



Udder types and associated traits affect milk composition and subclinical mastitis in Karayaka sheep

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ABSTRACT

This study was carried out to determine the relationships between udder type and udder traits and milk composition and subclinical mastitis in Karayaka sheep. For this purpose, udder types were determined and udder and teat traits were measured in 32 Karayaka sheep. In addition, milk fat, protein, lactose, dry matter contents, freezing point, SCC and pH were measured. Our results showed that udder type had an effect on right (RTL) and left (LTL) teat length, right (RTDM) and left (LTDM) teat diameter and teat distance (TD). In addition, udder type was found to have an effect on lactose and pH. High or moderate phenotypic correlations were found between teat traits and lactose, freezing point and pH. In addition, of the phenotypic correlations between udder and teat traits, only the correlation between RTL and SCC was significant. SCC showed high phenotypic correlations with fat, lactose, dry matter, protein, freezing point and pH. Our results showed that udder type was effective on teat size, the sheep whose teats were vertical had low milk lactose and high pH, and the sheep with this type of udder were found to have a higher probability of mastitis.

Key words: Lactose, pH, Sheep, Somatic cell count, Teat traits

In sheep breeding, in the selection for high milk yield, yield records and pedigree information of sheep in addition to visual traits such as udder traits are utilized (Seker *et al.* 2000). In sheep, udder traits are very important in terms of dairy characteristics, adaptation to machine milking (Makovicky *et al.* 2014), lamb growth and survival and udder health (Kaygisiz and Dag 2017). In the assessment of udder traits, either direct measurements or linear scoring method based on the scoring of visual traits of udder are utilized (Makovicky *et al.* 2014). In the direct measurement of udder, the measurement of traits such as udder depth (UD), udder width (UW), udder circumference (UC), teat distance (TD), teat length (TL), teat diameter (TDM) and teat floor distance (TFD) are utilized (Unal *et al.* 2008). Udder traits are determined by many genetic and environmental factors. These factors are traits such as animal breed, lactation number and period, milk yield level (Fernandez *et al.* 1997), breeding system, udder health and udder type (Sari *et al.* 2015). Udder type is determined with

the visual assessment of some morphological characteristics of udder and teat (udder depth, degree of separation of the 2 halves, and degree of suspension of the udder, teat placement), not based on measurement (Altincekic and Koyuncu 2011).

Sheep milk is used extensively in cheese production since it includes high fat and protein and these products are sold for high prices. Thus, since the composition of milk and the problems that may occur in its quality will have a negative influence on the quality, shelf life, sale of milk and human life; safe and quality milk in sheep breeding has become an important issue (Kiper and Alkan 2016, Akdag *et al.* 2017). The traits which determine the quality of milk are fat, protein, dry matter, lactose rates and SCC which make up the composition of milk and pH value, which determines the acidity level of milk. In addition, these traits can also be assessed as an indicator of diseases such as mastitis due to the damage in udder tissue (Akdag *et al.* 2017).

Mastitis is a disease which causes severe economic losses due to reduction of milk yield, deterioration of milk quality, and being left out of the herd and treatment costs (Akdag *et al.* 2017). Subclinical mastitis is a form of mastitis on the udder tissue, which does not cause visible changes. In the diagnosis of subclinical mastitis, biochemical tests, California Mastitis Test (CMT) and indirect diagnosis methods such as somatic cell count (SCC) are utilized (Bastan and Salar 2016, Akdag *et al.* 2017). Since SCC

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method is accepted to be the most reliable methods in the diagnosis of subclinical mastitis, the limit values for SCC in raw milk according to types of animals are determined legally. For this purpose, in many countries such as European Union and Turkey, limit values for SCC in raw milk have been determined for cattle and buffalo. However, the same situation does not apply to sheep and the legal limit value for SCC in raw ewes' milk has not been fully determined yet (Yuceer *et al.* 2015, Salari *et al.* 2018).

This study was carried out to determine the udder traits, milk composition and somatic cell count (SCC) and pH of milk in Karayaka sheep and to determine the relationships between udder type and udder traits and milk composition and subclinical mastitis.

MATERIALS AND METHODS

Karayaka sheep (32) of a private sheep farm which conducted semi-intensive sheep breeding in Samsun (semi-arid climate) province, were used. Birth records of the enterprise were examined and of the herd which contained 250 ewes, 32 ewes with the same lactation number and period (100–120 days of lactation) were determined and included in the study. No changes were made in the husbandry-feeding conditions of the chosen sheep and the regimes of the farm were applied. The sheep were fed from the beginning of May until the end of October only through grazing. Apart from these months, they were grazed in the daytime and fed with a ration consisting of 400 g barley meal, 300 g corn silage, 200 g dry alfalfa and 1 kg wheat straw. Water was provided *ad lib*.

In selected sheep, udder type was determined before milking and after this, udder traits were measured on the same day and the same milking. After the udder traits were measured, the sheep were milked and samples were taken to find out the pH value of the milk, SCC and milk composition.

Defining the udder type: The morphological assessment of the udder was made in the sheep chosen for the study and 4 different types of udder were defined. The method reported by Unal *et al.* (2008) was used in defining the udder type. Udder types were defined as type 1 (Udder lobes are non-segmented and teats are horizontal); type 2 (Udder lobes are slightly segmented and teats are horizontal); type 3 (Udder lobes segmented and teats are between horizontal and vertical); and type 4 (Udder lobes segmented and teats are vertical or close to vertical).

Measurements of udder and teat: Of the udder and teat traits, udder depth (UD), udder width (UW), udder circumference (UC), teat distance (TD), right teat-floor distance (RTFD), left teat-floor distance (LTFD), right teat length (RTL), left teat length (LTL), right teat diameter (RTDM) and left teat diameter (LTDM) were measured. UD, UW, RTL, LTL, RTDM, LTDM were measured with digital calliper, RTFD and LTFD were measured with measurement stick, UC was measured with measuring type. The measurement of udder traits was conducted as stated in Fig. 1 (Yuceer *et al.* 2015).

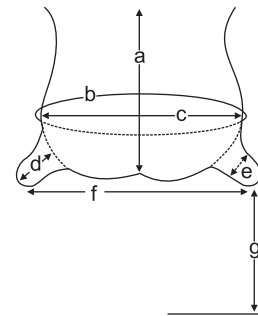


Fig. 1. Measurement of udder and teat traits. a, udder depth; b, udder circumference; c, udder width; d, teat length; e, teat diameter; f, teat distance, g, teat-floor distance.

Milk pH value measurement: After the measurement of udder traits was completed, the sheep were milked (while milking, different milking containers were used for each teat) and at least 40 ml milk samples were taken in 50 ml plastic sample containers, separately from each teat. In the milk samples taken, pH measurement was made by using glass electrode portable pH meter (Thermo Orion Star A1215).

Determining milk composition and SCC: In order to determine milk composition and SCC, milk samples of at least 40 ml were taken separately from both udder lobes of each sheep at the end of milking and they were put in sterile milk sample containers. Chemical tablets (Microtabs II), which inhibit microbial growth without influencing milk components and SCC, were added in milk samples and milk samples were transported to laboratory under cold chain conditions and they were analyzed. To find out milk SCC, fat, protein, lactose and dry matter ratios and freezing point, milk samples were first heated in a 40°C water bath. Combi 150 (Bentley) analysis device formed with the integration of somatic cell count device (Somacount 150) and milk components measurement device (Bentley 150) which works through Flow cytometry analysis method was used in milk analyses.

Statistical analyses: Coefficients of skewness and kurtosis and also normality test were performed to examine data structure. Therefore, non-normal distribution for SCC data was used logarithmic transformation with $SCC = \log_{10} SCC$. One-way ANOVA test procedure was executed to compare traits in udder and teats of relating udder types. Besides, differences of means of the groups were examined by DUNCAN's multiple comparison test. Traits of the left and right teats were also compared with t-test. GLM procedures were used to study the effect of teat and udder type on milk composition, pH and SCC. The Duncan test was performed to evaluate differences among the groups. Pearson correlations for the relationships of the udder type, udder traits, SCC, milk composition and pH were calculated. Probability values less than 0.05 were taken to be significant ($P < 0.05$). All calculations and analyses were performed with the SPSS package (version 21).

RESULTS AND DISCUSSION

The means of udder and teat traits of Karayaka sheep

Table 1. Comparison of udder traits for the udder type and teats (cm) (mean±SE)

Trait	Udder type				Overall
	1 (n=11)	2 (n=13)	3 (n=4)	4 (n=4)	
UD	12.68±0.32	12.57±0.31	12.79±1.21	11.97±0.97	12.57±0.25
UC	37.10±1.17	36.37±1.11	35.83±3.84	35.33±2.61	36.46±0.75
UW	9.95±1.04	9.91±0.36	9.77±0.57	97.24±0.21	98.93±0.39
RTL*	2.40±0.10 ^a	2.41±0.16 ^a	3.64±0.35 ^b	3.92±0.75 ^b	2.70±0.15
RTDM*	1.21±0.06 ^a	1.23±0.08 ^a	1.42±0.03 ^a	2.05±0.33 ^b	1.33±0.71
RTFD	30.25±0.97	30.87±0.74	30.00±1.32	30.33±3.33	30.50±0.56
TD *	16.65±0.77 ^a	14.70±0.46 ^{ab}	15.50±0.76 ^a	13.03±0.83 ^b	15.30±0.41
LTL*	2.29±0.12 ^a	2.38±0.20 ^a	2.95±0.33 ^{ab}	3.81±0.76 ^b	25.66±1.51
LTDM*	1.28±0.06 ^a	1.23±0.06 ^a	1.46±0.10 ^a	2.10±0.20 ^b	1.36±0.06
LTFD	29.45±0.66	31.33±0.57	30.33±2.89	28.50±3.05	30.25±0.53

	Teat		
	Right (n=32)	Left (n=32)	
TL	2.70±0.15	2.56±0.15	26.36±0.5
TDM	1.33±0.07	1.36±0.06	13.5±0.06
TFD	30.50±0.55	30.25±0.55	30.37±0.5

^{a,b}Different letters in the same row and for the same trait indicate a statistically significant difference ($P<0.05$). UD, Udder depth; UC, udder circumference; UW, udder width; RTL, right teat length; RTDM, right teat diameter; RTFD, right teat-floor distance; TD, teat distance; LTL, left teat length; LTDM, left teat diameter; LTFD, left teat-floor distance.

are presented in Table 1. In this study, means of the udder traits of Karayaka sheep were different from the values reported in researches conducted in various sheep breeds such as Ivesi (Dag and Zulkadir 2004), Kivircik, Tahirova and Karacabey Merinos sheep (Altincekic and Koyuncu 2011), Suffolk (Martinez *et al.* 2011) and Spanish Assaf (Perez-Cabal *et al.* 2013). In addition, the means of teat traits (Table 1) were different from the values reported for various breeds such as Ivesi (Seker *et al.* 2000), Tuj, Morkaraman (Kirmizibayrak *et al.* 2005, Sari *et al.* 2015), Lacaune (Milerski *et al.* 2006, Makovicky *et al.* 2014), Kivircik, Tahirova and Karacabey Merinos sheep (Altincekic and Koyuncu 2011), Anadolu Merinos sheep (Dogan *et al.* 2013). It was found that the values reported for udder circumference and teat diameter for Karayaka and Bafra (Sakýz × Karayaka G1 crossbreed) sheep, which had the same genotype with a rate of 25%, were similar to the values obtained in this study, while the values obtained for other traits were different (Unal *et al.* 2008). The reasons for different means of udder and teat traits obtained in this study and other studies were the sheep used in the researches having different breeds (Kirmizibayrak *et al.* 2005, Martinez *et al.* 2011, Makovicky *et al.* 2014), different lactation number (Altincekic and Koyuncu 2011) and different lactation period (Fuente *et al.* 1996, Martinez *et al.* 2011). A great number of environmental factors such as lactation number and period, body condition, udder health, breeding system and udder type are known to have an influence on udder and teat traits (Sari *et al.* 2015). Apart from environmental factors, another factor effective on udder and teat traits is breed. Dogan *et al.* (2013) explained the influence of breed with the heterozygote of the genes which determined udder traits. In addition, Fernandez *et al.* (1997)

reported that the heritability of udder and teat traits differed between 16–24%.

When the effect of udder type on udder and teat traits were examined (Table 1), udder type was found to have effects on teat lengths, teat diameter and teat distance ($P<0.05$). When compared with other udder types, sheep with udder Type 4 were found to have longer and wider teats and less teat distance. Dogan *et al.* (2013) reported that udder type had an influence on right teat length, teat distance, teat-floor distance and front udder depth. Fuente *et al.* (1997) reported that udder type affected teat size, udder depth, udder connection and udder shape. In addition, Unal *et al.* (2008) and Sari *et al.* (2015) reported that udder type in sheep affected udder width, while Dag and Zulkadir (2004) reported that udder type in sheep affected front udder depth. When right and left teat traits were compared (Table 1), teat length, diameter and teat-floor distance were found to have close values ($P>0.05$). Dag and Zulkadir (2004) found that in Awassi sheep, right and left teat length means were close and they were 3.85–3.76 cm, respectively. Dogan *et al.* (2013) reported that right and left teat lengths means were close and they were 2.64–2.73 cm, respectively, while right and left teat diameter means were close and they were 1.32–1.27cm, respectively.

Phenotypic correlation coefficients between udder traits and milk composition based on udder types are presented Table 2. When the phenotypic correlation coefficients between udder type and udder traits were examined, it was found that as the location of teat advanced to vertical (Type 4) from horizontal (Type 1–2 and 3), teat distance decreased and there was increase between teat length and diameter. In parallel with this result, Fernandez *et al.* (1997) reported that in udders with vertical teat, teats were long and as a

Table 2. Phenotypic correlation coefficients between udder traits and type, milk composition

Trait	Udder type	Fat	Protein	Lactose	Dry matter	Freezing point	pH
UD	-0.130	0.065	-0.144	0.342	0.015	-0.10	-0.023
UC	-0.145	0.129	-0.174	0.099	0.024	0.014	-0.044
UW	-0.036	0.173	0.008	-0.090	0.018	-0.170	0.075
RTL	0.632**	-0.064	0.213	-0.743**	-0.181	-0.387*	0.399*
RTDM	0.589**	-0.186	0.140	-0.783**	-0.316	-0.394*	0.391*
RTFD	0.004	-0.189	0.321	-0.495*	-0.347	-0.493*	0.431*
TD	-0.468*	0.491*	0.093	0.169	0.429*	-0.015	0.041
LTL	0.546**	0.153	0.099	-0.463*	0.049	-0.193	0.253
LTDM	0.620**	-0.013	0.229	-0.726**	-0.145	-0.383*	0.465*
LTFD	-0.030	-0.92	-0.045	-0.273	-0.208	-0.108	0.111
Udder type	-	-0.298	-0.060	-0.540*	-0.309	-0.211	0.197

* $P < 0.05$; ** $P < 0.01$. UD, Udder depth; UC, udder circumference; UW, udder width; RTL, right teat length; RTDM, right teat diameter; RTFD, right teat-floor distance; TD, teat distance; LTL, left teat length; LTDM, left teat diameter; LTFD, left teat-floor distance.

result, teat was enlarged due to the accumulation of milk on teat. Kominakis *et al.* (2009) reported that teat angle was negatively correlated with teat diameter and length. In sheep types with vertical teat, less distance between teats when compared with other types is an expected result. Median suspensory ligaments influenced appearance of the udder and the position of the teats. Median suspensory ligaments in the udder tissue allowed the udder to attach tightly to abdominal wall and make udder lobes more obvious. Since a strong connection prevents the low-hanging udder, it is a preferred trait in animal breeding. However, deep median bond decreases the distance between teats and causes the teats to get closer and to locate from horizontal to vertical (Sendag and Emre 2016). A great number of factors such as breed (Makovicky *et al.* 2014), lactation number (Akdag *et al.* 2017), lactation period (Martinez *et al.* 2011) and udder health (Sari *et al.* 2015) are influential in the length and diameter of teats, that is, on their sizes. However, different teat sizes in sheep within the same herd of a breed which have the same lactation number and period can be related with milk flow rate depending on the type of udder and udder type. Rovai *et al.* (2004) reported that in sheep with vertical teats, milking is easier and teat sizes differ based on milk yield and milk flow rate.

In line with the results about udder and teat traits, it can be said that udder type and teat traits should be taken into consideration in the selection based on udder traits. Udder type and accordingly the position of teats can affect especially new born lambs' reaching the teats and sucking milk because in sheep with horizontal teat, it is more difficult for the lambs to reach the teat and milk flow rate is slower when compared with sheep with vertical teat. Based on these, not being able to suck milk can negatively influence lambs' weight gain increase and their resistance to diseases and can decrease the growth performance of the lamb. Thus, in dairy sheep breeds, dairy characteristics and milking capability should be paid attention to, while in meat type sheep breeds, udder type and teat traits should be paid attention to in the selection of breeder in terms of

the lambs' growth performance. Makovicky *et al.* (2014) reported that in terms of milking characteristics and milking capability, teat position, teat sizes and udder depth can be assessed as the selection criteria. Kaygisiz and Dag (2017) stated that udder type in sheep is important in terms of lamb breeding and in case of upward and lateral position of teats, it will be difficult for small lambs to reach the udder and this will influence the lambs' nourishment and vitality.

When the effect of udder type on milk composition and pH was examined (Table 3), it was found that udder type affected only milk lactose and pH ($P < 0.05$) and sheep with an udder Type 4 had lower milk lactose and higher pH when compared with other types. Unlike the results of this study, Dogan *et al.* (2013) and Sari *et al.* (2015) reported that milk fat, protein, dry matter and lactose rates had close values according to udder types and udder type did not affect milk composition. When the composition of milk samples and pH taken from the right and left teats were examined (Table 3), fat, protein and dry matter and also freezing point and pH were found to be close ($P > 0.05$). Yuceer *et al.* (2015) reported milk pH taken from the right and left udder lobes of Sakýz \times Akkaraman G1 cross-breed sheep in the second month of lactation were close and they were 6.69- 6.71, respectively. Kominakis *et al.* (2009) reported that milk composition was not affected by teat traits.

When the phenotypic correlations of udder type with milk composition and pH were examined (Table 2); it was found that udder type had a high correlation only with lactose ($P < 0.05$) and that decreased lactose with the changes in the positioning of teat from horizontal to vertical (from Type 1 to Type 4). When the effects of udder type on milk composition and pH (Table 3) and the phenotypic correlations between these traits are examined together (Table 2), it is thought that the changes in the milk of sheep which have Type 4 udder can be resulting from subclinical mastitis because in this type of sheep (with vertical teat), there is a high possibility of the teat to be injured (Rovai *et al.* 2004). Teat injuries and lesions are important factors which cause udder infections and mastitis (Bastan and Salar 2016). Udder infection which occurs with mastitis can

Table 3. Comparison of milk composition and pH for the udder type and teats (mean±SE)

Trait	Udder type				Overall
	1	2	3	4	
Fat (%)	9.27±0.55	7.77±0.49	7.57±1.32	7.30±0.93	7.98±0.04
Protein (%)	5.68±39	5.97±0.35	5.14±0.94	5.56±0.66	5.58±0.31
Lactose (%)*	4.70±0.15 ^{ab}	4.68±0.14 ^{ab}	4.82±0.33 ^a	3.99±0.26 ^b	4.54±0.20
Dry matter (%)	20.74±0.66	18.81±0.59	19.10±1.58	18.55±1.22	19.30±0.54
Freezing point (°C)	0.54±0.01	0.52±0.09	0.56±0.02	0.52±0.01	0.54±0.01
pH*	6.52±0.08 ^a	6.68±0.08 ^{ab}	6.42±0.17 ^a	6.97±0.20 ^b	6.65±0.07

Trait	Teats		Overall
	Right	Left	
Fat (%)	8.14±0.48	8.34±0.49	8.24±0.34
Protein (%)	5.77±0.32	5.75±0.33	5.76±0.23
Lactose (%)	4.67±0.13	4.55±0.14	4.61±0.09
Dry matter (%)	19.55±0.59	19.48±0.59	19.52±0.42
Freezing point (°C)	0.537±0.008	0.53±0.008	0.53±0.006
pH	6.63±0.08	6.61±0.08	6.62±0.05

^{a,b}Different letters in the same row and for the same trait indicated a statistically significant difference ($P < 0.05$).

change the milk composition and cause increases in pH value and decreases in lactose value (Pir Yagci 2008). Thus, in sheep with Type 4 udder, the increase in pH value with the decrease in lactose value can be accepted as the indicator of subclinical mastitis.

When the phenotypic correlations between udder traits and milk composition and pH were assessed independently of udder type (Table 2); it was found that as RTL and RTDM increased and teats were closer to the floor, there was an increase in pH ($P < 0.05$) and a decrease in milk lactose ($P < 0.01$) and freezing point ($P < 0.05$). A similar relation was found between LTL and LTDM lactose ($P < 0.05$); between LTDM and freezing point and pH (Table 2). Sarý *et al.* (2015) reported that udder front and back depth had a significant correlation with only fat. Ayadi *et al.* (2014) reported that teat traits and milk fat were related. Kominakis *et al.* (2009) reported that udder traits were not related with milk composition. Environmental factors such as husbandry and feeding, lactation number, lactation period, season, milking number, gestation and udder health and genotype are known to affect milk composition. This study was conducted on a sheep herd of Karayaka with the same lactation number, lactation period, husbandry and feeding conditions which were milked once a day and the influence of a great number of environmental factors and genetic factors which can affect milk composition were eliminated. Thus, when the relationships between udder traits and milk composition were assessed, despite the change in teat traits, the increase in pH values and the decrease in milk lactose and freezing point can be related with udder health, that is, mastitis. Indeed, another result of this study, high correlations found between SCC and lactose, freezing point and pH (Table 5) support this result. The damage in udder tissue which occurs as a result of mastitis increases SCC and changes milk composition. The infection transmits from the blood to the milk and increases occur in the amount of

protein, enzyme and some minerals in the milk and changes occur in milk composition (Vural *et al.* 2016). There occurs an effort to balance the osmotic effect of the increased mineral with lactose concentration and decreases occur in the milk lactose level as a result of this (Abdelgawad *et al.* 2016). In addition, the transmission of the components constituting blood to milk through infection causes the pH value of milk to get closer to the pH value of blood and the infected milk to be mildly alkaline (Vural *et al.* 2016). In some of the studies conducted previously, it has been reported that the decrease in milk lactose (Sharma *et al.* 2014) and freezing point (Akdag *et al.* 2017, Caboni *et al.* 2017) and the increase in pH value (Caboni *et al.* 2017) can be accepted as an indicator of subclinical mastitis.

When the milk SCC values were compared according to udder types and teats (Table 4), the SCC values taken from right and left teats and the SCC of sheep with different udder types were found to be close ($P > 0.05$). When the phenotypic correlations between SCC and udder traits were examined (Table 5), SCC showed high positive correlation with RTL

Table 4. Comparison of SCC for the udder type and teats (mean±SE)

Trait	SCC
<i>Udder type</i>	
1	1.63±0.19
2	1.59±0.17
3	2.51±0.48
4	1.90±0.35
<i>Teats</i>	
Right	1.75±0.21
Left	2.06±0.24
Overall mean*	1.90±0.16
Overall mean**	187.59

*SCC = \log_{10} SCC; **SCC = $\text{SCC} \times 10^3$.

Table 5. Phenotypic correlation coefficients between SCC and pH, milk composition, udder traits and type

Trait	SCC
<i>Udder-teat</i>	
UD	0.240
UC	-0.197
UW	0.125
RTL	0.451*
RTDM	0.306
RTFD	0.332
TD	0.151
LTL	0.268
LTDM	0.313
LTFD	0.154
Udder type	0.183
<i>Milk composition</i>	
Fat	0.336*
Protein	0.663**
Lactose	-0.365*
Dry Matter	0.295*
Freezing Point	-0.400**
pH	0.615**

*P<0.05; **P<0.01. SCC = log₁₀SCC. UD, Udder depth; UC, udder circumference; UW, udder width; RTL, right teat length; RTDM, right teat diameter; RTFD, right teat-floor distance; TD, teat distance; LTL, left teat length; LTDM, left teat diameter; LTFD, left teat-floor distance.

(P<0.05) and moderate positive correlation with teat traits other than LTFD. In line with these results, it can be said that in parallel with the increase in teat sizes, SCC value also tends to increase. Similarly, Fernandez *et al.* (1997) reported that there will be an increase in the SCC count of sheep which have long teats. Perez-Cabal *et al.* (2013) reported that SCC had a positive phenotypic correlation with teat length and diameter.

Somatic cell is found naturally in milk and it is accepted as a significant indicator of milk quality and udder health (Li *et al.* 2014). Thus, somatic cell count is utilized in the quality of milk and dairy products and in differentiating between healthy udder lobes and lobes with mastitis (Bastan and Salar 2016). In this study, average SCC level of sheep in one millilitre was 187×10^3 (Table 4). In previous studies conducted on different sheep breeds, SCC value in millilitre was found as 237- 3264 $\times 10^3$ by Leitner *et al.* (2003) and between 5.12–6.17 (log SCC/ml) by Abdelgawad *et al.* (2016). It was found as 464×10^3 (on the second month of lactation) in Sakýz \times Akkaraman G₁ crossbred sheep by Yuceer *et al.* (2015) and as 201×10^3 in Tuj breed by Sari *et al.* (2015). In Karayaka sheep, Kiper and Alkan (2016) reported that SCC differed between 62 and 191×10^3 /ml for the first four lactations. SCC can differ as a result of many factors such as the animals' breed, lactation period and number, husbandry conditions, season, milking interval, sampling time, stress and trauma (Li *et al.* 2014). Thus, SCC reported in the present study and other studies differed from each other in terms of genotypic and environmental factors. Since the increase in SCC as a result of mastitis

affects the product quality and human health, acceptable SCC is determined for SCC in the milk of different species of animals. In the USA, the acceptable legal limit for SCC in sheep milk is 1×10^6 in tank milk (Li *et al.* 2014). On the other hand, no threshold value has been determined for SCC in sheep milk in European Union (Salari *et al.* 2018) and Turkey (Yuceer *et al.* 2015). In some studies, about the differentiation between healthy or infected sheep and about the determination of threshold value in raw milk, it has been reported that SCC should be less than 500×10^3 ml/millilitre (Souza *et al.* 2012, Salari *et al.* 2018). In the present study, the SCC can be seen to be far below the threshold value recommended in studies about average SCC for Karayaka sheep and the legal threshold value accepted by the USA.

When the phenotypic correlations between SCC's milk composition and pH are examined (Table 5); it can be understood that parallel with the increase in SCC, there will be an increase in fat, protein, dry matter and pH, while there will be a decrease in freezing point and lactose. This result showed that milk composition and pH are related with SCC in sheep and these characteristics can be used in the diagnosis of subclinical mastitis. Riggio (2012) reported that, protein, fat and pH increased while lactose decreased in sheep with mastitis. Caboni *et al.* (2017) reported that in milk with high SCC, fat, protein and pH were higher and freezing point was lower when compared with milk with low SCC. Leitner *et al.* (2003) reported that milk composition (fat, protein and lactose) differed between herds and in udders with mastitis, and milk lactose was lower when compared with healthy udders.

As a conclusion, it can be said according to our results that udder type affects teat sizes, milk lactose is lower and pH is higher in sheep with vertical teat and the probability of mastitis in these kinds of udder type (Type 4) can be higher. In addition, with the increase in teat sizes, SCC tend to increase and that there may be changes in milk composition and pH based on the increase in somatic cell count. Thus, in maternal sheep, in selection of breeding about ease of milking, lambs' growth performance and mastitis predisposition, it will be useful to take into consideration udder type and teat traits.

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