular techniques could potentially offer a means to enhance the milk composition of Norduz sheep. This avenue of research holds the promise of fostering improvements in the quality and attributes of Norduz sheep milk.

CONFLICTS OF INTEREST

The authors report no conflicts of interest.

AUTHOR CONTRIBUTIONS

Idea / Concept: DK
Supervision / Consultancy: DK, NÇ
Data Collection and / or Processing: DK, NÇ, AOT, BK
Analysis and / or Interpretation: SÜ, EG
Writing the Article: DK, AOT
Critical Review: DK, AOT, NÇ

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