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Effects of udder characteristics on milk yield and milk quality in Eşme sheep

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Abstract

The current study was conducted on 38 sheep in a private enterprise engaged in the breeding of Eşme sheep in Uşak province, and measurements were taken on the 30th and 60th days of lactation. Sheep were classified according to udder type, and the relationship between udder type, udder characteristics, milk yield, and milk quality was investigated. The effect of udder type on milk yield and milk quality was found to be inconsequential. The measurement date was found to have a substantial effect on udder depth, udder circumference, udder width, distance between teats, the distance between teat and ground, as well as on milk yield and milk quality. At the beginning of the lactation, the milk was of higher quality, but as the lactation progressed, both the quality and yield decreased. There was an effect of birth type on milk quality characteristics; milk quality decreased with multiple births. Quality characteristics including fat, dry matter, density, protein, lactose, and freezing point values were examined. Udder measurements and udder types of Eşme sheep are suitable for milking, and the breed satisfies breeders in terms of milk quality. Increasing support is necessary to promote the breeding of Eşme sheep.

Keywords: Eşme sheep, udder type, milk yield, milk quality
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Introduction

Sheep farming can be conducted anywhere in the world as long as the climate and environmental conditions are suitable. Türkiye is an ideal country for sheep farming. Generally, sheep breeds that have adapted to harsh climatic conditions and can make use of inadequate grazing lands are found in Turkey (Kaymakçı, 2010). Sheep farming, which is a part of Turkish culture, is an economic activity carried out in weak pastures within an extensive system in almost every region of the country. However, this method of production has drawbacks in terms of determining the true genetic potential of the animals. Although current data show that domestic animals have low milk and reproductive productivity, studies on them show that the variation in production characteristics is an important element in breeding these animals (Biçer *et al.*, 2019).

Within the scope of the "Public Breeding Projects" of the Ministry of Agriculture and Forestry, genetic progress and a sample herd were obtained. Breeding studies are generally carried out through hybridization. In the name of pure breeding, the breeding of meat–fleece, yield-oriented, and milk–seed productivity-oriented breeds has increased through imports in our country in recent years, and farms producing breeding stock have become an important sector (Anonymous, 2024).

Sheep numbers have been increasing in Türkiye in recent years. The sheep population, which was 26,972,000 animals in 2001, increased to 35,194,972 animals in 2018, and decreased from 44,687,888 in 2022 to 42,565,444 animals in June, 2023. There were 496,501 sheep in Uşak province and 175,000 of these were in the Eşme district (Anonymous, 2023).

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In Uşak province, there are 496,501 sheep (Anonymous, 2024). In the Eşme district of Uşak province, there are 175,000 sheep (Anonymous, 2022a). The origin of the Eşme sheep is the Dağlıç breed. With the crossbreeding of the Kıvırcık breed with the Dağlıç breed, the breed's characteristics started to form, and later, through Chios crossbreeding, the Eşme sheep breed was created. It is a breed with high milk and meat yield. Starting from the year 2011, both TÜBİTAK (The Scientific and Technological Research Council of Turkey) and local, community-led improvement projects have been initiated for the Eşme district sheep, aiming to improve the Eşme sheep breed (Anonymous, 2022b). The Eşme sheep breed was registered and officially recognized with the decision published in the Official Gazette, numbered 31240, and dated September 10, 2020 (2022c).

One of the characteristics taken into consideration in animal breeding is milk yield. The current study was conducted to determine the effects of udder characteristics on milk yield and milk quality in Eşme sheep. When the effect of udder type on milk quality was determined, udder type was chosen as a selection criterion in in sheep breeding studies. The current study is the first on udder characteristics and milk yields in Eşme sheep and the study serves as a foundation for future research in this area.

Material and Methods

The research was conducted in Uşak province following the approval of Uşak University Animal Experiments Local Ethics Committee (USAKHADYEK 2019/19-03).

Eşme district, where the research was conducted, is located 62 km southwest of Uşak province, its latitude is 38.3999 and longitude is 28.9714. This study was conducted on a total of 38 Eşme sheep, aged >4 y, within the integrated flock of the Eşme, as part of the Eşme Curly sheep project, on a privately-owned farm. The sheep's feeding needs are generally met by the pasture. Sheep are grazed in the pasture during the evening in the summer months (April–October) and during the daytime in the pasture in the winter months (November–March). On days when they are not taken out for pasture grazing, feeding is performed in the evening and morning. On days when the sheep are taken out for grazing, each sheep is given an average of 1 kg of corn silage, 0.3 kg of barley bran, and 0.1 kg of clover. During the lactation period, on days when the sheep do not go out to pasture, these amounts are given per sheep as a daily average of 2 kg of corn silage, 0.6 kg of barley bran, and 0.2 kg of clover. Sheep are not taken out for grazing during cold and rainy weather conditions. In cold weather conditions, the sheep are prevented from getting wet and they are fed with roughage, primarily.

The current study used Epstein's (1985) research for the identification of udder types (Figure 1).

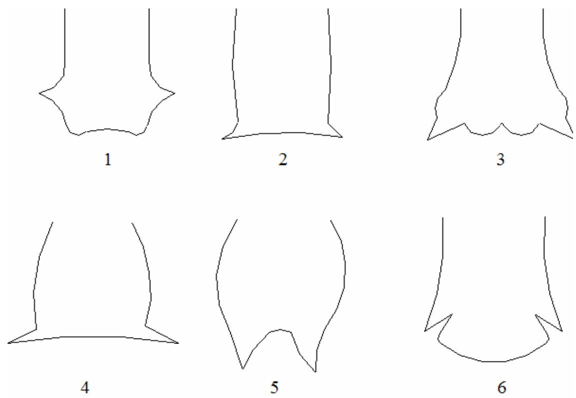
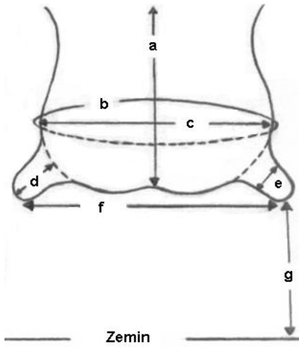


Figure 1. Udder types found in sheep (Epstein, 1985)

(1) Cylindrical udder, udder teats are upward and lateral,
(2) Cylindrical udder, udder teats are downwards and inclined,
(3) Pear-shaped udder, udder teats are downwards and inclined,
(4) Pear-shaped udder, udder teats are downwards and horizontal,
(5) Udder teats are big, udder which is downwards and vertical,
(6) Udder teats are upward and udder is inclined.

The udder types of the sheep used in the current study were determined based on observation using the types shown in Figure 1. Measurements were taken on the 30th and 60th days of lactation. Udder measurements were taken in the morning before releasing the sheep to the pasture and before the lambs were suckled. Udder measurements were taken using a measuring tape. The measurements taken for the udder and teats are presented in Figure 2.



a: Udder depth
b: Udder circumference
c: Udder width
d: Udder teat length
e: Udder teat diameter
f: Distance between udder teats
g: Distance between udder teat and ground

Figure 2. Udder and teat measurements scheme (Ünal *et al.,* 2008)

In the study, the determination of milk yield and its components was conducted simultaneously with udder measurements taken before morning grazing and before the lambs were suckled on the 30th and 60th days of lactation. In the study, 100-ml milk samples were collected from 38 sheep and placed into sealed, sterile sample containers. The samples were preserved under cold chain conditions (+4 ºC) and transported to the Uşak University laboratory. Subsequently, they were then analysed and the milk constituents (milk fat, somatic cell count, density, protein, lactose, salt, freezing point, conductivity) of the milk samples were determined using the Milkotester Master Classic LM2-P1 analysis device.

The statistical evaluation of the study data was performed using the repeated measures covariance analysis method and a mixed model approach. In the repeated measures covariance model, measurements on the 30th and 60th days were considered as repeated data for each characteristic under consideration. In the statistical model, udder type and birth type were included as factors and age as a covariate variable. To determine whether there were differences among categories of udder type and birth type, corrected means based on the age variable were compared using the Tukey method. During these multiple comparisons, corrected P-values were considered as the basis. All statistical analyses used in the study were performed using SAS 9.4 software (SAS Institute Inc., 2013).

Results and Discussion

External measures of udder size (circumference, width and depth of the udder) are strongly correlated with milk production in sheep. The morphological udder traits determining its suitability for machine milking (such as teat position and teat angle, udder depth, teat size, cistern height) are related to mammary gland health in sheep. Thus, the incidence of mastitis is noticeably higher in the udders that are unsuitable for machine milking (such as deep and hung udders, unfavourable position of teats) (Vrdoljak *et al.,* 2020*).* Udder type should be taken into consideration in milk-oriented breeding programs. Animals with larger udders have higher milk yields (Kukovics *et al.,* 1993). Udders with teats close to the ground, with larger circumferences and with greater depth tend to have a higher somatic cell count, which increases the risk of mastitis (Fernandez *et al.,* 1997).

The measurements were taken on the 30th and 60th days of lactation. The difference between measurement times was statistically significant, whereas birth types and udder types were similar (Table 1).

Table 1 Factors affecting udder depth, udder circumference, udder width (cm)

Udder Type	n	Udder Depth (cm) X̄ ± S			Udder Circumference (cm) X̄ ± S		Udder Width (cm) X̄ ± S	
		N.S			N.S		N.S	
1	4	1st measurement	12.5±1.23	11.75±1.0	40.08±2^A	35.08±1.54	24.04±1.56^A	19.17±1.25
		2nd measurement	11±1.23		30.08±2^B		14.29±1.56^B	
2	13	1st measurement	15.97±0.7^A	14.03±0.6	40.47±1.13^A	36.13±0.88	19.42±0.88^A	17.44±0.71
		2nd measurement	12.09±0.7^B		31.78±1.13^B		15.46±0.88^B	
4	15	1st measurement	14.24±0.69	13.5±0.6	38.05±1.11^A	34.33±0.89	19.83±0.87^A	16.95±0.72
		2nd measurement	12.76±0.69		30.62±1.11^B		14.07±0.87^B	
5	6	1st measurement	16.13±1	14.88±0.8	43.38±1.63^A	36.71±1.26	20.67±1.27	19.25±1.02
		2nd measurement	13.63±1		30.04±1.63^B		17.84±1.27	
		Measurement	***		***		***	
	38	1st measurement	14.71±0.47^A		40.49±0.76^A		20.99±0.6^A	
	38	2nd measurement	12.37±0.47^B		30.63±0.76^B		15.41±0.6^B	
		Birth Type	N.S		N.S		N.S	
	12	12 Single	14.35±0.65		36.27±0.95		19.35±0.77	
	19	19 Twins	13.72±0.55		35.43±0.81		18.05±0.66	
	7	7 Triplets	12.56±0.81		34.98±1.19		17.21±0.96	

N.S.: not significant, A,B: Difference between the groups with different letters in the same column is significant (*P <0.05; ***P <0.001)

In the study, it was determined that the measurement time affected the udder depth, circumference, and width (P <0.001), whereas the effects of udder type and birth type were similar in the sheep. The mean value determined for udder depth in sheep in the measurements made on the 60th day was 12.37 cm in the current study. On the 60th day, Mundan (2003) found a value of 14.8 cm in Chios × Akkaraman (G_1) sheep, whereas Ünal *et al.* (2008) reported it to be 14.8 cm in Bafra sheep. The results obtained in the current study were found to be lower than other studies. This may be due to the use of different breeds of sheep. Mundan (2003) found a value of 12.3 cm in Kıvırcık × Akkaraman (G_1), which is similar to the value obtained in the current study.

Altınçekiç & Koyuncu (2011) reported udder circumferences of 43.00 cm, 35.82 cm, and 34.34 cm for Tahirova, Kıvırcık, and Karacabey Merino breed sheep, respectively, whereas Sezenler *et al.* (2016a) found this value to be 45.9 cm in Bandırma sheep. Therefore, it can be said that there are differences and similarities in the measured values for udder circumference in relation to the milk yield.

In the second measurement of Eşme sheep (on the 60th day of lactation), the value obtained was lower than the 17.2 cm value found by Emediato *et al.* (2008) in Bergamasca sheep on the same day of lactation. Adamu *et al*. (2024) found that 13.70 cm udder length, 12.88 kg udder weight, 4.15 cm udder circumference, 2.71 cm teat length, and 1.67 cm teat width values were higher in the Yankasa breed during lactation than the Uda breed (P <0.05). The results are however in line with the results of the current study.

Sari *et al*. (2015) carried out a study on Tuj sheep and found that udder circumference, udder depth, lower udder height, upper udder height, and udder width values were strongly affected by the lactation stage (P <0.01). The effect of lactation order on udder measurements and the chemical composition of milk, and the effect of udder type on the chemical composition of milk was found to be non-significant (P >0.05). The results obtained concur with the present study.

In the current study, the distance between teats was not affected by udder type, whereas measurement time and birth type affected this (P <0.05) (Table 2).

Table 2 Factors affecting teat length and the distance between teats

Udder Type	n	Udder teat length, left (cm) X̄ ± S			Udder teat length, right (cm) X̄ ± S		Distance between udder teats (cm) X̄ ± S	
		N.S			N.S		N.S	
1	4	1st measurement	2.51 ± 0.3	2.42 ± 0.24	2.43 ± 0.22	2.29 ± 0.19	19.33 ± 2.09	18.45 ± 1.66
		2nd measurement	2.33 ± 0.3		2.15 ± 0.22		17.58 ± 2.09	
2	13	1st measurement	2.43 ± 0.17	2.36 ± 0.14	2.43 ± 0.13	2.34 ± 0.11	19.07 ± 1.18	15.07 ± 21.84
		2nd measurement	2.29 ± 0.17		2.25 ± 0.13		15.61 ± 1.18	
4	15	1st measurement	2.42 ± 0.17	2.45 ± 0.14	2.36 ± 0.13	2.32 ± 0.11	18.84 ± 1.16	18.34 ± 0.96
		2nd measurement	2.48 ± 0.17		2.27 ± 0.13		17.84 ± 1.16	
5	6	1st measurement	2.49 ± 0.25	2.19 ± 0.2	2.21 ± 0.18	2.1 ± 0.16	23.77 ± 1.7	21.44 ± 1.35
		2nd measurement	1.89 ± 0.25		1.99 ± 0.18		19.11 ± 1.7	
		Measurement	N.S.		N.S.		***	
	38	1st measurement	2.46 ± 0.12		2.36 ± 0.09A		20.25 ± 0.8A	
	38	2nd measurement	2.25 ± 0.12		2.17 ± 0.09B		17.53 ± 0.8B	
		Birth Type	N.S		*		*	
	12	12 Single	2.6 ± 0.15		2.52 ± 0.12A		20.59 ± 1.02	
	19	19 Twins	2.19 ± 0.13		2.14 ± 0.10B		18.98 ± 0.87	
	7	7 Triplets	2.27 ± 0.19		2.12 ± 0.15AB		17.11 ± 1.27	

N.S.: not significant, A,B: Difference between the groups with different letters in the same column is significant (**P* <0.05, ****P* <0.001)

In the current study, the udder measurements decreased as lactation progressed. The reason for this may be considered as an instinctive behaviour of sheep to store the milk in their udders for their lambs and not to let it down. In addition, the decrease in milk yield is also due to the change in the quality of the pasture over time.

Kaygısız & Dağ (2017) in Avassi sheep found that udder type I, II, III, IV and VI sustained the ratios of 31%, 1%, 42%, 3% and 23%, respectively. The average of total milk yield and lactation period were determined to be 244.39 ± 73.04 L and 173.81 ± 16.92 days, respectively. The study conducted by the researchers is consistent with the findings.

Nazmi Karkaj *et al.* (2021) carried out a study on Mohabadi goats; they found that the right and left udder length showed the highest correlation and right teat length significantly affected milk yield. In the current study, the effect of udder characteristics, milk yield, and milk quality on udder type was not substantial. In this respect, it differs from the study mentioned.

In their study with 50 sheep of the Lacaune breed imported from France, Panayotov *et al.* (2018) found that the udder width of the sheep was 12.35 cm, the udder depth was 16.85 cm, and the circumference was 41.46 cm. Udder length was found to be 2.70 cm, udder width was 1.38 cm and the distance between the teats was 15.78 cm. The results are in line with the results of the present study

The distance between the two teats is important for animals during the lactation period. If this distance is not at the desired values, it may cause problems, especially during the milking period and the suckling period of lambs.

In the current study, the effect of birth type on the diameters of left and right teats and the distance of teats from the ground was found to be important (*P* <0.05), and the effect of measurement time on the distance of teats from the ground was found to be significant (*P* <0.001) (Table 3).

Table 3 Factors affecting teat diameter (left-right) and the distance between teat and ground

Udder Type	n	Udder Teat Diameter Left (cm) X̄ ± S			Udder Teat Diameter Right (cm) X̄ ± S		Distance between Udder Teat and Ground (cm) X̄ ± S	
		N.S			N.S		N.S	
1	4	1st measurement	4.33 ± 0.52	4.27 ± 0.41	4.28 ± 0.51	4.28 ± 0.45	37.65 ± 1.75	39.53 ± 1.57
		2nd measurement	4.21 ± 0.52		4.28 ± 0.51		41.4 ± 1.75	
2	13	1st measurement	5.38 ± 0.29	5.13 ± 0.23	5.48 ± 0.29	5.08 ± 0.26	34.55 ± 0.99A	36.32 ± 0.89
		2nd measurement	4.88 ± 0.29		4.68 ± 0.29		38.09 ± 0.99B	
4	15	1st measurement	5.04 ± 0.29	5.19 ± 0.24	5.37 ± 0.29	5.4 ± 0.26	36.35 ± 0.99A	38.03 ± 0.9
		2nd measurement	5.34 ± 0.29		5.42 ± 0.29		39.71 ± 0.99B	
5	6	1st measurement	5.15 ± 0.43	4.82 ± 0.33	4.93 ± 0.42	5 ± 0.37	33.76 ± 1.42	35.6 ± 1.28
		2nd measurement	4.5 ± 0.43		5.08 ± 0.42		37.43±1.42	
		Measurement	N.S.		N.S.		***	
	38	1st measurement	4.98 ± 0.2		5.01 ± 0.2		35.58 ± 0.67A	
	38	2nd measurement	4.73 ± 0.2		4.86 ± 0.2		39.16 ± 0.67B	
		Birth Type	N.S		NS		***	
	12	12 Single	5.49 ± 0.25A		5.46 ± 0.28		35.72 ± 0.97A	
	19	19 Twins	4.51 ± 0.22B		4.78 ± 0.24		36.47 ± 0.82AB	
	7	7 Triplets	4.57 ± 0.32AB		4.57 ± 0.35		39.92 ± 1.20B	

N.S.: not significant, A,B: Difference between the groups with different letters in the same column is significant (P <0.05; ***P <0.001)

In a study conducted on Kıvırcık sheep, udder characteristics such as udder circumference, udder height, udder length, distance between two udders, teat width and teat length values were found to be 37.2 cm, 17.1 cm, 22.8 cm, 16.5 cm, 18.8 mm and 27.3 mm. respectively. The effect of control periods and live weight of ewes on the udder characteristics evaluated was found to be significant (P<0.05), and the effect of birth type was found to be insignificant (Akgün & Koyuncu, 2021) It is compatible with the study conducted. Karakuş & Ilyas (2020) on Iraqi Awassi sheep found that the effect of udder types on milk composition characteristics was insignificant. This is consistent with the results of the present study.

Milerski *et al.* (2020) in their study on a similar topic found that linear regressions of udder measurement traits only showed predictive trait ability for milk They found that measurements of hind udder depth and udder width can be used as a tool to increase milk production and herd management. However, they determined that the same was not true for predicting milk composition traits and somatic cell count.

Arcos-Álvarez, *et al.* (2020) concluded that there was an acceptable correlation (r = 0.60) between udder measurements, udder volume and daily milk yield in Pelibuey sheep. They stated that when direct measurements of milk production are not practically possible, measuring udders and their volumes is a viable alternative method to estimate milk yield production as an indirect method.

Kutan & Keskin (2022) found that the marketable milk yield and udder sizes were determined after weaning in sheep. At the end of the study, positive and significant (P<0.05 and P<0.01) correlations were calculated between teat length, teat circumference and udder width over the teat, and marketable milk yield. Researchers have found that milk yield increases as udder sizes increase in sheep, and this is consistent with the study.

In the current study, concerning the birth types, the difference in the singleton birth type was found to be significant when compared to the twin birth type (P<0.05), while it was deemed insignificant when compared to the triplet birth type. Banchero *et al.* (2004) reported that sheep giving birth to twins had larger teat diameter compared to those giving birth to singles. The data regarding teat diameters obtained from sheep giving birth to singles and twins in the current study were found to be different from the values reported by Banchero *et al.* (2004).

The current study examined milk quality characteristics, including milk fat content, milk quantity, and dry matter ratios. The analysis of the samples revealed that the type of udder did not have a significant effect on milk fat content, and birth type was found to have a significant effect (P<0.05). (Table 4).

In sheep, numerous factors such as genotype, management-nutrition, body condition, birth type, age and live weight have an impact on milk yield. Similarities and variations exist in characteristics observed throughout the lifetime of sheep, just as in other livestock species, depending on breed and individual traits (Tekel *et al.,* 2003). In the study conducted by Altın *et al.* (2003), the daily milk yield for Kıvırcık and Karya sheep was found to be 220 ml and 306 ml, respectively. In the study by Doğan *et al.* (2013), the daily milk yield for Anatolian Merinos breed sheep was 0.530 litres, and in the study by Haile *et al.* (2017), it was found to be 0.84 kg for Awessi breed sheep. In the current study, the daily milk yield results were determined to be 326 ml in the first measurement and 283 ml in the second measurement. It should be noted here that the results should be evaluated taking into account the control periods, the assessment method, and the results arising from breed differences. In this study, the daily average milk yield was found to be inversely proportional to the number of lambs born from a sheep. In this breed, since type 1udders are generally more suitable for milking when compared to other types of udder, lambs are able to suckle more easily and a higher amount of milk can be obtained.

Table 4 Factors affecting milk fat, daily average milk yield, and milk dry matter

Udder Type	n	Milk Fat (%) $\bar{X}$ ± S			Average Daily Milk Yield (ml) $\bar{X}$ ± S		Milk Dry Matter (%) $\bar{X}$ ± S	
		N.S			N.S		N.S	
1	4	1st measurement	7.43 ± 0.47	8.26 ± 0.41	377.14 ± 45.88	333.39 ± 38.56	11.97 ± 0.4	11.31 ± 0.36
		2nd measurement	8.01 ± 0.47		289.64 ± 44.08		10.64 ± 0.48	
2	13	1st measurement	7.59 ± 0.27	7.22 ± 0.23	329.01 ± 25.92	308.62 ± 21.95	12.93 ± 0.23^{A}	12.15 ± 0.21
		2nd measurement	6.85 ± 0.27		288.24 ± 24.94		11.36 ± 0.29^{B}	
4	15	1st measurement	7.8 ± 0.26^{A}	7.21 ± 0.23	286.41 ± 25.66	273.08 ± 22.21	12.76 ± 0.23^{A}	12.19 ± 0.21
		2nd measurement	6.63 ± 0.26^{B}		259.74 ± 24.80		11.63 ± 0.26^{B}	
5	6	1st measurement	7.07 ± 0.38	7.15 ± 0.33	312.61 ± 37.42	304.27 ± 31.44	12.86 ± 0.33^{A}	12.08 ± 0.3
		2nd measurement	7.22 ± 0.38		295.94 ± 35.95		11.29 ± 0.39^{B}	
		Measurement	**		*		***	
	38	1st measurement	7.74 ± 0.18^{A}		326.29 ± 17.6^{A}		12.63 ± 0.16^{A}	
	38	2nd measurement	7.18 ± 0.18^{B}		283.39 ± 16.94^{B}		11.23 ± 0.18^{B}	
		Birth Type	*		***		*	
	12	12 Single	5.49 ± 0.25A		5.46 ± 0.28		35.72 ± 0.97A	
	19	19 Twins	4.51 ± 0.22B		4.78 ± 0.24		36.47 ± 0.82AB	
	7	7 Triplets	4.57 ± 0.32AB		4.57 ± 0.35		39.92 ± 1.20B	

A,B: Difference between the groups with different letters in the same column is significant (**P* <0.05, ***P* <0.01, ****P* <0.001)

The average fat content in the research flock of Eşme sheep was determined to be 7.74% in the first measurement and 7.18% in the second measurement. At the first measurement of lactation, milk yield was higher and fat content was lower. However, as lactation progressed, the opposite was observed. Singh & Bhakat (2022) found that body weight in the pre- and postnatal period was strongly related to milk yield and udder health status.

Fat is one of the most important components of milk and the value of milk is often assessed based on its fat content. This value is ~6.99% on average (Barłowska *et al.,* 2011; Kiper, 2016). In other studies, Abd Allah *et al.* (2011) found fat content to be 5.62% in Rahmani sheep and 4.73% in Chios sheep; Sezenler *et al.* (2016b) reported 5.26% for Bandırma sheep, whereas Çelik & Özdemir (2003) and Yılmaz *et al.* (2011) found fat content to be 5.30% and 6.31%, respectively, in a Morkaraman breed sheep.

It can be said that this variation is due to differences in feeding, rearing practices, and climatic conditions. Additionally, the main reasons for the high fat content in the sheep of the research flock are believed to be the intensive supplementary feeding in addition to grazing and the reduction of milking from twice a day to once a day towards the end of lactation. The average dry matter ratio in the research flock of Eşme sheep was found to be 12.63% at the first measurement and 11.23% at the second measurement. There was a strong effect of measurement time on dry matter ratio (*P* <0.001). Udder type was similar between treatment groups, but the effect of birth type was statistically significant (*P* <0.05). The fat-free dry matter ratio in the milk obtained from sheep giving birth to singles was higher than that of sheep giving birth to twins and triplets. This finding of the study concurs with previous research, as Çelik & Özdemir (2003) reported a value of 11.41% for Morkaraman sheep, Pavic *et al.* (2002) found 11.45% for Travnik breed sheep, and Şahan *et al.* (2005) reported 10.93% for Awessi sheep.

In the current study, factors affecting milk quality characteristics such as density, protein, and lactose in milk were examined, and udder type did not affect these. Measurement time affected milk density (*P* <0.001), as did birth type (*P* <0.05) (Table 5).

Table 5 Factors affecting milk density, protein, and lactose in Esme sheep

Udder Type	n	Density (%) $\bar{X}$ ± S			Protein (%) $\bar{X}$ ± S		Lactose (%) $\bar{X}$ ± S	
		N.S			N.S		N.S	
1	4	1st measurement	31.19 ± 1.36	31.66 ± 1.8	4.34 ± 0.15	4.18 ± 0.16	6.55 ± 0.23	6.32 ± 0.2
		2nd measurement	32.12 ± 2.77		4.01 ± 0.22		6.1 ± 0.26	
2	13	1st measurement	36.25 ± 0.77	34.26 ± 1.05	4.69 ± 0.09A	4.52 ± 0.09	7.07 ± 0.13A	6.72 ± 0.11
		2nd measurement	32.27 ± 1.65		4.34 ± 0.12B		6.37 ± 0.15B	
4	15	1st measurement	35.91 ± 0.78	34.71 ± 0.99	4.63 ± 0.09A	4.45 ± 0.09	7 ± 0.13A	6.73 ± 0.11
		2nd measurement	33.51 ± 1.47		4.27 ± 0.12B		6.46 ± 0.14B	
5	6	1st measurement	37.35 ± 1.11	35.35 ± 1.47	4.7 ± 0.12A	4.4 ± 0.13	7.08 ± 0.19	6.71 ± 0.16
		2nd measurement	33.35 ± 2.26		4.1 ± 0.18B		6.34 ± 0.21	
		Measurement	*		***		***	
	38	1st measurement	35.17 ± 0.53^{A}		4.59 ± 0.06^{A}		6.92 ± 0.09^{A}	
	38	2nd measurement	32.81 ± 1.05^{B}		4.18 ± 0.08^{B}		6.32 ± 0.1^{B}	
		Birth Type	*		*		*	
	12	12 Single	35.69 ± 0.95^{A}		4.59 ± 0.1		6.88 ± 0.12	
	19	19 Twins	32.29 ± 0.84^{B}		4.32 ± 0.08		6.51 ± 0.10	
	7	7 Triplets	34 ± 1.14^{AB}		4.25 ± 0.12		6.47 ± 0.15	

N.S.: non-significant, A,B: Difference between the groups with different letters in the same column is significant (*P* <0.05; ****P* <0.001)

The protein content varied with measurement time (*P* <0.001) and birth type (*P* <0.05), but not udder type. The protein content of sheep milk is typically ~5.73% on average (Barłowska *et al.,* 2011; Kiper, 2016). De la Fuente *et al.* (2011) reported a protein content of 5.59% in Churra sheep milk, McKusick *et al.* (2000) found 6.72% in East Friesian sheep, Raicheva *et al.* (2009) reported values of 5.54% for Chios and 5.90% for West Balkan Mountain sheep. The current study found that the protein content obtained from the milk of Eşme sheep was lower compared to values in other studies. It is believed that this difference may be attributed to variations in nutrition and breed.

In a study examining milk yield and some milk quality characteristics in Akkaraman, Bafra, and Bafra × Akkaraman F1 sheep, the overall average was 5.85%, 5.02%, and 5.03% for protein (*P* >0.05); 4.89%, 5.04%, and 5.02% for lactose (*P* >0.05); 16.81%, 16.42%, and 16.67% for dry matter, respectively (Kahraman & Özkul, 2020). The results of the current study were low. The reason for this would be due to breed differences.

The lactose content varied with measurement time (*P* <0.001) and birth type (*P* <0.05), but not udder type. Sheep milk typically contains an average of 4.75% lactose (Barłowska *et al.,* 2011; Kiper, 2016). Tančin *et al.* (2017) found a lactose content of 4.59% in Lacaune sheep, Simos *et al.* (1996) reported 4.77% in Epirus mountain sheep, and Williams *et al.* (2012) observed a value of 4.49% in West African Dwarf sheep. The lactose content of Eşme sheep milk is higher than in the aforementioned sheep breeds, probably due to differences in nutrition and breed.

Marchall *et al.* (2023) in their study of dairy sheep in New Zealand found that age had a significant impact on all udder and teat characteristics, and was associated with lower milk, fat, protein, and lactose yield from udders above the hock. They found that the milk fat content of well-adhered udders was also lower. Sheep have associated backward-angled teats with lower milk and lactose yield. This is similar to the obtained results of the current study. Türkyılmaz *et al.* (2018) found that there was a positive correlation between udder depth density, protein, lactose, and ash in their study on Morkaraman sheep.

In a study conducted on Kıvırcık breed, the contents of fat, solids (not fat), protein, lactose, density, conductivity, and pH of milk samples taken during the control period were 7.7%, 11.2%, 5.,8%, 4,51%, 1,033 g/cm^3, 3, and 9. Treatment effects altered the content of daily milk yield, somatic cell count, fat, fat-free dry matter, density, protein, lactose, conductivity, and pH relative to the control (P <0.01), but these were not affected by either live weight or birth type. Udder characteristics were affected by live weight and treatment (P <0.05, P <0.01, respectively) but not type of birth (Akgün, 2019). The results indicate differences in the quality characteristics of the milk due to breed. Sari *et al.* (2015), in their study on Tuj sheep, found that the strongest positive correlations were between fat-free dry matter and density (0.92 and 0.96), lactose (0.95 and 0.96), mineral (0.98 and 0.99), and 70 months of lactation. The results were determined on the 100th day of lactation.

The milk samples were examined for salt, freezing point, and conductivity, and it was determined that the measurement time had a significant effect on the freezing point and conductivity (P<0.01), while the effect of udder type and birth type was found to be insignificant (Table 6).

Table 6 Factors affecting salt, freezing point, and conductivity in milk

Udder Type	n	Salt (%) $\bar{X} \pm S$			Freezing Point (°C) $\bar{X} \pm S$		Conductivity (mS/cm) $\bar{X} \pm S$	
		N.S			N.S		N.S	
1	4	1st measurement	0.93 ± 0.03	0.94 ± 0.03	-0.91 ± 0.06	-0.88 ± 0.04	4.19 ± 0.08	4.48 ± 0.11
		2nd measurement	0.95 ± 0.05		-0.84 ± 0.06		4.77 ± 0.19	
2	13	1st measurement	1.01 ± 0.02	0.98 ± 0.02	-1 ± 0.03	-0.92 ± 0.02	4.12 ± 0.04A	4.38 ± 0.06
		2nd measurement	0.95 ± 0.03		-0.84 ± 0.03		4.64 ± 0.11B	
4	15	1st measurement	1 ± 0.02	0.97 ± 0.02	-0.98 ± 0.03	-0.93 ± 0.02	4.09 ± 0.04A	4.54 ± 0.06
		2nd measurement	0.95 ± 0.03		-0.89 ± 0.03		5 ± 0.1B	
5	6	1st measurement	0.98 ± 0.03	0.94 ± 0.03	-0.95 ± 0.05	-0.9 ± 0.03	4.05 ± 0.06A	4.41 ± 0.09
		2nd measurement	0.9 ± 0.04		-0.86 ± 0.05		4.77 ± 0.16B	
		Measurement	*		*		***	
	38	1st measurement	0.98 ± 0.01^{A}		-0.96 ± 0.02^{A}		4.11 ± 0.03^{A}	
	38	2nd measurement	0.94 ± 0.02^{B}		-0.86 ± 0.02^{B}		4.79 ± 0.07^{B}	
		Birth Type	N.S		**		N.S	
	12	12 Single	0.99 ± 0.02		-0.98 ± 0.02^{A}		4.53 ± 0.06	
	19	19 Twins	0.94 ± 0.02		-0.87 ± 0.02^{B}		4.41 ± 0.05	
	7	7 Triplets	0.94 ± 0.02		-0.88 ± 0.03^{B}		4.42 ± 0.07	

N.S.: non-significant, A,B: Difference between the groups with different letters in the same column is significant (*P <0.05; **P <0.01; ***P <0.001)

Na^+, Cl^-, and K^+ are among the most important anions and cations in milk and play important roles in determining electrical conductivity (Hillerton & Walton, 1991). Conductivity varied with measurement time (P <0.001) but not birth or udder type. The electrical conductivity obtained in the current study was higher than the values reported by Peris *et al.* (1991) for Manchego sheep milk (4.06 mS/cm) and Ayar *et al.* (1998) for Karakaş and Hamdani sheep (4.030 mS/cm). Furthermore, no other studies related to salt and freezing point in sheep milk were found. Şeker *et al.* (2024), in their study on Bafra sheep, determined the freezing point of the milk as -0.80 ± 0.009°C and the conductivity as 5.26 ± 0.03. While the freezing point was compatible with the current study, the conductivity was higher.

Conclusions

In the current study, the differences in udder characteristics were due to the decrease in milk yield. The distance between the teats increased in the second measurement and this was thought to be due to the decrease in milk yield at the second measurement. As the number of lambings increased, the amount and frequency of suckling would increase and this would have an effect on the teat. The size of the teat is very important both for suckling and the use of the milking machine. In terms of milk quality, the amount of milk was higher at the beginning of lactation, whereas fat content increased as lactation progressed. Nutritional and environmental conditions play an important role. Milk quality decreased with multiple births. This is an indication that fertility affects milk quality. When examining the milk quality characteristics, the effects of breed and fertility characteristics should be considered. When looking at productivity in breeding studies, udder characteristics such as suitability for milking should also be considered. Udder measurements are also a trait used to estimate milk yield and these traits should be considered in selection studies. In the current study, udder measurements and types of Eşme sheep are suitable for milking, and the breed is satisfactory for breeders in terms of milk quality. To promote the breeding of the indigenous Eşme sheep, it is necessary to provide support and carry out promotional activities.

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Conflict of Interest Declaration

The authors declare that they have no conflict of interest.

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